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DATA COMMUNICATION AND COMPUTER NETWORKING
SYLLABI-BOOK MAPPING TABLE Data Communication and Computer Networking UNIT-I Fundamentals of Data Communication :AnalogVersus Digital, Fundamentals of Data Transmission Communication Modes Transmission System, Synchronous System, Communication Channnels-Modems : Classification of Modems Modem Based onRange Modems Based onLine Modems Based onOperationMode Modems Based on Synchronization Modems Based on Modulation. Data Transmission Protocol : Protocols An Overview of Networking The Role of Computer Networks in Development, Transmission Media : Introduction Transmission Concepts and Terms Master Sites Interconnection to Telephone. Unit-II Local Area Network : Local Area Network Baseband Versus Broadband LAN Hardware LAN Operating Systems. Implementing LAN : Implementation of LAN Using Fiber-Optic Cables Implementation of LAN UsingWirelessTechnologyFastLANs Non-standard LANs. Extending LAN : Transmission Concepts and Terms, Master sites, Interconnection to Telephone. Unit-III Data Transmission Network : Telephone Networks, Wan Technologies. TCP/IP and the Internet : History of Internet, Internet2 Internet Services Standards for TCP/IP and the Internet RFCS and the TCP/IP Standardization Process. NetworkArchitecturesand OSI, NetworkArchitecturesLayeringthe Communications Process The Need for Layered Solutions Open SystemsInterconnection (OSI) Model. Routing and Congestion Control : Routing Concepts Routing in WideArea Networks Hop-By-Hop versus Source Routing Congestion Control, Deadlocks. Queueing Theory: Basic Design Techniques : Basic Concepts, Queueing Model and Factors Traffic TheoryLost Call Rate. Unit-IV Wide Area Network : Introduction Network Using WAN and Network Services Communication Protocols Over WAN. Transmission Control Protocol/Internet Protocol (TCP/IP) : LAN Protocol and OSI TCP/IP Protocol Data Transmission by TCPand Ethernet Data Encapsulation Data RoutingTCP/IPServices andApplication Protocols. Data Link Layer Address : Physical Address. Naming, Addressing, and Routing : Network Layer Addresses Subnet Address Resolution Protocol (ARP) Domain NameSystem(DNS). Unit-V BroadbandNetwork: Local Loop TechnologiesAsymmetric

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Digital Subscriber Line (ADSL) High Bit-Rate Digital Subscriber Line (HDSL), Line Coding Techniques Wireless Local Loop (WLL). Security : Basic Requirements of Network Security,

Security Levels Data SecurityInvalidAccess/ PossibilityofEavesdropping Firewalls (Access Control) Encryption SecurityAgainst Remote Access. Electronic Mail and other Internet Services : Electronic Mail E-MailAddresses Format ofAMail Message Some Important Features of E-Mail ServicesAvailable on The Internet, Electronics Commerce and EDI, Electronic Commerce Internet:ATool for Electronic Commerce Electronic Data Interchange (EDI), Implementing EDI - Major Considerations User Characteristics and Electronic Commerce , Issues in Electronic Commerce. Syllabi Mapping in Book Unit-1: Unit-1: Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol (Pages 3-44) Unit-2: LocalArea Network, Implementing and Extending LAN (Pages 45-95) Unit-3: Data Transmission Network, TCP/IP and OSI Model (Pages 97-168) Unit-4: WideArea Network, TCP/IP and Data Link Layer Addressing (Pages 169-251) Unit-5: Broadband Network and Internet Services (Pages 253-324) INTRODUCTION 1 UNIT 1 FUNDAMENTALS OF DATA COMMUNICATION, COMMUNICATION CHANNELS AND DATA TRANSMISSION PROTOCOL 3-44 1.0 Introduction 1.1 Unit Objectives 1.2 Methods of Data Transmission 1.2.1 Analog versus Digital 1.2.2 Data Transmission 1.2.3 Comparison of Analog and Digital Data Transmission 1.2.4 Commuincation Modes 1.2.5 Synchronous System 1.3 Communication Channels: Bandwidth and Data Rate Throughout 1.4 Modems 1.4.1 Classification of Modems 1.4.2 Modems Based on Range 1.4.3 Modems Based on Line 1.4.4 Modems Based on Operation Mode 1.4.5 Modems Based on Synchronization 1.4.6 Modems Based on Transmission Medium 1.4.7 Amplitude Modulation 1.5 Data Transmission Proctocol 1.5.1 Protocols: Overview of Networking, Role of Computer Networks in Development 1.6 Transmission Media 1.7 Transmission Concepts and Terms 1.7.1 Extending LAN - Master Site and Interconnection to Telephone 1.8 Answers to 'Check Your Progress' 1.9 Summary 1.10 Key Terms 1.11 Self Assessment Questions and Exercises 1.12 Further Reading UNIT 2 LOCALAREA NETWORK, IMPLEMENTINGAND EXTENDING LAN 45-95 2.0 Introduction 2.1 Unit Objectives 2.2 Local Area Network 2.2.1 Broadband versus baseband 2.2.2 LAN Hardware and LAN Operating System 2.3 Implementation of LAN using Fiber-Optic Cables 2.4 Implementation of LAN usingWireless Technology 2.5 Extendling LAN : Transmission Concepts and Terms 2.5.1 Radio 2.5.2 VeryLowFrequency(VLF) 2.5.3 Microwave Transmission 2.5.4 Satellite Communication CONTENTS
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Levels of Security 5.4.3 Data Security 5.4.4 Basic Techniques 5.5 Firewalls 5.6 Data Encryption 5.7 Authentication 5.8 Viruses 5.9 Internet Privacy and Security Attacks 5.9.1 Key Management 5.10. Electronic Mail and Internet Services 5.10.1 Sending E-Mails via Internet 5.11 Electronic Commerce 5.11.1 Internet:ATool for Electronic Commerce 5.12 Electronic Data Interchage (EDI) 5.12.1 EDI Implementation 5.13 electronic commerce user characteristic and issues 5.13.1 Advantages and Disadvantages of E-commerce 5.13.2 limitations of E-commerce 5.14 Answers to 'Check Your Progress' 5.15 Summary 5.16 Key Terms 5.17 Self Assessment Questions and Exercises 5.18 Further Reading

Introduction NOTES Self - Learning Material 1 INTRODUCTION Computers have brought about major changes in all spheres of life. Today, it is extremelydifficult toimagine the world without computers.Computers helpus, communicateusingmodems, telephoneandWi-Fifacilitiesanditseemsasifyou arecommunicatingdirectlywitheach other.Internetlinksarecomputernetworks across the world so that users can share resources and also communicate with eachother.Theadvancesintelecommunicationtechnologieshavemadeitpossible forcomputerstointeractwitheachothertoprovideservicestoalllinesofbusiness. The studyof data communication and computer networks becomes essential to know more about computing techniques and communicationtechnologies. It is nowinevitableforeverybody,fromhigh-techcompanyprofessionalstoelementary students,tohaveagoodinsightoftheprinciplesofdatacommunicationtobecome aware of howit can be used in the growth of networking,and thereafterInternet, which has influenced almost everyaspect of life. Conveniences likeATM bank services,Internet,videoconferencing,wirelesstelephonyandelectronicmailcould not have been possible without data communication and computer networks. Communicationfacilitiesavailablewithanorganizationorwithanindividual,measure the level ofstandard forthem. This book is directlylinked to the various aspects ofdata communication and computer networking vis-à-vis related emergingtrends in network-centric information technology. It attempts to provide students a framework of data communicationandcomputernetworks,fundamentalconceptswhichhavealready madeaveryimportant placeinthe lifeofengineers,managers,professionals and individuals. It does not boast about making you a computer network expert or technician butpromisestofocusonthefundamental understandingofthevarious concepts involved inmodern data communicationandcomputernetworks. Data communication and computer networks form are an extremelyexcitingfield of study,andtherefore,agoodamountofemphasishasbeenputtoprepareobjective questionsalsosothat thereadermayenjoytheexercises inthemost effectiveway to test theirunderstanding of the concepts. This book provides a good learningplatform for students who need to be skilled inthearea of datacommunication andcomputer networks without going into the elaborate details of computer programming. It explains the underlying concepts of data communication and computer networks so that students may visualizecommunicationsystemsfromthehardwarelevelrightuptotheapplication level.Thisbookcoversmostofthecurrentlyrelevantareasofdatacommunication and computer networks. This book, Data Communication and Computer Networking, follows theSIMformatwhereineachUnitbeginswithanIntroductiontothetopicfollowed byanoutlineofthe'Objectives'.Thedetailedcontentisthenpresentedinasimple and an organized manner, interspersed with 'CheckYourProgress'questions to test the understanding of the students. A'Summary'along with a list of 'Key Terms'and a set of 'Self-Assessment Questions and Exercises'is also provided at theendofeach unitfor effectiverecapitulation.

Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning Material 3 UNIT 1 FUNDAMENTALSOFDATA COMMUNICATION, COMMUNICATION CHANNELS ANDDATATRANSMISSION PROTOCOL Structure 1.0 Introduction 1.1 Unit Objectives 1.2 Methods of Data Transmission 1.2.1 Analog versus Digital 1.2.2 Data Transmission 1.2.3 Comparison of Analog and Digital Data Transmission 1.2.4 Commuincation Modes 1.2.5 Synchronous System 1.3 Communication Channels: Bandwidth and Data Rate Throughout 1.4 Modems 1.4.1 Classification of Modems 1.4.2 Modems Based on Range 1.4.3 Modems Based on Line 1.4.4 Modems Based on Operation Mode 1.4.5 Modems Based on Synchronization 1.4.6 Modems Based on Transmission Medium 1.4.7 Amplitude Modulation 1.5 Data Transmission Proctocol 1.5.1 Protocols: Overview of Networking, Role of Computer Networks in Development 1.6 Transmission Media 1.7 Transmission Concepts and Terms 1.7.1 Extending LAN - Master Site and Interconnection to Telephone 1.8 Answers to 'Check Your Progress' 1.9 Summary 1.10 Key Terms 1.11 Self Assessment Questions and Exercises 1.12 Further Reading 1.0 INTRODUCTION Inthisunit,youwilllearnaboutthedatacommunication,variouschannelsfordata transmissionandtransmission Data Communication is a process of exchanging data or information. In case of computer networks this exchange is done between two devices over a transmissionmedium.Thisprocessinvolvesacommunicationsystemwhichismade upofhardwareand software. Thehardwarepart involves thesenderandreceiver devicesandtheintermediatedevicesthroughwhichthedatapasses.Thesoftware part involves certainrules which specifywhatis tobecommunicated,howit is to be communicated and when. It is also called as a Protocol.
Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning 4 Material Datatransmissionanddatareception(or,morebroadly,datacommunication ordigitalcommunications)isthetransferandreceptionofdata(adigitalbitstream or a digitized analog signal) over a point-to-point or point-to-multipoint communicationchannel.Examplesofsuchchannelsarecopperwires,opticalfibers, wireless communication channels, storage media and computerbuses. The data are represented as an electromagnetic signal,such as an electrical voltage, radio wave,microwave,orinfrared signal. In data communication terminology, a transmission medium is a physical pathbetween thetransmitterand thereceiver,i.e.,it is thechannel throughwhich data is sent from one place to another.Acommunication channel that is used to carry

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the data in the form of bits from the sender to the receiver

using LAN is known asTransmission media. Here, thetransmission of data canbe done using electromagnetic signals. In data communication, transmission media acts as a physical lane amongtransmitter & receiver.Theform of bits varies based on the type of network like for copper-based network; the bits are in electrical signals form whereas, in afibernetwork, thebits are inthelight signals form. 1.1 UNIT OBJECTIVES Aftergoingthroughthisunit,you willbeableto: ? Understandthefundamentalsofdatacommunication ? Discussthemethodsofdatacommunication ? Explaincommunicationchannels-modems ? Interpret datatransmission protocol ? Understand themodemofdatatransmission ? Define modem and discuss its types ? Discuss thevariousdatatransmission protocols ? Definetransmissionmedia ? Explainthetypes 1.2 METHODS OF DATATRANSMISSION Datatransmissioncanbedivided intoparallel andserial datatransmission. (i) Parallel Transmission One or more bytes of data are sent over two or more wires. Each wire transmits one digit of binary code. Therefore, sendingone byte (8 bits) of data requires 8 wires asshown in Figure1.1.In this type oftransmission,it is necessaryto detect where each byte of data is separated from the next. Normally, this detection is made onelapsed time base. Theinterface of aprinterwith PC is agoodexample for this case.

Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning Material 5 Fig. 1.1 Parallel Transmission System Two key issues occur in parallel transfer. The wire itself is the first issue. Minimum of nine wires (eight for data bits, one for circuit ground) are required. Many times extra wires are needed to control the flow of data across the interface. The other issue is with the nature of the bits or voltages itself. When there is change in the state of the bit/voltage from a one to zero, or vice versa, it happens at the rate of nanoseconds (one billionth of a second).A crucial part of the data transfer is the abruptness itself. The changes that occur slowly, i.e., between zero and one are not accepted as data. The electrical properties (capacitance and inductance) of a longer cable limit the suddenness with which a bit changes from zero to one, and corruption of data or loss becomes probable. Due to this, inherent speed in parallel transfer of data creates problems while transmitting over longer cables. Hence, its usage is limited to selected peripheral devices, such as printers used in close proximity to the computer, or that operates at high speed. (ii) Serial Transmission Dataissentoverasinglewireasshowninfigure1.2.Therefore,sendingonebyte does not require8 wires.Thesearesent oneaftertheother.Inthistransmission,it is necessary to detect where each bit is separated from the next and also where each block is separated from the next. Normally, theformer is detected based on elapsedtime,thelatterusingoneofavarietyofsocalledsynchronous system that willfollownext;forexample,theRS–232CinterfaceandEthernetcanbecitedin this category. Serial transmission is suitable for longdistance data transmission because it is less costly and more resistant to noise. Therefore, almost all transmissionlinesfordatacommunicationsystemsareserialtransmissionlines. Transmitting eight individual bits one after the otherinvolves eight times more time thantransmitting them all atthe same timeparallely.This speed lim it does notprovetobesignificantforseveralapplications.Comparedtotheinternal speed of the microprocessors, serial peripheral mechanisms are slower. They involvelong,mechanical processes which restricttheir speed: the speedsof their print-headsoftenlimittheprinters;thefrequencylimitationsofthetelephonelines affectthemodemsandtimeconsumingrotationalspeedlimitsthediskdrives.The speed that is built within the process of parallel data transfer is a waste on such peripheral mechanisms. The serial method thus, sacrifices a part of the speed whilesufficientlyservicingtheperipheraldevices.Insuchsituations,thesacrificein speed is unimportantcompared to theaddedtransmissionrangeandreliability.

Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning 6 Material Fig. 1.2 Serial Transmission 1.2.1 Analog versus Digital Data communication and networks deal with dataor information transmission. Datacanberepresentedinmanywayssuchasahumanvoice,abunchofnumbers, images, text and sounds, etc.Thereare two ways tocommunicate, display, store ormanipulateinformation,asfollows: ? Analog ? Digital Intheanalogformofelectroniccommunication,informationisrepresented as a continuous electromagnetic wave form as shown in Figure 1.3. Digital communicationrepresentsinformationinbinaryformthroughaseriesofdiscrete pulses as shown in Figure 1.4. Time Amplitude Fig. 1.3 Representation of Analog Signals Time Amplitude Fig. 1.4 Representation of Digital Signals

Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning Material 7 Analog Signal Analogis bestexplained bythetransmissionofsuch signals ashuman speech or sound, over an electrified copper wire. In its native form, human speech is an oscillatorydisturbanceintheairasshowninFigure1.3,whichvariesintermsofits volume,orpower(amplitude)anditspitchortone(frequency).Analogsignalsare thereforedefinedascontinuouselectricalsignalsvaryingintimeasshowninFigure 1.4.Analogousvariationsinradioorelectricalwavesarecreatedinordertotransmit the analog information signal for video or audio or both over a network from a transmitter(TVstationorCATVsource)toareceiver(TVset,computerconnected with antenna).At the receiving end, an approximation (analog) of the original information ispresented. Information that isanaloginits nativeform (imageand audio) can vary continuously in terms of intensity (brightness or volume) and frequency(colororTone)as shown in Figures 1.3and 1.4.Thesevariations inthe

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native information stream are translated, in an analog electrical network, into

variationsin thefrequencyandamplitudeofthecarriersignal.Inotherwords,

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the carrier signal is modulated (varied) in order to create an analog of the original informationstream. Theelectromagneticsinusoidalwaveformorsinewaveasshowninfigure 1.5canbevaried in amplitudeat afixed frequency,usingAmplitudeModulation (AM).Alternatively, the frequency of the sine wave can be varied at constant amplitude,

usingFrequencyModulation (FM).Additionally,bothamplitudeand frequency can be modulated simultaneously. Figures 1.6 and 1.7 represent a sinusoidal waveform in amplitude and frequencyform. The example of analog signal in the field of data communication is telephone voice signal in which the intensityofthe voice causes electriccurrent variations.At thereceivingend, the signal is reproduced in the sameproportion. Time Amplitude Fig. 1.5 Waveform in the Form of Sine Wave Time Amplitude Amplitude Fig. 1.6 Amplitude

Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning 8 Material Time Amplitude T Fig. 1.7 Frequency Representation Voice: A voice grade channel is approximately 4,000 Hz, or 4 kHz. Approximately3.3 kHz (200 Hz to 3,500 Hz) is used for the voice signal itself. Theremainingbandwidthisusedforthepurposeofnetworksignallingandcontrol inordertomaintainseparationbetweeninformationchannels.Whilehumanspeech transmission and reception encompasses a much widerrangeof frequencies, 3.3 kHz isconsideredtobequitesatisfactoryandcost-effective.Band-limitingfilters areusedincarriernetworks to constrain the amount ofbandwidthprovided for a voiceapplication. Video: ACATVvideo channel is approximately6 MHz.Approximately, 4.5MHzisusedforinformationtransmission,whilethebalanceisusedforguard bandstoseparatethevariousadjacentchannelsusingthecommon,analogcoaxial cablesystem. Digital Signal Computers are digital in nature. Computers communicate, store and process informationinbinaryform,i.e.,inthecombinationof1sand0s,whichhasspecific meaningincomputerlanguage.Abinarydigit(bit)isanindividual1or0. Multiple bit streamsareused in acomputernetwork.Thecomputersystems communicate inbinarymodethroughvariations inelectricalvoltage.Thedigitalsignalsthatare non-continuouschangeinindividualstepsconsistingofdigitsorpulseswithdiscrete values orlevels. The valueofeach pulseis uniform but there is anabrupt change fromonedigittothenext. Theyhavetwoamplitudelevels,whicharespecifiedas one of two possibilities like 1 or 0, high or low, true or false and so on. In other words,thedigitalsignalling,inanelectricalnetwork,involvesasignalwhichvaries in voltage to represent one of two discrete and well-defined states as depicted in Figure 1.8, such as either a positive (+) voltage and a null or zero (0) voltage (unipolar) or apositive (+) or a negative(–) voltage (bipolar). 1 0 0 0 1 1 0 1 0 1 0 +5V -5V Fig. 1.8 Binary Representation Forming Digital Signal

Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning Material 9 1.2.2 Data Transmission Fortransmissionacrossanetwork,datahastobetransformedintoelectromagnetic signals.Both,dataand signals canbeeitherofanalogtypeordigitaltype.Asignal is termed periodic if it has a continuouslyrepeating pattern. Therefore, the data andsignalsaretwoessentialbuildingblocksofanycomputernetwork.Signalsare the electric or electromagnetic encoding of data specifically used for data transmission.Adigitalsignalisacompositesignalwithaninfinitebandwidth. Signals Information exchangeis an essential part ofcommunication.It maybeexchange of information among users or equipment in the communication system. In the communicationcontext,signallingreferstotheexchangeofinformationbetween componentsrequiredtoprovideandmaintaindatacommunicationservice.Incase of PSTN (PublicSwitchedTelephoneNetwork),signallingbetween atelephone user and the telephone network mayinclude diallingdigits, providingdial tone, accessing a voice mailbox and sending a call-waiting tone etc. Looking at networking,perspectives,itistransmissionofserviceinformationsuchasaddresses, typeofserviceetc., between nodes and/orterminals ofanetwork.Inotherwords, itisaprocessofexchangingandgeneratinginformationbetweencomponentsofa telecommunications system to establish, release, or monitor connections (call handlingfunctions) and to control related network andsystem operations (other functions). Signalling System7 (SS7) SignallingSystem7(SS7)istheprotocol designedforpublicswitchedtelephone systemforprovidingservicesandsettingupcalls.Thevariousvalue-addedfeatures such as providing intelligence to PSTNservices come under the service of SS7. Earlierthesamephysicalpathwasusedforboththecall-controlsignallingandthe actualconnectedcall. This is calledin-band signallingtechnique.Thismethodof signallingwasinefficientandreplacedbyout-of-bandorcommon-channelsignalling techniques. Out-of-band signallingperforms its job byutilizingtwo networks in one.Asweknowthat inPSTN,ourvoiceanddataiscarriedovercircuit-switched network. It provides a physical path between the destination and source. The other one is the signalling network, which carries the call control traffic. It is a packet-switched networkusingacommon channelswitchingprotocol. Functions of SS7 ? It controls the network. ? The SS7 network sets up and tears down the call. ? It handles all the routing decisions and supports all telephony services includingLocalNumberPortability(LNP),remotenetworkmanagement, calledIDand forwarding. Inordertoaccomplishtheabovefunctions,SS7usesvoiceswitches,which are known as Service Switching Points (SSPs). They handle the SS7 control network as well as the user circuit-switched network. Basically, theSS7 control networktellstheswitchingofficewhichpathstoestablishoverthecircuit-switched

Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning 10 Material network. SSPs also queryService Control Point (SCP) databases using packet switchescalledSignalTransferPoints(STPs).TheSTPsrouteSS7controlpackets acrossthesignalingnetwork.TheconceptofSSP,STPandSCPhasbeenillustrated in Figure1.9. ? ? SSP SSP Voice Trunks STP SCP STP SCP SS7 Links SS7 Links Fig. 1.9 SS7 Signaling Points 1.2.3 Comparison of Analog and Digital Data Transmission Digitalsignalsareidentifiedthroughbitintervalandbitrate.Thebitintervalisthe time occupied by a single bit and

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the bit rate is the number of bit intervals per second

which is expressed in bits persecond or bps.Although analogvoice and video can be converted into digital, and digital data can beconverted to analog, even then,each format has its own advantages. Advantages of Analog Transmission Thefollowingaretheadvantagesofanalogtransmission: ? Analog transmission offers advantages in the transmission of analog information.Additionally,itismorebandwidth-conservativeandiswidely available. ? Analoghas an inherent advantage as voice, imageand videoare analogin nature.Therefore,theprocessoftransmissionofsuchinformationisrelatively straightforward in an analog format, whereas conversion to a digital bit stream requiresconversion equipment. Suchequipment increase cost,are susceptibletofailure,andcannegativelyaffectthequalityofthesignalthrough theconversionprocess, itself. ? Morebandwidthisconsumedbyarawinformationstreamindigitalthanin analogform.ThisisparticularlyevidentinCATVtransmission,where50or more analog channels are routinely provided over a single coaxial cable system. Without the application of compression techniques on the same cable system, onlya few digital channelscould be supported. ? Finally, analog transmission systems are already in place, worldwide. Interconnectionofthesesystemsisverycommonandallstandardsarewell established. As the majority of network traffic is voice and as the vast majority of voice terminals are analog devices, therefore, voice communication largelydependsonanalognetworks.Conversiontodigital networkswouldrequireexpensive,wholesaleconversionofsuchterminal equipment.

Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning Material 11

Advantages of Digital Transmission Thefollowingaretheadvantagesofdigitaltransmission: ? DigitalData: Whenitcomestothetransmissionofbinarycomputerdata, the advantage is with digital transmission. The equipment required for convertingdigitaldatatoananalogformatandsendingthedigitalbitstreams over an analog network can be expensive, susceptible to failure, and can createerrorsin theinformation. ? Compression: It is relatively easy to compress digital data, thus the efficiencyof transmission increases.As a result, image, video, voice and datainformationcanbetransmitted in substantialvolumesusingrelatively littlerawbandwidth. ? Security: Digital systemsofferbettersecuritywhileanalogsystems offer some measure of securitythrough the scramblingof several frequencies. Scramblingisfairlysimpletodefeat.Digitalinformation,ontheotherhand, can be encrypted to create the appearance of a single, pseudo-random bit stream.Thereby, thetruemeaning of, sets of bits andindividual bits orthe total bit stream that cannot bedetermined without the keythat unlocks the encryptionalgorithm thathas beenemployed. ? Quality: Digitaltransmissionoffersimprovederrorperformance(quality) as compared to analog. This is due to the devices that boost the signal at periodicintervalsinthetransmissionsysteminordertoovercometheeffects ofattenuation.Additionally,digitalnetworksdealmoreeffectivelywithnoise, whichisalwayspresentin transmissionnetworks. ? Cost: Thecost ofthecomputer componentsrequiredintransmissionand digitalconversionhasdroppedconsiderably.Atthesametimethereliability and ruggedness of those components has increasedover the years. ? Upgradability: It is relativelysimple to upgrade digital networks as the comprise of computer (digital) components. Such upgrades can enhance functionality improve error performance and increase bandwidth. Some upgrades canbe effected remotelyoveranetwork,eliminatingtheneed to dispatchexpensivetechniciansforthat purpose. 1.2.4 Commuincation Modes Fromtheviewpointoftransmission, communicationmodescanbeclassifiedinto thefollowingthreetypes: (i) Simplex Inthiscommunication mode, dataisalwaystransmittedonlyinonedirection.TV broadcastingisanexampleofsuchkindofcommunicationmode.Theinformation flows in onedirection across the circuit, withno capabilitytosupport a response in theotherdirection.Simplex transmissiongenerallyinvolves dedicatedcircuits as shownin Figure 1.10. Simplex circuits are analogous toescalators, doorbells, firealarmsandsecuritysystems.

Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning 12

Material Fig. 1.10 Simplex (ii) Half Duplex In this mode data is transmitted in one direction at atime, forexample,a walkie-talkie.Thisisgenerallyusedforrelativelylow-speedtransmission,usuallyinvolving two-wire, analog circuits as shown in Figure 1.11. Due to switching of communication direction, datatransmissioninthismoderequiresmoretimeand processesthanunderfullduplexmode.Examplesofhalfduplexapplicationinclude lineprinters, pollingofbuffers andmodem communications(manymodemscan supportfullduplex also). Fig. 1.11 Half Duplex (iii) Full Duplex In afull duplex mode datacan be transmitted inboth directions at thesame time. In general, four wires, as shown in Figure 1.12, are required for full duplex transmission.Fullduplextypicallyrequirestwosimplexcircuits,oneoperatingin eachdirection.All wide-band and broadbandcircuits arefull duplexin nature,as theycontainmostofthemultichannelcircuits.Moretypicalexamplesoffullduplex applicationsincludechannellinksbetweenhostprocessors,channellinksbetween controllers/concentrators and hosts, and other applications involving the interconnectionofsubstantialcomputingsystems.Services,suchasFrameRelay, SMDS(SwitchedMultimegabitDataService)andATM(AsynchronousTransfer Mode) arebasedon full duplex transmission. Fig. 1.12 Full Duplex 1.2.5 Synchronous System Thereceivingequipmentcannotdetect wherethetransmitteddatabeginsorends, if data does not include anysign indicatingthe separation of dataitems. In serial transmission, sendingequipment converts each ofthe characters into abit string and sends them sequentially over the transmission line. To receive correct information,thereceivingequipmentmustbeabletoreadthevalueofeachbitand also determinewhich bits are thebeginningandend ofeach character.

Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning Material 13 Forthisreason,receivingequipmentmustsynchronizewithsendingequipment duringreception ofdata. Synchronization refers tocorrectdetectionbyreceiving equipmentatthebeginningandendofdatathatwassentfromsendingequipment. Systems employed for this detection are called synchronization systems. Synchronous systemscan beclassified intothreecategories: ? Asynchronous systems (start-stop). ? Character synchronous systems (SYN synchronous). ? FlagSynchronoussystems. (i) Asynchronous System Asynchronous or character framed transmission as shown in Figure 1.13, is a method that grew out of telegraphy. From Latin and Greek, it translates as 'not togetherwithtime'.Inotherwords,itisnotsynchronous.Asynchronoustransmission isastart-stopmethodoftransmissioninwhichasignbitisaddedtothebeginning and end of each character (8 bits) in order to detect the separation of data items. Fig. 1.13 Asynchronous System These sign bits are called a start bit and stop bit, respectively.Thestart bit alerts thereceivingterminaltothetransmissionofsomethingworthyofitsattentionand astopbitinformsthereceivingterminalthatthetransmissionofthatsetofinformation befinished.Additionally,asynchronoustransmissionaddsaparitycheckingbitfor relativelypoor errorcontrol. The framing ofthe data withthese threeor four bits ofcontrol informationyields an overhead, orinefficiency,factorof20percent to 30 per cent. In almostall cases, a PCand amodem exchangedataasynchronously.The lengthofthestartandstopbitcanbespecifiedthroughPCcommunicationsoftware. Generally, astart bit is 1-bit long.Thelength ofastopbit canbe selectedas 1, 1.5 or 2 bits.Normally, the stop bit is also 1-bit long. (ii) Character Synchronous System Figure 1.14 shows a character synchronous (SYN synchronous) system. With this system, specialcharacters areadded tothebeginningofadatablockto allow detection of separation of data items. These special characters are called SYN characters.Thecharacterstring oftheSYNcharacteris 00010110.Upon receipt ofthischaracter,receivingequipmentdeterminesthatallsucceedingdataconsists of data bits. It then receives each succeeding 8 bits as one character. Normally, the sending equipment sends 2 or more SYN characters before sending data to ensuresynchronizationwithreceivingequipment.Thereceivingequipmentremains attentivetoSYNcharacters at all times so that it canreceivebit stringsother than SYN characters as data. String containing 00010110 (the same as the SYN character) cannot be used to transmit data.

Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning 14 Material Fig. 1.14 Character Synchronous System (iii) Flag Synchronous System Figure 1.15 shows a flag synchronous system. Within this system, a special bit string is sent before and after each data block to allow detectionof separation of data items. This string also continues to be sent when no data is beingsent over the transmission line. This string is calleda flag and consists of 01111110.The receivingequipmentconsidersbitstringsasdataiftheyarenotflagsofthisformat. Fig. 1.15 Flag Synchronous System Withthissystem, data ofadesired bit length canbesent. It mayseem impossible to send the same data bit string as the flag, i.e., 01111110. A method called transparencycan be used to send this flag as data. Transparencymeans that receiving equipment will use thesameformat as sendingequipment to receiveanydatainits original format.Tosendthesamebit string as the 01111110 flag string as data with a flag synchronous system, a techniquecalledzerobitinsertionorbitstuffingisused.Thistechniqueisexplained below: Ifthesendingequipment detectsabitstring11111(5consecutive1s)inthe data,itinserts a0 bitat theend tosend 111110.Ifthereceivingequipment detects abitstring111110,itdeletesthe0attheend.Althoughtheflag01111110contains abitstring11111, thesendingequipmentsendstheflagasiswithoutinsertinga0. When this technique is used, the data string 01111110 is converted into 011111010. Therefore, the same bit string, cannot appear in the dataas the flag. CheckYourProgress 1. What aretwo keyissues in parallel transfer? 2. What are the ways of data representation? 3. How the datais represented in computers? 4. Whatissignalling? 5. Definesignallingsystem.

Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning Material 15 1.3 COMMUNICATION CHANNELS Channel bandwidth maybesimplydefinedasthesizeoftherangeoffrequencies that canbetransmitted throughachannel. Inotherwords,wemaydefineit as the volumeofinformationperunittimethatacomputer,person,ortransmissionmedium canhandle. Itis measured in Hertz(Hz). Bandwidthisexpressedasdataspeedin bits per second (bps) in digital systems while as the difference between highest frequencyto lowestfrequencyin analogsystem.Bandwidthdetermines howfast data flows on a given transmission path. It is determined as the amount of data transmittedorreceivedperunittime.Asithasalreadybeenexplainedinnoisethat low bandwidth signal produces less internal noise comparedto high bandwidth signal; thereforethisis preferred. However,inthis case,wehavetosacrifice data transmissionspeed.Therefore,atrade-offbasedontheperformancerequirements is required to be determined. Bandwidth is dependent on the varietyand physical characteristics of the transmissionmedia,theamountofnoiseinthecommunicationchannel,themethod of data encoding, etc. Channel data transmission rate (bit rate) Thehighestnumberofbitsthattransmitsinunittimethroughthephysicaltransmission media determines the channel data transmission rate. The unit of channel data transmissionrateisbitspersecond (bps).In1924,H.Nyquistgavethemaximum rateofdataofanoiselesscommunication channel.Further,C.Shannonextended the work of Nyquist and proposed a data rate for random noise. Nyquist stated that if an arbitrary signal has been run through a low pass filter of bandwidth H, the filtered signal can be reconstructed by sampling the signaltwicethefrequencyofthesignal.Mathematically, Maximum data rate = 2H Log 2 W/Second where,Wrepresents thenumber of discretelevels in the signal The above is a case of a noiseless channel. If random (internal) noise is present, the situation deteriorates rapidly. As we have already explained that SNR is given bya quantity10 log 10 S/N dB. Therefore, Shannon stated that the maximum data rate of anoisychannel whose bandwidth is H Hz and whosesignal to noise ratio S/N is given by Maximum data rate = H log 2 (1+S/N) Channel capacity Channel capacityis theamount of informationpassedthrough acommunication linkortransmissionchannel inunit time.Itis measuredinbits persecond. Transmission time It is the time taken bya signal to pass overa communicationlink or transmission media.Transmissiontimeis measured inseconds.It is calculatedbydividingthe maximum numberof bits in amessage bydata rate.The data rate is measured in bits persecond (bps). It is also given as thepacket length divided bythe channel capacity.

Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning 16 Material Propagation time (channel latency) It isthetimetaken byasignalorinformationtopropagateorpassfromthesource to thedestinationoveracommunicationlinkortransmissionmedia.Propagation time isdeduced bydividingthelength ofthecommunicationchannel ordistance from the source to the destination by the speed of signal propagation. The propagation speed of electromagnetic signals is normallytaken as the speed of light. The characteristics of the mediums, the speed of signal propagation and transmissiondistancearethemajorfactorsinfluencingchannellatency. Throughput Throughput maybe defined as the number of bits, characters,or blocks passing througha datacommunication system overaperiod oftime. Transmission time + Propagation on time bits in length Packet Throughput = Channel utilization The traction of the channels data rate that is used for the transmission of data is knownaschannelutilization.Fromthethroughputitisobservedthatthepropagation time and transmission time are two different parameters which are dependent uponthepathlengthandpacketlength, respectively(numberofbitsinamessage). Hence, a 1 a on Utilizati Channel where,aisgivenastheratioofpropagationtimeandtransmissiontimeand is knownas bit length. We may now consider an example to understand the above concepts. Suppose, a channel data transmission rate is 10 Mbps and time taken byone bit to transmit through channel 10 −7 seconds. The signal propagation speed in the medium is 2 × 10 8 m/s. The transmission rate is 1bit /10 −7 seconds that is equal to 107 bit per second (bps). Therefore, bit length will beequal to 2 ×10 8 m/s/10 7 bpswhich isequal to 20 meters. 1.4 MODEMS Thesquarewavesordigital signals arecomposedofwidespectrumandareprone to attenuation in the signal strength and distortion due to different frequency components of the signal. These signal impairment effects are not suitable for baseband (DC)signalling for higher speed and longdistances. Theyare suitable onlyforslowspeedsandovershortdistances.Thedatacommunicationalsoseeks to communicate over large distances. Hence, another technique called AC signalling is employed in which a continuous wave called sine wave is used.A sine wave is characterised by frequency, amplitude and phase.Anyone of the characteristics ofasinewaveismodulated inaccordancewiththeinformationso that the information can be transmitted over large distances inwhich sine wave acts as acarrier for information.
Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning Material 17 A devicethat accomplishes theabovefunction inwhich it accepts a series of bits inthe form of 0 and 1 as input and produces amodulatedcarrieras output at the transmitting end and a reverse operation at the receiving end is called a modem. In other words, a modem is an electrical component that can connect another modem over an analog telephony network. When two modems are connected, theycan send each other atwo-waystream ofdigitalbits.Acomputer sendsinformationtoanothercomputerlocatedataremotelocationusingmodems. Themodemreceivesdigitalinformationfromthecomputer,translatesittoananalog signalusingdigital-to-analogconverterunit(DAC)andsendstheanaloginformation tothePSTN.Ontheotherside,whenreceivingdatafromthenetwork,an analog-to-digitalconverter(ADC)unitisbeingusedtoretrievethedata.Itisimportantto know that DAC/ADC units are noisy units and are thus limitations on the performanceofthemodem. Thedatacommunicationtechniques weredevelopedbasedontheexisting telephonenetworksothat no extraexpendituremaybeincurredoninfrastructure.
Itwasthevoicecommunicationthathadnecessitatedthecommunicationbetween remote computers and computing devices using theexistingtelephone network for voice communication. Most of the telephone lines were installed for voice communication,andtherefore,theywereabletotransmitonlyanaloginformation. On the other hand, the computers and related computing devices were based on digitalsignalintheformofpulsesor0and1.Therefore,tousetheexistingtelephone linesortheanalogmedium,adevicethatmayconvertdigitalsignalintoanalogand vice versa was needed. This device is known as the modem and stands for modulatordemodulator.Itperformsthefunctionofmodulatinganddemodulating asignal. A modem, therefore, receives serial binarydata as its input. It modulates some of the characteristics of a sine wave like amplitude, frequency or phase generatedbyitinaccordancewiththeinput signalsothatthebinarysignalmaybe transmitted overlong distances.Areverseprocedure takes place at the receiving end where thereceived signal is demodulated to retrieve the binarysignal as the output of the modem which can be inputted to the digital device at the receiving end for further processing. In other words, the modem changes the analog informationintodigitalpulsesatthecomputerorthedigitaldeviceatthereceiving sideofthecommunicationlinkorchannel. Conventionally, modemsweredevised forcommunicationbetweenahost computer and data terminals. Subsequently, they were also deployed to communicate between remotecomputers and computing devices.As theywere usedtocommunicatebetweenremotedigitaldevices,theirdatatransmissionrates were also subjected to increase from 300 bps to 28.8 Kbps. The modem technologies were also upgraded to involve data compression techniques. However,theyincreasedtheadditionalburdenoferrordetectionanderrorcorrection tomaintainreliability. Therefore, the modem can be considered as a peripheral device for computers to enable two remote computers to communicate over standard telephone lines.Modems are developed in different shapes and sizes forvarious types of applications and needs. The word modem stands for modulator/

Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning 18 Material demodulator and performs the conversion of digital signals to analog signals (modulation)and viceversa(demodulation)as showninFigure1.16. Inordertoestablishinteroperabilityamongdifferenttypesofmodemsfrom differentmanufacturers,standardsformodeminterfaceweredeveloped.Modems are deployed to perform various types of functions. Some of them are used in voiceandtextmailsystems,facsimiles,etc.,andothersareattachedorassimilated intomobilephonesorlaptopsmakingdatatransmissionpossiblefromanylocation to anyother. In future, modems maybe utilized for other types of applications. Modem speeds are still around 28/56 Kbps and further increase in speed will be possibleonlyon digital phone technology, likeISDNandfibreopticlines.Some ofthenewapplicationsarevideophonesinwhichsimultaneouscommunicationof voice and data are performed. Fig. 1.16 Connecting Two Computers via Modems Modems continuouslygenerate a carrier signal to send information so that the information maybedelivered from onelocationto anotherremotelocation. The informationtobetransmittedissuperimposedonthecarriersignal.Inthismanner, thetransmittedinformationvariesormodulatesthiscarriersignal.Thetermsbaud and bps used to measure the data rateare verypopular with this technologyand arecontinuallyused interchangeably. However, theyarenot thesameat all. Thenumberofpulsestransmittedinasecondcharacterizesthecarriersignal in which each pulse is called a baud. The bps stands for bits per second and indicates the numberof bits that can be transmitted duringonepulse(one baud). Similarly, kbps stands forkilo bits persecond. Therefore, bps = baud × number of bits per baud. Thebaudandbpsoftencreateconfusionbecauseearlymodemswerebased on 1 bit per baud and used to transmit only 1 bit per baud. In such a case, for example,a2400 baud modem will also transmit 2400 bps.However, because of theneedofhigherspeeds, modems aredesignedto havemorenumberofbits per baud. Thedifferencebetween baud and bpscan beunderstoodfromthis analogy. Bit ratemeans thenumber ofbits (0 or1)transmittedduringone secondoftime. Thenumberofchanges in signalperunit oftimetorepresent thebitsis calledthe modem's data rate. This rate is expressed in terms of baud.Asignal unit may haveoneormorethanonebits.Therefore, baudsignifies thenumberoftimesper secondthelineconditioncan switchfrom 1to0.Baudrateandbitrate,whichare expressedinbitspersecond, arenotsimilar,asnumberofbitsmaybetransmitted Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning Material 19 bythemodemthroughthechannelineachsignalchange(somebitscanbesendas

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one symbol). The relation between bit rate and baud is that bit rate

is equal to baudratemultipliedbythenumberofbits representingeachsignal unit.Bitrateis alwaysmorethanorequaltobaudratebecausebaudratedeterminesthebandwidth

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required to transmit the signal. The signal maybe in the form of pieces or block that

maycontain bits.Afewer bandwidth is

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required to move these signal units withlargebitsfor an efficient system.To understandthe relationbetweenbit and baud rate, we consider an analogy of car, passengers and highway with signal units,bitsandbandwidth respectively. A car has

a capacity of carrying a maximum

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of five passengers at a time. Supposeahighwaymaysupport only1000cars perunittimewithoutcongestion, when each car on the highway carries five passengers, it is considered that the highwayis capable of providing services without congestion. Thus,

it is thought thatthehighwayprovidesanexcellentservice.Inanotherscenario,whenall

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these 5000 passengers wish to go in separate cars, they require 5000 cars

while the highwaycanonlysupport 1000carsatatime.Theservicesofferedgetdeteriorated because the

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highway's capacityis meant onlyfor 1000 cars. It does not bother as to whether these 1000 cars are carrying 1000 passengers or 5000 passengers or more. To support more cars, the highway needs to

be widened. Similarly, the numberofbaudsdetermines the bandwidth. 1.4.1 Classification of Modems Modems are classified based on these characteristics: ? Range: Short Haul, Voice Grade (VG), Wide band. ? Line Type:Theyuse dial-up, leased or private circuits. ? Operation Mode: Half Duplex, Full Duplex, Simplex are based on the directionofflowofinformation. ? Synchronization: Asynchronous, Synchronous. ? Modulation:Based onmodulation techniques suchasAM,FM/FSK,PM. ? Transmission Media: Radio, Optical, Dial-up. 1.4.2 Modems Based on Range (a) ShortHaul Short haul modems are widely deployed overprivate lines and are not part of a public system. These are economical solutions to systems of short ranges up to 15 km.

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Short haul modems canalso be used onan end-to-end length ofthedirect connection longer than 15 km, when bothends of the line

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called local loops are servedbythesameexchangeinthetelephonesystem.Theyaredistance-sensitive, because signal attenuation happens as the signal travels through the line. The

transmissionratemustbereducedtoensureconsistentanderror-freetransmission onlongerdistances. There aretwo main types ofshort haul modems: Analog Modems: They use a simple modulation method. Sophisticated devices for error control or equalizers are not employed. They operate at a
Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning 20 Material maximum rate of9600 bps, but thereare some, which support higherrates up to 64,000 bps. Line drivers: They increase the strength of the digital signal. Unlike conventional modems, theydo not transmit carriersignals tothecommunication channel.Linedriversareinexpensive,tinyanddonothaveapowersupply.Power supplytothelinedriveris providedthroughtheRS232connectoroftheterminal. (b) Voice Grade (VG) Voice grademodems have afrequencyrangeof moderate tohighdata rate.They havenolimitationabout distanceandarethereforeusedforlongdistances.These modemsareexpensiveand involveexpertiseintheirmaintenanceandtuning. Communication channels areleased lines and dial-upand uses telephone network for datatransmission on a dedicatedor dialed connection. Wideband Wideband modems find their use

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in large-volume telephone line multiplexing dedicated forcomputer-to-computer links. Theyprovidehigh data rates. 1.4.3 Modems Based on Line (

a) Leased Line Leased,privateordedicated linescomprising fourwiresarefortheexclusiveuse ofleasedlinemodems. Ithas twopairs outofwhichit useseitherpairforasimple point-to-pointconnectionorseveralconnectiononamulti-dropnetworkforpolling oracontentionsystem. In atelephonenetwork,theirtransmissioncharacteristics generallyensuretoprovidecertainspecifications.Inanothercase,ifthelinkincludes anyradiotransmission, its qualitymaybeas variable as that ofa switchedline. (b)Dial-up Dial-up modems are used for point-to-point connections on the PSTN by any combinationofmanualorautomaticdiallingoranswering.Thequalityofthecircuit mayvaryfrom carriers to carriers. It uses two-wire links.Afour-wire line can be used as

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a pair of two-wire lines for transmittingand receiving. In this case, the signals inthe two directions are kept

totallyseparate to avoid interference. 1.4.4 Modems Based on Operation Mode (a) Half Duplex As itsname indicates, the signal can bepassed in either direction,but not in both simultaneously.TheconceptofhalfduplexisexplainedinUnit1. Echo-suppressors are available in a telephone network which allow transmissioninonlyonedirection. Becauseofthisreason,thechannelactsashalf duplex. Echosuppressorsareslowlybeingreplacedbyechocancelers,whichare theoreticallyfull-duplex devices.Whenamodemis connectedtoatwo-wireline, itsoutputimpedancecannotbematchedexactlytotheinputimpedanceoftheline whichcausessomeofits transmittedsignaltoalwaysreflect back.Forthisreason half- duplex receiveraredisabled whentheir local transmitter is operative. Half-duplexmodems canwork in full-duplex mode.

Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning Material 21 (b) Full Duplex Fullduplexmeansthatsignalscanbepassedineitherdirection,simultaneously,as explainedearlier. Fullduplexrequirestwo-wirelineswheretwosimultaneoussignalsinopposite directions flow.Thisnecessitates theabilityofcircuits toseparateareceivesignal fromthereflection ofthetransmittedsignal.This isaccomplishedbyeitherFDM inwhichthesignalsinthetwodirectionsoccupydifferentfrequencybandsandare separated byfiltering, orbyechocanceling.Infull duplex,modems mayprovide full data rate in both directions or reduced data rate ineither direction.

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Modems that provide a low-speed reverse channel are sometimes called split-speed or

asymmetricmodems. (c) Simplex Simplextransmissionallowstransmissioninonedirectiononly.Aremotemodem foratelemeteringsystemcanbeconsideredasanexampleofsimplextransmission. Echo Suppressor and Echo Canceler A2-wirecircuit and thetrunk,which is a 4-wirecircuit,forms alocalloop.At the junction, echoes occur and the person speaking on the telephone hears his own words after ashort delay. Echo suppressors are used to eliminatethe problem of echoes.Theyareinstalled on lineslongerthan2000km.Incaseof short lines the effect of echoes are too fast to detect them.An echo suppressor differentiates between human speech coming from one end and echoes produced at junction becauseofimpedance mismatch of theconnection. It then suppressestheechoes going in the reverse direction. The device compares the levels at its two input ports. Itinserts an attenuatorinthe return pathofthetalkingend tosuppress echo and vice versa.
Echosuppressorsimprovethequalityoftelephonelines.Ithowever,prevents full-duplex datatransmission, which wouldotherwisebepossible,evenovera2- wire local loop. Sometimes, in a 2-wire local loop, a part of the bandwidth is allocatedin theforward direction and otherinthereversedirection.It alsoresults in delay because of switching time in either direction even if the half-duplex transmission is adequate.Moreover, theyare designedtoreverse upon detecting humanspeech and not digital data. In case of data, if it does not detect a specific tone, it shuts down and remains as long as the carrier is present. Echo suppressors are slowly being replaced by echo cancelers, which allow a certain amount of double-talking and do not require capture time for any one talker to assume control of the connection. 1.4.5 Modems Based on Synchronization (a)Asynchronous Modems Most modems that operate in

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slow and moderate rates, up to 1800 bps, are asynchronous.Asynchronousmodems operateinFSK(FrequencyShift Keying) modulation.Two frequencies for transmission and

anothertwofor receivingare
Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning 22 Material used. Asynchronous modems can be connected with different modes in a communicationmedia.Theymayuse: ? 2-wire or4-wire interface ? Switchedlinesorleased lines ? Interfacetocallunit/automaticanswer,whendialing-up (b)

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Synchronous Modems Synchronous modems operate in the audio range, at rates up to 28.8 kbps in

audiolines.Theyareused intelephones systems.Theusualmodulationmethods arephasemodulation and mix ofphaseandamplitudemodulationat rates higher than4800bps.Equalizersareusedinsynchronousmodemstooffsetthemismatch oftelephonelines. Theseequalizerscan beclassifiedintothreemaingroups: Fixed/Statistical equalizers: They

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offset the signal according to the average of the known attenuation in each frequency.

Theyare

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used to operate at low rates ina dial-up line. Manually adjusted

equalizers: They are tuned to optimal performance foragivenline. Theyneed tobetuned frequentlywhenthelineisofalowquality andchangesits parameters frequently. Automatic equalizers: They are tuned automatically depending on the linequalitywhentheconnectionisestablished. The operation of synchronous modems is similar to that of asynchronous modems. 1.4.6 Modems Based on Transmission Medium In additionto dedicated wires, modemsarealsousedwithothermedia,including RFtransmission,glassfibresandconventionaltelephoneconnections.Therefore, modems can also be classified based on the medium used. For example, RF transmission andglass fibres. Basically, threetypes ofmodems areinuse: (a) Radio Modems Thesecanbeusedtosenddataacrossapairofglassfibresusingaradiofrequency signal. (b) Optical Modems These can be used to send data across a pair of glass fibres using light. Such modems use an entirely different technology than modems that operate over dedicated wires. (c) Dial-up Modems Dial-upmodemscontainacircuitrythatmimicsthatofatelephone.Thatis,modems can simulatelifting the handset, dialing, or hangingup thetelephone. Second, a telephonesystem isdesigned to carrysound,adialupmodem uses acarrierthatis anaudibletone.Third,althoughtheysendallthedatathroughasinglevoicechannel, apairofdial-upmodemsofferfullduplexcommunication.Thatis,asingletelephone connection between two dial-up modems usually allows data to flow in both directions.

Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning Material 23 (d) Cable Modems It is a modem meant tooperate over cable TVlines and to facilitateyour desktop PC to connect with the Internet. Cable modems are devices that enable high- speedaccess totheInternet viaacable televisionnetwork.Whilesimilarinsome respectstoatraditionalanalogmodem,acablemodemissignificantlymorepowerful and capableof delivering data about 500 times faster. Thecoaxialcableused incableTVhas greaterbandwiththanatelephone line.Thisallowsittoachieveextremelyfastaccesstothelnternet.Anotheradvantage is that millions of homes alreadyhave a connection for cableTV. It has tried to overcomemanytechnicaldifficulties.Infact,thecoaxialcableusedincableTVis simplex innaturewhilean Internetconnectionrequires aduplextypeconnection where data needs to flow from theclient to the server. Cablemodems which can offer speeds up to 2 mbps are available in the market. A cablemodem needs two connections. One connection goes tothe cable wall outlet and the other to aPC ortoa set-topbox foraTVset.Althoughacable modem does modulation between analog and digital signals, it is a much more complexdevicethanatelephonemodem.Itcanbeanexternaldeviceorintegrated within acomputeror set-top box.Typically,thecablemodem attaches astandard 10BASE-TEthernet card in the computer. Figure 1.17 explains the general concept ofdata communication between two computers. Communication between two computers is accomplished with the helpofmodems. In thefigureeach computeris connected witha modem that converts digital signal output of the computerto analog output so that it maybe transmitted through transmission media that maybe wired or wireless.At the receivingendthemodemconvertsanalogsignaloutputofthetransmissionmedia intodigital inputso that thecomputercouldunderstandit.

DTE Modem Medium Modem DTE Fig. 1.17 Data Communication between Two Computers 1.4.7 Amplitude Modulation AmplitudeModulation(AM)refers tothemodulationoftheamplitudeofthecar- rier as analog sine wave. It occurs when a signal to be modulated is applied to a carrier frequency.Thecarrier frequencymaybea radio wave orlight wave.The amplitude ofcarrierwave changes accordingtothe amplitudeofthe modulating signal and the frequencyof carrierremains unchanged. Basically, theAM signal represents a sum of three sin waves of different frequencies. These are $f_c - f_m$, f_c , $f_c + f_m$. The sin wave with frequency f_c possesses the same amplitude as the un- modulatedcarrier.Theothertwowavesofequalamplitudesanddifferentfrequen- cies as $f_c - f_m$, $f_c + f_m$ are called as lower and upper side band respectively. The amplitudeofthelowerband and upperband,whichareequal,areproportional to

Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning 24 Material the amplitude of the modulating signal. It is clear from the above that the band- width is equal to $2f_m$, whichis deduced as the difference between theupper band andlowerbandfrequencies.Thus,theAMsignalconsistsofthecarriersignal,plus upper and lower side bands. This is known as Double Side Band -Amplitude Modulation (DSB-AM),ormore commonlyreferredtoasAM.This is shown in Fig.1.18.Astheinformationtobetransmittediscontainedinthesidebands,hence thecarrierfrequencyistransmitted at arelativelylowleveltoavoidtheadditional circuitryat the receivingend to generatethe carrier frequencyfordemodulation. This type of transmission is known as Double Side Band - Suppressed Carrier (DSB-SC). Fig. 1.18 Amplitude Modulation of a Carrier Wave It is also possible to transmit asingle side band. The advantageis a reduction inanalogbandwidthneededtotransmitthesignal.Thistypeofmodulationisknown as Single Side Band - Suppressed Carrier (SSB-SC) and is ideal for Frequency Division Multiplexing (FDM).Another type of analog modulation is known as Vestigial SideBand modulation.This isalmost likeSingleSideband,except that thecarrierfrequencyis preserved and oneofthesidebandsis eliminatedthrough filtering.VestigialSidebandtransmissionisusuallyfoundintelevisionbroadcast-ing.Amplitudemodulationisrarelyusedindividuallyasitishighlysensitivetothe impactsofattenuationandlinenoise.Themodulatingindexisgivenas: $m = E_{max} - E_c / E_c$ The above Equation, we may derive the followingequation for modulating indexm: $E_{max} - E_{min}$ $m = E_{max} + E_{min}$ Angle Modulation In anglemodulation, carrieris beingreproducedas follows: $f_c = B \sin É_c t + ? 2$ In the equation, there is an argument of sin as $? c t +? 2$ which can be varied in accordance with equation 1 and thus producingeither frequencyorphasemodu- lation. Ineither case, theamplitudeof the carrier remains unchanged with incre- mental change in $? c t + ? 2$. Frequency Modulation FrequencyModulationreferstothemodulationofthefrequencyoftheanalogsine wave as shown in Fig. 1.19 where the instantaneous frequencyof the carrier is

Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning Material 25 varied in proportion of the variation ofthe modulated carrier with respect to the frequencyoftheinstantaneousamplitudeofthemodulatingsignal.Itmaybesaid in asimpleword that itoccurs when thefrequencyofacarrierisvariedinpropor- tiontotheamplitudeofinputsignal.UnlikeAM,thefrequencyofthecarriersignal isvaried.FrequencyvariationsaremoreimmunetonoiseandthereforeFM mod- ulation is considered more immune to noise thanAM. This leads to the overall improvementinsignal-to-noiseratioofthecommunicationssystem.AsinFMonly frequencyisvaried,thereforetheamplitudeofthemodulatedsignalremains con- stant,whichgivesrisetoconstant power.However,thefrequency-modulatedsys- temimposesaconstraintintermsofbandwidthrequirement.Theyrequireagreat- erbandwidth totransmitFMsignal thantheAM.ThemodulatingindexforFMis givenasbelow: ^{2} = f p /f m , where ^{2} = Modulation index, f m = frequencyof the modulating signal and f p = peak frequencydeviation From theFig.1.19, it is inferredthat theamplitudeofthemodulatedsignal al- waysremainsconstant,irrespectiveoffrequencyandamplitudeofmodulatingsig- nal. It meansthat themodulatingsignaladds nopowerto thecarrierinfrequency modulationunliketoamplitudemodulation.FMproducesaninfinitenumberofside

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bands spaced bythe modulation frequency, f m that is not in case ofAM. There- fore,AM considered a linear process whereas FM as a nonlinear process. It is necessaryto transmit all side bands to reproduce a distortionfree signal. Ideally,

thebandwidthofthemodulated signal isinfiniteinthis case.Ingeneral thedeter- minationofthefrequencycontent ofanFM waveformis

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complicated,but when^{2} is small,thebandwidth oftheFM signal is 2f m . Onthe other hand when^{2} is large, the bandwidth is determined (empirically) as 2

f m (1 + ^{2}). Fig. 1.19 Frequency Modulation Fig. 1.20 Phase Modulation
Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning 26 Material Phase Modulation PhaseModulation(PM)islikefrequencymodulation.Unlike,variationinthefre- quencyof

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the carrier wave as in FM, the phase of the carrier wave is varied. In PM,theinstantaneous amplitudeofthemodulatingsignal varies thephase ofthe carrier proportionately. Modulating index for PM is given as ^{2} = "?, where "?is the peak phase deviation in radians.As in the case of angular modulation argu- ment of sinusoidal is varied and thereforewe will have thesame resultant signal properties for frequencyand phase modulation.Adistinction in this case can be made onlybydirect comparison of the signal with the modulating signal wave,

Figure 1.20. Phasemodulationandfrequencymodulationareinterchangeable.Phasemod- ulationisobtainedbyselectingthefrequencyresponseofthemodulatorsothatits outputvoltagewillbeproportionaltointegrationofthemodulatingsignal.Whenit is differentiated, itgives frequencymodulation.Bandwidthandpowerissues are sameasthatof thefrequencymodulation. 1.5 DATATRANSMISSION PROCTOCOL In telecommunication technology, communication protocol is defined as the characteristicsetofstandardnormsandrulesusedforconnection,communication, data representation, data transfer, signalling, authentication and error detection thathelpinsendingdataorinformationthroughaspecificcommunicationchannel. Basically, it follows standard rules so that the network systems work properly. These protocol rules govern the syntax, semantics and synchronization of communication and areimplemented byhardware, software,oracombinationof both. It also defines theworking behaviourofa hardware connection. Nowadays,telecommunication technologyhasconnectionlessnetworking system tocommunicatebetweentheendpointsofnetworksforsendingmessages from one end point to another. The device configured at one end of the network transmitsdatatoanyconnectedrecipientevenwithoutconfirmingthattherecipient is there to receive the data. Problems maybe encountered during transmission andthedatamayhavetobesentseveraltimes.Thisisnotthecasewithconnection- oriented protocols. Thenetwork administrators avoid the use of connectionless protocols becauseitis not easytofilter malicious packets usingafirewall. While TCP/IP is a connection-oriented protocol, Internet Protocol (IP) and User Datagram Protocol (UDP)are connectionless protocols. A wide range of communication protocols were definedbyauthentic and standardorganizationsthroughouttheworld.Themostcommonandwell-known protocol suite is TCP/IP, which is termed as the base of Internetworking communications. The IP exchanges information between routers and helps the routers to select the proper path for network traffic, whereas the TCP ensures that the data packets are smoothlyand reliablytransmitted across the network without anyerror. LANandWANareconsidered as critical protocols in network communications. TheLANprotocols areauthenticfor thephysical anddata link layersofcommunicationoverotherspecifiedLANmedia,i.e.,Ethernetwiresand wireless radio waves.TheWAN protocol is authentic for thethree lowest layers

Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning Material 27 of the OSI(Open System Interconnection) model and helps in communication with the help of other wide-area media, i.e., fibre optic and copper cables. The OSImodelprotocolsfordatacommunicationperformthecommunicationfunctions over one or more layers of the seven layers of the OSImodel. Protocols can begrouped into different suites accordingto their technical functions.Aprotocol can defineoneormultiple protocol suites;for example, the Gigabit Ethernetprotocol IEEE802.3z whichisbasicallyaLANprotocolis also usedforMANcommunications. Thefollowingarethecharacteristicsofcommunicationprotocols: ? Theyhelpdetectthephysicalconnection(connectionorconnectionless) and the existence of the end-points or nodes. ? Theynegotiatewithdifferentconnectednodes. ? Theycheck for how to start and end a message. ? Theyhelpinformattingamessage. ? Theyidentifycorrupted messages and helpin error correction. ? Theyterminatethesession orconnection. Common communication protocols Thefollowingarethecommoncommunicationprotocols: ? IP (Internet Protocol) ? UDP (UserDatagram Protocol) ? TCP(TransmissionControl Protocol) ? DHCP(DynamicHost Configuration Protocol) ? HTTP(HypertextTransfer Protocol) ? FTP(FileTransfer Protocol) ? Telnet (TelnetRemoteProtocol) ? SSH (SecureShell Remote Protocol) ? SMTP(SimpleMailTransferProtocol) ? IMAP(Internet MessageAccess Protocol) Types of network communication protocols Thenetworkcommunicationprotocolsalsohavestandardsetsofrulesthatgovern thecommunicationprocessbetweencomputerswhichareconnectedtoordefined onanetwork. Theseareintheform ofbasicguidelines whichhelp toregulatethe access method, physical topologies, types of cabling and speed of data transfer on anetwork. Thefollowing are thecommonnetworkprotocols: ? Ethernet ? LocalTalk ? TokenRing ? FDDI ? ATM

Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning 28 Material 1.5.1 Protocols: Overview of Networking, Role of Computer Networks in Development In themainframe and minicomputer environment, each user is connectedto the main system through a dumb terminal that is unable to perform anyof its own processing tasks. In this computing environment, processing and memory are centralized. However, this type of computerization has its merits but the major disadvantage is that the system could get easily overloaded as the number of users, and consequently, terminals, increase. Second, most ofthe information is centralizedtoonegroupofpeople,thesystemsprofessionals,ratherthantheend- users. This type of centralized processing system differs from the distributed processingsystemused byLANs. Inadistributedprocessingsystem,most ofthe processingisdoneinthememoryofindividualPCsorworkstationsbesidessharing expensive computer resources likesoftware,disk files, printers and plotters, etc. There mayariseaquestion as to whyPCs cannot beconnectedtogether in a point-to-point manner. The point-to-point scheme provides separate communication channels for each pair of computers. When more than two computers need to communicate with one another, the number of connections grow quicklyas the number of computers increase. Figure 1.21 illustrates that twocomputersneedonlyoneconnection,threecomputersneedthreeconnections and fourcomputersneed six connections. Figure1.21alsoillustrates that thetotal numberofconnectionsgrowmore rapidly than the total number of computers. Mathematically, the number of connections needed for N computers is proportional to the square of N: Point-to-point connections required =(N 2 – N)/2 Fig. 1.21 (a), (b), (c) Number of Connections for 2, 3, 4 Computers, Respectively Addingthe N th computer requires N–1 new connections, whichbecomes a very expensive option. Moreover, many connections mayfollow the same physical path.Figure1.22 shows apoint-to-pointconnectionforfivecomputerslocatedat twodifferent locations,say, ground and first floorofabuilding.

Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning Material 29 Fig. 1.22 Five PCs at Two Different Locations As there are five PCs, therefore, ten connections will be required for point-to-pointconnection.Outofthesetenconnections,sixpassthroughthesamelocation, therebymaking point-to-point connection an expensive one. Byincreasing one PC in the above configuration, at location 2 as shown in Figure 1.22, the total number of connections will increase to fifteen. Out of these connections, eight connections will passthrough thesame area. Definition Privatelyowned networks offer consistent, fast paced communication channels which are optimized to connect information processing tools in a restricted geographical area. These are known as LocalArea Networks (LANs). A shared, local (restricted-distance) packet network for computer communication is a form of LAN.Acommon medium is used byLAN to link peripherals and computers so that the user can share access to databases, files, host computers,peripherals and applications. LANs,inadditiontolinkingthecomputerequipmentavailableinaparticular premises,alsoprovidesaconnectiontoothernetworkseitherthroughacomputer, whichisattachedtobothnetworks,orthroughadedicateddevicecalledagateway. ThemainusersofLANsincludebusinessorganizations,researchanddevelopment groups in science and engineering, industry and educational institution. The electronic orpaperless office concept is possible with LANs. LANs offer raw bandwidth of 1 Mbps to 100 Mbps or more, although actual throughputoftenismuchless.LANsarelimitedtoamaximum distanceof onlyafewmilesorkilometers, althoughtheymaybeextendedthroughtheuseof bridges, routers, and other devices. Data is transmitted in packet format, with packet sizes ranging up to 1500 bytes and more. Mostly, IEEE develops LAN specifications, althoughANSIand other standard bodiesare alsoinvolved. CheckYourProgress 6. What are threecategories of synchronous systems? 7. Definechannelbandwidth. 8. What ischannel capacity? 9. What is a modem? 10. List the variouscommon network protocols. 11. DefineLAN.

Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning 30 Material 1.6 TRANSMISSION MEDIA The datasignal travels through this medium.There aretwogeneral categories— bounded (guided) and unbounded (unguided) media.Twistedpair,coaxial cable and fibre optic cables are all bounded media. Data signals travel within the boundariesofthetransmissionmedia.Ontheotherhand,microwaveandsatellite transmissions, bothtravel through theair,whichhas noboundaries,hencecalled un-boundedtransmission. Guided Transmission Media Boundedmediaorwired transmissionsystemsemployphysicalmedia,whichare tangible.Alsoknownasconductedsystems,wiredmediagenerallyemploymetallic orglassconductorswhichservetoconduct,someformofelectromagneticenergy.

employingacoppermedium. Fibreopticsystems conductlight oropticalenergy, generallyusingaglass conductor.Theterm boundedorguidedmediameansthat the signal is contained within an enclosed physical path. It also refers to the fact that someformofinsulation, claddingandshieldis usedtobindthesignalwithin the core medium. This improves the signal strength over a distance and in the process enhances theperformanceofthetransmissionsystem.Fibreandcoaxial opticalcableandtwistedpair(bothshieldedandunshielded),systemsfallintothis category. Twisted Pair Wires Figure 1.23 shows a pair of copper wires twisted together and wrapped with a plastic coating as a twisted pair and which has a diameter of 0.4–0.8.The error rate of transmission and the electrical noise is reduced by the twisting. Each conductorisseparatelyinsulatedbysomelow-smokeandfire-retardantsubstance. Teflon(r)flouropolymerresin,polyvinylchlorideandpolyethylenearesomeofthe substances usedforinsulation purposes. Fig. 1.23 Two Wires Open Lines Thetwistingprocess serves to improvetheperformanceofthemedium by containing the electromagnetic field within the pair. Thereby, the radiation of electromagneticenergyisreduced and thestrengthofthesignal withinthewireis improvedoveradistance.Thisreductionofradiatedenergyalsoservestominimize the impact on adjacent pairs in a multiple cable configuration.This is especially importantinhigh-bandwidthapplicationsashigherfrequencysignalstendtolose power more rapidlyover a distance.Additionally, the radiated electromagnetic fieldtendstobegreaterathigherfrequencies,impactingadjacentpairstoagreater extent. Generally, more twists per foot means a better performance of the wire. These are popular for telephone networks. The energyflow is in guided media. For the last eight decades, until satellite and microwave radio communications weredeveloped,telecommunicationsexclusivelyusedmetallicwires.Thecopper

 wirehasdevelopedintoanestablishedtechnologywhichisstrongandcost-effective. Incertainapplications,nickeland/(or)evenaluminummetallicgoldplatedcopper, copper alloyand copper covered steel, conductors are employed. Themaximumtransmissionspeedislimitedinthiscase.Thecopperconductor that carries analog data can be used to carrydigital data also in association with modems. Amodemisadevicethatchanges analogsignalsintodigitalsignalsand vice versa. In this category, datarate is restricted to approximately28 Kbps.The useofbettermodulation and codingschemes ledtotheintroductionofIntegrated Services DigitalNetwork (ISDN)along withan increaseddatarateof128Kbps. LocalArea Networks (LANs) also use twisted pairs.These networks were also upgraded to support high bit rate real time multimedia. InAsymmetric Digital Subscriber Lines (ADSL) technology, a new technique was introduced which intended to use two copper loops at a data rate of 1.544 Mbps. This data rate is developed as per the user direction in the network and data rates upto 600 Kbps from the user to the network. Therearetwocategoriesoftwistedpaircables—withandwithoutshielding. In Figure 1.24, an Unshielded Twisted Pair (UTP) is shown as a copper mediumwhichwasfirstusedintelephonesystemsbyAlexanderGrahamBelland is now being utilized more and more for transmitting data. It is beingfrequently usedforhorizontalwiring.Itstatesthelinkbetweentheendinthecommunication closet and the outlet which is further restricted to 90 metres.Acommunication closetisuniversaltoeveryapplicationworkingoverthemediaandisindependent of the type of media. Thesuggested connectorsandmediaforhorizontalwiringarediscussedas follows: ? 150 Ohms ShieldedTwisted Pair (STP) contains 2 pairs (IBM connector or RJ45). ? 100 Ohm UTP contains 4 pairs and 8-pin modular connector (ISDN). ? 62.5/125 containsmulti-modefibre. ? 50 Ohm coaxial (thin)-IEEE10BASE2, standard BNC connector. AUTP cable contains 2 to 4200 twisted pairs. Flexibility, cost-effective media and usability of both data communication and voice are the biggest advantages ofUTP. On theother hand,themajor disadvantage of UTPis thefact thatthebandwidthislimited.Thislimitslongdistancetransmissionwithlowerror rates. Single pair Fig. 1.24 Unshielded Twisted Pair (UTP)

Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning 32 Material ShieldedCopperorSTP UTPandShieldedTwistedPair(STP)differfromeachotherinthemetallicshield orscreenwhichsurroundsthepairs,whichmayormaynotbetwisted.Asillustrated inFigure1.25,thepairs canbeindividuallyshielded.Asingleshieldcansurround acablecontaining multiple pairs orboth techniques can beemployed in tandem. Theshielditselfismadeofcopper,aluminiumorsteel.Theshieldwhichiselectrically grounded,isintheformofawovenmesheorametallicfoil.Althoughlesseffective, theshieldsometimesisintheformofnickeland/(or)goldplatingoftheindividual conductors. Fig. 1.25 Shielded Twisted Pair (STP) Configuration The advantageof shielded copper is that performance is enhanced because both electromagneticinterferenceandemissionsarereduced.Ifemissionsarereduced, thentheelectromagneticfieldisconfinedwithintheconductor.Thismaintainsthe signal strength. In other words, signal loss is reduced. Moreover, a reduction in emissionsensuresthathigh-frequencysignalsdonotinterferewithadjacentcables or pairs.The shielding process ensures immunityfrom interference as it reflects theelectromagneticnoisefromsuchoutsidesourcesasradiosystems,wires,cables and electric motors. Juxtaposed with shielded copper, the shielded twisted pair has many disadvantages. Sincetherawcost ofacquisitionisgreaterit ismore expensiveto producethemedium.Moreover,theshield'sadditionalweightmakesitdifficultto deploy.Therefore,thecostofdeploymentincreasesevenfurther.Eventheshield's electricalgroundingrequiresmoreeffortandtime. General Properties of Twisted Pair Cables Thefollowing arethegeneral properties oftwistedpaircables:
Gauge:Itisameasureofthethicknessoftheconductor.Amediumperforms better if thewire is thick. This is because thick wires offer less resistance which in turn ensures a strongsignal over a givendistance. Thicker wires also havethe advantage of greaterbreak strength. The gaugenumbers are retrogressive. In other words, the larger the number, the smaller the conductor.
Configuration:Inasinglepairconfiguration,thepairofwires isenclosed in a jacket or sheath, made of teflon, polyvinyl chloride or polyethylene. Usually, multiple pairs are so bundled as to minimize deployment costs associated with connecting multiple devices (forexample, modems, data terminals and KTS or KeyTelephone System telephonesets or electronic PBX orPrivate Branch eXchange) at asingle workstation.
Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning Material 33 Bandwidth:Theeffectivecapacityoftwistedpaircabledependsonseveral factors,includingthespacingoftheamplifiers (repeaters),thelengthofthe circuit,andthegaugeoftheconductor.Youmustalsorecognizethatahigh- bandwidth (highfrequency)application maycauseinterferencewith other signalsonotherpairsincloseproximity.
ErrorPerformance:Signalqualityisinvariablyimportant,moresoinrelation to data transmission. Twisted pair is susceptible to the impacts of outside interference.Awirethat islightlyinsulated actsas anantennae.It therefore absorbs errant signals. It follows then, that twisted pairs aresusceptible to the impact of outside interference. Potential sources of Electromagnetic Interference (EMI) include electric motors, radio transmissions and fluorescent light boxes.As transmission frequency increases, the error performance of copper degrades significantly with signal attenuation increasingapproximatelyas the squarerootoffrequency. Distance:Twistedpairisdistance-limited.Asthedistancebetweennetwork elementsincreases,attenuation(signalloss)increasesandqualitydecreases atagivenfrequency.Asbandwidthincreases,thecarrierfrequencyincreases, attenuation becomes more of an issue, and amplifiers (repeaters) must be spaced more closely. Security: Insecurityis an inherent feature of twisted pair. Placingtaps on UTPisasimpleexercise.Moreover,theradiatedenergyiseasilyintercepted throughtheuseofinductive coilsorantennae, without therequirement for placement ofa physical tap. Cost: The rearrangement, deployment and acquisition costs of UTP are verylow,atleastininsidewireapplications.Inhigh-capacity,long-distance applications, such asinterofficetrunking, however,therelativecost isvery high, due to the requirements for trenchingor boring, conduit placement, andsplicingoflarge,multipaircables.Additionally,therearefinitelimitsto the capacity and other performance characteristics of UTP, regardless of theinventivenessoftechnologists.Hence,thepopularityofalternativessuch as microwaveand fibre-optic cable.
Applications:UTP'slowcostperformancehasincreaseditsapplicationin short-haul distribution systems or inside wire applications. Current and continuing applications include the local loop, inside wire and cable and terminal-to-LAN. UTP no longer is deployed in long haul or outside the premisestransmissionsystems. Theapplicationofshieldedcopperislimitedtoinsideapplicationsduetoits additional cost. Specifically, it is generallylimited to applications in high-noise environments. It is also deployed where high-frequencysignals are transmitted andthereisconcernabouteitherdistanceperformanceorinterferencewithadjacent pairs.ExamplesincludeLANsandimagetransmission. Coaxial Cable Thecorefactorthatlimits atwistedpaircableisduetotheskineffect.Theflowof the current in the wires is likely to flow only on the wire's outer surface as the frequencyofthetransmitted signal raises,thus,lessoftheavailablecross-section is used. The electrical resistance of the wires is increased for signals of higher frequencywhich leads to higher attenuation. Further, significant signal power is
Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning 34 Material lost due to the effects of radiation at higher frequencies. Thus, another kind of transmissionmediumcanbeusedforapplicationsthatrequirehigherfrequencies. Boththeseeffects areminimized bycoaxial cable. A coaxial cable, as shown in Figure1.26 is a robust shielded copper wire two-conductorcableinwhichasolidcentreconductorrunsconcentrically(coaxial) insideasolidoutercircularconductor.Thisformsanelectromagneticshieldaround the former that serves to greatlyimprove signal integrity and strength. The two conductorsareseparatedbyinsulation.Alayerofsuchdielectric(non-conductive) material asTeflon or PVC, protects the entire cable. The coaxial cable comes under thecategoryof bounded mediaand is still an effective medium to use in data communication. For better performance the coaxial cablecontainsshields which makeit costly.Cabletelevisionuses coaxial cables. LANs function over coaxial cable to the 10BASE5, 10BASE2 and 10BASET specifications.Generally, a coaxial cable allows longer distance transmission instead of twisted pair cable at a higher data rate. However, this is costly.

veryhigh speed. Thesignalonbasebandcablemustbeamplifiedataspecifieddistance. It is used for local area networks. (ii) Broadband:Itcantransmitmanysimultaneoussignalsusingdifferent frequencies. Jacket Core insulation Braid Shield Centre core Fig. 1.26 Coaxial Cable Configuration General Properties of Coaxial Cable Thefollowingarethegeneral propertiesofcoaxial cable: Gauge:Thegauge of coaxial cable is thicker than thetwisted pair.While this increases the available bandwidth and increases the distance of transmission, it also increases the cost. Traditional coaxial cable is quite thick, heavyand bulkyof which Ethernet LAN 10BASE5 is an example. Ethernet LAN 10BASE2 is of much lesser dimensions but offers less in termsofperformance. Configuration: Coaxial cables comprise of a two-conductor wire which is single,withan outershield (conductor)madeofsolidmetal andacentre conductor.At times, stranded or braided metal is employed. Twin axial cables contain two such configurations within a single cable sheath. The centreconductorcarriesthecarriersignalandtheouterconductorisgenerally used forelectrical grounding. Coaxial cableconnectivitycanbeextended

 through the useof twisted pair with a BALUN (BALanced/UNbalanced) connectorservingtoaccomplishtheinterface. Bandwidth: The effective capacity of coaxial cable depends on several factors.Theseincludethespacingofamplifiers,thelengthofthecircuit,the gaugeofthecentreconductorandotherintermediatedevices. Theavailable bandwidth over coaxial cable is verysignificant, hence it is used in high capacityapplications, such as image anddatatransmission.

ErrorPerformance:Coaxialcableperformsexceptionallywellduetothe outershielding.As a result, itis often used indataapplications. Distance:

transmissionsoverdistancesofanysignificance. Security:Coaxialcableisinherentlyquitesecure.Itisrelativelydifficultto placephysicaltaps on coaxial cables. Radiationof energyisalsominimal. Hence,its interceptionis not easy.

Cost:Theacquisition,deploymentandrearrangementcostsofcoaxialcables are very high, compared with UTP. In high capacity data applications, however, that cost is often outweighed by its positive performance characteristics. Applications:

Currentand continuingapplications includeLANbackbone, host-to-host, host-to-peripheral and CATV. Optical Fibre Youhaveseeninthepreviousssection,thatthegeometryofcoaxialcablesignificantly reducesthevariouslimitingeffectsandthemaximumsignalfrequency.Hence,the information rate that can be transmitted using a solid conductor, although very high,is limited.This is alsothecasefortwisted lines.An optical fibreisdifferent fromthetransmissionmedia.Thetransmittedinformationiscarriedthroughabeam oflightwhich is fluctuatinginaglass fibreinsteadofawireoranelectricalsignal. Thistypeoftransmissionhasbecomestrongsupportfordigitalnetworksowingto itshigh capacityand otherfactorsfavourablefordigitalcommunication. Fig. 1.27 Fibre Optic Cable — General View

Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning 36 Material Fibre optic transmission systems are opto-electric in nature. In other words, a combinationofopticalandelectricalelectromagneticenergyisinvolved.Thesignal originatesasanelectricalsignal,whichistranslatedintoanopticalsignal,theoptical signal is subsequentlyreconverted into an electrical signal at the receiving end. Figure1.27showsaclean,thinglassfibrereflectinglightinternallyasthetransmission carrieslightwith encoded data.Fibres canbendwithoutbreakingwiththehelpof aplasticjacket.LightEmittingDiode(LED)orlaserinjectedlightfortransmission intothefibre.Receivers that arelightsensitivetranslatelight backintodataat the other end. Theoptical fibre consists ofanumberofsubstructures asshowninFigure 1.28. In this case, the core is made of glass. The glass core carrying the light is encircledbyaglasscladdingwhichhaslowerrefractiveindex.Thus,blendingthe light andconfiningitto thecore.Asubstratelayerofglass encircledthecorethus, adding to the diameter and the power of the fibre.This layer of glass, however, doesnotcarrylight.Themechanicalprotectionscoverthesecondarybuffercoating andprimarybuffercoating. Fig. 1.28 Glass Fibre Optic Cable, Side View and Cross Section The light pulse travels down the centre core of the glass fibre. Surrounding the innercoreisalayerofglasscladding,withaslightlydifferentrefractiveindex.The claddingservestoreflectthelightwavesbackintotheinnercore.Surroundingthe cladding is a layer of protective plasticcoating that seals the cable and provides mechanicalprotection.ThisisshowninFigure1.22.Typically,multiplefibresare housedinasinglesheath, which maybeheavilyarmoured. Lightpropagatesalongtheopticalfibrecoreinoneofthefollowingwaysas given belowdepending on the typeand width of corematerial used. 1.7 TRANSMISSION CONCEPTS AND TERMS Before discussing the different types of transmission medium, it is necessaryto knowthebasic concepts and terminologiesassociatedwiththetransmissionofa signal.Inthetransmissionofdata,therangeofcarrierfrequenciesdepends onthe natureofthemediumandtherequirementsoftheapplicationssupported.Therefore, frequencyspectrum maybe defined as the range of frequencies beingsupported byaparticulartransmissionmedium.Theactualrangeoffrequenciessupportinga given communication is known as a pass band.These are given intheTable 1.1.

Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning Material 37 Table 1.1 Frequency Spectrum Name of Band Frequency Range Wavelength Usage Audible 20 Hz–20 kHz <100Km Voice Extremely/Very Low Frequency (ELF/VLF) Radio 3 kHz–30 kHz 100–10 Km Radio Navigation, Weather, Submarine Communications Low Frequency (LF) Radio 30 Hz–300 kHz 10–1 Km Radio Navigation, Maritime Communications Medium Frequency (MF) Radio 300 kHz–3 MHz 1 Km–100 m Radio Navigation, AM Radio High Frequency (HF) 3 MHz–30 MHz 100–10 m Citizens Band (CB) Radio Very High Frequency (VHF) Radio 30 MHz–300 MHz 10–1 m Amateur (HAM) Radio, VHF TV, FM Radio Ultra High Frequency (UHF) 300MHz–3GHz 1 m–10 cm Microwave, Satellite, UHF TV Super High Frequency (SHF) Radio 3 GHz–30 GHz 10–1 cm Microwave, Satellite Extremely High Frequency (EHF) Radio 30 GHz–300 GHz 1 cm–.1 mm Microwave, Satellite Infrared Light 103–105 GHz 300–3μ Infrared Visible Light 1013–1015 GHz 1–.3μ Fiber Optics X-Rays 1015–1018 GHz 103–107μ N/A Gamma and Cosmic Rays <1018 GHz >017μ N/A Thesymbolsusedhavethefollowingmeanings: K (Kilo) = 1,000, M (Mega) = 1,000,000 (1 million), G(Giga) = 1,000,000 (1 billion) T (Tera) = 1,000,000,000 (1 trillion) cm = centimetre (1/100 metre) mm = millimetre (1/1,000 metre) μ = micron (1/1,000,000 metre) (a) Bandwidth In a very general way, bandwidth may be defined as the range of frequencies assignedtoachannel.Inotherwords,wemaysaythatbandwidthisthedifference expressedin hertz,between thehighestandthelowest frequencies ofaband.The higherthebandwidth,themorewillbethedatatransmissionrateorthroughput.It should be noted that bandwidth and data transmission rates are very closely interrelated. Clearly, any transmission system becomes more attractive if the available bandwidth is greater, introduced errors are fewer, and the maximum distancebetweenvarious network elements (amplifiers,repeaters andantennae) is greater.

Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning 38 Material (b) Distances Thehigherfrequencysignalsoffergreaterbandwidth.Theyalsosuffertoagreater extentfromsignalattenuationthanlowerfrequencies.Thisresultsinmoreerrorsin transmission,unlesstheamplifiers/repeaters areplacedcloselytogether.Itclearly demonstrates thecloseand direct relationshipbetweenbandwidth, distance, and errorperformance. Bandwidth,inthiscontext,referstotherawamountofbandwiththemedium supports. Error performance refers to the number or percentage oferrors which areintroducedintheprocessoftransmission.Distancereferstotheminimumand maximum spatial separation between devices over a link, in the context of a complete,end-to-end circuit. (c)

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Propagation Delay Propagation delayrefers to the length oftime required for a signal to travel from

transmittertoreceiveracrossatransmissionsystem.Whileelectromagneticenergy travels at roughly the speed of light (30,000 km per second) in free space, the speedofpropagation fora twistedpairor coaxial cableis afractionofthis figure. Thenatureofthetransmissionsystemwillhaveconsiderableimpactonthelevelof propagationdelay.Inotherwords, thetotallengthofthecircuitdirectlyinfluences thelengthof time it takesfor thesignal to reachthe receiver. (d) Security Security, in thecontext of transmission systems,addresses the protectionof data from interception as it transverses the network. Particularlyin the case of data networking,itisalsoimportantthataccesstoaremotesystemandthedataresident onitbelimitedtoauthorizedusers;therefore,somemethodofauthenticationmust be employed inorder to verifythat the access request is legitimateandauthentic. (e) Resistance to Environmental Conditions Resistancetoenvironmentalconditionsappliesespeciallytowiredsystems.Twisted pair,coaxialandfibreopticcablesaremanipulatedphysicallyastheyaredeployed andreconfigured.Clearly,eachhascertainphysicallimitstotheamountofbending and twisting (flex strength) it

longitudinalstressitcansupport(tensilestrength)withoutbreaking(breakstrength). Fibreopticcablesarenotoriouslysusceptibletobreaking.Cableshungfrompoles expandandcontractwith changesinambienttemperature; whileglassfibreoptic cables expand and contract relatively less, and twisted pair copper wires are moreexpansive. Resistancetoenvironmentalconditionsalsoappliestoairwavesystemssince reflective dishes, antennae and other devices used in microwave, satellite and infraredtechnologiesmustbemountedsecurelytodealwithwindandotherforces of nature.Additionally, the towers, walls and roofs on which theyare mounted must be constructed and braced properlytowithstand such forces. (f) Physical Dimensions Thephysicaldimensions ofatransmissionsystem haveto beconsideredas well. This is especially true, once again, in the case of wired systems. Certainly, the sheer weight of a cable system must be taken into account as one attempts to deployiteffectively.Thebulk (diameter)ofthecableisimportant,as conduitand
Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning Material 39 racewayspaceisoftenatapremium.Thephysicaldimensionsofairwavesystems mustalsobelookedinto,asthesizeandweightofthereflectivedishandmounting system (e.g., bracket and tower) mayrequire support. (g) Cost and Ease of Installation Costisaconcernintheselectionofanappropriatetransmissionmedium.Itincludes the cost of acquisition, deployment, operation and maintenance (O&M), and upgradation orreplacement. It is noteworthyto comparethecosts ofdeployment ofwiredversuswireless media. Wiredtransmissionsystemsrequireright-of-wayandthisshouldbesecured. Wiredtransmissioninvolves acost componentintheform ofinfrastructure.This includesdiggingoftrenchesandboringofholesunderstreetssothatcablescanbe pulled and poles may be mounted. In addition, amplifiers or repeaters may be placed.Suchcosts arenot trivial.Unlikewiredsystems,wirelesssystems require secured right-of-way and antennae. It maybe inferred that the deployment of wiredsystemsis morecostly. 1.7.1 Extending LAN - Master Site and Interconnection to Telephone There are numerous methods to extend LAN which includes wired options and wireless options. The 'LAN Extenders' use the existingnetwork or inexpensive telephone cables to extend an Ethernet network beyond 100m without using an optical fiber cable system.ANetwork Extender device is used to extend a LAN beyond 100m, while up to 2000m the inexpensive RJ-11 telephone or RJ-45 network (copper) cables are used. A Wide Area Network (WAN) is a telecommunications network that typically extends over a large geographic area for extending the computer networking.WANsareoftenestablished withleasedtelecommunicationcircuits. WANs are specificallyused to connect LANs (LocalArea Networks) and other types of networks all together such that the users and computers of one geographicallocation caneasilycommunicatewithusers andcomputers ofother geographical locations, as shown in the Figure 1.29.You will learn about LAN extensionandcellularnetworksinunit2. Fig. 1.29 WAN Connecting LANs
Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning 40 Material CheckYourProgress 12. Whichtransmissioniscalledun-boundedtransmission? 13. Which are two types of coaxial cables? 14. What is a pass band? 1.8 ANSWERS TO 'CHECK YOUR PROGRESS' 1. Two key issues occur in parallel transfer. The wire itself is the first issue. Minimum of nine wires (eight for data bits, one for circuit ground) are required. Many times extra wires are needed to control the flow of data across the interface. The other issue is with the nature of the bits or voltages itself. When there is change in the state of the bit/voltage from a one to zero, or vice versa, it happens at the rate of nanoseconds (one billionth of a second). Acrucial part of the data transfer is the abruptness
Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning Material 41 10. Thefollowingarethecommonnetworkprotocols: ? Ethernet ? Local Talk ? Token Ring ? FDDI ? ATM 11. Privately owned networks offer consistent, fast paced communication channels which areoptimized to connect informationprocessingtoolsina restricted geographical area. These are known as LocalArea Networks (LANs). 12. Mmicrowaveandsatellitetransmissions,bothtravelthroughtheair,which has no boundaries,hencecalled un-boundedtransmission. 13.

veryhigh speed. Thesignalonbasebandcablemustbeamplifiedataspecifieddistance. It is used for local area networks. (ii) Broadband:Itcantransmitmanysimultaneoussignalsusingdifferent frequencies. 14. Theactualrangeoffrequenciessupportingagivencommunicationisknown as a pass band. 1.9 SUMMARY ? Datatransmission canbedivided intoparallelandserial datatransmission. ? Avoicegradechannelisapproximately4,000Hz,or4kHz.Approximately 3.3 kHz (200 Hz to 3,500 Hz) is used for thevoicesignal itself. ? CATV video channel is approximately 6 MHz CATV video channel is approximately 6 MHzApproximately, 4.5 MHz is used for information transmission, ? Computersaredigitalinnature.Computerscommunicate,storeandprocess information inbinaryform, i.e.,inthecombinationof1sand0s. ? For transmission across a network, data has to be transformed into electromagneticsignals.Both, dataand signalscanbeeitherofanalogtype ordigital type. ? Information exchange is an essential part of communication. It may be exchangeofinformationamongusers orequipmentinthecommunication system. ? Signalling System 7 (SS7) is the protocol designed for public switched telephonesystemforprovidingservices andsettingupcalls. ? Digitalsystemsofferbettersecuritywhileanalogsystemsoffersomemeasure ofsecuritythrough thescramblingofseveralfrequencies.

Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning 42 Material ? Inafullduplex modedatacanbetransmittedinbothdirectionsatthesame time. ? Channel bandwidth may be simply defined as the size of the range of frequencies thatcan betransmitted throughachannel. ? Conventionally, modemsweredevised forcommunicationbetweenahost computeranddataterminals. ? Modems continuouslygenerateacarriersignal tosendinformationsothat the information may be delivered from one location to another remote location. ? Short haulmodems arewidelydeployedover privatelines andarenot part ofapublicsystem. ? Voicegrademodems haveafrequencyrangeofmoderatetohighdatarate. ? Dial-up modems are used for point-to-point connections onthe PSTN by anycombination ofmanualorautomaticdialingoranswering.Thequality of thecircuit mayvaryfromcarriers to carriers. ? Synchronous modems operate in the audio range, at rates upto 28.8 kbps inaudiolines ? Dial-upmodemscontainacircuitrythatmimicsthatofatelephone.Thatis, modemscansimulateliftingthehandset,dialing,orhangingupthetelephone. ? Inthemainframeandminicomputerenvironment,eachuserisconnectedto themainsystemthroughadumbterminalthatisunabletoperformanyofits own processing tasks. ? Privately owned networks offer consistent, fast paced communication channels which areoptimized to connect informationprocessingtoolsina restricted geographical area. These are known as LocalArea Networks (LANs). ? Therearetwocategoriesoftwistedpaircables—withandwithoutshielding. (i) UnshieldedTwistedPair(UTP) (ii) ShieldedTwisted Pair (STP)) ? The corefactorthat limits atwisted paircableisduetotheskineffect. The flowofthecurrentinthewiresislikelytoflowonlyonthewire'soutersurface as thefrequencyof the transmitted signal raises, thus, less of the available cross-section is used. 1.10 KEY TERMS ? AnalogSignal:It is anycontinuous signal where thetimevaryingfeature ofthesignal represents someothertimevaryingquantity. ? Signalling: It refers to the exchange ofinformation between components requiredtoprovideand maintain datacommunicationservice. ? SignallingSystem7: SignallingSystem 7 (SS7) isthe protocol designed forpublicswitchedtelephonesystem forprovidingservicesandsettingup calls. Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning Material 43 ? HalfDuplex:In halfduplex mode, dataistransmitted inonedirectionat a time,forexample, awalkie-talkie. ? FullDuplex:Inafullduplexmode,datacanbetransmittedinbothdirections at thesame time. ? Bandwidth:Itisdefinedas therangeoffrequenciesassignedtoachannel. ? Propagation Delay: It

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refers to the length of time required for a signal to travel

fromtransmitterto receiveracrossatransmissionsystem. 1.11 SELF ASSESSMENT QUESTIONS AND EXERCISES Short-Answer Questions 1. What are the different communication modes from the view point of transmission? 2. What are thefunctions of SS7? 3. What is amodem? Describeits function. 4. What are thedifferent types of modems? 5. Writethecharacteristicsofcommunicationprotocols. 6. What advantages do coaxial cables offer overtwisted pair cables? 7. What arethesuggested connectors and mediaforhorizontal wiring? 8. What do you mean byparalleland serial transmission? Long-Answer Questions 1. Describetheadvantageofanalogtransmission. 2. Explainthesignificanceofdigitalsignalsindatacommunication. 3. What arethedifferent types ofmodem? Explain. 4. Describesimplex,halfduplexandfullduplexmodeofcommunicationwith the helpof adiagram. 5. Compare fibre optical cable with UTP cable when used as transmission mediainLANs. 6. Write adetailed noteon: (i) Twisted paircable (ii) Coaxialcable (iii) Optical fibrecable 1.12 FURTHER READING Forouzan, Behrouz A. Data Communications and Networking. New Delhi: Tata McGraw-Hill, 2004. Stallings,Williamand RichardVan Slyke.BusinessDataCommunications.New Jersey: PrenticeHall, 1998. Fundamentals of Data Communication, Communication Channels and Data Transmission Protocol NOTES Self - Learning 44 Material Black, Uyless. Computer Networks. New Jersey: Prentice Hall, 1993. Stallings,William. Data andComputer Communications. NewJersey: Prentice Hall, 1996. Tanenbaum,Andrew S. Computer Networks. New Jersey: Prentice Hall PTR, 2002. Stallings, William. Data and Computer Communications. NJ: Prentice-Hal, 1996.

Local Area Network, Implementing and Extending LAN NOTES Self - Learning Material 45 UNIT 2 LOCALAREANETWORK, IMPLEMENTINGAND EXTENDINGLAN Structure 2.0 Introduction 2.1 Unit Objectives 2.2 Local Area Network 2.2.1 Broadband versus baseband 2.2.2 LAN Hardware and LAN Operating System 2.3 Implementation of LAN using Fiber-Optic Cables 2.4 Implementation of LAN usingWireless Technology 2.5 Extendling LAN : Transmission Concepts and Terms 2.5.1 Radio 2.5.2 VeryLowFrequency(VLF) 2.5.3 Microwave Transmission 2.5.4 Satellite Communication 2.6 Master Sites and inter connection to telephone 2.7 Answers to 'Check Your Progress' 2.8 Summary 2.9 Key Terms 2.10 Self Assessment Questions and Exercises 2.11 Further Reading 2.0 INTRODUCTION ALocalAreaNetwork(LAN)isacomputernetworkthatinterconnectscomputers withinalimitedareasuch asaresidence, school,laboratory,universitycampusor office building. LAN is a group of computers or other devices interconnected within a single, limited area, typicallyviaEthernet orWi-Fi. Bycontrast, a wide areanetwork(WAN)notonlycoversalargergeographicdistance,butalsogenerally involvesleased telecommunicationcircuits.Ethernet andWi-Fi arethetwomost common technologies in use for local area networks. Historical network technologiesincludeARCNET,TokenRing,andAppleTalk. LANnetworkingrequiresEthernet cablesandLayer2switchesalongwith devices that can connect and communicate using Ethernet. Larger LANs often include Layer 3 switches or routers to streamline traffic flows. ALAN enables users to connect to internal servers, websites and other LANs that belong to the same WAN. Ethernet and Wi-Fi are the two primary ways to enable LAN connections. LAN implementation uses several network devices, like a router, switch, network cable (UTPcable), and PC orlaptop as user. Some offeatures that used inthisLANnetworkarewebsiteblocking, (DynamicHostConfigurationProtocol) DHCP, Hotspot, and bandwidth.

Local Area Network, Implementing and Extending LAN NOTES Self - Learning 46 Material Inthisunit,youwilllearnaboutlocalareanetwork,LANoperatingsystems, implementingLAN,fastLANs,non-standardLANs,extendingLAN,transmission concepts and terms, master sites, and interconnection to telephone. 2.1 UNIT OBJECTIVES Aftergoingthroughthisunit,you willbeableto: ? Definelocalareanetwork ? ExplainLANoperatingsystems ? UnderstandtheimplementationofLANusingopticalfibrecableandwireless technology ? Discuss fast LANs, and non-standard LANs ? Understand howto extend LAN ? Understand transmissionconcepts and terms ? Illustratemastersites ? Analyzeinterconnectiontotelephone 2.2 LOCALAREA NETWORK LocalArea Network technologyconnects people and machines within a site.A LocalArea

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Network (LAN) is a network that is restricted to a relatively small area

as shown in Figure 2.1. LocalArea Networks (LANs) can be defined as privatelyownednetworks offering reliable highspeedcommunication channels that are optimized to connect information processing equipment in a small and restrictedgeographicalarea,namely,anoffice,abuilding,acomplexofbuildings, a school or a campus.

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A LAN is a form of local (limited-distance), shared packet network for

computercommunications.LANsinterconnectcomputersandperipherals overa common medium so that users are able to share access to host computers, databases,files,applications,andperipherals.Theycanalsoprovideaconnection to othernetworks eitherthrough acomputer,whichis attachedto both networks, or through a dedicated device called a gateway. Fig. 2.1 Local Area Network (LAN) The components used byLANs can becategorizedintohardware,cabling standards,andprotocols.VariousLANprotocols areEthernet,TokenRing:TCP/
Local Area Network, Implementing and Extending LAN NOTES Self - Learning Material 47 IP, SMB, NetBIOS and NetBeui, IPX/SPX, FibreDistributed Data Interchange (FDDI) andAsynchronousTransfer Mode (ATM). LANs are used almost exclusivelyfor data communicationover relativelyshort distances such aswithin an office, officebuildingorcampus environment. LANs allow multiple workstations to share access to multiple host computers, other workstations, printers and other peripherals, and connections to other networks. LANs are also beingutilized for imaging applications. They are being used for video and voice communication as well,althoughcurrentlyonaverylimitedbasis. LANapplicationsincludecommunicationbetweentheworkstationandhost computers, other workstations and servers. The servers may allow sharing of resources.Resourcescouldbeinformation,datafiles,e-mail,voicemail,software, hardware (hard disk, printer, fax, etc.) and other networks. LANbenefitsincludethefact thatahigh-speedtransmissionsystemcanbe sharedamongmultipledevicesinsupportoflargenumberofactiveterminals and a large number of active applications in the form of a multi-user, multitasking computer network. LAN-connected workstations realize the benefit of decentralized access to very substantial centralized processors, perhaps in the formofmainframehostcomputerandstoragecapabilities(informationrepositories).
Additionally,thecurrenttechnologyallowsmultipleLANstobeinter-networked through theuse of LAN switches, routers, etc. Disadvantages ofLANsincludeconcern forsecurityoffilesandaccounts. 2.2.1 Broadband versus Baseband There exist two LANtransmission options, basebandandbroadband. Baseband LANs,which isthemostprevalentbyfar,isasingle-channelsystemthat supports a single transmission at any given time. Broadband LANs support multiple transmissionsviamultiplefrequencychannels. Baseband may use UTP, Coaxial or Fibre Broadband using coaxial cable Channel 1 2 3 Fig. 2.2 Broadband versus Baseband
Local Area Network, Implementing and Extending LAN NOTES Self - Learning 48 Material Broadband LANs Broadband LANs are multichannel, analog LANs as shown in Figure2.2. They are typicallybased on coaxial cableas the transmission medium,although fibre opticcableisalso used. Individual channelsofferbandwidthof1to5Mbps,with 20 to 30 channels typically supported.Aggregate bandwidth is as much as 500 MHz.Its characteristics are: ? Stations connected via RF modems, i.e., radio modems accomplish the digital-to-analog conversion process, providing the transmitting device access toan analog channel. ? Digitalsignal modulatedonto RFcarrier(analog). ? Channel allocation based on FDM. ? Head-Endforbidirectionaltransmission. Advantages ? Greaterbandwidth ? Data, voice and video can be accommodated on broadband channel ? Greaterdistances Disadvantages ? Highcost,requires modems ? Lack of well-developed standards ? Cabledesign ? Alignmentandmaintenance Some broadband LANs are referred to as 10Broadband36 where 10 stands for 10Mbps,Broadbandformultichanneland36for3600metresmaximumseparation between devices. Baseband LANs BasebandLANisasinglechannelconnection,supportingasinglecommunication atatimeasshownin Figure2.2.Theyaredigitalinnature.Totalbandwidthof1to 100Mbps isprovidedovercoaxialcable,UTP,STP,orfibreopticcable.Distance limitationsdependonthemediumemployedandthespecificsoftheLANprotocol.
BasebandLANphysicaltopologiesincludethering,bus,tree,andstartopologies. Baseband LANs are, by far, the most popular and the most highly standardized. Ethernet, Token Passing, Token Ring and FDDI LANs are all baseband.Theyareintended onlyfordata,as datacommunicationis,afterall,the primaryreasonfortheexistenceofLANs. Thecharacteristics ofthis system may besummarizedasfollows: ? Noneed ofmodems—lowcost installation ? Bidirectionalpropagationofsignal ? Unmodulateddigitalsignal ? Singlechannel ? Stations connected viaT connectors

Local Area Network, Implementing and Extending LAN NOTES Self - Learning Material 49 Advantages ? Simplicity ? Low cost ? Easeofinstallationandmaintenance ? High rates Disadvantages ? Limiteddistances ? Data andvoice only 2.2.2 LAN Hardware and LAN Operating System The attached devices to a cable in anytopologyare referred nodes, hosts or sta- tions. In addition to them, LANs maymake use of other devices to control phys- ical access tothe shared medium, toextend themaximum reachofthe LAN, and to switchtraffic. Such hardware is in the form of NIC/NIU, transceivers, MAU, hubs, bridges, routers, and gateways. Fig. 2.3 Frame Format for IEEE 802.3 Network Interface Card (NIC) This is also known as Network Interface Unit (NIU). NIC is a hardware card to provide physical access from a node to the LAN medium. The NIC can be fitted into the expansion slot of a PC, or it can exist as a separate box.Astandalone, multiportNICcanserveanumberofdevices,therebyprovidinganadditionallev- el of contention control.Astandard IEEE NIC are encoded with a unique hard- ware coded logical address.Transceivers are embedded inNIC/NIU and MAU. MAU (MediaAccess Unit, or MultistationAccess Unit)are standalone devices that contain NIC in support of one or more nodes. LAN Operating Systems ALANOperatingSystem,orNetworkOperatingSystem(NOS),issoftwarethat providesthenetworkwithmulti-user,multitaskingcapabilitiesandsupportscom- munications and resource sharing. Thus, aLAN operatingsystem is used to pro-videthebasicframeworkfortheoperationoftheLAN.Theoperatingsystemdoes not confine to one environment but it has distributed modules across the LAN environment. Theymaybe located in server and client. LAN architecture is an exampleofclientserverarchitectureinwhichaclientisauserinterfacelikeacom-puterwithseveralapplicationslikewordprocessing,spreadsheetordatabase.The client and serverare on the samecomputer network or LAN.The client requests a server for certain services. The servers are usuallya multi-port computer with largememoryandenablingmultipleclientstosharetheirresourcesalongwithper-

Local Area Network, Implementing and Extending LAN NOTES Self - Learning 50 Material formingcertain functionsindependently. Servers aredatabaseenginescapableof processing client requestsfor information. Servers alsomanage thedata. In addition tosupporting multitasking and multi-useraccess, LAN operating systems provide for recognition of users based on passwords, user IDs, and ter- minal IDs.On thebasis ofsuchinformation,LANoperatingsystems canmanage securityusing access privileges.Additionally, aLANoperatingsystem provides multi-protocolrouting,aswellasdirectoryandmessageservices.DOS-basedLAN operatingsystemsincludeNovell NetWareandSunMicrosystems'TOPS/DOS. OS/2 and UNIX-based LAN operating systems include Banyan VINES, IBM LAN Server, Microsoft LAN Manager, and Novell SFTNetWare. CheckYourProgress 1. What is a LocalArea Network (LAN)? 2. What are the components used byLANs? 3. Namethetwo LAN transmission options. 4. Define baseband LAN. 5. What do you understand by NIC? 6. What is aLAN operating system? 2.3 IMPLEMENTATION OF LAN USING FIBER-OPTIC CABLES ThesharedmediumforLANsincludesmostofthetransmissionmediadiscussed inpreviously.Althoughcoaxialcablewastheoriginalmediumandstillisusedwidely invariousconfigurations,twisted-pairhas recentlybecomethemedium ofchoice inmanyenvironments.Fiberopticcableisusedwidelyasabackbonetechnology. WirelessLANsgenerallyarelimitedtospecialradiotechnologies,althoughinfra- red technologyis used in certain applications. Microwaveand infrared systems areusedto connect LANs andLANsegments inacampus environment.Satellite rarelyis used in anyway,as propagation delayrendersit generallyunsatisfactory forinteractivecommunications. Implementation of LAN using Coaxial Cable Coaxial cableisstill apopular transmissionmediafor LAN.Thecoaxial cableis consideredas theforemosttransmissionmediumtoimplantLANs.However,the coaxial cableis considered an expensiveoption in terms ofits cost,deployment, reconfigurationandmaintenancebutduetoitsexcellentperformancecharacteristics, it is the most widely deployed transmission media. The advantages of coaxial cable include high bandwidth of the order of 500 MHz and more, good error performanceandnodistancelimitation.Additionally,securityishighanddurability is excellent. On the other hand, the costs of acquisition, deployment, and reconfiguration arehigh.Thedisadvantages ofcoaxialcablehavebeenmitigated to alargeextent through thedevelopment of newcoaxialdesigns. Thevariations ofcoaxialdesignsarethicknetandthinnet.Inthefollowingsectionsbothbaseband and broadband versions of Ethernet/IEEE 802.3are explained.

Local Area Network, Implementing and Extending LAN NOTES Self - Learning Material 51 10Base5 (Thick Net/Yellow Ethernet) This uses traditional thick baseband coaxial cable in bus topology to connect multiple computers as shown in Fig. 2.4. This singletransmission lineis calleda segment.Acoaxial cable 10mm in diametre, known as a thick coaxial cable is used as a transmission line.Aterminator is connected at each end of the cable. Note that proper data communication cannot be assured if even one of these terminators is missingornot properlyconnected. Atransceiverisusedtoconnectacoaxialcableandterminals.Atransceiver cable (also referred to as anAUI(Attachment Unit Interface) cable) is used to connect atransceiverand theNIC.Themaximum lengthofthis cableis50metre. Upto100transceiverscanbeconnectedtoeachsegment.Theminimumallowable distance between transceivers is 2.5 metre. Fig. 2.4 Hardware Configuration of 10Base5 10Base stands for 10Mbps and baseband transmission system. The 5 of 10Base5 signifya maximum of 500-metresegment length.The segmentmaybe extended upto 1500 metres byusing repeaters. Fig. 2.5 Transceiver Transceiver The transceiver exchanges data signals handled bythe NIC and electric signals sent over a transmission line.A15-pin D-SUB connector shown in Fig. 2.5 is usedtoconnecttransceiversandtransceivercables.Multiporttransceiversupports more than one NIC. 10Base2 (Thin Net/Black Ethernet) Thisis alsoknown as 10Base2,usescoaxialofthinnergaugeof5mm indiametre and bus topology as in the case of 10Base5 so that multiple computers can be connectedto asingletransmission lineasshowninFig.2.6.Primarilyitwas used in office environments. The thinner cable is less costly to acquire and deploy,

Local Area Network, Implementing and Extending LAN NOTES Self - Learning 52 Material althoughits performance is less in terms oftransmission distance.Because ofits cost it is sometimes called as cheapnet. 10Base2signifies in thesame manner as 10Bases5 except 2 is signified here as 200 metres maximum segment length (actually185 metres). ABNC(BayonetNeilConnector)oraT-connectorisusedtoconnect a cable and terminals or terminators. Note also that the NIC for 10Base2 can be connected directlyto aT-connector because this NIC has a built-in transceiver. Only up to 30 nodes per segment can be connected. The minimum allowable distance is 0.5 metre between consecutiveconnections. Fig. 2.6 Hardware Configuration 10Base2 Fig. 2.7 BNC/T Connector BNC/T-connector The Fig. 2.7 shows the BNC connector and T-connector. These are simple connectors that cannot exchange data.An NIC andT-connectormust be directly connected. Implementation of LAN using Twisted Pair Recentlytwisted pair has become verypopular as a LAN medium.Although its performance characteristics areless appealing, its low cost and high availability certainlyare attractive. Unshielded Twisted-Pair (UTP) cable's performance is verygood at low data rates. LANuses the same cable which telephone sets use. This enables to deploy Category 5 UTP pairs to each jack to ensure that voice anddataterminalsshareasinglewiringsystem.Additionally,UTParealsocapable ofworkingatveryhighdataratesupto100Mbpsbutforshortdistances.Shielded twisted-pair (STP)sometimes is used inLAN technology. STPs aremore useful intheenvironmentsusceptibletoEMI/RFIbecauseUTPdatatransmissionmight cause interferenceon adjacent pairs.
Local Area Network, Implementing and Extending LAN NOTES Self - Learning Material 53
ImplementationsofdifferentLANsusingUTPCablesareexplainedbelow. 10BASET (Twisted pair Ethernet) This uses Cat 3, 4, or 5 UTP. 10BaseTtranslates to 10 Mbps, Baseband,Twisted pair.10BaseTactuallyis a wirehub that servesas amultiport repeater,as well as acentralpointofinterconnection. Figure2.8showsthehardwareconfigurationof 10BaseT.Astar type topologyis used.The device shown at the center is known as hub.Aconnector known as RJ45 is connected at each end of the cable. The hubhasmultipleports,eachofwhichisconnectedtonodeusingNICviatheUTP cable. Each of the NIC for the 10BaseT has a built-in transceiver as do those of the10Base2.Themaximum distancebetweenthe10BaseThubandtheattached deviceis100 metres/segment. Fig. 2.8 Hardware Configuration 10BaseT Hub Hubs receive signals through one port and send them through all other ports as showninFig.2.9. That is, aLANconfigures with hubs physicallyfalls under the categoryof astar typetopology. However, logically,it falls underthe categoryof abustypetopology. Commerciallyavailablehubs normallyhaveeightorsixteen ports. CDDI (Cable Distributed Data Interface) CDDIis also known asTPDDI(Twisted-pair DistributedDataInterface). CDDI employs Cat 5 UTP as an inexpensive means of connecting workstations and peripherals to FDDIfibre optic backboneLANs.Atransmission rates up to 100 Mbpsmaybeachievedinthisscheme.Themaximumallowabledistancebetween hub and the device is not specified categoricallybut generallyit is kept less than 20metres. Cat 3 UTP often is used for 4 Mbps token ring LANs, cat 4 UTP has a bandwidth of 20 MHz and commonlyis used for 16 Mbps token ring LANs. Ethernet Expansion Themaximum allowablelength ofasegmentforthe10Base5is500metre.Upto 100nodes can be connected to a segment. That is upto 100 transceivers can be connected. Repeaters are used to connect terminals that are separated from one another beyond the distance specified above, or to connect more than a limited number of nodes. Each repeater has two ports so that it receives signals through oneoftheseportsandsendsthemthroughtheotherportafteramplification.Figure
Local Area Network, Implementing and Extending LAN NOTES Self - Learning 54 Material 2.10shows anexampleofthe10Base5LAN.Upto1024nodescanbeconnected to a LAN expanded by using repeaters. Fig. 2.9 Hub Configuration Fig. 2.10 10Base5 Ethernet Expansion 5-4-3 Rule The number of repeaters that can be used is limited. In the case of data communication between terminals, data can be sent through only up to four repeaters.Therefore,maximumfivesegmentscanbeprovidedbetweenterminals. Of these five segments, only up to three can be connected to terminals and are called as populated.The other two arelink segments as shown in Fig. 2.11.This limitationiscalledthe5-4-3rule(fivesegments,fourrepeatersandthreepopulated segments). Thosesegments that are not or cannot be connectedto anyterminals arecalledlink segments. Fig. 2.11 Example of Maximum Configuration
Local Area Network, Implementing and Extending LAN NOTES Self - Learning Material 55 10Base2 Expansion Themaximumallowablelengthof10Base2is185metre.Upto30canbeconnected to segment. Repeaters areused as with the10Base5 to connect terminals that are separated from oneanother bymore than the above distance or to connect more nodes than theabovelimit. The limitationstothe numberofrepeatersthat canbe used arethe same as thosefor the 10Base5.As with the 10Base5 (5-4-3rule), up to 1024 nodes can be connected to a LAN expanded byusing repeaters. This is shown inFig. 2.12. Fig. 2.12 10Base2 Expansion 10BaseT Expansion The maximum allowable length of a cable between a hub and terminal is 100 metreinthiscase. Cascadeconnectionisemployedtoconnectahubandterminal thatareseparatedfromoneanotherbymorethantheabovedistance.Thisconnection is alsoappliedwhen moreports thanavailablearerequired.Thenumbersofhubs that can be connected are limited up to four only. In a cascade connection the hub at downstream from other must have a port to beused exclusivelyfor cascade connection. This port iscalled an uplink portasshown inFig. 2.13.Almost allhubshavesuchaport. However,ifthehubs are connected without uplink ports, a special cable, called a cross cable, is used to connect thehub ports. Hub can be considered a kind ofrepeater with multiple ports (multiport repeater). This is whythenumber of repeaters andhubsthat can be used is the same. Fig. 2.13 10BaseT Expansion

Local Area Network, Implementing and Extending LAN NOTES Self - Learning 56 Material Stackable Hub Thenumbersofhubs arelimitedto fouronlyforcascadeconnection.Sometimes more ports arerequired. In this casestackable hubs are used.Each stackablehub hasaspecialinterfacedesigned toconnectit toanotherstackablehubas shownin Fig. 2.14.Connecting stackable hubs through this interface allows thesehubs to betreatedasasinglehub.Thisinterfaceisproductdependent.Themaximumnumber ofstackablehubs that can beconnectedvaries dependinguponttheproduct used. Fig. 2.14 Stackable Hub Table 2.1 Ethernet Specifications Ethernet Specification The above Table 2.1 shows the major Ethernet specifications described so far. Notethat themaximum network length means themaximum allowabledistance between nodes. Implementation of LAN using Fibre-optic Cable Duetoits outstanding performance characteristics, fibre-optic cableis also used in LANs. FDDI(Fibre Distributed Data Interface) is the current LAN standard (IEEE and ANSI) for such a network. FDDI can be extended to the desktop, eitherdirectlyorthrough theuseof twisted-pair in aCDDIapplication. • FDDIisthestandard (ANSIX3T9-5;IEEE802.2) forafibreoptic, token- passingringLAN • Highbandwidth-100 Mbpswithfull duplex interfaces • Excellent errorperformance in the rangeof 10 –14 • Fibre is capableoftransmitting datatoverylongdistances • Separation formultimode fibre can beas much as 1.2miles (2 km)
Local Area Network, Implementing and Extending LAN NOTES Self - Learning Material 57 • 37.2 miles (62 km)over singlemode fibre • Excellentsecurity • The maximum framesizeis 4500B capable ofaccommodatingthe native frame sizes ofall standard LAN networks • Costlyacquisition,deploymentandreconfiguration. • Protectionofoptical fibreis veryimportant sinceit isextremelyfragile. • The fragilityof fibre acts as a deterrent to the applicationof FDDI. FDDI specifications ask for a dual countr-rotating ring as shown in Fig. 2.15, which provides a measure of redundancy. If the primaryringfails, a Dual Attached Station (DAS)or a DualAttached Concentrator(DAC) can still communicatewith anyotherdevicebytransmittingthroughthesecondary ring. Fig. 2.15 FDDI dual counter-rotating ring 2.4 IMPLEMENTATION OF LAN USING WIRELESS TECHNOLOGY Wireless LANsoffertheobvious advantageofavoidanceofcablingcosts,which can be especially important in a dynamic environment where there is frequent reconfiguration of the workplace.Additionally, wireless LANs provide LAN capabilities in temporary quarters, where costly cabling would have to be abandoned.Eachworkstationisfittedwithalowpowerradioantenna.Theantenna is thenconnected to otherhub antennaeand to the servers,peripherals, and hosts viacabledconnections,whichalsoconnectmultiplehubantennaefortransmission between rooms, floors, and buildings. In order to serve multiple workstations, spread-spectrum radio technology is used to make effective use of limited bandwidth. Spread spectrum involves scatteringpackets of adata stream across a rangeof frequencies, rather than using a single transmissionfrequency.Aside benefitofspread-spectrumisincreasedsecurity,asthesignalisvirtuallyimpossible to intercept. ? WirelessLANisarelativelyimmaturetechnology. ? Acquisition costs arenot particularlylowwhencomparedtowired LANs, althoughreconfigurationcostsarevirtuallynon-existent. ? Frequency range—900 MHz, 2 GHz, and 5 GHz bands.
Local Area Network, Implementing and Extending LAN NOTES Self - Learning 58 Material ? Ahubantennaeislocatedatacentralpointfromwhereline-of-sight canbe establishedwiththevariousterminalantennae. ? Bandwidth of a wireless radio LAN—4 Mbps ? The effective throughput is more in the range of 1 to 2Mbps per hub. ? Theinfraredtransmissiontechniquecanalsobeused.PDA(PersonalDigital Assistant) make widespread use of infrared to establish links with workstationsandotherPDAfordatatransfer.Enhancedinfraredtechnology recently has been demonstrated at speeds of 1.5, 4, and even 155 Mbps. ? Error performanceand securityareissuesofsome significance. Somewireless LANs also usedirect sequencetransmission,whichmeans thatasignalissentsimultaneouslyoverseveralfrequencies,andthereforeincrease its chances ofgettingthroughtotheaccesshub.Figure2.2Hardware 16showsan exampleofhardwareconfiguration. Hub Hub Hub Server Fig. 2.16 Wireless LAN Configuration WLANis mostlyamix of wireand wireless media havinganaccess point orwirelessrouterthatisconnectedtoawirednetworkviaacoaxialcable,universal serial bus (USB),or Ethernet connection. Thedevices youwant toconnect tothe wirelessLANmusthaveaperipheralcomponenttocommunicatewiththeaccess point. IEEE 802.11a and IEEE 802.11b are wireless network standards with a datarateofonly2Mbpsand11Mbpsrespectively.Theyhaveadistancelimitation upto100feetfromtheaccesspointrouter.Thisuses2.4GHzband.IEEE802.11g allowsspeedsupto54Mbps.ThiswirelesstechnologyisknownasIEEE802.11g, Wireless-G, or 54g, and continues to use the 2.4 GHz band. Exponential growth rates in mobile communication systems, enhanced awarenessinsocietyandderegulationofformermonopolizedmarketshavepaved thewayfortheeasyuseofmobilecommunicationsystemsas well as anewset of issues, techniques and solutions. Digital Cellular networks are the wireless extensions of traditional PSTN or ISDN networks and allow for nationwide or evenworldwideseamlessroamingwiththesamemobilephone.Cellularnetworks havetraditionallybeenthepreservesofvoice.However,datatrafficiscontinuously growing.Mostofthemobilephoneshavetheabilitytosendandreceiveshorttext messages, and an increasing number now incorporate more advanced Internet

Local Area Network, Implementing and Extending LAN NOTES Self - Learning Material 59 capabilities such as World Wide Web onto mobile and wireless devices. New applicationsandnewmobilenetworkswillbringubiquitousmultimediacomputing to the radios, Personal DigitalAssistants (PDAs), laptops and mobile phones.
Thesedevicemayalsogetconvergeandmanymorefunctionswillbeavailableon onedeviceonly.
Thisunitattemptstointroducethefieldofmobilecommunicationsanddigital datatransfer.Itrequiresanunderstandingofcommunicationandnetworkingwhich have beenadequatelyprovided in theprevious chapters. There aretwo different kinds of mobility. If you ask aquestion about the appearance ofa computer after 20yearsormoreyouwillnotgetan accurateanswerbutmanypeoplemaypredict thatmost computerswillcertainlybeportable.Therefor,auserwillhavetoaccess the network without any wires i.e. wireless. Keeping on view these features in mind, we can say that there are two different kinds of mobility.These are user mobilityand device portability. In case of user mobilitya user can access to the sameorsimilartelecommunicationservicesatdifferentplaces.Unlikeusermobility, deviceportabilityallowsthemovementofdevicewithorwithoutuser.Thenetwork anddevicearchitectureensuresthecommencementofcommunication.Theterm wireless isused in thecontextofdeviceportability. A numberof mobile and wireless devices are available in different forms dependinguponvariousapplications.Someofthesedevicesaresensor,embedded controllers, pager, mobile phones, personal digital assistant (PDA), palmtop, notebook,etc. Theavailabilityoflowcost microprocessorsanddigital switching madethewirelesscommunicationpopularamongthemasses. Cellular Radio Definition Cellular radio has another popular names as cellular mobile or mobile phone. Radio is basically a device, which uses receiver and transmitter. Wireless communicationcanalsobecarriedoutwithoutusingradio.Theinterferencecaused by high power line to radio transmission is also an example of wireless communicationthoughitistermedasnoise.Inductiveandconductivecircuitsand devices can communicatewirelesslyforlimited distancewithless reliabilityand implementation problem. Thereforethese techniques can not betermed as radio transmission. Thetermradiomaybedefinedasconsistingofmodulationandradiationof the signal. Modulation techniques have been discussed in details. Therefore, a transmitterandan antennaare usedto modulateand radiatethemodulatedsignal within radio spectrumas shown in Figure2.17.Onthehandat the receivingend, an antennaand areceiveris requiredto demodulatethe signal.Ifthetransmitting and receiving end are receiving and transmitting, a transceiver (consisting of transmitterandreceiveroperation)is employed.Intelephonesystem asweknow that a voice with bandwidth of approximately4 kHz modulates the current of a telephoneline.Wirelesscan bedefinedas theradiotransmissionandreceptionof signals bymeans ofhigh frequencyelectricalwaveswithoutaconnectingwire.
Local Area Network, Implementing and Extending LAN NOTES Self - Learning 60 Material VLF LF MF HF VHF UHF SHF EHF Infra- red Visible light

69% **MATCHING BLOCK 34/106** W

VLF: Very low frequency LF: Low frequency MF : Medium frequency VHF: Very high Frequency HF: High frequency UHF: Ultra high frequency SHF: Super high frequency EHF: Eextremely high frequency 10

kHz 100kHz 1MHz 10MHz 100MHz 1GHz 10GHz Fig. 2.17 Radio Spectrum A cellular system is thecommunications systems thatdividea geographic region into sections, called cells, each having its own dedicated frequency.The frequencyofacell maybereusedafter theinterference zone.Nowwecandefine cellularradioorcellularmobileormobilephoneas acommunicationsystemthat consists of a combination of radio transmission andPublic SwitchedTelephone Network (PSTN) to permit telephone communication to and from mobile subscriberswithinaspecifiedarea.Thisrequiresacellulararchitecture,whichhas been described in the subsequent sections. For digital communications, several competing cellular systems exist. These are Global System for Mobile Communication (GSM),CDMA, etc. Basic Wireless Principles
Acellularmobilecommunicationssystemconsistsofalargenumberoflowpower wireless transmitters to createcells. Thesecells coveracertainarea andtypically called as base station. Depending upon the power level the size of cells can be decided. In this way, the radii of a cell may vary from ten of meters to tens of kilometersinabuildingtoacityrespectively.Itwillalsodependuponthesubscriber density and demand within a particular area. The shape of cell may not be a perfecthexagonorcircleanddependsupontheenvironment.Whenamobileuser travels from cell to cell, their conversations are “handed off” between cells in order tomaintain seamless service. Cells canbeadded as perthe demands based upontheuserdensityornewlycreatedareas. Channels(frequencies)usedinone cell can be reused in another cell after some distance and thereforeit uses Space DivisionMultiplexing(SDM).Frequenciesforcommunicationmayvaryfromvery highfrequency(VHF)to–microwaverange.Regulationbodiesoftheconcerned countries regulate these. The signal may be analog or digital with amplitude, frequencyandphasemodulation.Themultiplexingandaccesstechniquesarespace divisionmultiplexing(SDM),frequencydivisionmultiplexing(FDM),timedivision multiplexing(TDM),andcodedivisionmultiplexing(CDM). The advantages of mobile communication may be looked into higher capacity, higher number of users, less transmission powerneeded, more robust, decentralized base station deals with interference, transmission area etc. The disadvantages are fixednetworkneededforthebasestations,handover(changing fromonecelltoanother)necessary,interferencewithothercellssuchasco-channel, adjacent-channel. Itisnowevidentthatcellularnetworksareessentialforwirelesstransmission.
Weoughttoknowaboutthecellularconcept,frequencyreuse,channelallocation, call setup, locationmanagement, cell handoffs, optimizations interms of power

Local Area Network, Implementing and Extending LAN NOTES Self - Learning Material 61 control and cell capacity and implementations of GSM, GPRS, 3G etc. The importantissuesonwirelesscommunicationarecellsizing,frequencyreuseplanning andchannelallocationstrategies. GSM Cellular Radio System Inthebeginningaround1980s,analogcellulartelephonesystemsweredeveloping in Europe and each country were developing its own system and thus making themconfinedwithintheircountryboundaries.Lateron,theneedforanEuropean public land mobile system were realized. In 1982 the Conference of European Posts andTelegraphs (CEPT) formed a studygroup called the Groupe Spécial Mobile (GSM) to develop a pan-European standard with the objectives of providinggood subjectivespeech quality, support forinternational roamingetc. The proposed system was expected to meet certain criteria as mentioned below: ? Good subjectivespeech quality ? Low terminaland servicecost ? Supportforinternationalroaming ? Abilitytosupporthandheldterminals ? Support fora rangeofnewservices and facilities ? Spectralefficiency ? ISDNcompatibility Subsequently, European Telecommunication Standards Institute (ETSI) published phase I of the GSM specifications in 1990 by 1993 there were 36 GSM networks were deployed in 22 countries and gradually over 200 GSM networks includingDCS1800 and PCS1900aroundthe world.With theentryof NorthAmerica, GSM systems now exist on every continent, and GSM is now knownasGlobalSystemforMobilecommunications.Theanalogcellularsystems likeAMPS inthe United States andTACS inthe UnitedKingdom werereplaced asdigitalsystemkeepinginviewtheadvantages ofdigitalsystem incompression algorithmsanddigitalsignalprocessingalloverthe world In brief, we may now saythat GSM is a digital mobile communications systembasedonEuropeanstandardwhichhasbeendefinedwithintheframework of the European Telecommunications Standards Institute (ETSI), and in the meantime has been adopted by 396 network operators in 150 countries. It was designedtobecompatiblewithISDNsystems andtheservicesprovidedbyGSM are a subset of the standard ISDN services (speech is the most basic). General Features of GSM GSM (Global SystemforMobileCommunications)is asecond-generation(2G) digital mobile telephones standard using a combinationTime Division Multiple Access (TDMA) and FrequencyDivision MultipleAccess (FDMA)tosharethe bandwidth among as manysubscribers as possible. ? GSM provides only 9.6 kbps data connection. Increase in data rates can be achieved when GSM changes into a radio service based on wide band code division multiple access,and not TDMA.
Local Area Network, Implementing and Extending LAN NOTES Self - Learning 62 Material ? GSMdigitizesandcompressesvoicedata,thensendsitdownachannel withtwootherstreamsofuserdata,eachinitsowntimeslot.Itoperates at either the 900, 1800 or 1,900MHz frequencybands. ? Theuplinkanddownlinkfrequenciesfor GSMaredifferentandtherefore achannelhasapairoffrequencies80MHzapart.Theseparationbetween uplinkanddownlink frequenciesiscalledduplex distance. ? In a channel the separation between adjacent carrier frequencies is known as channel separation which is 200 kHz in case of GSM. ? The services supported by GSM are telephony, fax and SMS, call forwarding,callerID,callwaitingandthelike. ? GSM supports data at rates up to 9.6 kbps on POTS (Plain Old Telephone Service), ISDN, Packet Switched Public Data Networks, and Circuit Switched Public DataNetworks. ? TheaccessmethodsandprotocolsforGSMmaybefromX.25orX.32. ? Being a digital system, GSM does not require a modem between subscriber and GSM network. However, an audio modem is required insidetheGSM network to establish connection with POTS. GSM Subscriber Services Therearethreebasictypes ofservices offeredthroughGSM.Thesearetelephony orteleservices,dataorbearerservicesandsupplementaryservices.Bearerservice provides thenecessarydata or controlsignal for different entities and interfaces. An interface is an access point between two entities, which will be described subsequently under GSM architecture. Telephony services comprise of voice services between different subscribers. The supplementaryservices are used to enhance the features of bearer and teleservices. In this wayGSM provides the followingservicestosubscribers: ? Dual-tonemultifrequency(DTMF)—DTMFsignalsaretonesignals used for various control purposes via the telephone network and are different from dial pulses. This can pass through theentirechannels to the subscriber and therefore offer itself to various schemes for remote control after theconnection is established. One example is the remote controlofananswering machine. ? Short message services (SMS)— SMS is a message consisting of a maximum of160alphanumericcharacters.SMScanbesent toorfrom a mobile stationeven when the subscriber's mobilestation is powered off or has left the coverage area. In this case the messageis stored and offered back to the subscriber when the mobile station is powered on or the subscriber has come back to the coverage area of the network. ? Facsimile group III— GSM supports CCITT Group 3 facsimile.A special fax converter in the GSM system enables afax connected with GSM tocommunicatewith anyanalogfax inthe network. ? Call forwarding— This is a supplementaryservice, which enables a subscriber to forward incoming calls to another number on his own convenience.
Local Area Network, Implementing and Extending LAN NOTES Self - Learning Material 63 Theotherservicesarecellbroadcast,voicemail,faxmail,barringofoutgoing andincomingcallsconditionally,callhold,callwaiting,conferencing,closeduser groups etc. GSM consists of manysubsystems, such as the mobile station (MS), the base station subsystem (BSS), the network and switchingsubsystem (NSS) and theoperation subsystem(OSS). Mobilestation(MS),thebasestationsubsystem (BSS)togetherformsaradiosubsystem. Figure2.18showsthevariousispartsof GSM architecture, whichhas been further, explainedinFigure2.18. OSS MS BSS NSS User data flow Control flow RSS Fig. 2.18 An Overview of GSM Architecture Architecture of the GSM network ThegenericGSMnetworkarchitectureisshowninFigure2.19,whichiscomposed of three subsystems as the radio subsystem (RSS), the network and switching subsystem (NSS) and the operation subsystem (OSS). Thesubscribercarries the Mobile Station, which is part of RSS. Cell BTS U m MS MS BTS MS BSC BSC MSC MSC A A bis SIM PSTN H L R H L R V L R H L R H L R V L R EIR AUC OMC RSS NSS OSS BSS O Fig. 2.19 Architecture of Mobile Communication System

Local Area Network, Implementing and Extending LAN NOTES Self - Learning 64 Material TheRSSis basicallyconsistingofradiospecificequipmentsuchasmobile station(MS),basestationsubsystem(BSS)tocontroltheradiolink.Theconnection between RSS and NSS is established withAinterface basedon circuit switched PCM-30 system with 2.048 Mbit/s date rate. The chief components of RSS are BSS, cellularlayout and base stationcontroller (BSC). Radio Substation (RSS) The RSS consists of the components that are necessaryin order to allocate the radio resourcesto theindividual subscribers.It principallyconsists ofthemobile terminals (mobile phone or mobile station, MS) and the base station subsystem (BSS). Base Station Subsystem (BSS) The MobileStation and theBaseStation Subsystem communicate acrossthe U m interface, also known as the air interface or radio link.ABSS is controlled bya BSC as shown in Figure 2.19. A BSS maintains radio connections to an MS, coding/decoding of voice and data rate adaptation to/from the wireless network part. There maybe manyBSS in aGSM networkand eachBSS contains several MS, base transceiver station (BTS) and a base station controller (BSC) along withthecellularlayout.ThesecommunicateacrossastandardizedAbisinterface, allowingoperationbetweencomponents madebydifferentsuppliers. Mobile Station (MS) Asshownin Figure2.19thatMSisbasicallymobileequipment whichcomprises ofalluserequipmentandsoftwareneededformobilecommunicationandasmart cardcalledtheSubscriberIdentityModule(SIM).Figure2.20(thehandset)shows the MS, which contains a SIM card in the form of a verysmall chip inside the equipment. Fig. 2.20 Mobile Station/Cellular Phone TheSubscriberIdentityModule(SIM)containsallsubscriberinformation necessary for identifying GSM subscriber. Broadly, it holds a subscriber's InternationalMobileSubscriberIdentity(IMSI),authenticationkeyandalgorithm. SIM is independent ofthe deviceorhandset in whichit is beingusedbecause an MScanbeidentifiedviaInternationalMobileEquipmentIdentity(IMEI).Assoon as theSIM is inserted intohandset, itbecomes immediatelyprogrammedforuse. Therefore, it canbeinserted into anyhandset. If youhaveforgottento carryyour handset but arecarryingyourSIM card, it can beinsertedinanyborrowedphone foruse.Without SIM ahandsetcan access onlyemergencyservices.Advances in memory and processing capacity has enabled SIM cards to be programmed to
Local Area Network, Implementing and Extending LAN NOTES Self - Learning Material 65 displaycustom menus for personalized services and thereforemakes it different fromconventionalcellularphones.Typicallymobilestationshavetransmittedpower from2Wto1Wdependinguponthecellsize.Ifcellsizeissmaller,thetransmitted power will be less. Cellular Layout Cellsarethebasicconstituentsofacellularlayoutwithcellsites.Cellsiteisdefined as the location where base station and antennas are placed. A cell is simply represented bysimplehexagon. The sizeof a cell mayvaryfrom tenofmeters to tens ofkilometersin abuilding toacityrespectively.Factorsfordeterminingcell size basically look for numbers of users to be supported and multiplexing and transmission technologies.Thesizeofcells,incaseofGlobalSystem forMobile Communication (GSM)and Personal Communication Service(PCS) are much smaller in the range of 10 Kms. There is a provision to provide umbrella cell, whichisalargecellthatincludesseveralsmallercells.Thisavoidsfrequenthandoffs forfastmovingtraffic. Figure2.21representsthecellsandcellsiteswithincellularlayout.Cellsare furthersplitintosectorsorindividual areastomakethemmoreefficientand tolet them tocarrymore calls. Cell site Fig. 2.21 Cells and Cell Site within Cellular Layout As showninthe Figure2.21 thatantennatransmits inward toeachcell and therefore covers a portion of each cell instead of the whole cell. The portions covered bythe antenna are called sector. Base Transceiver Stations (BTS) and Antennas A base transceiverstation is responsible to communicate withhosts inits cell by meansofpassingall calls cominginand goingout ofacell site.TheBTS orBase Transceiver Station is also called an RBS or Remote Base station. Each base transceiver station covers a certain transmission area, which is a cell, and it is allocated a portion of the total numberof channels available.Agroup of nearby basetransceiverstationsformsanetworkandusesallavailablechannelsmutually. A network of radio BTS and antennas covers a large geographical area to cater large numbers of subscribers in the form of cells for analog and digital mobile communicationandneedtoberugged,reliable,portablewithminimumcost.BTS arehousedwithallradioequipmentsuchasantennas,signalprocessors,amplifiers etc to handle the radio-link protocols with the mobile station and for radio transmission. Placementofbasetransceiverstationisalsoanimportantissue.Figure2.21 shows a cell site, which mayconsidered as edge-excited cell. Base station may

Local Area Network, Implementing and Extending LAN NOTES Self - Learning 66 Material also be placed near center of cell and known as center excited cell. Figure 2.22 showsacentrallyexcitedcell.Theactualcellistheblueandredhexagon,withthe towers at the corners, as has been depicted in Figure 2.22. Fig. 2.22 Centrally Excited Cell Frequencyselection for each base transceiver station is a veryimportant factor.Incorrectselectionoffrequencymaygenerateinterferencewithneighboring cells. The transceivers outside the interference range of other transceiver may reusethefrequencies being used byothertransceiver. Antenna always transmits inward to each cell and area serveddepends on topography,population,andtraffic.Thoughtheoreticallytheseradiatesequallyin all directionshoweverinreality,theyhavedirectiveeffectsandthereforesectored antennas are used. Mobile stations (MS) communicate onlyvia the BTS and a BTS isconnectedtoamobilestation(MS)viaU m interfaceandA bis interfacewith BSC as depicted in Figure 2.19. The U m interface basicallyconsists of FDMA, TDMACDMAetc.requiredforwirelesstransmission.OntheothersideaBTSis connected to BSC viaA bis interfaceconsisted of 16 or 64 kbits/sconnections.As it isalreadymentioned that GSMutilizesTimeandFrequencyDivision Multiple Access (TDMA/FDMA) to divide up the bandwidth among as many users as possible.TheFDMAinvolvesthedivisionuptothemaximumof25MHzbandwidth into124carrierfrequenciesspaced200kHzapart.Oneormorecarrierfrequencies are then assigned to each BTS depending upon the traffic.FDMA channels are further divided in time with a burst period of approximately0.577ms, using a TDMA technique. Theburst period is a fundamental unit of timein this TDMA technique. Subsequently, eight burst periods are grouped into a TDMAframe whichformsthebasicunitforthedefinitionoflogicalchannels.Onephysicalchannel is one burst period per TDMA frame. Abasetransceiverstationmayhaveitsownhierarchywithpicocellscovering building interiors, microcells covering selected outdoor areas, and macrocells providing more extensive coverage to wider areas as shown in Figure 2.23.As demandincreases,morechannelsareneededandthereforenumberofbasestations is increased and transmitter power is decreased correspondingly to avoid interference.EachBTSisconnectedtoaBSCthroughfixedlinkswherealltraffic gets gathered first for the onward journeyto MSC.

Local Area Network, Implementing and Extending LAN NOTES Self - Learning Material 67 Macro cell Micro cell Picocells in building coverage Higher data rate Slower data rate Fig. 2.23 BTS Own Cell Hierarchy Base Station Controllers (BSC) BSC is alsoapart ofRSSand basicallymanages severalbasetransceiverstations (BTS)at atimebyprovidingalink betweenwireless devicessuchas cell phones, and the PSTN. It is the connection between the mobile station and the mobile services switching center. Base station controller is nothing but a high capacity switch.Thisswitchperformscontrolandmanagementfunctionssuchashandover fromoneBTStoanotherwithintheBSS,managementofradionetworkresources and handlingof cell configuration data,control of radio frequencypower levels, settingoftransceiverconfigurationsandfrequenciesforeachcelletc.Thenumber of BSC mayvaryfrom cellto cell dependingon the complexityandcapacityofa carrier's system. It also multiplexes the radio channels onto the fixed network connections.BSCalsoenablescompressionoftrafficemergingfrommobilephones evenfurtherbyusingatranscoder/rateadaptationunitwhichcarriesoutencoding andspeechdecodingand rateadaptationfortransmittingdata.Thisanadditional advantage of BSC as the voice coders in the handset have alreadycompressed voiceanddataandputsthetrafficintoaformattheMobileSwitchcanunderstand. Figure 2.19 illustrates theposition of BSC inGSM architecture. Network and Switching Subsystem Thenetworkswitchingsubsystem(NSS)constitutesthefixednetworkcomponent ofthemobileradiotelephoneservicenetworkat oneendandbetween themobile radio telephoneservicenetwork and otherpublicnetworksontheotherhand.Itis composed of theMobile Services SwitchingCenter (MSC),the Home Location Register(HLR)and theVisitorLocation Register(VLR).

Local Area Network, Implementing and Extending LAN NOTES Self - Learning 68 Material Mobile Switching Center (MSC) The other popular name for MSC is mobile switch (MS) and mobile telecommunicationsswitchingoffice(MTSO). The MSC coordinates call set-up to and from GSM users. Each mobile switch manages dozens to scores of cell sites. Each MSC is connectedto a base station at one end and to other MSCs and PSTN or ISDN on the other hand throughfixed links.InthiscaseeachMSC acts asalocalswitchingexchangethat handlesswitchingofmobilesubscriberfromonebasestationtoanotherandlocating the current cell of a mobile subscriber. Besides, it providesall the functionality suchasregistration,authentication, locationupdating,handover,andcallrouting to a roaming subscriber. MSCs thus form a fixed backbone for a mobile communication.Anadditional MSC mayalsobe providedto establishlink with otherfixednetworks.ItistermedasGatewayMSC.MSCprovidestheseservices in conjunction with several functional entities, which together form the NSS. Therefore, the main tasks of MSC are entrusted upon as interworkingfunctions (IWF), mobilitymanagement operations, data service units (DSU), SS7. Large systems mayhave two or more MSCs. As shownin Figure 2.19 BSCs interact with a MobileServices Switching Center (MSC), which is a high capacityISDN switch, through aninterfaceA. It basicallygatherstrafficfromdozensofcellsandpassesitontothepublicswitched telephone network (PSTN). The mobile switch controls the entire network by interacting with distant databases and the public switchedtelephone network or PSTN. MSC also performs the administrativefunctions in the form of checking thevalidityofauser'saccountbeforelettingacall gothrough,deliverssubscriber serviceslikeCallerID, and pagesthemobilewhenacallcomes in.Italsohandles all signaling needed for call set up, call release and handover of calls to other MSCs byusingstandard signaling system7 (SS7). Home location register and visitor location registers are the two chief databases.Theseinteractwith MSC for performingsignalingandadministrative functionsandprovidethecall-routingand roamingcapabilitiesofGSM. Home Location Register (HLR) The HomeLocation Register (HLR) whichhas its main taskas association with MSC. The HLR consists of a database, which contains subscriber's all administrativeinformation alongwith thecurrent locationinGSMnetwork.The informationincludessubscriber'sinternationalmobileequipmentidentity(IMEI) number, directorynumber, current city, last visited area and the class of service subscriberhas. TheVLR temporarilycontains administrativeinformationthat is relativetowhatevermobileis currentlyinits area. The Home Location Register (HLR) is an integral part of mobile communication, which keeps a profile of a user or a subscriber. HLR keeps the current location ofeachmobilethatbelongstotheMSC towhichit isinteracting. The subscriber's home service provider maintains it. Home Location Register performs the functions such as deliveryof calls, information and messages to

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subscribersattheircurrentlocationsbyusinguserprofileinformation.Incaseofa roaminguser,theuser's dataismaintained at onelocationwhichmakes database administratorfunctionseasy.Aroamingsubscribermeansthatheiscomingunder different MSCs and the servicing MSC just collects information about the user fromhishomeMSC.Thisfacilitatesinreducingadministrativeerrorsandduplication expenses. The HLR maintains user information in the form of static and dynamic information.ThestaticinformationistheInternationalMobileSubscriberIdentity (IMSI), account status, service subscription informationauthentication keyand options etc. The dynamic information is the current location area of the mobile subscriberwhichis theidentityofthecurrentlyservingVisitorLocation Register (VLR)toenabletheroutingofmobile-terminatedcalls.As soonasa mobile user leaves its current location area the informationin the HLR is updatedso that the mobile user can be localized in the GSM network. The HLR handles SS7 transactions with both Mobile Switching Centers (MSCs)and VLR nodes. Visitor Location Register (VLR) VisitingLocation Register(VLR) as its name implies maintains temporaryuser information (such as current location area) falling under the other MSCs being visitedbythesubscriberormobileuserbutwhoseHomeLocationRegister(HLR) is elsewhere. VLR therefore controls and manages call request from subscriber who is out of the area covered bytheir homesystem and currentlylocated in the geographicalareacontrolledbytheVLR.Thisis achievedbycopyingall relevant information for the subscriber from the its HLR. VLR alsoprovides interfacing withPSTNas pertherequirement.Therefore, its maintasksareassociationwith MSC, IMSI, TMSIand roaming. This mechanism of maintaining VLR avoids frequentHLRupdatesandlongdistancesignalingofsubscriberinformation.When a call is initiated from theoutside the subscriber homearea, the MSC ofthat area VLR contacts the appropriate MSC usingSS7 signalingwhich inturn relays the HLR information to the VLR. The VLR sends routing information back to the MSC under which the mobile subscriber is currentlyvisiting and this creates a temporaryrecord for the subscriber in that VLR. InnutshellwecansaythatboththeHLRandVLRworktogethertoprovide local connection as well as roamingoutsidethelocal servicearea. Operation Subsystem (OSS) TheOperations andMaintenanceCenteroverseestheall-important functions for proper operation and setup of the network and therefore provides Telecommunication Management Network (TMN). It alsoprovides interface to NSS via O-Interface that maybe X.25 Interface. The followingparts have been defined: Operation and Maintenance Center Figure 2.25 shows the position of OMC in GSM network. It allows monitoring andcontrollingofthesystemaswellasmodifytheconfigurationoftheelementsof

Local Area Network, Implementing and Extending LAN NOTES Self - Learning 70 Material thesystem.It providesall necessaryinformationforcontrollingpointofviewand uses an interface O as shown in Figure 2.19. O interface is SS7 with X.25. It manages and controls the traffic load of the BSS. Basically, the management functionsincludetrafficmonitoring,statusreportofnetworkelements,subscriber andsecuritymanagement.Thesubscriberandsecuritymanagementisaccomplished throughaccountingandbilling. TheAuthentication Center (AuC) TheAuthenticationCenter(AuC)isconsideredasubsystemoftheHLRasshown inFigure2.19andisusedforauthenticationandsecuritybygeneratingauthentication algorithms, cryptographic codes etc. It is a secured database to protect the subscriber identity and data transmission as mobile station and interfaces are vulnerablefromsecuritypointofview.Itgeneratesandsendsarandomlygenerated numbertothemobileforcorrect replyback.TheSIMinsidethemobilegenerates another number with the aid of the its encryption keyand the received number fromAuC. The MSC will proceed the call only when it receives the expected number back from mobile. In this manner a call is authenticated and therefore AuC is responsible for maintaining all data needed to authenticate a call and to thenencryptboth voicetrafficandsignalingmessages. The Equipment Identification Register (EIR) EIR fulfills the securityand authenticationrequirement of GSM. Itis aprotected database for the subscriber and equipment identification number (IMEI) that contains a list of all valid mobile equipment on the network, where each mobile station is identified byits International MobileEquipmentIdentity(IMEI).Each SIMcardhasasecretkeyforauthenticationandencryptionovertheradiochannel. This made availableto EIR. GSM networkchecks the type andserial number of amobiledevicethrough EIR databaseanddetermines whetherornottoofferany service. It also monitors and stops the use of the stolen mobile when the owner reports about theft.It also maintains adatabaseof malfunctioning devices. GSM System Radio Interfaces Ashasbeenshownintheprevioussectionsand Figure2.19thatGSMarchitecture consistsofanumberofentitiestohandlethedifferentrequirementsofcallprocessing at differentstages.Amobile station,which digitizes and encodes voice, requires anaccess to aBTS controllingacell withincellular outlay.ThisBTS further gets connectedtoBSC, which is inturn connectedtoMSCtosendthecalloutsidethe cellular outlay on MS either in the same network or on different network. The connection betweendifferent entities isachievedbyusinginterfaces ateachstage because the requirement of data at each stage is different from another stage and differentequipmentfromanymanufacturerwillworktogether.Thisisastandardized methodforpassinginformationbackandforthandcanbeamechanicalorelectrical link connecting equipment together.We maynow discuss the various interfaces onebyonein thefollowingsections.

Local Area Network, Implementing and Extending LAN NOTES Self - Learning Material 71 The Radio Interface U m U m istheradiolinkbetweenamobilestationandabasestation.Themobilestation usesmanytechniquestocreatephysicalchannelsthroughFDM(FrequencyDivision Multiplexing)andTDM(TimeDivisionMultiplexing).ItusesFDMA/TDMAfor accessingthecellularnetworkwherecellscontainingBTSarearrangedusingSDM techniques. GSM 900 operates on afrequencyrange of 890-915MHz for uplink and 935-960 MHz for down link. It uses different frequencies for uplink and downlinktoavoid interference and differentpowerrequirement at MSand BTS. FrequencyDivisionMultiplex(FDM)isusedtodividetheavailablefrequency band in GSM. The available bandwidth is therefore 25 MHz, which is into 124 carrierfrequencies,spaced200kHz apart usingFDMAtechnique.TimeDivision MultiplexStructure(TDM)providesphysicalTDMchannels,timeslotsandTDMA frame. The fundamental unit of time in this TDMA technique is called a burst period.Typically, GSM has manyburst types such as normal burst, access burst, synchronization burst,frequencycorrectionburst anddummyburst. In the normal burst case, a burst period lasts 15/26 milliseconds (ms) or approximately577 ms. Figure2.24 describesGSM timeslotsfornormal burstof 577 ms which includes 30.5 ms for guard space. Guard space is provided to avoid overlap with other bursts, different path delays and delaybecause of the transmitteron-offoperation.Slotsholdindividualcallinformationwithintheframe, thatis,themultiplexedpiecesofeachconversationaswellassignalingandcontrol data. Guard space Tail User data S Training S User data Tail Guard space 3 bits 57 bits 1 bit 26 bits 1bit 57 bits 3 bits 546.5 ?s 577 ?s Fig. 2.24 GSM Time Slots for Normal Burst Such types ofeight burst periods aregrouped into a TDMAframe of time duration of 4.615ms.This is theTDMAscheme.As has alreadybeen described that the available bandwidth of 25 MHz is divided into 124 carrier frequencies, spaced200 kHz apart. Each 200 kHz carrier frequencycontains eight such types of TDMA frames, each of 4.615 ms time duration that gives the concept of a channel. Therepetitionof oneparticulartimeslots every4.615 msmakes up one basicchannel.Abasestationmayhaveoneormorecarrierfrequencies.Eachtime slot consists ofavoicechannel. Channelcomprisesof apairofradiofrequencies fortransmissionand reception separatelyincellularradio.Therefore,achannelis a dedicated time slot within a data or bit stream, which repeats after a certain period of time. Channels can further be divided into dedicated channels and common channels. Both the dedicated and common channels are allocated to a mobilestation but thelatterisused bymobilestationsinidle mode.

Local Area Network, Implementing and Extending LAN NOTES Self - Learning 72 Material A normal burst contains a training packet of 26 bits surrounded on both sides bytwo packets of 57 bits each of user dataand two packets of 1bit each of stealingbit. Stealing bit is denoted as S in Figure 2.24.Thereafter, 3 tail bits are addedon eachside. Thepurposeof26-bit trainingsequence isto reconstruct the originalsignalbycomparingitwiththereceivedpattern.Trainingsequenceisofa knownpattern. Logical Channels and Frame Structure Itisexplainedearlierthatwhenaslotrepeatedevery4.615msconstituteaphysical channelwhich maybesplit intoseveral(logical)channels.TDMAisusedtosplit carrier frequency of 200 kHz into 8 time slots. Figure 2.25 explains a TDMA frame.Theseslotsareknown as 8logical channels.Alogical channel is therefore defined by its frequencyand the TDMAframe time slot number. GSM 900 has 124physicalfull duplex channels or248 physical half-duplex channels.As there are8timeslotsforeachphysicalhalf-duplex channel,hence248channelwillhave a total of 1984 logical half-duplex channels. In a cellular system, a cell can only useoneseventh ofthetotalnumberoffrequencies therefore283(1984/7)logical half-duplexchannelspercellareusedeffectively.Thelogicalchannelcanbedivided in trafficchannels used foruserdataand signalingchannelsreservedfornetwork managementmessages. Figure 11.9 TDMA Frame Traffic channels (TCH) 0 1 2 - - - - 67 - - - - - - 122 123 1 2 3 4 5 6 7 8 Guardspace Tail Userdata S Training S User data Tail Guardspace 3bits 57bits 1bit 26bits 1bit 57bits 3bits 546.5?s 577?s 124 channels allocation under FDMA in GSM 900 TDMA Frame - 4.615 ms Fig. 2.25 TDMA Frames Atrafficchannel(TCH)isdefinedforspeechanddataat therates of9.6kb/ s,4,8kpbsand2.4kbps.Itcomprisesofgroupof26TDMAframeswhichincludes 24framesfortraffic,1 frameforthe SlowAssociatedControlChannel (SACCH) andremaining1frameis currentlyunused.Thelengthofthese26TDMAframes arekept 120ms. This TCHframestructuredefines thedurationofaburst period. The half-duplex distance in timeis 3 burst periods. Besides,these full-rateTCH, there are also half-rate TCH available to make the capacityofthe system double
Local Area Network, Implementing and Extending LAN NOTES Self - Learning Material 73 Control Channels (CCHs) Controlchannelsasitsnameimpliesarebasicallyusedtocontrolthelogicalchannels and takes different form depending upon the task assigned to these channels. It basically controls medium access, allocation of traffic channels or mobility management. Depending upon the task performed bythese channels, theyare categorized in three categories such as broadcast control channels (BCCH), commoncontrolchannels(CCCH)anddedicatedcontrolchannels(DCCH).These can be accessed both byidle mode and dedicated mode mobiles. Broadcast Control Channel (BCCH) BCCHis aunidirectional downlink point-to-multi-point-signalingchannel from BTS to MS. It is used byBTS to broadcast control information to all MS in that particular cell about cell identifier, options available within this cell (frequency hopping)andthefrequencyavailableinthecell andcellsinitssurrounding. Ithas frequency correction channel (FCCH) and synchronization channel (SCH) as subchannels whichareusedtocorrectfrequencyandtosynchronizethemobileto thetimeslot structureofacell bydefiningtheboundaries ofburst periodsandthe timeslotnumberingrespectively.EverycellinaGSMnetworkbroadcastsexactly one FCCH and one SCH. Common Control Channel (CCCH) CCCH is a bi-directional point-to-multi-point-signalingchannel that exchanges thesignalinginformationfornetworkaccessmanagementandtransportsinformation regardingconnectionsetupbetweenMSandBTS.BTSusespagingchannel(PCH) tofindoutthelocationofMSbypagingpriortodownlinkpackettransfer.Whenever a mobile wishes to establish a call, it uses Random Access Channel (RACH) wheremobileusesSlottedAlohachanneltorequestaccesstothenetwork.Access grant channel is a downlink only, which replies to a random access channel and allocateanstandalonededicated channel (SDCCH)toamobileforsignalingwith a low data rate of 782 bps in order to obtain a dedicated control channel for subsequentsignaling. Dedicated Control Channel (DCCH) These are bi-directional and are multiplexed on to a standard channel for registration, location updatingand authenticationinordertoset upacall orTCH. Each SDCCH and TCH is associated with slow associated dedicated control channels (SACCH)forcontrol and supervisorysignals associatedwiththetraffic channels. GSM also uses Fast associated dedicated control channels (FACCH) which captures time slots from the TCH and are used for control requirements such as handover where MS and BTS need to be transferred large amount of data. GSM specifies amultiplexing schemeto integrate several frames where a periodicpatternof26slotsoccursinallTDMframeswithaTCH.Thecombination of theseframes is called trafficmultiframe. Out of the26 frames, 24 areused for traffic,oneisused fortheSlowAssociatedControl Channel(SACCH)andoneis currentlyunused.Itis alreadymentioned thatthedurationofoneTDMAframeis 4.615msandthereforedurationofamultiframewillbe120ms.Likewise,control

Local Area Network, Implementing and Extending LAN NOTES Self - Learning 74 Material multiframe comprises of 51 TDMA frame with a duration of 235.4 ms. These multiframewithappropriatecombinationgenerateslogicalchannelhierarchysuch assuperframeandhyperframe.Asuperframeisgeneratedwiththecombinationof 26 and51 multiframes. 2048 superframes constitute ahyperframe. Protocols GSM has threefunctional layers. These arephysical, data link andlayer three in correspondencewithOSImodel.Figure2.26showsthefunctionallayersofGSM. In OSImodel, the lower three layers usuallyterminate in the same node but it is nottrueincaseofGSM.InGSMthefunctionalityisspreadoverdistinctfunctional entities with standardized interfaces between them. For instance, the RR part of layerthreeisspread overtheMS,BTS, BSC,andMSC.Thethreelayers provide connectivity to BSSs, MSCs, and across MSCs. MS CM MM RR LAPD m Radio MSC LAPD m Radio LAPD PCM RR' BTSM BTS BSC PCM LAPD RR' BTSM BSSAP SS7 CM MM BSSAP LAPD m Radio SS7 U m A bis A 16/64 kbits/s 64/2048 kbits/s Fig. 2.26 Protocol Architecture for GSM Physical Layer The layer as shown as radio in Figure 2.26 is the lowest layer which provides transferofbitstreamsoverthephysicalradiolinksthroughU m interface.Ithandles all radiospecific functions such as creation of bursts, multiplexingof bursts into TDMA frame, synchronization with BTS, channel coding, error detection and correctionandqualitycontrolonthedownlink.Thedigitalmodulationandsecurity relatedissuessuchasencryption ofdigitaldataarecarriedovertheradiointerface between MS and BTS. Data Link Layer ItisrequiredtointroducelayertwoasdatalinklayerforsignalingbetweendifferentEntities inaGSMnetwork.AprotocolforLAPD m isdefinedatlayertwobasedon an adaptation of ISDN link access procedure for D channel (LAPD). Unlike LAPD, it does not requiresynchronizationorchecksummingforerrordetection, whichis handledat physical layer. LAPD m providesareliablededicatedsignaling

Local Area Network, Implementing and Extending LAN NOTES Self - Learning Material 75 link between the MS and BSS on the air interface. The communication onA bis interface between BTS and BSC is established byusing the standard LAPD.A reliable data link service is provided between BSC and MSC through Message Transfer Part (MTP) of SS7. Layer2 exploits MTP1 ofSS7 for communication betweendifferentMSCs, from MSC toHLR andAUC andalso connectingwith PSTN via GMSC (Gateway MSC). Layer 3 The layer threechieflycomprises of radio resourcemanagement (RR), mobility management (MM) and call control management (CM). Location update, authentication, andTemporaryMobile Subscriber Identity(TMSI) reallocation arethefunctionsofmobilitymanagement.CMperformsestablishment,maintenance, andterminationofacircuit-switchedcall.Othersupporting-SupplementaryService (SS) support, Short Message Service (SMS) support Radio Resource Management (RR)— The radio resource management sublayer(RR)terminates at theBSSand isusedtoestablishphysical connections over theradio forcall-related signalingand traffic channels betweentheMS and BSS. RR manages and provides control functions for establishment, operation and release of a dedicated radio channel connection between MS and various BSCs forthedurationofthecall.Thisprotocolalsoprovidesstableuninterrupted communications path between the MSC and MS over which signalingand user datacanbeconveyed. TheRR'layeris thepartoftheRR layerisimplementedin the BTS to provide functions between the BTS and BSC. The RR tasks such as transferring the RR information to the BSC, which are not managed by the RR' protocol in the BTS, are handled by the Base Transceiver Station Management (BTSM). The BSSs have a LAPDm and RR layertotalk to the MS,but useaseparatestacktocommunicatewithMSCs.This stack consists ofa MessageTransfer Part (MTP) of SS7 and BSSAPand SCCP sublayer,which replacetheRR layerontheMS.TheBSSAPandSCCPsublayer implement call, resource,and signalingmanagement andmessagingbetweenthe BSS and MSC. The BSS ManagementApplication Part (BSSMAP) protocols provideRRmessagesbetweentheBSCandMSC.SignalingConnectionControl Part (SCCP)is used abovelayer2 betweenBSCs and MSCsandbetweenMSCs and different databases such as HLR,AuC, etc.

Thehandoverorhandoffisalsoresponsibilityoftheirlayers.TheBSC, BTS, and MS control most of the functions, though some are performed bythe MSC inparticularforinter-MSC handoffs.TheMSCorBSSusessignal strength measurementsandcellcongestioninformationtodeterminewhenahandoffshould occur. Handoff notifications are sent to respectiveVLRs, which inturn forward them toHLRs. MobilityManagement(MM)— Themobilitymanagement sublayer(MM),on top of the RR, is terminated at the MSC and is used to establish, maintain, and release connections between the MS and the network MSC. It alsotakes care of maintaining the location data, in addition to the authentication and ciphering procedures.

Local Area Network, Implementing and Extending LAN NOTES Self - Learning 76 Material TheCommunicationManagement(CM)—OntopofMMliestheconnection managementsublayer(CM).CMprotocolcontrolsend-to-endcall establishment andinitiatescallssettingupat thesubscriber'srequest.Itsfunctionsaredividedin three categories. These are call control, which manages the circuit-oriented services, supplementaryservices management, whichallows modifications and checkingofthesupplementaryservices configuration andSMS,which provides point-to-point short message services. There are some more protocols used in GSM network. These are TransactionCapabilitiesApplicationPart(TCAP)protocolandMobileApplication Part (MAP)protocol.TCAP sits aboveSSCP andsupports transactions between 2 nodes of network to manage transaction on an end-to-end basis. MAP is used between MSC,VLR, HLR, andAuC in form of queryand response messages. Call Setup TheHomeLocationRegister(HLR)andVisitorLocationRegister(VLR),together withtheMSC,providethecall routingand roamingcapabilities ofGSMwherea subscribercanroamnationallyandeveninternationally.Thisisnotpossibleinthe fixed network, where a terminal is semi-permanentlywired to a central office. Localization andcallingsystem in GSMalways knows whereasubscriberis and his phone number remains valid worldwide. It requires frequent updates of the subscriber'swhereabouts. HLRprovidesthecurrent locationandVLR keeps the track of MS and informs the HLR about the current location of MS and in turn HLR sends all subscribers data needed to new VLR. When a mobile subscriber roams into a new location area i.e. new VLR in terms of GSM technology, this VLR automaticallydeterminesthatitmustupdatetheHLRwiththenewlocation information, whichit does usinganSS7 LocationUpdateRequestMessage.The HLRrespondswithamessagethatinformstheVLRwhetherthesubscribershould be provided servicein thenew location. This location updateand call set uprequires several numbers: ? Mobile Subscriber ISDN (MSISDN) Number - The MSISDN is the numberthat callers use to reach a mobile subscriber.This consists ofcountrycode(suchas91forIndia),thenationalsubscriberdestination code and the subscriber number. The national subscriber destination (NSD) is the address of the GSM provider. ? International MobileSubscriberIdentity (IMSI) Number– This is a unique identification number allocated to each mobile subscriber independentlyofMS in theGSMsystem usedinternallyandcannot be dialed. It sits inside SIM card, which can be carried over anywhere and can be used in anyMS. Subscriber mobilityis provided through mapping the subscriber to the SIM card rather than the terminal. The IMSI is made up of three parts. These are the mobile country code (MCC) consisting of three digits, the Mobile Network Code (MNC) consisting of two digits and the Mobile Subscriber Identity Number (MSIN) with up to 10 digits. ? Temporary Mobile SubscriberIdentity (TMSI) – TMSIhas valid temporarilyandlocalsignificanceonlyintheareahandledbytheVLR.

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ItisusedinplaceoftheIMSIforthedefiniteidentificationandaddressing of the mobile station and nobody can determine the identity of the subscriber bylistening to the radio channel. It resides onthe SIM card andVLRonlyand aVLRchanges it regularly.Itis not thepartofHLR. GSM uses the4 byte TMSIforlocal subscriber identification. ? MobileStationRoamingNumber(MSRN)- MSRN isa temporary location-dependent ISDNnumber assigned bythelocallyresponsible VLR to each mobile station in its area. The calls are routed to the MS byusingthe MSRN and MSRN generated in VLR is passed from the HLR to the MSC on request. The MSRN contains the current visitor countrycode(VCC),thevisitornational destinationcode(VNDC),the identificationofthecurrentMSCalongwiththesubscribernumber(SN). GSM calls maybe classified into two types. These are mobile terminated call(MTC)whichmaygetoriginatedeitherfromMSorfixedlinephone.Another is mobileoriginated call (MOC). Theaddresses as explained aboveare required in both thecases. WhenasubscribereitherfromafixedlineorMScallstoanMS bydialingGSM mobile subscriber's MSISDN, PSTNroutes mobile terminated calls totheGatewayMSC which requests routinginformationforthecallerfrom HLR and VLR by using the information in the MSISDN. The gateway MSC querythe HLR based on the MSISDN to obtain routing information required routingthecalltothesubscribers'currentlocationandthereforecontainingatable linkingMSISDNstotheircorrespondingHLR.Oncetheaddressofthedestination HLR is determined, the gateway MSC routes the call to the MSC in which the calleriscurrentlyroamingbysendingaRoutingInformationRequesttotheHLR. HLRmapstheMSISDNtotheIMSIafterhavingreceivedtheRoutingInformation Request to establish the identity of the subscriber and the current location of subscriberwiththehelpofthecurrentVLRaddress.ThecurrentVLRalsoprovides the MobileStation Roaming Number (MSRN) to HLR on querythrough which the mobile subscriber can be contacted and remains valid for the call duration. TheHLR then identifies the correct MSC byidentifyinga temporaryIDgiven to the mobile bytheVLR for thepurposeof anonymity. In case of mobile originating call a MS requests BSS to set up a call with PSTN. BSS check ups with the MSC and connects the call. Handover Hand-over becomes necessary when mobile moves from area of one BSC into another area of the same or into another BSC. Handover involves a number of proceduresdependinguponthelocation.Thesearedefinedforeachofthefollowing cases: ? Intra-cellhandover—Itinvolvesthetransferofconnectionsfromone channel to another channel on thesame BTS. ? Inter-cell, intra-BSC handover— It involves the transfer of the connection from one BTS to another BTS onthe same BSC. ? Inter-BSC, intra-MSChandover— The connection is transferred betweenBTSs belongingto two different BSCswithin oneMSC.

Local Area Network, Implementing and Extending LAN NOTES Self - Learning 78 Material ? Inter MSC handover— The connection is required to transfer to a BTS between two cells within another MSC. As explained previouslyin RR underlayer3that aBSCtakes the decision to perform ahandover. Either BSC or MS mayassistthe handover. In thecase of BSCassistedhandover,BSCmonitorsthesignallevelofthemobileandhandover occursifsignallevel fallsbelowthreshold.Thisincreases loadonBSCbecauseit monitors signal level of each mobile and determines target BSC for handover. Duringa connection, BTS gets reports from the MS received signal level for all the BTSs it can receive using each SACCH frame after 480 ms. The reports about the received signal strength are usuallyforwarded directlyto the BSC by BTS where it is analyzed using BTSM protocol and based onanalysis, the BSC initiates the handover procedure. Thus MS immediatelyfollows the command sent bytheBTS to switchoverto thenewBTS andstarts transmittingonthenew channel.Thiscompletesthehandoverandreleaseofthepreviouschanneloccupied bythe MS. IncaseofmobileassistedhandovereachBSCperiodicallytransmitsbeacon to mobile. When mobile hears a stronger beacon from a new BSC, it sends an acknowledgement and changes routing tables to make new BSC its default gateway. New BSC acknowledges the MS and begins to route call at its new destination. In the areas controlled byother MSC's, the call handover is handled similartomobileassistedcasewithadditionalHLR/VLReffortandlocalcallmay becomelong-distancecall. CheckYourProgress 7. Which deviceisused to connect a coaxial cable and terminals? 8. Whatistheminimumallowabledistancebetweenconsecutive connections? 9. Defineradio. 10. DefineGSM(GlobalSystemforMobileCommunications). 2.5 EXTENDLING LAN : TRANSMISSION CONCEPTS AND TERMS

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Apart from the components needed bythe conventional wired LAN, a wireless LAN needs additional components. Theyare the transmitters and receivers at Radio Frequency(RF) or InfraRed (IR). The RF transmitter and receivers need

antennastoperformtwo-waycommunication.Usuallyatrialinstallationiscarried

71%	MATCHING BLOCK 38/106	SA	BCAP-51 DCN.pdf (D161530873)

out before theactual implementation. Hubs, bridges,networkoperatingsystem, servers, and other components are function exactlyas on awired LAN. Mobile Clients Mobile clients are portable computing devices that act as clients. The following are some ofthe portable mobile systems. ? Laptop computers: Laptop PCs with two-way communication facility (transceiver)

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Palmtops or Personal Digital Assistants (PDAs) with communication capability ? Portable FAX ? Cellularphones Special Units For network management and efficient communication, a wireless LAN needs

additionalequipments.Theyare: Communicationunits: Theseunitscommunicatewithinthenetworkand alsowithother networks. Datacollectingunits:

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These units collect data from other systems. Security units: These units take care of thenetwork security. Transceivers: A transceiver is a half-duplex device. It performs transmission and reception of data within awireless LAN. It cantransmit in one directionata time. Portable bridges:

A portable bridge can support the Internet working functions.TwowirelessLANscancommunicatewitheachotherusingabridge.It canbeatransceiverorasatelliteport orothercommunicationunitthat

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provides a bridgeservice. Working of Wireless LANs Wireless LANs use electromagnetic waves (radio or infrared technology) to

communicateinformationfromonepointtoanotherwithoutrelyingonanyphysical connection. Radio waves are often referred to

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as radio carriers because they simplyperform the function of deliveringenergyto a remote receiver.The data

beingtransmitted issuperimposed on theradiocarriersothat itcanbeaccurately

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extracted at the receiving end. This is generallyreferred to as modulation of the carrier by the information being transmitted. Once the data is superimposed (modulated) onto the radio carrier, the radio signal occupies more than a single frequency,

sincethefrequencyorbitrateofthemodulatinginformationaddstothe carrier.
Multipleradiocarrierscanexistinthesamespaceatthesametimewithout

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interfering with each other if the radio waves are transmitted on different radio frequencies.

Toextractdata, aradioreceivertunes intooneradiofrequencywhile
rejectingallotherfrequencies.InatypicalwirelessLANconfiguration,atransmitter/
receiver(transceiver)device,calledanaccesspoint,connectstothewirednetwork from afixed location, usingstandard cabling.Theaccess pointreceives,

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buffers, and retransmits data between the wireless LAN and the wired network infrastructure.Asingle access point can support a small group of users and can function within a range of less than one hundred to several hundred feet. The access point (

ortheantennaattached totheaccesspoint)isusuallymountedhigh but maybemounted essentiallyanywhere

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that is practical as longas the desired radio coverageis obtained. End-users access thewireless LANthroughwirelessLANadapters,which areimplemented as add-on cards in notebook or palmtop computers,as cards in desktop computers, or integrated within hand-held computers. Wireless LAN

Local Area Network, Implementing and Extending LAN NOTES Self - Learning 80 Material
adaptersprovideaninterfacebetweentheclientNetworkOperatingSystem(NOS)
andtheairwavesviaanantenna.Thenatureofthewirelessconnectionistransparent to the NOS. Transmission Media Wireless LANs may use either radio wave technology or infrared technology (optical) for transmission of data. Each technology comes with its own set of advantagesandlimitations.Thepropertiesofthesetwotechnologiesarediscussed here. Radio Wave Technologies Radiowaves propagatefreelyon air.Theyareusedformanyapplications.Radio broadcast, television, telephony, and defence applications use radio waves.The band used for a specific application is highlysignificant and cannot be used for
otherapplications.Therearenationalandinternationalagreementsintheselection
ofaspecificbandforanapplication.Radiowavetransmissionandreceptionrequire highlysophisticated circuitry. Both the transmitter and the receiver must work withinashortband.Thefollowingaretheproblemsassociatedwithradiofrequency transmission. Path loss: Signal-to-Noise Ratio (SNR) is defined as the ratio of power ofthereceivedsignaltopowerofthenoiseinthereceivedsignal.Theperformance ofthecommunicationsystemisgoodifthisfactorisimproved.Butthedesignwill be morecomplex if this parameteris to be improved.Increasingthetransmitting powerorreducingthedistancebetweenthetransmitterandreceivercanimprove the SNR. Adjacentchannelinterference: Interferenceisanotherphenomenonthat
affectstheradiofrequencytransmission,whenthesamefrequencybandisallocated to twoadjacenttransceivers, resultingin interference.Hence,interferenceoccurs whenoneusefulsignalismixedupwithanothersignal.Thisproblemcanbeavoided by dividing the available band into sub-bands and allotting different bands to adjacent transceivers. Multipath:
Anotherproblemwithradiowavetransmissionisthemultipath. Areceiverat anypoint canget two typesofsignal from thetransmitter.Oneis the direct signal and the other is the reflected signal. Everyobject reflects the radio
wave.Hence,thereceivercangetmultiplereflectedsignalsthroughvariouspaths. The signal strength is additive at certain points and out of phase at some other points. Hence, the receiver can get peak power at some points and minimum power at some other points. This phenomenon is known as frequencyselective fading.Byemployingtwoantennasatquarterwavelengthseparation,thisproblem can be solved. Narrowband Technology Anarrowbandradio systemtransmitsandreceives userinformationonaspecific radio frequency.Narrowband transmission uses singlefrequencymodulation,set up mostlyinthe5.8 GHz band. The biggest advantageofnarrowband systems is highthroughputbecausetheydonothavetheoverheadinvolvedwithbroadband systems. RadioLAN is an example of a system with narrowband technology.

Local Area Network, Implementing and Extending LAN NOTES Self - Learning Material 81 Undesirablecrosstalkbetween communicationschannelsisavoidedbycarefully coordinating different users on different channel frequencies. Ina radio system, privacy and non-interference are accomplished by the use of separate radio frequencies. Theradioreceiverfiltersout allradiosignals exceptttheonetowhich it is tuned. From the customer's point of view, one drawback with narrowband technology is that the user must obtain a license for the usage of the specific frequency. Direct Sequence Spread Spectrum (DSSS) technology Most wireless LAN systems use this technology in which more bandwidth is consumed compared to narrowband transmission.Withdirect sequence spread spectrum,thetransmissionsignalisspreadoveranallowedband(forexample,25 MHz).Arandom binarystring called a spreading code is used to modulate the transmitted signal. The data bits are mapped to a pattern of 'chips' at the source and mapped back into a bitstream at the destination. The number of chips that represent a bit is called the spreading ratio. The higher the spreading ratio, the morethesignal isresistant tointerference,at theexpenseofincreasedbandwidth. The Federal Communication Commission for international radio transmission recommends that the spreading ratio must be morethan ten.Most products have a spreading ratio of less than twentyand the new IEEE802.11 standard requires aspreadingratioofeleven.Thetransmitterandthereceivermustbesynchronized with thesame spreading code.To an unintended receiver,DSSS appears as low- power wideband noise and is rejected (ignored) bymost narrowband receivers. Frequency-Hopping Spread Spectrum (FHSS) technology Thistechniquesplitsthebandintomanysmallsub-channelseachof1MHz band. Thesignalthenhopsfromsub-channelto sub-channeltransmittingshortburstsof data on each sub-channel for a set period of time called dwell time.The hopping sequencemustbesynchronizedatthesenderandthereceiver,otherwisethewhole information will be lost. Frequencyhopping is less susceptible to interference becausethefrequencyisconstantlyshifting.Thismakesfrequency-hoppingsystems extremelydifficult to intercept. This feature gives frequency-hopping systems a highdegreeofsecurity.To jamafrequencyhoppingsystem,thewholebandmust be jammed. These features are very attractive to agencies involved with law enforcement or the military. To an unintended receiver, FHSS appears to be a short-durationimpulsenoise. Infrared technology Atechnology, little used in commercial wireless LANs, is infrared.Infrared has extremelyhighfrequency,higherthanradiowaverange.Theyareinthefrequency range of 10 14 Hz and higher. Infrared technology is used in optical fibres, TV remote control, CD players, etc.

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IR systems are simple in design and therefore inexpensive. Theyuse the same signal frequencies used on fibre optic links. IR

systemsdetectonlytheamplitudeofthesignalandsointerferenceisgreatlyreduced. Characteristics of Infrared Transmission Infrared systems need special infrared emitters and infrared detectors. Infrared transmissionisperformedintwoways.Thefirstmethodusesthedirectmodulation
Local Area Network, Implementing and Extending LAN NOTES Self - Learning 82 Material
andthesecondusescarriermodulation.Thedirectmodulationschemeisdescribed belowaswireless LANs use onlydirect modulationscheme. Direct Modulation Direct modulation, often referred as on-offkeying, is widelyusedinoptical fibre systems.Alightsource,usuallyaLightEmittingDevice(LED)isdirectlyswitched on bya binary1 and switched off byabinary0. The direct modulation system is similar to theone shown in Figure 2.27.The source bit stream is encoded, using a standard encoding technique prior to modulation. The encoded data is then modulated,usingamodulator. Pulsepositionmodulationorasimilarmodulation technique is employed to reduce the power requirements. Modulated signal is then fed to the LED device.At the receiving side, an optical band-pass filter is used toselect the required band that contains the transmittedsignal component. Thephoto-detectorproduces electrical signal,whichis inthemodulatedform.A demodulator extractsthe encoded data from this and a decoderrecovers the data intheoriginalform.Directmodulationiscommonlyusedwithinaroomorasmall area wherethe transmitter and thereceiverare in theline of sight. Fig. 2.27 Optical Transmission System Operating Modes Infraredlinkscan beused intwodifferent modes.Theyaredirect(point-to-point) mode and diffuse (omnidirectional) modes. In a point-to-point mode, the light emitter is directly pointed to the detector. Hence, low power emitters or less- sensitive photo detectors can be used. This mode of operation is adequate for providing a direct wireless link between two portable devices. Direct systems givearangeofa coupleof kilometres and canbeused outdoors.Italso offers the highest bandwidthand throughput. High performance-directedIR is impractical for mobileusers and is thereforeused onlytoimplementfixedsub-networks. Inthediffusemode,theinfraredlightfromthesourceisopticallydiffusedto scatterthelighttoawidearea.Thus, thismodeissuitableforbroadcastoperation. Omnidirectional IR systemsprovideverylimitedrangeandtypicallyreduces the coverage range to 30 to 60 feet, and are occasionally used in specific wireless LAN applications.All the detectors withinthe room can receive the signal from onetransmitter;eachwithvaryingphase.Thephasevariationisduetothevariations ofpathlengthbetweenthetransmitterandthereceiver.Multiplereflectionsoflight also cause phasevariation. This phenomenon is knownas multipath dispersion. This problemdoes not affect thecommunicationprocess much inatypical room environment. Signal rate up to 1 Mbps can be satisfactorilyachievable. Beyond this rate,intersymbol interferencecauses themajorproblem.
Local Area Network, Implementing and Extending LAN NOTES Self - Learning Material 83 Benefits and Drawbacks
Benefits:IRsystemsarenotbandwidthlimitedandthuscanachievetransmission speeds greaterthan

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the other systems. Infrared transmission operates inthe light spectrum and does not require a license from the

Federal Communications Commission (FCC)tooperate. IR technologywas initiallyverypopularbecause of its high data rates and relativelycheap price. Drawbacks:The transmissionspectrum ofinfraredsystemis shared with the sunlight and other sources, such as fluorescent lights. If there is enough interferencefromthesesources, itcanrendertheLANuseless.IRsystemsrequire an unobstructedline-of-sight. IR signals cannotpenetrateopaque objects. Wireless Transmission Wireless transmissionsystems do not makeuseofa physical conductor,orguide to bind thesignal. In thiscase, data aretransmittedusingelectromagneticwaves. Therefore,theyarealsoknownasunguidedorunboundedsystems.Energytravels throughtheairratherthancopperorglass.Hencethetermradiatedoftenisapplied towireless transmission.Finally, such systemsemployelectromagneticenergyin the form

100% **MATCHING BLOCK 47/106** **W**

of radio or light waves that are transmitted and received across space,

andarereferredtoasairwavesystems.Thetransmissionsystemsaddressedunder this category include microwave, satellite and infrared. There are different techniques to convert the data suitable for this mode of communication. Radio wavescantravelthrough walls andthroughanentirebuilding.Theycantravel for long distances using satellite communication or short distance using wireless communication. Radio wavesneed attentionandcautionwhenthistechnologyis usedfordeliveryofreal timeapplicationslikemultimediacontentsbecauseradio links aresusceptibleto fading, interference,random delays,etc. Table 2.2 Bounded Media Comparison Chart 2.5.1 Radio Itis atechniqueinwhichdatais transmittedusingradiowavesandthereforeener- gytravelsthroughtheairratherthancopperorglass.Conceptuallyradio,TV,cellular phones,etc., usesradio transmission in oneform oranother.Theradiowaves can travelthroughwallsandthroughanentirebuilding.Dependinguponthefrequency, theycantravellongdistanceorshortdistance.Satelliterelayistheoneexampleof longdistancecommunication.Therefore,eachfrequencyrangeisdividedintodif- ferentbands,whichhasaspecificrangeoffrequenciesintheradiofrequency(RF) spectrum.TheRFisdividedindifferentrangesstartingfromverylowfrequencies (VLF)toextremelyhigh frequencies (EHF).Figure2.28shows eachband witha definedupperandlowerfrequencylimit.
Local Area Network, Implementing and Extending LAN NOTES Self - Learning 84 Material Fig. 2.28 Radio Frequency Range and Types of Transmission Media Twotransmitterscannot sharethesamefrequencybandbecauseofthemutual interferenceandthereforebandusageisregulated.TheInternationalTelecommu- nicationUnion(ITU)regulates international useoftheradiospectrum.Domestic useoftheradio spectrumis regulatedbynational agencies suchasWireless Plan- ningandCoordination (WPC)in India.WPC assigns eachtransmissionsourcea bandofoperation,atransmitterradiationpattern,andamaximumtransmitterpow- er.TheTable 2.2 shows the bands and frequencyranges. Omni directional or di- rectional antennas are used to broadcast radio waves dependinguponband. The transceiverunit,which is consisted oftransmitter andreceiveralongwiththean- tenna,determinesthepowerof RFsignal. Othercharacteristics ofradio waves is thatinvacuumallelectromagneticwavesorradiowaves travelatthesamespeed, i.

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e., at thespeed of light which is equal to 3 × 10 8 metre per seconds. In anyme- dium this speed gets reduced and also becomes frequencydependent. In case of

copperthe speedoflight becomes approximatelytwo thirdsofthespeed oflight. The basic features of the radio waves are as follows: • theyare easy to generate • theyhavethesamevelocityinvacuum • theymaytraverselongdistances • theyareomnidirectional • theycanpenetratebuildingeasilysotheyfindextensiveuseincommunica- tion bothindoor and outdoor • theyare frequencydependent.At lowfrequencytheycan

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pass through ob- stacles. However, the power falls offsharplywith distance from the source because power is inversely proportional to cube of the distance from the source.At HF theytravel in straight lines and

bounceoff obstacles.

Local Area Network, Implementing and Extending LAN NOTES Self - Learning Material 85 2.5.2 Very Low Frequency (VLF) The VLF method takes advantage of electromagnetic radiation generated in the lowfrequencybandof3-30kHzbypowerfulradiotransmittersusedinlong-range communicationsandnavigationalsystems.Atlargedistancesfromthesource,the electromagneticfieldis planarandhorizontalandtheelectriccomponentEliesin averticalplaneperpendicularto theHcomponent inthedirectionofpropagation and follow the ground.AM uses VLF band.This band of frequencies cannot be used for datatransferbecause theyofferrelativelylow bandwidth. 2.5.3 Microwave Transmission Microwavetransmissionisaformofradiotransmissionwhichusesextremelyhigh frequencies.AllthespecifiedfrequencyrangesareintheGHzrangeandthewave-lengthinthemillimetrerange.Sincethesetypesofhighfrequencysignalsareprone toattenuation,hence, amplification is requiredafteraspecificdistance.Theradio beamsarehighlyfocussedinordertoincreasethetransmissiondistanceofthesig-nals.Thetransmitantennais centred inaconcavemetallicdishwhichfocusesthe radiobeamwithmaximumeffect,asillustratedinFig.2.29. Similarlythereceiver dishisalsoconcaveinnaturewhichcollectsthemaximumamountofincomingsig- nal. It is a point-to-point transmission system, instead of a broadcast system. Also eachantennamust be withintheline ofsightofthenext antenna.Dueto the curvatureoftheearth,themicrowavesignalhops arelimitedtoamaximum of80 km. General Properties of Microwave Transmission Configuration: Microwave radio consists of an antennae at the center of a re- flective dish which is attached to the structure such as a tower or a building. Ca- bles connectthe antennaeto theactual equipment. Bandwidth: Bandwidth in excess of 6 Gbps is commonin microwavetransmis- sion. ErrorPerformance:Assumingproperdesign,digital microwaveperforms well in thisregard.However, environmental interferences suchas,precipitation,haze, smogandsmokecreatetroubles forhigh frequencytransmission,yet microwave performs much betterin this regard. Distance:Athigherfrequencies,microwaveisdistancelimited,whichcanbeover- comethrough complex arrays ofantennaeincorporatingspatialdiversityinorder tocollectmoresignals. Security: As is thecase with all radio communicationsystems, microwaveis in- herentlyinsecure,which canbeimprovedthrough encryption. Fig. 2.29 Point-to-point Microwave
Local Area Network, Implementing and Extending LAN NOTES Self - Learning 86 Material Table 2.3 Microwave Frequency Bands Cost:Eventhoughtheacquisition,deploymentandrearrangementcostcanbevery high, yet, microwave compares veryfavourablywith cabledsystems, which re- quireright-of-way,trenchingandconduit andsplicing. Applications: Microwave was originallyused for longhaul voiceand datacom- munication since it was found to be the most attractive alternativeto cable sys-tem.Howevertherecentupsurgeoffibreopticcommunicationsystemiscurrently used in this regard. Contemporaryapplications includeprivate networks, inter- connectionsofcellularradioswitchesandanalternativeofcabledcommunication systemindifficultterrain. 2.5.4 Satellite Communication Satelliteradioisanon-terrestrialmicrowavetransmissionsystemutilizingaspace relaystation.Satelliteshaveprovedinvaluableinextendingthereachofvoice,data, andvideocommunications around theglobeandintothe mostremoteregions of theworld.ExoticapplicationssuchastheGlobalPositioningSystem(GPS)would havebeenunthinkablewithoutthebenefitofsatellites.Contemporarysatellitecom-municationssystemsinvolveasatelliterelaystationthatislaunchedintoageosta- tionary,geosynchronous, orgeostaticorbit.Suchsatellitesarecalledgeostation- arysatellite. Such an orbit is approximately 36,000 kms above the equator as depictedin Fig. 2.30.At that altitudeand in anequatorial orbitalslot,the satellite revolvesaroundtheearthwiththesamespeedasofthat thespeedofrevolutionof earthandmaintains its relative position overthe same spot ofthe earth's surface. Consequently, transmit and receive earth stations can be pointed reliablyat the satelliteforcommunicationspurposes. The popularityofsatellite communications has placed great demands on the international regulators to manage and allocate available frequencies,as well as thelimitednumberoforbitalslotsavailableforsatellitepositioningaremanagedat national,regionalandinternationallevels.Generallyspeaking,geostationarysatel- lites arepositioned approximately2 apart inordertominimiseinterferencefrom adjacentsatellitesusingoverlappingfrequencies.Suchhighfrequencysignalsare especiallysusceptibleto attenuation in theatmosphere. Therefore,in caseofsat- ellitecommunication twodifferent frequencies areused ascarrier frequencies to avoidinterferencebetweenincomingandoutgoingsignals.Thesecanbelistedas follows. Uplink frequency: It is the frequencyused to transmit signal from earth station to satellite.Table 2.3 shows thehigher of the twofrequencies that is usedfor the uplink.Theuplinksignalcanbetailoredstrongerandthereforecanbetterdealwith atmosphericdistortion.Theantennaat transmittingsideis centeredinaconcave, reflective dish that serves to focus theradio beam, with maximum effect, on the receivingsatelliteantenna.Thereceivingantenna,similarly, is centeredina con-cavemetaldish,whichservestocollectthemaximumamountofincomingsignal.

Local Area Network, Implementing and Extending LAN NOTES Self - Learning Material 87 Fig. 2.30 Satellites in Geostationary Earth Orbit Downlinkfrequency:It isthefrequencyusedtotransmit thesignalfrom satellite to earthstation. In otherwords, thedownlinktransmission is focusedonapartic- ular footprint, or area of coverage.The lower frequency, used for the downlink, canbetter penetratetheearth's atmosphereand electromagneticfield,whichcan acttobendtheincomingsignalmuchaslightbendswhenenteringapoolofwater.
Broadcast:Thewidefootprintofasatelliteradiosystemallowsasignaltobebroad- cast overa wide area. Therebyanynumber (theoreticallyan infinite number) of terrestrial antennae can receive the signal, more or less simultaneously. In this manner,satellites canserveapoint-to-multipoint networkrequirement througha singleuplinkstationandmultipledownlinkstations.Recently,satelliteshavebeen developed which canserveameshnetworkrequirement,wherebyeachterrestrial sitecancommunicatedirectlywithanyothersite.Previously,allsuchcommunica- tions wererequiredtotravelthroughacentralizedsite,knownasaheadend.Such ameshnetwork,ofcourse,imposesanadditionallevelofdifficultyonthenetwork intermsofmanagementoftheflowanddirectionoftraffic.
General Properties of Satellite Communication Configuration:Satellitecommunicationsystems consist ofantennaeandreflec- tive dishes, muchas in terrestrial microwave.The dish serves to focus the signal from atransmitting antenna to areceiving antenna. The send/receivedishes that make up the earth segment are of varying sizes, depending on power levels and frequencybands. Theygenerallyare mounted on a tripod or othertype of brace, which is anchored to the earth, pad or roof, or attached to a structure such as building.Cablesconnecttheantennaetotheactualtransmit/receiveequipment.The terrestrial antennae support a single frequencyband for example, C-band, Ku- band orKa-band.Thehigherthefrequencybands thesmallerthepossiblesizeof thedish.Therefore,whileC-bandTVdishestendtoberatherlarge,Ku-bandDBS (Direct Broadcast Satellite) TV dishes tendto be verysmall.The space segment dishesaremountedonasatellite,ofcourse.Thesatellitecansupportmultipletrans- mit/receivedishes,dependingonthevariousfrequencieswhichitemploystosup- port variousapplications, and depending onwhether it covers anentirefootprint ordividesthefootprintintosmallerareasofcoveragethroughtheuseofmoretightly focused spot beams. Satellite repeaters are in the form of number of transpon- ders.Thetransponders accept the weakincomingsignals,boost them,shift from the uplinkto thedownlink frequencies,and transmit the informationto theearth stations.
Bandwidth:Satellitescansupportmultipletranspondersand,therefore,substantial bandwidth, witheachtranspondergenerallyprovidingincrementsinbandwidth.
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ErrorPerformance:Satellitetransmissionissusceptibletoenvironmentalinter- ference, particularlyat frequencies above 20 GHz. Sunspots and other types of electromagneticinterferenceaffectsatelliteandmicrowavetransmission.Addition- ally,somesatellitefrequencybands, forexample,C-bandneeds careful frequen- cymanagement.As a result ofthese factors, satellite transmissionoften requires ratherextensive errordetection and correctioncapabilities. Distance: Satellite is not considered to be distance limited as the signal largely travels through the vacuum of space. Further each signal travels approximately 36,000 kms in each direction. Propagation Delay: Geostationarysatellites,byvirtue of their high orbital alti- tude,imposerathersignificant propagationdelayonthesignal.Hence,highlyin- teractivevoice,data,andvideoapplicationsarenot effectivelysupportedviatwo- waysatellitecommunications. Security:Asisthecasewithallmicrowaveandotherradiosystems,satellitetrans- missionisinherentlynot secure. Satellitetransmissionisespeciallyvulnerableto interception, as thesignal is broadcast overtheentireareaofthefootprint.There- fore,theunauthorizedusermustknowonlythesatelliteandassociatedfrequency rangebeingemployed.Securitymustbeimposedthroughencryption(scrambling) ofthesignal.
Cost:Theacquisition,deployment,andrearrangementcostsofthespacesegment ofsatellitesystemscanbequitehighinseveralmillions dollars.However,thesat- ellitecan beshared byalargenumberofusers,witheachuserperhaps connecting a large numberof sites.As a result, satellite networks oftencompare veryfavor- ablywithcabledsystems ormicrowavesystemsformanypoint-to-multipoint ap- plications. Applications:Satelliteapplications aremanyand increasingrapidlyas thetradi- tionalvoiceanddataserviceshavebeenaugmented.Traditionalinternationalvoice and data services have been supplanted to a considerable extent by submarine fibreopticcablesystem.Traditional, applicationsincludeinternational voiceand data,remotevoiceand data, television and radiobroadcast,maritimenavigation, videoconferencing, inventorymanagement andcontrol throughVSATs, disaster recoveryand paging.More recent and emergingapplications include airnaviga- tion, Global Positioning Systems (GPS), mobilevoice and data becauseof Low EarthOrbitSatellites (LEOs),AdvancedTrafficManagement Systems (ATMS), DirectBroadcastSatellite(DBS)TV,IntegratedDigitalServicesNetwork(ISDN), interactiveTelevision,andinteractivemultimedia. Very SmallAperture Terminals (VSATs): VSATs or VerySmallApertureTer- minals areabreed ofsatellitesysteminvolvingterrestrial dishesofverysmall di- ameter (aperture). Operating in the C-band and Ku-band,VSATs aredigital and aredesigned primarilyto support data communicationson a point-to-multipoint basis forlarge private networks in applications such as retail inventorymanage- ment and credit verification and authorisation. While some newer systems also support mesh networks and voicecommunications,theyareunusual atthis time. Bandwidth is in channel increments of56/64Kbps, generallyupto an aggregate bandwidth of 1.544 Mbps.

Local Area Network, Implementing and Extending LAN NOTES Self - Learning Material 89 2.6 MASTER SITES AND INTER CONNECTION TO TELEPHONE Intelecommunications,theterm'Interconnection'isthephysicallinkingofacarrier's networkwithequipmentorfacilitiesnotbelongingtothatnetwork.Thetermmay refertoaconnection between acarrier's facilitiesandtheequipment belongingto its customer, or to a connection between two or more carriers. In the United States regulatorylaw, interconnection is specificallydefined as,"The linkingof two or more networks for the mutual exchange of traffic". One of the keytools used by regulators in the field of telecommunications markets is to impose interconnectionrequirementsondominantcarriers. Currentlythestandardelectricalconnectorforinterconnectionintheworld is the registered jack familyof standards, especiallyRJ11 (Registered Jack 11). This was introduced bythe Bell System in the 1970s, followinga 1976 Federal Communications Commission (FCC)order. Since then, it has gained popularity worldwide, and is a de facto international standard.ARegistered Jack (RJ) is a standardized telecommunicationnetwork interfaceforconnectingvoiceanddata equipment to a service provided by a local exchange carrier or long distance carrier.RegistrationinterfaceswerefirstdefinedintheUniversalServiceOrdering Code(USOC)systemoftheBell SystemintheUnitedStatesforcomplyingwith the registration program for customer-supplied telephoneequipment mandated bytheFederalCommunicationsCommission(FCC)inthe1970s.Thespecification includesphysicalconstruction,wiring,andsignalsemantics.Accordingly,registered jacks are primarilynamed bythe letters RJ, followed bytwo digits that express the type.Additionallettersuffixes indicate minor variations.For example,RJ11, RJ14,andRJ25arethemostcommonlyusedinterfacesfortelephoneconnections for one-, two-, and three-line services, respectively. Thecommunications infrastructureof theInternet consistsof its hardware components and a system of software layers that control various aspects of the architecture.As with anycomputer network, the Internet physicallyconsists of routers, media (such as, cabling and radio links), repeaters, modems, etc. The Internetcarriesmanyapplicationsandservices,mostprominentlytheWorldWide Web(WWW),includingsocialmedia,electronicmail,mobileapplications,Internet telephony,filesharing,andstreamingmediaservices. NetworkSwitchingSubsystem(NSS)orGSM(GlobalSystem forMobile Communications) core network is the component of a GSM system that carries outcalloutandmobilitymanagementfunctionsformobilephonesroamingonthe network of base stations. It is owned and deployed bymobile phone operators andallowsmobiledevices to communicatewitheachotherandtelephones inthe wider Public SwitchedTelephone Network (PSTN). Wirelesscommunicationisthetransferofinformationbetweentwoormore points that do not use an electrical conductor as a medium bywhich to perform thetransfer.Themostcommonwirelesstechnologiesuseradiowaves.Withradio waves, intended distances can be short, such as a few meters forBluetooth or as farasmillionsofkilometresfordeep-spaceradiocommunications.Itencompasses
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varioustypesoffixed,mobile,andportableapplications,includingtwo-wayradios, CellularTelephones,PersonalDigitalAssistants(PDAs),andwirelessnetworking. Other examples ofapplications of radio wireless technologyinclude GPS units, wireless computermouse, keyboards and headsets,headphones, radio receivers, satellitetelevision, broadcasttelevisionandcordless telephones. Cellular Phones The development of cellular phones is recent one. This is alsoknown as mobile phone and as its name implies it is designed for mobile users who need to make telephonecallsfromdifferentlocationswhentheyareusuallyawayfromhomeor office.Therapiddevelopmentinhardwaretechnologyhelpsindesigningsuchkind ofportabletelephonesets sothatusermaycarryitwithintheirofficebagorpock- et duringmovement. Cellularphoneusesradiofrequenciesto establishaccess to anearbycellsitewhichisanaccesspointforcellularcalls.Thecellularphonereg- ularlycommunicateswiththenearestcellsitetoinform thenetworkthatit is con- nected. Cell Site This maybe defined as

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a circular geographical area that handles cellular phones within its defined physical boundary.

Acellularnetwork as shown inFig. 2.31 is consideredconsistingofoverlappedcellssothatalargerareawithlowprobability ofcalldroppingmaybeprovided.This overlappingstructurehelpsinkeepingthe call intact as a user moves location from one cell site to another. Inthis case, the callistransferredtothenearestcellsiteresponsibleforthatphysicalarea.Cellular telephonesaresuitableforlargergeographicalareasincludingremotesites.Itsaves thecost ofcopper wire and effortsin layingthe sameindenselypopulated areas. Each cell site shown in Fig. 2.31 is connected to a master site, which acts as an access point for a particular cellular network. Master site furnishes an intercon- nection to the regular telephone network. Calls handled byeach cell site are re- layed backto themastercellsite, which then relaysit tothetelephonenetworkas shown inFig. 2.32. Fig. 2.31 Cellular Networks Fig. 2.32 Cellular Network Consisting of Individual Cells Connections to Telephone Exchange Theforward cellcan reusefrequencies usedin theprevious cell.This helps in sharing the same frequencyband. Manycalls can be handled byone frequency especiallywheredigitalphones areused.

Local Area Network, Implementing and Extending LAN NOTES Self - Learning Material 91 Satellite Cellular Telephone This works onthe sameprinciple ascellularphonesbut uses LowEarthOrbiting (LEO) satellites. Theadvantages of satellitecellularphonemaybeseeninits ca- pabilitytocover much wider geographical area. This is particularlya good tech- nologyinmountainousterrainandatsea.Unliketocellularphones,satellitecellu- larphone requires a large number ofcells andtheir accuratepositioningto avoid blindspots. Blindspots arethespaceswherenocelloverlappingorcell is present therefore no call can be made at such spots. CheckYourProgress 11. What is a PSTN or public switched telephone network? 12. What is Path loss signal-to-noise ratio (SNR)? 13. What do you understand bytheterm interconnection? 2.7 ANSWERS TO 'CHECK YOUR PROGRESS' 1. ALocalArea Network (LAN) is anetwork that is restrictedto a relatively smallarea. 2. The components used byLANs can becategorizedintohardware,cabling standards, and protocols. 3. The two LAN transmission options, baseband and broadband. Baseband LANs, which is the most prevalent byfar, is a single-channel system that supportsasingletransmissionat anygiventime.BroadbandLANs support multipletransmissionsviamultiplefrequencychannels. 4. Baseband LAN is a single channel connection, supporting a single communicationatatime. 5. NIC is also known as Network Interface Unit (NIU). NIC is a hardware cardtoprovidephysical access from anodetotheLANmedium.TheNIC can be fitted into the expansion slot of a PC, or it can exist as a separate box. 6. A LAN Operating System, or Network Operating System (NOS), is softwarethatprovidesthenetworkwithmulti-user,multitaskingcapabilities andsupports communicationsand resourcesharing. 7. Atransceiverisusedtoconnectacoaxialcableandterminals.Atransceiver cable(alsoreferred to as anAUI(Attachment Unit Interface)cable)isused to connect a transceiver and the NIC. 8. The minimum allowable distance is 0.5 metre between consecutive connections. 9. Thetermradiomaybedefinedasconsistingofmodulationandradiationof thesignal. 10. GSM(GlobalSystemforMobileCommunications)isasecond-generation (2G)digitalmobiletelephonesstandardusingacombinationTimeDivision

MultipleAccess(TDMA)andFrequencyDivisionMultipleAccess(FDMA) to share thebandwidth among as manysubscribers as possible. 11. PSTNorpublicswitchedtelephonenetworkrelatestothepublictelephone network. It is based on circuit-switched connection and can be compared to the Internet terms, referring to a public IP network based on a packet- switchedconnection. 12. Pathloss signal-to-noiseratio (SNR)is definedas theratioofpowerofthe receivedsignaltopowerofthenoiseinthereceivedsignal.Theperformance ofthecommunicationsystem is good ifthisfactoris improved. 13. Theterm'Interconnection'isthephysicallinkingofacarrier'snetworkwith equipmentorfacilitiesnotbelongingtothatnetwork.Thetermmayreferto a connection between a carrier's facilities and theequipment belongingto its customer, or to a connection between two or more carriers. 2.8 SUMMARY ? LocalArea Network technology connects people and machines within a site.

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A Local Area Network (LAN) is a network that is restricted to a

relativelysmallarea. ?

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A LAN is a form of local (limited-distance), shared packet network for

computercommunications. ? LANs are usedalmost exclusivelyfor datacommunicationoverrelatively short distances such as within an office, office building or campus environment. ? There are two LAN transmission options, baseband and broadband. ? BroadbandLANsaremultichannel,analogLANs.Theyaretypicallybased on coaxial cableas the transmissionmedium,although fibre opticcable is also used. ? Baseband LAN is a single channel connection, supporting a single communicationatatime. Theyaredigitalinnature. ? NIC is a hardware card to provide physical access from a node to the LAN medium. The NIC can be fitted into the expansion slot of a PC, or it can exist as a separate box. ? A LAN Operating System, or Network Operating System (NOS), is softwarethatprovidesthenetworkwithmulti-user,multitaskingcapabilities andsupports communicationsand resourcesharing. ? The transceiver exchanges data signals handled bythe NIC and electric signalssentoveratransmissionline. ? Hubsreceivesignalsthroughoneportandsendthemthroughallotherports. ? Themaximumallowablelengthofasegmentforthe10Base5is500metre. ? The number of repeaters that can be used is limited. In the case of data communicationbetweenterminals,datacanbesentthroughonlyuptofour repeaters.

Local Area Network, Implementing and Extending LAN NOTES Self - Learning Material 93 ? Wireless LANs offertheobvious advantageof avoidanceofcablingcosts, whichcanbeespeciallyimportantinadynamicenvironmentwherethereis frequent reconfigurationoftheworkplace. ? WLANis mostlyamix of wireand wireless media havinganaccess point or wireless routerthat is connected to a wired networkviaacoaxial cable, universalserial bus(USB), orEthernet connection. ? A cellular system is thecommunicationssystems thatdividea geographic regioninto sections,called cells, each havingitsowndedicatedfrequency. ? In a channel theseparation between adjacent carrierfrequencies is known as channel separation which is 200 kHz incase of GSM. ? The generic GSM network architecture is composed of three subsystems astheradiosubsystem(RSS),thenetworkandswitchingsubsystem(NSS) and the operation subsystem (OSS). ? Cellsarethebasicconstituentsofacellularlayoutwithcellsites.Cellsiteis defined as the location where base station andantennas are placed. ? A base transceiver station is responsibleto communicate with hosts in its cell bymeans ofpassingallcalls cominginandgoingout ofacell site. ? The network switching subsystem (NSS) constitutes the fixed network component of the mobile radio telephone service network at one end and between the mobile radio telephone service network and other public networks on the other hand. ? TheAuthentication Center(AuC)is considereda subsystemof the HLR. ? EIR fulfills the security and authentication requirement of GSM. It is a protecteddatabaseforthesubscriberandequipment identificationnumber (IMEI)thatcontains alist ofall valid mobileequipmentonthenetwork ? It is requiredto introducelayertwoas datalinklayerforsignalingbetween different entitiesinaGSM network. ? Hand-over becomes necessarywhen mobilemoves from areaofone BSC into another area of the same or into another BSC. ? Intelecommunications,theterm'Interconnection'isthephysicallinkingofa carrier'snetworkwithequipmentorfacilitiesnotbelongingtothatnetwork. ? Thecommunications infrastructureof theInternet consistsofits hardware components andasystem ofsoftwarelayersthat controlvariousaspectsof thearchitecture. 2.9 KEY TERMS ? LocalAreaNetwork (LAN): Aform of local (limited-distance), shared packet networkforcomputercommunications. ? Baseband LAN: It is a single-channel system that supports a single transmissionatanygiventime. ? BroadbandLAN:Itsupportsmultipletransmissionsviamultiplefrequency channels.

Local Area Network, Implementing and Extending LAN NOTES Self - Learning 94 Material ? NetworkInterfaceCard(NIC):It isahardwarecardtoprovidephysical access from a node to the LAN medium. ? LAN OperatingSystems: It is software that provides the network with multi-user, multitasking capabilities and supports communications and resourcesharing. ? Transceiver: It is used to exchange data signals handled bythe NIC and electricsignalssentoveratransmissionline. ? The Subscriber Identity Module (SIM): It contains all subscriber informationnecessaryforidentifyingGSMsubscriber. ? CommonControlChannel(CCCH):Itisabi-directionalpoint-to-multi- point-signalingchannelthatexchangesthesignalinginformationfornetwork accessmanagementandtransportsinformationregardingconnectionsetup between MS and BTS. ? PublicSwitchedDataNetwork(PSDN):Itisanetworkthatisaccessible to the public. It assists packet-switched data as well as PSTN. ? MicrowaveTransmission: It is a form of radiotransmission which uses extremelyhigh frequencies.All the specified frequencyranges are in the GHzrangeandthewavelengthinthemillimeterrange. ? Uplink Frequency: It is the frequencyused to transmit signal from earth stationtosatellite. ? DownlinkFrequency:It isthefrequencyusedtotransmitthesignal from satellitetoearth station. ? CellSite:Itisdefinedasacirculargeographicalareathathandlescellular phoneswithinitsdefined physical boundary. 2.10 SELF ASSESSMENT QUESTIONS AND EXERCISES Short-Answer Questions 1. Give the advantages as well as disadvantages of broadband LAN. 2. What are broadband LANs? Write its characteristics. 3. Which is the foremost and most popular transmission media for LAN. Discuss. 4. What is a transceiver? How does it works? 5. What arethebasicwireless principles? 6. Definehub. 7. State the 5-4-3 rule. 8. Whyfibre-optic cableis used in LANs? 9. What is a WLAN? 10. Writeanoteoncellularlayoutindatacommunication. 11. What are BaseStation Controllers (BSC)?

Local Area Network, Implementing and Extending LAN NOTES Self - Learning Material 95 12. What arethe advantages and disadvantagesof telephone networks? 13. What arethe benefits and drawbacks of infra-red technology? 14. What arethegeneral properties ofmicrowavetransmission? 15. Discussthegeneralpropertiesofinfraredtransmission. Long-Answer Questions 1. BrieflydescribeLANOperating Systems. 2. Explainthe10Base5(ThickNet/YellowEthernet)indetail. 3. DescribetheimplementationofLANusingopticalfibercablepair. 4. Analyze thebasic types ofservices offered through GSM. 5. Explain thearchitectureoftheGSM networkwithappropriatediagrams. 6. Discuss theradiointerface(Um)in detail. 7. Explain the OSImodel used in GSM. 8. Write thedetailed noteon: (i) Infraredtechnology (ii) Microwavetransmission (iii) Satellitetransmission 9. What doyou understand byinterconnectiontotelephone? Explain. 2.11 FURTHER READING Forouzan, Behrouz A. Data Communications and Networking. New Delhi: Tata McGraw-Hill, 2004. Stallings,Williamand RichardVan Slyke.Business DataCommunications.New Jersey: PrenticeHall, 1998. Black, Uyless. Computer Networks. New Jersey: Prentice Hall, 1993. Stallings,William. Data andComputer Communications. NewJersey: Prentice Hall, 1996. Tanenbaum,Andrew S. Computer Networks. New Jersey: Prentice Hall PTR, 2002. Stallings, William. Data and Computer Communications. NJ: Prentice-Hal, 1996.

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 97 UNIT 3 DATATRANSMISSION NETWORK, TCP/IPAND OSI MODEL Structure 3.0 Introduction 3.1 Unit Objectives 3.2 Data Transmission System 3.2.1 Data Communication Equipment 3.2.2 Data Terminal Equipment 3.2.3 Communication Software 3.3 Telephone Networks 3.3.1 Dial up Telephone Networks 3.3.2 Advantages and Disadvantages of Telephone Networks 3.3.3 Telephone Network Standards 3.3.4 Leased Lines 3.3.5 Public Switched Telephone Network (PSTN) 3.3.6 PSDN 3.3.7 ISDN: Broadband Communications 3.3.8 ISDN Standards 3.3.9 Internet Service Providers (ISPs) 3.4 WANTechnologies 3.5 History of Internet 3.5.1 Standards for TCP/IP and the Internet 3.5.2 RFCS and TCP/IP Standardization Process 3.6 Network Architectures 3.6.1 Layering the Communications Process 3.7 Need for Layered Solutions and Open Systems Interconnection (OSI) 3.7.1 Open Systems Interconnection (OSI) Model 3.7.2 LayeredArchitecture of OSI 3.8 Routing Concepts 3.8.1 Strategies for Routing 3.8.2 Shortest Path Routing 3.8.3 Flooding in Hop 3.9 Congestion Control 3.9.1 General Principles of Congestion Control 3.10 Deadlocks 3.10.1 Deadlock Conditions 3.11 Queueing Theory: Basic Design Techniques 3.11.1 Queueing Models 3.12 Answers to 'Check Your Progress' 3.13 Summary 3.14 Key Terms 3.15 Self Assessment Questions and Exercises 3.16 Further Reading 3.0 INTRODUCTION Data transmission is the transfer of datafrom one digital device to another.This transfer occurs via point-to-point data streams or channels.These channels may previouslyhavebeenintheformofcopperwiresbutarenowmuchmorelikelyto bepartofawirelessnetwork.Theeffectivenessofdatatransmissionreliesheavily

ontheamplitudeandtransmissionspeedofthecarrierchannel.Networkcongestion, latency,serverhealth,andinsufficientinfrastructurecandecreasedatatransmissionrate. Networkarchitectureisthedesignofacomputernetwork.Itisaframework for the specification of a network's physical components and their functional organization andconfiguration,its operational principlesandprocedures,aswell as communicationprotocols used. Intelecommunication,thespecificationofanetworkarchitecturemayalso include a detailed description of products and services delivered via a communicationsnetwork,aswellasdetailedrateandbillingstructuresunderwhich services are compensated. The OSI Model (Open Systems Interconnection Model) is a conceptual frameworkusedtodescribethefunctionsofanetworkingsystem.TheOSImodel characterizescomputingfunctionsintoauniversalsetofrulesandrequirementsin order tosupport interoperabilitybetween different products and software. Queueing theoryis the mathematical studyof waiting lines, or queues.A queueing model is constructed so that queue lengths and waiting time can be predicted.Queueingtheoryisgenerallyconsideredabranchofoperationsresearch because the results are often used when making business decisions about the resources needed to provide a service. In this unit, you will lean about data transmission network, telephone networks,WANtechnologies,networkarchitectures andOSImodel,routingand congestion controland queuingtheory. 3.1 UNIT OBJECTIVES Aftergoingthroughthisunityouwillbeableto ? Understand datatransmission system ? Understand thetelephone networks ? Explain the OSImodel fortelephonenetworks ? ComprehendWANtechnologies ? ExplainTCP/IPmodel ? Discuss theservices ofinternet ? Explain standardsforTCP/IP ? Discuss open systemsinterconnection (OSI) model ? Understand the need for OSImodel ? Interpret routingand congestion control ? Defineroutinganditsneed. ? Discuss thestrategies forrouting ? Explaingeneralprinciplesofcongestioncontrol ? Definedeadlock ? Explainqueuingtheoryanditsmodels

3.2 DATATRANSMISSION NETWORK Fromtheadventofthehumanrace,wantingtocorrespondgavewaytotheprogress of variousmethodsand practices on thebasis ofsituations andtechnologythat is available.Theinitialtypesofcommunicationweresigns,gesturesandwritingsthat were illustratedon the caves, walls,etc. Whenlanguagewas developed usage of symbols, papyrus and paper made it easy to capture communication for future use. The continuous desire for communication past the physical boundaries encouraged man to use diverse practices.Afew of these practices were formed onthebasisofusinggesturesduringstorytelling,soundandanimation. Claude Elwood Shannon in the year1948, worked for theBellTelephone Company in the United States of America. Figure 3.1 displays the model of communication he proposed. This has become the basis of explanation of communicationsincethen. Source Sender Channel Message Signal Noise Signal Message Receiver Destination Fig. 3.1 Shannon's Model of Communication Themodelapplied,isbasedonoralcommunicationbetweentwopeople,is asfollows: Source — Thebrain Message — Theidea, thought Sender — Thetransmittingdevice,themouth Channel — Themediumthemessagetravels over:air Receiver — Thereceivingdevice:theear Destination — Thebrain Inanyformofcommunication,themessageisaffectedbythemessageasit movesacrossfromthesendertothereceiverinthechannel.Datacommunications isabouttransmittinginformationbetweentwolocations.Thetransmissionbroadly involvessendingandreceivingtheinformation.Informationisthus,sent between machinesconnectedwitheachotherbyphysicalwiresorradiolinks.Themachines maybe transmitter, telephone, computer, etc. Manyjobsthat weredoneonacentralizedcomputerbasedontimesharing can now be done on standalone Personal Computers (PCs). Large number of dispersedusercansharedatabaselocated atacentralplaceorat remotelocations inanN-tierenvironment.Thisisthereasonwhythegrowthofdatacommunication facilities is taking place together with the use of PCs so that a computer communicationfacilitycanbeestablishedinnetworkform. Adatacommunication systemis acomputersystemthatcollectsdatafrom remotelocations through datatransmission circuits, thenoutputs processed data to remote locations. A data communication system consists of data terminal equipment, a data communication circuit and an information processed unit. A data communication circuit transmits information input from the data terminal

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equipmenttotheremoteinformationprocessingunitortransmitsprocessingresults to the data terminal equipment. The information processing unit processes the data.ThisisshowninFigure3.2.Someexamplesofdatatransmissioncircuitsare telephonenetwork, leasedline,ISDN, packet switchednetwork,framerelay,cell relay, etc. Fig. 3.2 Data Communication Systems In data communication system, data is transmitted from terminals to the information processingunitthrough datacommunicationcircuits.Thesearetwo typesofdatatransmissionmethodsthatareusedtotransmitdatafromitsoriginto theinformation processing.Theseareas follows: 1. Offline: Computers are not connected bycommunication circuits. Data is transmitted between a terminal and information processing unit througha magnetic tape andmagneticdiskpacks. 2. Online: Computers are connected bycommunicationcircuits. Data can be instantly transmitted between a terminal and information processingunit. Components of Data Communication System Thedatacommunicationsystemconsistsofthefollowing: 1. TransmitterorSenderofData:These maybeterminals,computers and mainframes,etc. 2. Medium:Themedium,throughwhichthedataistransmitted,canbecables, Radio Frequency(RF) wave, microwave, fibreoptics, infrared, etc. 3. Receiver:As the name implies, it is the device, which receives the data transmitted.Theseareprinters,terminals,mainframes,computers,cellphone, etc. IntheFigure3.2,thetransmitter—mediuminterfaceandmediumreceiver interfacehavebeenshownbydottedlines.Thetransmittermaybeadevicewhich transmitssignalinsuchaformatthatisnotcompatiblewiththemedium.Similarly, medium provides signal in unacceptable format to receiver. Hence, the signal fromtransmittertomediumandmediumtotransmitterrequireconversionofsignal from oneform to another as per the requirement. 3.2.1 Data Communication Equipment Data circuit terminating equipment is also known as Data Communication Equipment(DCE).DCEistheequipmentthatinterfacesthesourcewiththemedium andviceversa.DCEincludesmodems,DSUsandCSUsandFrontEndProcessors (FEPs). Each device is located at both ends of acommunication circuit.
Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 101 DCE worksas follows: ? In a data station, the equipment that performs functions, such as signal conversion and coding, at the network end of the line between the Data Terminal Equipment (DTE) and the line and that maybe a separate or an integral partoftheDTEorofintermediateequipment. ? The interfacing equipment that maybe required to couple the DTE into a transmission circuit orchannel and from a transmissioncircuit or channel intotheDTE. ? DCE is a device that communicates with a DTE device in RS-232C communications. ? Usually, the DTE device is the terminal or computer and the DCE is a modem. ? When two devicesthat areboth DTEor bothDCEthatmust beconnected together without a modem or a similar media translator between them, a NULLmodem must be used. 3.2.2 Data Terminal Equipment DataTerminalEquipment(DTE)istheequipmentwhichisadatacommunication system terminal that inputs and outputs data. In general, data terminals have a humanmachineinterface.AtypicalexampleofDTE isanAutomatedTellerMachine (ATM)at abank. In otherwords,DTEisthecomputertransmittingandreceiving
equipment,includingawidevarietyofdumbterminals(terminalswithoutembedded
intelligenceintheformofprogrammedlogic),intelligentterminalsandintheform ofhostcomputers, such asmainframesandminicomputers. DTE works as follows: ? Anendinstrumentthatconvertsuserinformationintosignalsfortransmission orreconvertsthereceived signalsintouserinformation. ? The functional unit of a data station that serves as a data source or a data sink and provides for the data communication control function to be performed in accordancewith link protocol. ? TheDTEmaybeasinglepieceofequipmentoraninterconnectedsubsystem of multiple pieces of equipment that perform all the required functions necessaryto permitusers to communicate. ? AuserinteractswiththeDTEortheDTEmaybetheuser.TheDTEinteracts withtheDCE. ? Usually,theDTEdeviceistheterminalorcomputerandtheDCEisamodem. 3.2.3 Communication Software Now, in wider sense we may understand that a transmitter or sender may be a
terminal(computer)responsibleforwithcommunicationandapplicationsoftware controls the terminal and processes data. There maybe more than one terminal connected to the sender. Communicationssoftwareisgenerallyembeddedinthecomputeroperating system.Alternatively, it can take the form of a systems task underthe control of
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thecomputer'soperatingsystem.Theroleofcommunicationssoftwareistoassist
theoperatingsysteminmanaginglocalandremoteterminalaccesstohostresources, to managesecurityand to perform certain checkpoint activities. Figure 3.3 explains more clearlythe components of data communication system with devices as DTE, DCE and medium. DTE, DCE and medium as depicted in Figure 3.2 have been replaced by computer with communication software,Modulator DEModulator(MODEM) andtelephoneline,respectively. DTE DCE Medium DCE DTE Fig. 3.3 Data Communication System with Interfaces 3.3 TELEPHONE NETWORKS The earliest electronic network is the telephone system. This is shown in Figure 3.4. This telephone network commonlyuses analogtechnologythat was quitedifferentfromdigitaltechnologyusedinthecomputer-basednetworks.The advantagesofdigitaltechnologyovertheanalogtechnologyintermsofeconomics and services forced the telephone industryto move rapidly to install fiber and digital networks. The telephone network transmits analog signals and hence a modemisrequiredwheneveracomputerorterminalisconnectedtothetelephone
lineasshowninFigure3.4.Themodemthenconvertsdigitaldatafromacomputer
toananalogsignalthatcanbetransmittedviaatelecommunicationlineandconverts theanalogsignalreceived to computer data. 3.3.1 Dial up Telephone Networks The telephone networkconsists ofthesubscriber's line,switchboards,andtrunk lines as shown in Figure 3.4. Each subscriber line has an address i.e. telephone number.Whenacallertransmitsadialsignal totheswitchboard,theswitchboard connectsthecaller'ssubscriberlinetothatofthereceiver,enablingcommunication.
Thetrunklinebetweenthecallerandthereceiverisoccupieduntileitherdiscontinues thecommunication. When the telephone system is to connect with a network, it becomes necessaryto dial the telephonenumber to select thetarget deviceon the network as shown in Figure 3.4.Adevice called Network Control Unit (NCU) performs this, and mostof theavailablemodems, includethis NCU.

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 103 Telephone Network Mode Mode Fig. 3.4 Telephone Network The Computer Communication System – An example TheComputercommunicationsystemisanexampleofasystemusingthetelephone Network as shown in Figure. The system is used to send and receive mail, connectiontoInternet,iftheaccountisTCP/IP,postmessagesonaBulletinBoard systembyaccessingthehostcomputersystemofaISPthroughtelephonenetwork. Telephone Network Exchange Mode Rout User User Modem Modem Fig. 3.5 An Example 3.3.2 Advantages and Disadvantages of Telephone Networks Advantages ? It is circuit-switchingnetwork, therefore, anyreceiver canbeselectedand thereisvirtuallynotransmissiondelay. ? As it is widelyspread thereforeit is available at a low price. Disadvantages ? It requires a long time for connection. Adial-up operation is necessary before the line can be connected to the receiver. This dial-up time is too longto useindatacommunication systems. ? It has low transmission speed. ? Thelinequalityis not sufficientfor datatransmission, andis thereforenot appropriateforhigh-speed datatransmissionbecausetelephonelineswere originallydevelopedforaudiocommunication.

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 104 Material 3.3.3 Telephone Network Standards TheVSeriesRecommendationsfromtheITU-Tincludethemostcommonlyused modem standards and other telephone network standards. Prior to the ITU-T standards,theAmericanTelephoneandTelegraphCompanyandtheBell System offered its own standards (Bell 103 and Bell 212A) at verylow transfer rates. Another set of standards, the Microcom Networking Protocol, or MNP Class 1 through Class 10 (there is no Class 8), has gained some currency, but the developmentofaninternationalsetofstandardsmeansthesewillmostlikelyprevail and continue to be extended. (Some modems offer both MNP and ITU-T standards.) In general, when modems handshake, theyagree on the highest standard transfer rate that both can achieve. 3.3.4 Leased Lines A computer can be connected permanentlyto the Internet using leased lines as showninFigure3.6 in addition to a modem androuter. These lines are based on speedoftheconnection, installationcost, andrecurringmonthlycharges. Anexampleofusageofleasedlineisasysteminwhichonlyoneterminalis connected to the host computer. Though multiple computers/terminals using multiplexingcan beconnectedtoonesystemviaasingleleasedline.Ituses FDM for an analog leased line or TDM method for digital leased line. DSU (Digital ServiceUnit)unitis usedinsteadofmodem fordigital line.Leasedlinesmayalso be used to connect LANs. Fig. 3.6 Leased Line Configuration Telephonenetworks areintended to transmit analogsignals.It uses layer1 (Physical Layer) of the OSI model as shown in Figure 3.7. It is the service to provide physical media. Therefore, telephone networks can carry any type of protocol data. The data transmission speed depends on the performance of the modemand qualityoftheline. Circuit Switching Application Presentation Session Transport Network Data Link Physical Application Presentation Session Transport Network Data Link Physical Physical Fig. 3.7 OSI Model for Telephone Network

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 105 3.3.5 Public Switched Telephone Network (PSTN) PSTN or Public Switched Telephone Network relates to the public telephone network. It is based on circuit-switched connection and can be compared to the Internet terms, referring to a public IP network based on a packet-switched connection.ThetermPSTNwasinitiallyusedforfixed-lineanalogtelephonesystem but nowadays, duetotheadvancement intechnology,it isalsoreferredfordigital circuit- switched telephone network including both mobile and fixed. ITU-T technical standard and an addressing rule (telephone number) E.163/E.164 are followed bythe PSTN. PSTNistheglobal compilation ofinterconnects madeforassistingcircuit- switched voicecommunication.The conventional Plain OldTelephone Service (POTS) is provided byPSTN to dwellers and to various enterprises. Some of the DSL, VoIP and other Internet-based network technologies also make use of some parts of PSTN . Almost 64 Kbps bandwidth is supported bythe basic PSTNnetworklink. ThePSTNlines,incaseofresidences,areintheformofcoppercablestransferring the data in such a bandwidth. The dial-up modems make use of 56 Kbps of the total bandwidth while joined to the phone line. The SignallingSystem#7 (SS7) signallingprotocol is used bythePSTN. TheevolutionPSTNhasgonefromanalogtechnologytodigitaltechnology. In analogtechnology, the data deliveryis directlybased on the accessible data. Contraryto that, the digital technologyInvolves sending data after it has been manipulatedintothedigitalformat.DSL,ISDN,FTTXandcablemodemsystems are some forms of digital PSTN. PSTNrequire64kbps channel as thevital digital circuit whichalsoknown as digital signaling 0/DS0. SS7 is used as a communication protocol between telephone exchanges by which the calls are routed to the destination. Being a circuit switch-base communication protocol, SS7 includes all the accessible resources which areused bya singlededicated call connection. Alimitation to the PSTN capacityis DS0, as it is a natural Time Division Multiplexing(TDM)thatimplies thateverycalldatamix withoneanotherthat is time-based.InPSTN,thedeliveryisusuallydonethroughmultiplexingofvarious DS0togetherwith DS1 foroptimizingthetransmission.DS1canbesub-divided intotwoparts, namely, 24 DS0,also called asT1that is locatedinNorthAmerica orJapan and32 DS0,also calledas E1 that isinmost oftheothercountries. Both T1 and E1 are known as the Transmission type. The hardware of PSTN can handle onlyoneTransmission type due to which it always requires a hardware base that needs to be bought on the transmission plan. ISDN and other non-PSTN services have comparativelymore speed and acquirefeatures dueto which theyaremore preferableforusingtheInternet.For instance, wile using a non-PSTN service like ISDN or DSL, voice and data can be used simultaneouslywith the use of onlyone line instead of getting another phonelinefor accessingInternet which is thecasewithotherservices.

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 106 Material 3.3.6 PSDN Public Switched Data Network (PSDN) is a network that is accessible to the public. It assists packet-switched data as well as PSTN. EarlierPSDNwas termed as PSS(Packet SwitchStream)thatwas aX.25- basedpacket-switchednetwork. ThebasicpurposeofPSS was topresentleased- line connections between LANs and also the Internet with the help of PVCs (PermanentVirtualCircuits).Now,astechnologyisadvancingdaybyday,PSDN is not onlylimited to frame relayandATM (Asynchronous Transfer Mode) that are as providers of PVCs, but also extended to various other packet switching methods like IP, GPRS, etc. Bywatching the working of PSDN, one mayconsider it to bea replica of the data networks such as ISDN (Integrated Services Digital Network),ADSL (AsymmetricDigitalSubscriberLine),SDSL(SymmetricDigitalSubscriberLine) and VDSL(Very-high bitrate DSL). However, a closer studyof PSDN shows that it is a lot more than these. The PSTN circuit switched network is used by ISDN whereas, DSL is point-to-point circuit mode communication services imposed over the PSTN local loop copper wires, commonlyused for entryto a network of packet switched broadband IP. 3.3.7 ISDN: Broadband Communications ISDN which is short for Integrated Services Digital Network is a set of CCITT/ ITU standards usedfordigital transmissionoverordinarytelephone copperwire and other media. This technology uses ISDN adapters in place of modems and provides very fast speed up. ISDN requires adapters at both ends of the transmission. In reality, a widespread network with the potential to deliver at high data rates is required to deliver multimedia. Currently, ISDN is implemented in the formofthenarrowband.Thisisthebestmediumavailableforaccessanddelivery. ManyintheindustryconsiderISDNasthetoolforpromotingmultimedia,achannel through which multimedia will gain acceptance. The governments of various countries are coming out with plans and policies to implement ISDNas soon as possible. Integrated Services Digital Network in concept is the integration of both analog or voice data together with digital data over the same network. ISDN integrates theseon a medium thatis designedforanalogtransmission. However, broadbandISDN(BISDN)willextendtheintegrationofbothservicesthroughout the rest of the end-to-end path through fibre optic and radio media. Broadband ISDNwillcompriseframerelayserviceforhigh-speeddatacapableofbeingsent in large bursts, the Synchronous Optical Network (SONET) and the Fibre DistributedDataInterface(FDDI).BISDNwillsupporttransmissionfrom2Mbps andmuchhigherbut unspecifiedrates. Definition of ISDN ISDN is a network architecture in which digital technology is used to convey information from multiplenetworks to the end-user.This information is end-to- enddigital.
Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 107 Features ? Offers point-to-point delivery. ? Network access andnetwork interconnectionformultimedia. ? Differentdatarates from 64Kbpsupto2Mbpsarecommerciallyavailable whichcanmeetmanyneedsfortransportingmultimediaandisfourtomany times morethantoday's analoguemodems. ? Call set-up times are under one second. ISDN can dramaticallyspeed up transferofinformationovertheInternetoroveraremoteLANconnection, especially rich media like graphics, audio or video or applications that normallyrun at LAN speeds. ? ISDN will be the feeder network for broadband ISDN based on ATM standards. Although ISDN could be cheaper, particularly in the case of widespread use, it is likely to be cheaper than ATM connections and more widespread in availability for a long time. It is, therefore, an important tool in bringingmultimediaapplications toawiderangeofusers. There are two forms of ISDN service: narrow band and broad band. Narrow band ISDN Narrow band ISDN is digital servicewhere the transport speeds are 1.544 Mbps (T1) or less. Narrow band ISDN provides forthe followingservices: ? CircuitSwitchedVoice — Circuitswitchedvoiceserviceisadigitalvoice servicethat offersmanyofthecapabilitiesofabusiness.Itiscentredovera 4-wire ISDNDigitalSubscriberLine (DSL). ? CircuitSwitchedData — Circuit switched data service provides end- to-end digital service to pass data or video information over the public network. ISDN uses out-of-band signallingto establishand maintain data connections,whichrequirespecialprocessing. ? LowSpeedPacket — ISDNlinesareequippedwithapacketconnection that is used to manage ISDN connections. This monitoring capabilityis provided byusing the D channel on a DSL. The D channel is a 16 Kbps X.25 connection that is also capable of passing low speed packet while alsorelayingcallprocessinginformation. ? High Speed Packet — ISDN lines are also equipped with two B channels. Each Bchannel is a 64Kbps channel that can beused for circuit switched voice, circuit switched data, or high-speed packet service. To provision high-speedpacket service oneortwoof the64Kbps Bchannels areconnected(permanentvirtualcircuit)tothepacketnetworkthusproviding a 64 Kbps X.25 connection. Broadband ISDN service BroadbandISDNServiceis adigitalserviceinexcessof1.544Mbps.Thisdigital service can bein the form ofFrame Relay, SMDS, orATM.Broadband ISDN is the service of the future. The higher speeds offered are required to support the

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 108 Material manyapplicationsoftheInformation SuperHighway.Therangeofspeedsforthe Broadband ISDN services usuallyrange from 25 Mbps up to the Gigabit range. The two speeds that are most often discussed are OC 1 that is 155Mbps and OC 3 that is 622 Mbps. The speeds in the Broadband are made possible bythe high qualityof the digital facilities in place on the network. The earlydata protocols such as X.25 required extensive overhead to insure the deliveryof data. Error correction and flow control were performed at a number of intermittent points alongthewayofadataconnection.Thenewdigital facilitiesandtheintroduction of fibre optics have eliminated this need up to a maximum extent. High-speed broadband services relyforthe most part on theupper layerprotocols to perform these functions on an end-to-end basis. B(bearer) channels and a D(delta)channel.Voice, data andother services arecarriedbyBchannelswhilecontrolandsignallinginformationiscarriedbythe Dchannel. Basic RateAccess or BRAoffers an ISDN user simultaneous access to two64Kbps datachannels usingtheexistingtwistedpaircoppertelephonecable as shownin Figure 3.8. ? Eachdatachannel is considered aB-channel andis capableofcarrying voice or data. D-channel is another channel that operates at 16 Kbps and is used to signal between user devices and the ISDN. Therefore, 144 Kbps is the total datarateofBRA. Theterm 2B+Darises from the twoB-channelsandthesinglesignalingchannel.BRAisalsoreferredto as I.420 following the CCITT recommendation. Basic rate ISDN is meant for lowcapacityusage as is needed bysmall businesses. ? BasicRateAccess(BRA) provides an ISDN user with simultaneous access to two 64 Kbps data channels using the existing twisted pair copper telephone cable as shown in Figure 3.8. Each data channel is referredtoas aB-channel andcancarryvoiceordata.Anotherchannel, the D-channel, operates at 16 Kbps and is used for signaling between userdevices and the ISDN. The totaldata rate of BRAis therefore144 Kbps.Thetwo B-channels and thesinglesignalingchannel giveriseto the term 2B+D. BRA is also referred to as I.420, after the CCITT recommendation. Basic rateISDN is intended forlow capacityusage, such as thatrequired for small businesses. Fig. 3.8 Basic Rate Interface ? Primaryrateaccess service provides up to 30 independent 64 Kbps B channels and a separate 64 Kbps D channel to carry the signaling. This basicallyprovides digital access viaa T1 line as shown in Figure

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 109 3.9.AT1 line provides a 1.544 bandwidth.This bandwidth is divided into twenty-four64Kb channels. The ISDNPRIservice uses 23of the T1 channels to provide Bchannel access and uses the24th channel for signalingpurposes.ISDNcall control proceduresusepacket messages to initiate,monitor, and releaseconnections.In aBRIconnectionthese messages are routed via the D channel. On the PRI service the / connection/callcontrolmessagesareroutedoverthe24thchannelwhich is the D channel in this instance. The total data rate of PRA is 1.544 Mbps. Primary rate access is often referred to as 23B+D because of the number of B-channels and D-channels, or I.421 because of the CCITTrecommendationfrom which it istaken. This form ofaccess is primarilyintendedforuseinsituationswhichrequirealargetransmission capacity,suchaswhenorganizations makevoiceanddatacallsthrough an Integrated Services PBX. Primary Rate Interface Dchannel Bchannels Fig. 3.9 Primary Rate Interface 3.3.8 ISDN Standards Products forISDNtechnologyfrom different vendors evenwithsimilarfeatures andoptionsmaycreatesomecompatibilityissues.CCITTaftergooddeliberations over the years published the first significant ISDN standards in a number of red binders in 1984 and they were simply known as the Red Book standards. The groupsubsequentlymetfouryearslaterwhichculminatedinthepublicationofthe 1988BlueBookstandards. Theseinternational publications werethefoundation for the evolving ISDN national standards. The CCITTeventuallywas reformed into the group, which is now called the ITU–T. The standards used to define ISDN makeuse of the OSIreference model with thefirst threelayers ofthis OSI referencemodel. The two standard ISDN connectors are used as follows: (i) To access basic rate ISDN, an RJ-45 type plug and socket (like a telephoneplug)is usedthrough unshieldedtwistedpaircable. (ii) To access primaryrate ISDN a coaxial cable is used. The ISDN passive bus whose maximum length can be 1 km is a cable in user premises. It allows the attachment of up to eight devices to the basic rate ISDNinterface.AsonlytwoB-channelsareavailable,onlytwooftheeightdevices cancommunicateat anyone time.Therefore, each device is requiredtocompete for access to the passive bus.

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TheequipmentavailableforISDNincludesthefollowing: ? Video conference PC cards ? Gateways or bridges for LAN access (of which some are based on PC cards or stand alone boxes) ? Terminaladapters ? ISDN internal computerterminal adapter cards All theissues related toAPIstandardforinternal computeradapters canbe avoided ordealt with usingan external ISDN terminal adapter.Most serial ports onaPChadlimitedspeedofabout19.2 Kbpstill nowwhichiswhythisapproach was not feasible. Of late, internal PC cards have come in which work asynchronouslyup to 115 Kbps. When used along with an appropriate external terminaladapter,thiscouldhavemultimediaapplicationsworking. ISDN is accessed through one of two services, named by the CCITT as Basic RateInterface (BRI) and PrimaryRate Interface (PRI).BRIprovides 144 Kbps usingthe existing twisted paircopper telephonecable. BRIincludes2Bchannels and 1-Dchannel.This maybewrittenas 2B+D. B channel (bearer) provides 64 Kbps data transmission and can carryvoice or data. D channel (Delta) operates at 16 Kbps and is used for control, i.e. for signalling between user devices and the ISDN. Therefore, the total data rate of BRAistherefore144 Kbps.Audiodigitizedusingpulsecodemodulation(PCM). PRIalsocalled'30B+D'owingtothenumberofB-channelsandD-channels, is capableofcarryingthirtyindependentdata/voicechannelsof64Kbpseach.Its structure consists of a 64 Kbps D-channel for singling between devices and the network as well as a 64kbps channel for synchronizing and monitoring. 2.048 Mbps is the total data rate of PRI. It is also referred to as I.421 as per the recommendation of CCITT from whichitistaken.Thistypeofaccessismainlymeantforuseinsituationsrequiring a large transmission capacity such as when organizations make voiceand data calls usinganIntegrated Services PBX. ISDN internetworking equipment ISDN canbeused bymanydifferent internetworkingdevices as follows: ? TerminalAdapters(TAs) —— These are external devices that help in connectingX.21 andotherconventional datainterfacetoanISDN circuit. This allows non-ISDNequipment to use the ISDN.Terminal adapters are used byinternetworkingmanufacturers without anapprovednative ISDN interfacefortheirdevices. A demerit of this solution is that all information from the D-channel does notpass through theTA.Therefore, full advantageofISDN facilities cannot be taken by the non-ISDN equipment such as Calling Line Identification. ? ISDN Bridges —— Being rather simple, bridging is amongst the most popularandcommonlyusedmethodsoflinkingLANs.Onemajorproblem
Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 111 faced with ISDN bridging is the control of its use of the ISDN network. Bridges aresimpletosetup anduseas theyforwardbroadcastsandsimilar data bydefault. This implies that overISDN, calls will bemade to convey non-essential datawhich might proveto becostlyinthelongrun. This can be avoided if bridges are configured in such a way that broadcasts from particular addresses are blocked and certain protocols areunderstood.However,themajorpluspointofbridges,thatis,simplicity, is lost. Bridges are appropriate for backing up ISDN. ? ISDNRouters ——Amuch more effective technique of utilizingISDN forLANnetworkingisrouting.Itistheapproachadoptedbyallnetworking vendors.DataistransmittedovertheISDNnetworkonlywhenitisactually required.Inotherwords,unlikebridges,onlynecessarybroadcastmessages are sent toensureefficient and effectiveuseofbandwidth. It is possible to simplifytheconfiguration.Unnecessarytrafficisblockedoutusingfilters. Merits (i) Highquality - ISDNconnectionsaredigital pipes withlowerror rate (ii) Flexible - ISDNconnectionscanbeestablishedbetweentwo locations at anytime provided the locations have ISDNwhichislikeaconfiguredleasedline.Itoffers an almost transparent and quick call set-up. Therefore, formost users, the natureof dial-up is transparent. (iii) Economical - Rent is payed for ISDN just as in atelephonecall. The cost of using ISDN is similar to that of the telephoneservice.Itis quitecost-effectivewhenit comestointermittentLANto LANconnectivity. (iv) Widelyavailable - ISDNisnowavailablewidelyfollowinggovernment initiativesinvariouscountries. 3.3.9 Internet Service Providers (ISPs) Internet Service Provider (ISP) is a companythat access internet services. This service providerprovides a software package in which you get registration with theprovidingservices.Onceyou registeredwithusername,passwordanddialing phone number, you can access ISP by paying the monthly fee. This software package is equipped with modem that is connected with internet services. Good ISPshavetheirownleased-lineprovidedbytelecommunicationproviders. Some of thelargest and popularISPsareAt&TWorldNet, MCI,IBM Global Network, UUNet, PSINet, Netcom etc. It is sometimes known as internet access provider. There are183 ISPs in India.TheTable 3.1 showsthe list of ISPs havingall India license:
Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 112 Material Table 3.1 ISPs in India BSNL RPGInfotech Gateway systems RailTel Corporation i2i Enterprise CMC Sifi ERNET India GTL Tata Power Broadband Essel VSNL Jumpp India Bharti Infotel RailTel Corporation Astro India Network Primus Telecommunication India Siti Cable Network World Phone Internet Services Escorts Communication Reliance L&T Finanace In2Cable (India) Reliance Spectra Net Reach Estel Communication Fig. 3.10 Services of ISP In the Figure 3.10, ISPprovides web, Email andVoIPetc. as main services. ISP includes domainnameregistration and hosting,internettransmit,dial-uporDSL access,lease-lineandcollocation.Youcantakeyourdomainname,securedwebsite andhigh-availabilitywebserverswiththisfacility.Supposeafirewallisimplemented with twoseparateEthernet interfaces. Thefollowingfigureshows howtwo ISPs are connected with Internet. Fig. 3.11 Two ISPs Connected with Internet
Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 113 In theFigure3.11, thefollowingexplanationcan beanalysedasfollows: ? The Ethernet eth0 connects to ISP1. The IP address of eth0 is 206.124.146.176 and ISP's gateway router has address as 206.124.146.254. ? The Ethernet eth1 connects to ISP2. The IP address of eth1 is 130.252.99.27 and ISP's gateway router has address as 130.252.99.254. ? The Ethernet eth2 connects to local LAN.
Thefollowinggraphshowstheinternetserviceprovidersinworld: Function of ISP Commercial ISPs easily access and communicate with individual or various organizationsacrossnet.Theyarefacilities-basedcarriers,forexample,telephone and cablecompanies.Theinterconnected routers areassembledwithISP known asautonomoussystem(AS).ISPoperatesAStoinformationprovidersviaGoogle andYahoosearchengines.
Theyexchangetrafficnetworkingfromothernetwork. This processis calledpeering. Thenetworks areconnectedtoInternet Exchange (IX). Fig. 3.12 ISP Network

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 114 Material
IntheFigure3.12,ISPinterconnectswithIXprovidingTier-1andothernetworks. TheTier-1 network provides the largest service with reference toISP. Peeringis settlementfreethereforenomoneytransactionisdonebetweenISPandcommercial businesshouses.
CheckYourProgress 1. What aretwo types of data transmission methods? 2. Writethecomponentsofdatacommunicationsystem. 3. What do you understand bythe term DCE? 4. Whichis theearliest electronicnetwork? 5. State the components of telephone networks. 6. DefinePSTN. 7. Which are two forms of ISDN services? 3.4 WAN TECHNOLOGIES This technologyconnects sites that arein diverselocations.WideAreaNetworks (WANs)connectlargergeographicareas, suchas NewDelhi,India,ortheworld. The geographical limit ofWAN is unlimited. Dedicatedtransoceanic cablingor satelliteuplinks maybeusedto connectthistypeofnetwork.Hence,aWANmay be defined as a data communications network covering a relatively broad geographicalareatoconnectLANstogetherbetweendifferentcitieswiththehelp oftransmissionfacilitiesprovidedbycommoncarriers,suchastelephonecompanies. WAN technologies operate at the lowerthree layers of theOSIreference model. These arethe physical data link and network layers. Figure 3.13 explains the WAN, which connects many LAN together. It alsousesswitchingtechnologyprovidedbylocalexchangeandlongdistancecarrier. Fig. 3.13 Wide Area Network (WAN)
PacketswitchingtechnologiessuchasAsynchronousTransferMode(ATM), Switched Multimegabit Data Service (SMDS), Frame RelayandX.25 are used toimplementWANalongwithstatisticalmultiplexingtoallowdevicestouseand sharethesecircuits.
Thedifferencebetween MANandWANmaybeunderstoodonlyfrom the services being used bythem. WAN uses both the local and long distance carrier while MAN uses onlylocal carrier. Hardware and protocols are same as in case of MAN.
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ThereisalotofconfusionbetweenLANtechnologyandWANtechnology. The answer lies in how data is switched. Switching techniques are described subsequently in this chapter. It is the LAN/(WAN) integration that makes the network work. After all, people and machines not only need to be accessible locally,butfromdifferent sites aswell. 3.5 HISTORY OF INTERNET TheInternet, WWW andInformationSuperHighwayaretermswhichhavedeep impactinthelivesofmillionsofpeoplealloverthe world.Thewidespreadimpact of Internet across the globe could not be possible without the development of Transmission Control Protocol/Internet Protocol (TCP/IP).This is the protocol suitedevelopedspecificallyfortheInternet.Theinformationtechnologyrevolution couldnothavebeenachievedwithoutthisvastnetworkofnetworks.Ithasbecome a fundamental part of the lives of millions of people all over the world.All the aforesaid services, basically, provide us the necessarybackbone for information sharinginorganizationsandwithincommoninterestgroups.Thatinformationmay be in several forms. It can be notes and documents, data to be processed by anothercomputer, files sent to colleagues, and evenmore exoticforms of data. During late 1960s and 1970s, organizations were inundated with many different LAN and WAN technologies such as packet switching technology, collision-detectionlocalareanetworks,hierarchicalenterprisenetworks,andmany otherexcellent technologies.Themajordrawbacks ofallthesetechnologieswere thattheycouldnotcommunicatewitheachotherwithoutexpensivedeploymentof communicationsdevices.Thesewerenotonlyexpensive,butalsoputusers at the mercyofthemonopolyofthevendortheyweredealingwith.Consequently,multiple networking models were available as a result of the research and development efforts made by many interest groups. This paved the wayfor development of another aspect of networking known as protocol layering. This permits communication between applications.Afull range ofarchitectural models were recommendedandimplementedbyvariouscomputermanufacturersandresearch teams.Asaresultofthisknow-how,todayanyusergroupcanfindanarchitectural modelandaphysicalnetworkthataresuitabletotheirspecificneeds.Thisincludes cheap asynchronous lines with no other error recoverythan a bit-per-bit parity function,throughfull-functionwideareanetworks(privateorpublic)withreliable protocols such as private SNA networks or public packet switchingnetworks to high-speed but limited-distancelocal areanetworks. It is now evident that organizations or users are using different network technologies to connect computers overthenetwork.Thedesire ofsharingmore and more information among homogeneous or heterogeneous interest groups motivated the researchers to devise a technology whereby one group of users couldextenditsinformation system toanothergroupwhohadadifferent network technologyanddifferentnetworkprotocols.Thisnecessitywasrecognizedinearly 70s by a researchers' group in USA, who hit upon a new principle popularly knownasinternetworking.Otherorganizations,suchasITU-T(formerlyCCITT) andISO,also becameinvolvedinthis areaofinterconnectingnetworks.All were

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 116 Material tryingtodefineasetofprotocols,layeredinawell-definedsuite,sothatapplications areabletocommunicate with eachother, regardless oftheoperatingsystems and underlyingnetworktechnology. Internetworks The availability of different operating systems, hardware platforms and the geographicaldispersionofcomputingresourcesnecessitatedtheneedofnetworking in such amanner that computers ofall sizes couldcommunicatewith each other, regardless of the vendor, the operating system, the hardware platform, or geographical proximity.Therefore,wemaysaythat internetworkingis ascheme forinterconnectingmultiplenetworksofdissimilartechnologies.Tointerconnect multiplenetworksofdissimilartechnologies, bothadditionalhardwareandsoftware should be used. This additional hardware is positioned between networks and software on each attached computer. This system of interconnected networks is called an internetwork or an Internet. To develop standards for internetworking, the US Defense Advanced Research Projects Agency (DARPA) funded research projects. ARPAnet, a project of DARPA, introduced the world of networking with protocol suite concepts such as layering, well before ISO's initiative in this direction. DARPA continued itsresearch for an internetworkingprotocol suite. This maybeseen in the earlyNCP (Network Control Program) host-to-host protocol to the TCP/IP protocolsuite,whichtookitscurrentformaround1978.DARPAwaswellknown for its pioneering of packet switchingover radio networks andsatellite channels and ARPAnet was declared an operational network with responsibility of administeringittoDefenseCommunicationsAgency(DCA)in1975.TCP/IPhad not yet been developed. ARPAnet was basically a network based on leased lines connected by special switching nodes, known as Internet Message Processors (IMP). Many researchers were involved inTCP/IPresearch by1979.This motivated DARPA to form an informal committee to coordinate and guide the design of the communicationprotocolsandarchitecture.ThecommitteewascalledtheInternet Control andConfiguration Board (ICCB). The first realimplementation oftheInternet waswhenDARPAconverted themachines of its research networkARPAnet to use thenewTCP/IPprotocols. After this transition which started in 1980 and finished in 1983, DARPA demanded that all computers willing to connect to itsARPAnet must useTCP/ IP. The US military adopted the TCP/IP as standard protocol in 1983 and recommended that all networks connected to theARPAnet conform to the new standards.

ThesuccessofARPAnetwasmorethantheexpectationsofitsownfounders and TCP/IP internetworking became widespread. As a result, new wide area networks (WAN) were created in the USA and connected to ARPAnet using TCP/IP protocol. In turn, other networks in the rest of theworld, not necessarily basedontheTCP/IP protocols, wereaddedtothesetofinterconnectednetworks. ComputingfacilitiesalloverNorthAmerica,Europe,Japan,andotherpartsofthe world are currently connected to the Internet via their own sub-networks,

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 117 constituting the world's largest network. In1990,ARPAnet was eliminated, and the Internet was declared as theformal global network. DARPAalso funded a project to develop TCP/IPprotocols for Berkeley UNIXontheVAXand to distributethedevelopedcodes freeofchargewith their UNIX operating system. The first release of theBerkeleySoftware Distribution (BSD)toincludethe TCP/IP protocolset was made availablein 1983(4.2BSD). This led tothespreadofTCP/IPamonguniversities and researchcenters andhas becomethestandardcommunicationssubsystemforallUNIXconnectivity.There are many updated versions of BSD code available. These are 4.3BSD (1986), 4.3BSD Tahoe (1988), 4.3BSD Reno (1990) and 4.4BSD (1993). Someexamplesofthedifferent networksthat haveplayedkeyroles inthis development aredescribed below: Internet The word Internet is an acronym of the word 'internetwork' or 'interconnected network'. Therefore, it can be said that the Internet is not a single network, but acollectionofnetworks.Thecommonalitybetweentheminordertocommunicate with each other is TCP/IP. The Internet consists of the following groups of networks: (a) Backbones: These arelargenetworks that exist primarilyto interconnect other networks. Some examples of backbones are NSFNET in the USA, EBONE in Europeand large commercial backbones. (b) Regionalnetworks:Theseconnect,forexample,universitiesandcolleges. ERNET (Education and Research Network) is an example in the Indian context. (c) Commercial networks: They provide access to the backbones to subscribers,andnetworksownedbycommercialorganizationsforinternal use and also have connections to the Internet. Mainly, Internet Service Providers comeinto this category. (d) Localnetworks: Thesearecampus-wide universitynetworks. The networks connect users to the Internet using special devices that are called gateways or routers. These devices provide connection and protocol conversion of dissimilar networks to the Internet. Gateways or routers are responsibleforroutingdataaroundtheglobalnetworkuntiltheyreachtheirultimate destination as shown in Figure 3.14. Thedeliveryof data to its final destination takes placebased on someroutingtable maintained byrouterorgateways. These arementioned atvarious places in thisbookasthesearethefundamental devices toconnectsimilarordissimilarnetworks together. Overtime,TCP/IPdefinedseveralprotocolsetsfortheexchangeofrouting information. Each set pertains to a different historic phase in the evolution of architecture of the Internet backbone.

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 118 Material Ethernet 10 Mbps Ethernet 10 Mbps Router Router Router WAN 1200- 600Mbps WAN 1200- 600Mbps Token-ring 4Mbps, 16Mbps Fig. 3.14 Local Area Networks Connected to the Internet via Gateways or Routers ARPAnet ARPAnet was built by DARPA as described earlier. This initiated the packet switchingtechnologyintheworldofnetworkingandthereforeissometimesreferred to asthe'grand-daddyofpacketnetworks'.TheARPAnet was established in the late 1960s for the US Department of Defense with the aim to accommodate research equipment on packet switching technologybesides allowing resource sharingfortheDepartment's contractors.Thisnetworkincludes researchcentres, some government locations and military bases. It soon became popular with researchersforcollaborationthroughelectronicmailandotherservices.ARPAnet marks the beginningof Internet.ARPAnet provided interconnection of various packet-switching nodes (PSN) located across continental USA and Western Europe using 56 Kbps leased lines. ARPAnet provided connection to minicomputers running a protocol known as 1822 (after the number of a report describing it) and dedicated it to the packet-switching task. Each PSN had at least two connections to other PSNs (to allow alternate routing incase of circuit failure) and up to 22 ports for user computer connections. Later on, DARPA replaced the 1822 packet switching technologywith theCCITT X.25 standard. Theincreaseindatatrafficmade56Kbpscapacityofthelinesinsufficient.ARPAnet has now been replaced with new technologies as backbone for the research side of theconnected Internet. Internet2 ThesuccessoftheInternetandtheconsequentfrequentcongestionoftheexisting backboneshasledtheresearchcommunitytolookforalternatives.Theuniversity community, together with government andindustrypartners,and encouraged by thefundingagencies,hasstartedtheInternet2project.Internet2hasthefollowing objectives: (a) Tocreateahighbandwidth;leading-edgenetworkcapabilityfortheresearch communityintheUS. (b) Toenableanewgenerationofapplicationsandcommunicationtechnologies to fullyexploit thecapabilities ofbroadbandnetworks. (c) Torapidlytransfernewlydeveloped technologiestoalllevelsofeducation and to the broader Internet community, both in the U.S. and abroad.

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 119 Internet services TheInternet isbecominganecessarytoolratherthanaconvenienttool insociety. It hasproved its utilityinall walks oflife,suchas education,economy,andsocio- political arenas.This is becauseofthe presenceofextensivenetworks withwide information sources,commercial vehicles, Internet andprovisionofapplications andinformationtocarryoutusefultasks.DailyusersoftheInternetareallowedto access theseapplications to reach otherusers, which was not possible few years ago.Todaytheycanbeaccessedonhis/herterminalinaveryshorttime.Moreover, theyarenotrequiredtoknowthedetailsofthetechnologyunderlyingtheInternet. This is the major reason behind the popularity of Internet among laymen. The information availableon the Internet is makingthem more confident about their areaofworkingandwithoutwhichtheyfeel theirproductivityandprofitabilityof theirbusinesses wouldbeseriouslyaffected. Followingisasummaryofthemostwidespreadapplicationsontheinternet today: WorldWideWeb(WWW) The World Wide Web is also known as the Web, WWW or W3. It is a global systemofhypertextandmultimediaservices.WWWisaclient-servermodelbased on TCP/IP protocols and consists of browsers as clients and Web servers as servers.Web servers use HTTP(HyperText Transmission Protocol) and HTML (HyperText Markup Language) to make the WWW hypertext and multimedia servicesavailableto clientsovertheInternet.WWW supports hypertexttoaccess several Internet protocols on asingleinterface. Hypertext orHypermediasystem allows interactiveaccessto collections ofdocuments.Thesedocuments canhold text (hypertext), graphics, sound, animations and video. These documents are linked together and may be seen as non-distributed and distributed. In non-distributed documents, all documents are stored locally (like CD-ROM). In distributed style, all documents are stored on remote servers. Internet supports various protocols and networkservices.This includes e- mail, FTP, Gopher, Telnet, Usenet News. In addition to these, theWorld Wide Web has its own protocol. The WWW provides a single interface for accessing all these protocols. Thiscreatesaconvenientanduser-friendlyenvironment.Itisnolongernecessary to be conversant in these protocols. The web gathers together these protocols into a single system. Because of this feature, and the web's abilityto work with multimediaandadvancedprogramminglanguages,theWWWisthefastest-growing component oftheInternet. The operation of the web relies primarily on hypertext. HyperText is a document that contains links (pointers) to other documents.Abutton represents theselinks.Asinglehypertextdocumentcancontainlinkstomanydocuments.In thecontext oftheWeb, button orgraphics mayserveas linkstootherdocuments, images,video,and sound. A page represents each document. The initial page for individual or organization is called aHomePage. Thepagecancontainmanydifferenttypesof information and must specifycontent, typeof content, location andlinks. These

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 120 Material pages areformatted with HTMLratherthanfixedWYSIWYG(WhatYouSeeIs WhatYou Get) representation (e.g., Word).With HTML,tags are placed within thetexttoaccomplishdocumentformatting,visualfeaturessuchasfontsize,italics and bold,and the creation ofhypertext links.Graphics mayalso be incorporated intoanHTMLdocument.TheHTMLisanevolvinglanguage,withnewtagsbeing added as each upgrade of the language is developed and released. The web provides a vast array of experiences including multimedia presentations, real-time collaboration, interactive pages, radio and television broadcasts, and the automatic push of information to a client computer. Newer programminglanguagessuchasJavaandJavaScriptareextendingthecapabilities of the Web. E-mail Electronicmail,ore-mail,allowscomputerusers locallyandworldwidetoexchange messages. E-mail users have an electronicmailbox into which incomingmail is dropped. Messages sent through e-mail can arrive within a matter of seconds. Theuseraccessesthesemailswithamailreaderprogram,calledmailuserinterface that is usually associated with computer account. One user mayhave different electronic mailboxes. The electronic mailbox is identified byan e-mail address andisgivenauser'saccountID.Thisisnotalwaystruebecauseonnon-networked multi-user computer,e-mail address is justaccount ID. Mail delivery among networked computers is more complicated. In this case,mailmustidentifycomputeraswellasmailbox.Syntactically,e-mailaddress iscomposedofcomputernameandmailboxname,forexample,user_id@domain. E-mailmessageformatcontainsheaderandbody.Headerincludesdelivery information and bodycarries message part. The header and bodyare separated byablankline.An e-mailmessagecanonlybetransmittedinformof7-bitASCII (American Standard Code for Information Interchange) data.ASCIIis a 7-bit code, resulting in a maximum of 128 characters. The data in e-mail could not contain arbitrarybinaryvalues, e.g., executable program. There are techniques for encoding binarydata so that it maybe transported. Apowerfulaspectofe-mailistheoptiontosendelectronicfilestoaperson's e-mail address. Non-ASCII files, known as binaryfiles, may be attached to e- mail messages.Thesefiles arereferred to as MIME(MultipurposeInternet Mail Extensions) attachments. MIME extends and automates encoding mechanisms andwas developedtohelp e-mail softwarehandleavarietyoffiletypes.It allows inclusion ofseparatecomponents, i.e., programs,pictures, audioclips inasingle mailmessage.Thesendingprogramidentifiesthecomponentssothatthereceiving program can automatically extract and inform mail recipients. Many e-mail programs, including Eudora and Netscape Messenger, offer the abilityto read fileswritten in HTML,whichis itselfofMIMEtype. E-mail communication isactuallya two-part process.The user composes mailwithane-mailinterfaceprogram.Thismailtransferprogramdeliversmailto the destination and waits for the mail to be placed in outgoing message queues. SMTP (Simple Mail Transfer Protocol) is a standard application protocol for deliveryofmailfromsourcetodestination.Itprovidesreliabledeliveryofmessages

usingTCPandmessageexchangebetweenclientandserverincludinge-mailaddress lookupande-mail address verification. Thee-mailcanbeconsideredasanelectronicversionofpaper-basedoffice memo,whichisquick and muchcheaperthanawrittencommunication.Because e-mailisencodedinan electronicmedium, fast,automaticprocessingintheform of sorting and replyis possible. It allows quick, asynchronous communication across the Internet. Asynchronous communication consists of asynchronous characters as output at a rate that is independentlygenerated bythe transmitter. The asynchronous characters are actually self-synchronized because they are framed by Start and Stop bits that delineate the character. E-mail is the most widelyused Internet service in theworld. Thebest featureof themail is its quick and reliabledeliveryof messages sinceit is contained as short data. Telnet Apopular utilityprovided byTCP/IPis theTELNET.Telnet is a virtual terminal emulation facilitythat allows auserto connect toaremote system as ifthe user's terminal was hard wired to that remote system. This works on client server architecture.Thereis onetelnetserverhostingvariousfiles anddatabases toshare a client machine that accesses these resources. Telnet is a program that allows loggingintocomputersontheInternetandusingonlinedatabases,librarycatalogs, chat services, and more. For a computer to work on telnet the basic need is that its address should be known. This can consist of word (rag.gov.in) or numbers (140.147.254.3). The operation of this service is very simple. It requires just typingof theword telnet and then the address.Telnet is availableon the WWW. Probably the most common web-based resources available through telnet are librarycatalogs.Alink to atelnet resourcemaylooklikeanyotherlink,but it will launchatelnetsessiontomaketheconnection.Atelnet programmust beinstalled on local computer and configured toWeb browser, in order to work. FTP(FileTransferProtocol) The file transferfacilities are usuallyprovidedfor bya mechanism known as the FileTransferProtocol(FTP).Itisasimplefeatured'filemoving'utilitythatallows a record oriented (one record at a time) transfer, a block transfer (which moves chunk ofa file) or an image transfer.To transfera file, the user invokes the host, FTP utilityspecifiesfilename,type(ifnecessary),remotedestination. This is both a program and a method used for transfering files between computersontheInternet.AnonymousFTPisanoptionthatallowsuserstotransfer filesfromthousands ofhost computerson theInternet totheirpersonal computer accounts. Filetransfer is quite rapid.FTP sites contain books,articles, softwares games, images, sounds, multimedia, course work,data sets, etc.

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Archive A computer site stores a large amount of public domaininformation, shareware software and

manytypes of documentation.Archive functions as acatalogue of FTP sites.Archive is a program that searches all the FTP sites on the Internet, whichareavailableonitsmasterlist,andstoresthefilenamesinacentraldatabase. This databaseisavailableforuserstosearch.Whenausercontactsanarchivesite and enters a search string, archive searches the database and returns a list of all

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 122 Material filesthat containthat string. The list provides with the address tocontact and the directories where thefiles are stored. Some archives are heavily used and must be supported bymultiple sites, whichareoftenlocatedfarapart. Eachsiteshouldideallyhaveidenticalinformation available,therefore, theyaremirrors ofeachother.Whenonesitegetsanewfile, it must be mirrored to theother sites, usuallybyusingFTP. SMTP It stands for Simple Mail Transfer Protocol. SMTPis a defined standard for e- mail over the TCP/IP protocol and therefore is widely used on the Internet.A utilitythatissomewhatpopularprovidesamechanismbywhichausercanspecify adestinationaddress,aparticularpath tofollow(ifdesired),andamessage.Alle- mail servers usethis protocol for messagedeliveryand receipt. E-maildiscussiongroups Oneofthebenefits oftheInternetistheopportunityit offerstopeopleworldwide tocommunicateviae-mail.TheInternetishometoalargecommunityofindividuals whocarryoutactivediscussionsorganizedaroundtopic-orientedforumsdistributed by e-mail. There are all kinds of discussion groups, such as sports, politics, software,troubleshootingetc. whereusers posttheirqueriesintheform ofe-mail and others reply. Networkinformationserver News, Gopher, and WWWare special servers for information, which require a client software package for access. They can be thought of as network databases. Each server is powerful with some interconnectivity. Each server requires a client application to allow the user to access information. The main purpose of these client/servers is to help a user navigate the Internet to find informationandfiles. ? News – News constitutes broad topics called news groups, to which people can post or respond to posts. News is available via Usenet, Internet, and some commercial services.Almost nobody carries all the news groups. User access is through a news reader application that accesses a news server. There are many variations of news readers. UsenetNewsis aglobalelectronicbulletinboardsystem inwhichmillions of computer users exchange information on a vast range of topics. There are thousands of Usenet newsgroups in existence. While many are academic in nature, numerous newsgroups are organized around recreational topics. Serious computer related work takes place in Usenet discussions. A few e-mail discussion groups also exist as Usenet newsgroups. ? Gopher – Before the advent of the WWW, Gopher was the document access protocol of choice. Gopher is a menu utilitymainlyfor text-based documentsontheInternet,whichusesFTPforretrievingfilesfromarchive sites. Gopheralso uses a search utilitycalledVeronica for aiding users in findingfilesintheGopherarchivesites.Veronicacandokeywordsearches whereasArchiecan onlysearch forfile names.
Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 123 IRC, chatand instant messaging IRC is theInternetRelayChat servicein whichparticipantsaroundtheworldcan ‘talk’toeachotherbytypinginrealtimeonhundredsofchannels.Thesechannels are usually based on a particular topic. To have access to IRC, an IRC software program is essential.This program connects theusertoanIRCserverand allows himtovisitIRCchannels. ChatprogramsarenowcommononthеWeb.Theyaresometimesincluded as a feature of a web site, where users can log into the chat room to exchange comments and information about thetopics addressedon thesite. Avariation of chat is the phenomenon of instant messaging.With instant messaging, a user on the Web can contact another user currentlylogged in and type a conversation. Thereareotherservices availableon Internet likeFAQ (FrequentlyAsked Questions), RFC (Request for Comments), FYI(ForYour Information), MUD (Multi UserDimension)andWAIS (WideAreaInformationServer). MUDs are multi-user virtual reality games based on simulated worlds. Traditionallytextbased,graphicalMUDsnowexist.ThereareMUDsofallkinds on the Internet, and manycan be joined free of charge. MUDs are accessible by Telnet. WAIS provides information lookup services to libraries and databases on the Internet.AsimpleWAIS client allows the user to select databases to search from a list. The user then provides keywords to search for, and theWAIS client allows the user to view anymatches found. This is cumbersome once the list of databases grows into thousands. Screen afterscreen of database names scroll by one after another. 3.5.1 Standards for TCP/IP and the Internet The group of people who were responsible for monitoring and reviewing the progress made in the effort to develop TCP/IP initiated byUS Department of Defense was known as the InternetActivities Board (IAB). Gradually, the IAB evolvedfromaDARPA-specificresearchgroupintoanautonomousorganization. Its memberschaired smallergroups calledInternetTaskForces (ITFs).EachITF was required to deal with different aspects of the evolution of TCP/IP and the Internet. In1989, the IABwasreorganized.Twosubsidiarygroupswere created, viz., the Internet EngineeringTask Force(IETF) and the Internet ResearchTask Force (IRTF). The former was assigned the task of developing the Internet standards, and the latter was maderesponsible for researchanddevelopment. In 1992, theInternet Society(ISOC) was formed as the standardizingbodyfor the Internet communityand theIABwasrenamedas theInternetArchitectureBoard (IAB).This group itself relies onthe Internet EngineeringTaskForce (IETF) for issuingnewstandards, and on theInternetAssignedNumbersAuthority(IANA) forcoordinatingvaluessharedamongmultipleprotocols. 3.5.2 RFCS and TCP/IP Standardization Process Within theIETF, subsidiaryworkinggroups are formed tolookafterthespecific aspectoftheoverallInternetprotocolsuite.Therearegroupsdedicatedtonetwork
Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 124 Material management, security,and routing, amongotherinterests.TheRFC isa seriesof technical paperscommonlyreferred toasRequest forComments (RFCs).This is responsiblefor reviewingand publishingnew standards documents. RFC series aretraditionallyreferencedusingnumbersinachronologicalorderbasedongradual developmentandispubliclyavailableontheInternettobothworkgroupmembers andthegeneral publicfordiscussionpointofview. The Internet Standards Process is described in RFC2026. The Internet StandardsProcess —Revision3 is concernedwithallprotocols,procedures,and conventions that areused in orbythe Internet,whetheror not theyarepart of the TCP/IP protocol suite. The objectives of the Internet Standards Process are to achievetechnicalexcellence,priorimplementationandtesting,clear,concise,and easilyunderstooddocumentation,openness andfairnessandtimeliness. Theprocessofstandardizationincludessubmissionofthenewspecification to theIESGfortechnical discussion andfeasibility,andalsoforpublicationas

callnotificationtoallowthespecificationtobereviewedbythewholeInternet community.AfterthefinalapprovalbytheIESG,anInternetdraftisrecommended to theInternet EngineeringTaskforce (IETF),another subsidiaryof theIAB,

RFC. It mayalso be revisedovertimeorphased out whenbettersolutionsarefound.IftheIESGdoes notapproveofanewspecificationafter,orifadocumenthasremainedunchanged withinsixmonthsofsubmission,itwillberemovedfromtheInternetdraftsdirectory. CheckYourProgress 8. DefineWorldWideWeb (WWW). 9. Howise-mailuseful? 10. What do you understand bytheterm TELNET? 11. Whatisthefunctionofarchive? 3.6 NETWORKARCHITECTURES
TCP/IP

all sizes, regardless ofthehardware oroperatingsystemplatforms supportingthem.
Overtheyears,TCP/IPhasbecomethemostwidespreadamongtoday'sprotocols. One reason for TCP/IP's popularity is the public availability of its protocols' specifications.Inthissense,TCP/IPcanjustifiablybeconsideredanopensystem. Most users rely on TCP/IP for the purpose of file transfers, electronic mail (e-mail),andremotelogin services.
Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 125 Network Architectures Network architecturedefines the communications products andservices, which ensure that various components work together. In the early days of data communicationsystems,themajorityofcommunicationswerebetweentheDTE and the host computer. Therefore, transmission control procedures were alone enoughascommunicationprotocols.However,recentcomputersystemslinkwith othersystemstoformanetworkwhichresultinasituationwheredifferentprotocols serving for different purposes is required. Hence, the network architecture represents a systemization of the various kinds of protocols needed to build a network. Computer manufacturers have developed different protocols as needed. This means that each type of computer needed to support different protocols. This necessitated large development and maintenance costs. All computer manufacturers,asshowninTable3.2,workedtogethertostandardizeandsystemize protocolstolinktheirmodelsandreducethedevelopmentandmaintenancecosts thereby.This washow each manufacturerbuilt hisown network architecture. Since the concept of the network architecture was first introduced, connecting computers of the same manufacturer has become easier. However, from a user's perspective, the ideal form of network architecture is one which enables machines of all manufacturers to connect to each other.Therefore, the need of standardization of network architecture arose. Table 3.2 Network Architecture by Vendor Manufacturer Networkarchitecture IBM System NetworkArchitecture (SNA) DEC Digital NetworkArchitecture (DEC) Borroughs Borroughs NetworkArchitecture (BNA) UNIVAC Distributed CommunicationArchitecture (DCA) Toshiba Advanced Network System Architecture (ANSA) NEC Distributed Information ProcessingArchitecture (DINA) Honeywell Distributed SystemEnvironment (DSE) The following are ways to achieve connection between different manufacturers: ? ProtocolConverters: Thesearedevicesthat translatefromonenative protocol into another, for example, fromASCIIto IBM SNA/SDLC ? Gateways: These arehardware/software combinations that connect devices running different native protocols. In addition to protocol conversion, gateways provide a gateway connection between incompatible networks. Examples include Ethernet-to-Token Ring gateways, X.25-to-Frame Relaygateways, andT-carrier-to-E-Carrier InternationalGatewayFacilities (IGFs). In addition to the above, ProtocolAnalyzers are available as diagnostic tools for displaying and analysing communications protocols.Analysers allow technicians, engineers and managers to test the performance of the network to ensurethatthesystemsandthenetworkarefunctioningaccordingtospecifications.

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 126 Material LAN managers, for instance, use protocol analysers to perform network maintenance and troubleshootingand to plannetworkupgradesand expansions. Example of TCP/IP Operations TCP/IP Layers and Protocols TCP/IP defines a suite of communications and applications protocols in layer structure,witheachlayerhandlingdistinctcommunicationservices.TCP/IPdefines a four-layer model as shown in Figure 3.15 consisting ofApplication, host-to- host, Internet, and NetworkAccess layers. This architecture is based on three sets of interdependent processes, namely, application-specific processes, host- specific processes, and network-specific processes. A p p l i c a t i o n L a y e r (a p p l i c a t i o n - s p e c i f i c p r o c e s s e s) H o s t t o H o s t L a y e r (H o s t - s p e c i f i c p r o c e s s e s) I n t e r n e t L a y e r (r o u t i n g p r o c e s s e s) N e t w o r k A c c e s s L a y e r (n e t w o r k - s p e c i f i c p r o c e s s e s) Fig. 3.15 TCP/IP Communication Architecture Thefollowingareexamplesofconcernsthat eachoftheseprocesses shouldhandle: Application-specific processes: TCP/IP defines the External Data Representation (XDR)protocol to provideanagreementbetweenthedatasyntax runningbetweenthedifferentplatforms. Host-specificprocesses: Itistheresponsibilityofthehost-specificprocess toestablish,maintain,andreleaseaconnectiononbehalfofanapplicationwithout losingtrackofotherlogicalconnectionsonmultiuser/multitaskingoperatingsystems. Therefore,itensuresthatdataintegrityismaintainedwithoutconfusingtheidentity ofthecommunicatingapplications. Network-specific processes: These are processes that concerns with the deliveryof data to the transmission medium and route data across networks untilitreachesitsultimatedestination. The correspondence between the TCP/IP and OSI model is shown in Figure 3.21. From Figure 3.15, the relationship between the twofigures maybe established. Layer 5, 6 and 7 corresponds to application layer(4thlayer)ofTCP/ IP communication architecture. In a similar manner layer 4 and 3 of OSIcan be relatedwiththehost-to-hostlayerandInternet layerofTCP/IPsuite,respectively.

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The physical layer and data link layer of OSI is similar to the network layer of

TCP/IP. 3.6.1 Layering the Communications Process Open Systems Interconnection (OSI) was set up as an international standard for network architecture. The International Organization forStandardization (ISO) tooktheinitiativein settingupOSI.
Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 127 Layering the Communication Process OSIhas two meanings. It refers to: (i) Protocols that are authorized byISO (ii) OSIbasic reference model OSIreference model divides the required functions of the network architecture into several layers and defines the function of each layer. Layering the communications processmeans breaking down thecommunicationprocess into smaller and easier to handle interdependent categories, with each solving an importantandsomehowdistinctaspectofthedataexchangeprocess.Theobjective of this detail is to developan understandingofthecomplexityandsophistication that this technologyhas achieved, in addition to developing the concept for the innerworkingsofthevariouscomponentsthatcontributetothedatacommunications process. Physical data encoding Information exchanged betweentwocomputersis physicallycarriedbymeansof electrical signals assuming certain coding methods. These codings can be characterizedbychangingvoltagelevels,currentlevels,frequencyoftransmission, phasechanges,oranycombination ofthesephysical aspects ofelectricalactivity. For two computers to reliably exchange data, they must have a compatible implementationofencodingandinterpretingdatacarryingelectricalsignals.Over time,network vendors defined different standardsforencodingdataonthewire. Figure 3.16 shows one such standard, namely,bipolar data encoding. Fig. 3.16 Bipolar Data Encoding Inbipolarencoding, binarydataissimplyrepresentedbytheactualsignal level, inwhich a binary1is encoded using afixed voltagelevel (forexample, +5 volts) and a binary0 is encoded using a negative voltage level (for example, −5 volts). Transmission media This deals withthe typeofmediaused (fibre,copper,wireless,andsoon),which is dictated by the desirable bandwidth, immunity to noise, and attenuation properties. Thesefactorsaffectthe maximum-allowablemedialengthwhilestill achievingadesirablelevelofguaranteeddatatransmission. Data flow control Data communications processes allocate memoryresources,commonlyknown as communication buffers, for the sakeof transmission and reception of data.A computerthat is in theprocessof receivingdata runstheriskoflosingdatawhen itscommunicationbuffersexhaust.This canbeavoidedbyemployingadataflow control mechanism as shown in Figure 3.17. For proper data flow control, the receivingprocessmustsenda'stepsending'signaltothesendingcomputer,ifitis

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 128 Material unable tocope up with therate at which data is beingtransmitted bythe sending computer. Later, when data communication buffer is available, the receiving computersends'resumesending'signal. } } Sending computer Fig. 3.17 Data Flow Control Mechanism Data frame format Informationexchangebetweencomputers,communicationprocessesneedtohave followingforaccomplishingtheseaspects oftheexchangeprocess: ? The receiving computer must be capable of distinguishing between an informationcarryingsignalandmerenoise. ? There should bea detection mechanism to detect whether the information carryingsignalisintendedforitselforsomeothercomputeronthenetwork, orabroadcast(amessagethatisintendedforallcomputersonthenetwork). ? Thereceivingendshouldbeabletorecognizetheendofdatatrainintended forreceiverbeforeit engages itselfto recover data fromthe medium. ? Thereceivingendaftercompletionofreceivingofinformation,mustalsobe capableofdealingwithandrecognizingthecorruption,ifany,introducedin theinformationdueto noiseorelectromagneticinterference. Toaccommodatetheaboverequirements,dataisdeliveredinwell-defined packages called data frames as shown in Figure 3.18. This frame belongs to the Ethernet packet format and has been explained earlier in the unit on LocalArea Network. The receiving end compares the contents of this data frame. If the comparison is favourable, the contents oftheInformation fieldaresubmittedfor processing.Otherwise,theentireframeisdiscarded.It is importanttorealizethat the primary concern of the receiving process is the reliable recovery of the informationembeddedintheframe. Preamble (P) 1010.10 SED 10101011 SA DA L FCS Fig. 3.18 Frame Format for IEEE 802.3

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 129 Routing Withthegrowthofnetworksize,trafficalsogrowsaffectingtheoverallnetworkin performance and responses.To manage a situation likethat, network specialists breakthe network into multiplenetworks, interconnectedbyspecializeddevices that include routers, bridges, brouters and switches (refer Figure 3.19). The routing approach requires implementation of various processes in cooperation,bothin routersandworkstationswiththesoleobjectiveofdelivering thedata,intelligentlytothefinaldestination.Suchexchangeofdatacantakeplace betweenanytwo workstations, within orwithout thesame network. Fig. 3.19 Router connecting Two Networks The network address and the complete address In addition to the data link address, which should be guaranteed tobe unique for each workstation on a particular physical network, all workstations must have a higher-level address in common. This is known as the network address. The network address is verysimilarin functionand purpose to the conceptofa street name.Astreet name is common to all residences locatedon that street. Unlike data link addresses, which are mostly hardwired on the network interface card, network addresses are software configurable. It should also be noted that the data structure and rules of assigningnetworkaddresses varyfrom onenetworkingtechnologyto another. Inter-process dialogue control When two applications engage in the exchange of data, theyhave established a session between them. Consequently, a need arises to control the flow and the directionofdataflowbetweenthemforthedurationofthesession.Dependingon the nature ofthe involved applications, the dialogue type might have tobe set to fullduplex,halfduplex,orsimplexmodeofcommunication.Evenaftersettingthe applicablecommunicationsmode,applicationsmightrequirethatthedialogueitself bearbitrated.Forexample,inthecaseofhalfduplexcommunications,itisimportant that somehow applications knowwhen to talk andfor how long. Session recovery Another application-oriented concern is the capabilityto reliablyrecover from failuresataminimumcost.Thiscanbeachievedbyprovidingacheckmechanism whichenablestheresumptionofactivitiessincethelastcheckpoint.Asanexample,

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 130 Material considerthecaseofinvokingafiletransferapplicationtohavefivefilestransferred from point Ato point B on the network. Unless a proper check mechanism is madetotakecareoftheprocess, afailureofsomesort duringthetransferprocess mightrequiretheretransmissionofallfivefiles,regardlessofwhereintheprocess failuretookplace.Checkpointingcircumventsthisrequirementbyretransmitting onlytheaffected files,savingtimeandbandwidth. Presentation problems Whenever two ormore communicating applications run on different platforms, anotherconcernarisesaboutthedifferencesinthesyntaxofthedatatheyexchange. Resolving these differences requires an additional process. Good examples of presentation problems arethe existing incompatibilities betweentheASCIIand EBCDIC standardsofcharacterencoding, terminalemulation incompatibilities, andincompatibilitiesduetodataencryptiontechniques. 3.7 NEED FOR LAYERED SOLUTIONS AND OPEN SYSTEMS INTERCONNECTION (OSI) Layeringinvolvesbreakingthe communication process into different categories anddealingwiththemaccordingtothestepstowhichtheybelong.Categorization must takeinto account theinterdependencyof someprocesses relativetoothers. Atleastthreeadvantagescouldbeachievedbyusingthelayeredapproach,including thefollowing: ? Specialization: Solution developers can specialize in one or the other category of problems, which, given the rate at which the technology is advancing, is more affordable than an approach based on integrating all problems intoone category ? Minimal cost: Using the layered approach, it is easier for vendors to introduce changes to, or even replace, an entire layer,whileleavingothers intact. ? Freedom of choice: As you will see later, users benefit from layering because it provides them the freedom to implement networks that can be tailored to meet their needs. Network Design and Problem of Communication between Layers Network design experts came up with the hierarchical network designto help in developingatopologyinbetweendiscretelayers.Forexample,whilerouterswith mediumspeedcanconnectbuildingswithineachcampus,high-speedWANrouters can carrytraffic across the enterprise.WAN backbone and switches can connect userdevicesandserverswithinthebuildings. The physical layer determines the type of network design exclusively designed for the physical layer and connected to higher levels such as data link, network,session,transport,presentationandapplicationlayers.Italsodetermines whether data transfer uses simplex, half-duplex or full duplex modes of communication.

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 131 In the data link layer, the network is generally designed as Ethernet, ARCNETandTokenRing.ThefollowingTable3.3showsthecontentofEthernet Address usingdataframes in adatalink layer: Table 3.3 Content of Ethernet Address 64 bits 48 bits 48 bits 16 bits 368-12000bits 32 bits Preamble Destination Source Frame Type Data Frame Cyclic Address Address Redundancy Checks(CRC) In this layer, the network is designed according to the content of data frame to detect and correct datacorruption in thenetwork communicationchannel.
Thenetworklayerdeliversunitsofdataasindividualpackets.Thenetwork designers design theprotocols used forroutingdata. The Transport Layer delivers datawithin ahost computerandthen hands the data over to the transport layer. The source transport layer carries a virtual conversation with the destination transport layer.The network is designed on a hop-to-hop basis. Table 3.4 Network Design of Peers Process among Discrete Layers Application

Physical Layer ? Physical Layer TheTable 3.4 shows how dotted lines among the correspondinglayers (in each host) indicate avirtual conversation ofdifferent layers.Network designers often recommendameshtopologytomeet theavailabilityrequirementbecauserouters areconnectedto single-link delaybetweentwosites.This layeris responsiblefor getting data from or sending data to each network that manages flow control on an end-to-end basis. A session layer network is designed to occasionally merge the session andtransportlayers.Therefore,networkdesignersdesignthehierarchicaltopology forthis layer. The presentation layer handles printers, video displays and file formats. So, hierarchical topologyis asuitablenetworkdesignforthis layer. Theapplication layer dealswithnetwork-wideapplications whichinclude electronic mail and distributed databases. Generally,API forms a session layer upon anapplication layer. It provides file services, network printer services and mail services.The network designs includedin this layer are,Novell's Netware, Banyan'sVINESandArtisoft'sLANtastic.Figure3.20showstheinterconnection between the layers of OSI.
Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 132 Material Fig. 3.20 Interconnection between Layers of OSI 3.7.1 Open Systems Interconnection (OSI) Model TheOSImodelofdatacommunicationwasdevelopedin1984bytheInternational StandardizationOrganization (ISO).OSIspecifies aseven-layermodel as shown in Figure 3.20. In addition to forming the basis of the ongoing development of OSI's own protocols, the model is used bythe industryas theframe of reference whendescribingprotocolarchitecturesandfunctional characteristics. The International Standard Organization (ISO), in an effort to encourage open networks, developed an open systems interconnect reference model. The modellogicallygroups thefunctionsandsetsrules,calledprotocols,necessaryto establish and conduct communication between two or moreparties. The model consists of seven functions, often referred toas layers as shownin Figure 3.21.
Thelastthreelayersaremainlyconcernedwiththeorganizationofterminal software and are not directly the concern of communications engineers. The transportlayeristheonewhichlinksthecommunicationprocessestothissoftware- oriented protocols. The basic philosophy of the seven-layer model is that each layer maybe defined independently of every other layer. Thus, from the user point of view, interchangetakeseffectacrosseachoperationandpassesdownthroughthelayers ofthemodeluntildatainterchangeisaffectedthroughthephysical connection. Thetoplayeris used bythetransmitting device where dataisplacedinto a packet under a header. Theprotocoldataunit that consists ofdataandheader,arehandledbyeach of the successive lower layers as data flows across the network to the receiving node.Data flowsthrough thelayermodelandeach ofthesuccessivehigherlayer stripoffttheheaderinformation. Another alternative standards approach was being led by the CCITT (ConsultativeCommitteeonInternationalTelephonyandTelegraphy)andtheISO (International Organization for Standardization) parallelytothe development of TCP/IP by DARPA. The CCITT has now become the ITU-T (International TelecommunicationsUnion-TelecommunicationStandardizationSector).

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 133
Theoutcomeofthisjointattemptwasthecreationoftheosi(OpenSystems Interconnect) reference model (ISO 7498). This outlines aseven-layer model of datacommunicationwiththebottomlayercomprisingphysicalandtransportlayers andtheapplicationprotocols formingtheupperlayers.Eachlayerofthemodel is responsible for specific functions. Theoperation of a network protocol stack is understood on the basis of this model (figures 3.20 and3.21). It is also used as a reference tool to compare network stack.
APPLICATION PRESENTATION SESSION TRANSPORT NETWORK NETWORK DATA APPLICATION PRESENTATION SESSION TRANSPORT NETWORK NETWORK DATA Fig. 3.21 The OSI Reference Model Implementations Each layerprovidessomeofthefunctionstothelayeraboveitinreturnfor thefunctionsprovidedbythelayerbelowit.Inthisfashion,messagesaretransmitted vertically through the stack from one layer to the other. Logically, each layer communicates directlywithits peer layerontheother nodes. 3.7.2 Layered Architecture of OSI The Physical Layer (Layer 1) Thislayerdescribesthephysicalmediaoverwhichthebitstreamistobetransmitted. Ittellsabouttheelectricalandmechanicalaspectsofdatatransmissiontoaphysical mediumthatincludessettingup,maintaininganddisconnectingphysicallinksapart fromtrans-mittingdata.Itisprimarilyconcernedwithmovingbitsfrom onenode to next overthephysical link. It accepts data from the Data link layer in bit streams for subsequent transmission over thephysical medium.At this layer,the mechanical (connector type), electrical (voltage levels), functional (pingassignments), and procedural (handshake) characteristics aredefined. RS-232C/D is anexampleof a physical layerdefinition. The Data Link Layer (Layer 2) It takes the bits that are received by the physical layer and detects errors. This ensures the proper sequence of transmitted data by establishing an error-free communicationpath overthephysicalchannel betweennetworknodes.Framing messagesfortrans-mission,checkingintegrityofreceivedmessagesandmanaging accesstothechannelanditsuseareitsmainwork.Hence,thislayeris responsible forthereliabletransferofdataacross thephysicallink.Itsresponsibilities include such functions as data flow control, data frame formatting, error detection, and linkmanagement.
Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 134 Material The Network Layer (Layer 3) The network layersets up appreciate paths between various nodes andto do this itusesasoftwarethathandlesPDUstotransportthemtothefinaldestination.The Internet Protocol (IP) operates at this layer. It ismainlyresponsibleforproviding routing services across the Internet. It also shields the above layers from details abouttheunderlyingnetwork(thenetworktopologyandroadmap)andtherouting technologythatmighthavebeen deployedtoconnectdifferentnetworkstogether. Inadditiontorouting,thislayerisresponsibleforestablishingandmaintainingthe connection. The next three layers are task oriented and have to do with the operations performed bythe user rather than with the network. The Transport Layer (Layer 4) Thislayerguaranteestheorderlyandreliabledeliveryofdatabetweenendsystems. Data is received from session conrol layer and transported to network control layer.Thetwo protocols used hereincludetransmissioncontrol protocolorTCP and OSItransport protocol or TP's five levels. The transport layer also performs additionalfunctionssuchasdatamultiplexingandde-multiplexing.Thislayerdivides upatransmittingmessageintopacketsandreassemblesthemaththereceivingend. The Session Layer (Layer 5) The session layeris responsibleforestablishing,maintaining,andarbitratingthe dialoguesbetweencommunicatingapplications.Itisalsoresponsiblefortheorderly recoveryfromfailuresbyimplementingappropriatecheckpointingmechanisms. The Presentation Layer (Layer 6) Formattinganddisplayingofdata,receivedbyterminalsandprintersarefunctions performed bythe presentation layer. It is concerned with differences in the data syntaxusedbycommunicatingapplications.Thislayerisresponsibleforremedying thosedifferencesbyresortingtomechanismsthattransformthelocalsyntax(

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specific to the platform in question) to a common one for the purpose of data exchange. For example, it performs

conversion betweenASCII and EBCDIC character codes, does data compression and encrypts data if necessary. The Application Layer (

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Layer 7) The application layer provides support servicesfor user and application tasks. It determines how the user is using the data network. It allows the user to use the network. For example, it provides network-based services to the end user. Examplesofnetworkservicesaredistributeddatabases,electronicmail,resource sharing, file transfers, remote file access and network management. This layer defines the nature of the task to be performed.

OSI Protocol of Different Layers BeforegoingontotheOSIprotocolofdifferentlayers,letusfirstdefineaprotocol. A protocol is a set of conventions that governs the format and control of the interactionthattakesplaceamongfunctionalunits. The OSI architectural model was developed by ISO (International OrganizationforStandardization).

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 135 The modelcomprises seven layers— thefirst fourlayers arereferred to as thelowerlayers whereas thelast threelayers are referredtoastheupperlayers. Responsibilities of the Seven Layers Application Layer: Layer seven is the highest layer which interprets data and mayalsoindulgein encryption ordecryption. Applications using the network learn the technique of sending requests, specifying filenames and responding to requests.At this layer, PDU or Protocol Data Unit is called data and this layer not onlysends requests to the presentation layer but also interfaces directlywith the application processes. It also performs commonapplicationservicesfortheseprocessessuchasvirtualterminalandvirtual fileprotocols aswell as job transferand manipulationprotocols. Presentation Layer: Thesixth layerhelps determinetherepresentation of data bycomputers [ASCII, GIF.].As in the seventh layer, PDU is referred to as datainthis layer. This layer provides a response to the

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service requests received from the Application Layer and also sends service requests to the fifth layer

called the SessionLayer. Conversion ofan EBCDIC-codedtext filetoanASCII-codedfile is an example of a presentation service. Within the end-user systems,

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the Presentation Layer relieves the layer above it of concern regarding syntactical differences in

therepresentation ofdata. Session Layer: Layer number 5 establishes a communication session, provides securityand authentication. NetBIOS is alayer5protocol.TheSession Layer responds to the service requests from the layer above it and sends service requests to thefourth layer which is theTransport Layer.This layer manages the dialoguebetweenend-userapplication processes.Itfacilitates eitherhalf-duplex or duplex operation and establishes procedures related to adjournment, restart, check-pointingandtermination. Transport Layer: The fourth layer provides transfer correctness, data recoveryandflowcontrol.TCPisalayer4 protocol.Inthislayer,PDUis referred to as a segment. This layer responds to service requests coming from the fifth layerand sends service requests to thethirdlayer,that is, theNetwork Layer.The TransportLayeris mainlyresponsibleforensuringtransparencyinthetransferof databetweenend-users. Therefore, it relievestheupperlayers ofanyconcernsor issues regardingprovision ofcost-effectiveandreliabledatatransfer. Network Layer: Layer three is concerned with assigning addresses and packet forwarding techniques. Here, PDU is called a packet. This layer is responsible for responding to service requests from the fourth layer, that is, the Transport Layer and issues service requests to the layer below, that is, the Data LinkLayer.TheNetwork Layer providesthefunctional andproceduralmeans of transferringdatasequencesofvariablelengthfromasourcetoadestinationthrough one or more networks, but at the same time, maintains the quality of service requested bythe fourth layer, that is, theTransport Layer. Functions performed bythe Network Layer include flow control, network routing, error control and segmentation/desegmentation.
Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 136 Material Data Link layer: Thesecond layer is concernedwith transmitting frames over the Net [start/stop flags, additional bit/byte stuffing, checksum and CRC] andFrameformat.Examplesoflayer2protocolsareATM(AsynchronousTransfer Mode),CAN(ControllerAreaNetwork)bus,StarLAN,HDLC(High-levelData Link Control),ADCCP(Advanced Data Communication Control Procedures) and LocalTalk (a protocol used withApple computer systems).
Differentdatalinklayerspecificationsdefinedifferentnetworkandprotocol characteristics. Thesecond layeris subdividedas follows: MediaAccess Control (MAC): Controls access and encodes data for the PhysicalLayerintoasignallingformatthatisvalid. Logical Link Control (LLC): Provides theNetwork Layer with thelink to the network. PDU is referred to as a frame at this layer. Thislayerrespondstoservicerequestsfromthethirdlayerandissuesservice requeststothefirstlayer.Thislayerprovidestheproceduralandfunctionaltechniques fortransferringdata between network entitiesand detectingas well as rectifying errors that maytake place at thefirst layer, that is, the Physical Layer. Note: HDLC and ADCCP are examples of data link protocols for point-to-point and packet-switched networks; and LLC is an example of a data link protocol for LANs. PhysicalLayer:Thisisthefirstlayerofthemodelwhichdefinesthephysical and electrical implementation of the bus. In other words, it defines the hardware andsignal-levelimplementationofthebus.Itisalsoconcernedwithnetworkcabling, datatransmissionencoding,typesofconnectors,physicaldatarates and maximum transmissiondistances.Atthislayer,informationisplacedonthephysicalnetwork medium. Examples of a physical layer specification include RS-232 and RS422. Here, aPDUis referred to as abit. This layer fulfils theservicerequestsreceived fromtheDataLinkLayer.TheimportantresponsibilitiesofthePhysicalLayerare asfollows: (a) Itestablishesandterminates aconnectiontoacommunicationmedium (b) It participates in the process wherein the communication resources are effectivelysharedamongmultipleusers,e.g.,contentionresolutionandflow control. (c) It facilitates conversion between the digital data representation in user equipmentandthecorrespondingsignalstransmittedoveracommunication channel. Fig. 3.22 OSI Protocol Stack

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 137 CheckYourProgress 12. What does TCP/IP stands for? 13. Whotooktheinitiativein settingup OSI? 14. What doesthe physical layer determines? 15. Which layer is the first layer oftheOSImodel? 3.8 ROUTING CONCEPTS The IP addressing mechanism requires hosts and networks so that a host on the network can transmit and receive IP packets.The host could bea workstation or a router. Routingrefers to the process of movingdata from onehost computer to another byselecting the shortest and most reliable path intelligently.This is the pathorrouteoverwhichdataissenttoitsultimatedestination.IProutingprotocol makes the distinction between hosts and gateways.Ahost is the end system to which datais ultimatelydelivered.An IPgateway, ontheotherhand,is therouter that accomplishes theact of routing databetween two networks.Arouter can be aspecializeddevicesupportingmultipleinterfaces,withconnectionstoadifferent network as shown in Figure 3.23 or a computer multiple interfaces (commonly calledamultihomedhost)withroutingservicesrunninginthatcomputer. Fig. 3.23 IP Router Providing Services between Two Networks By OSI norms and standards, a gateway is not only a router but also a connectivitydevice that provides translation services between two completely hybrid networks. For example, a gateway (not a router) is needed to connect a TCP/IPnetwork to anAppleTalk network. It is important to know that both hosts and IP routers (gateway) perform routingfunctionsandtherefore,compatibleimplementationsoftheIPprotocolare necessaryat both ends. In other words, datagrams are submitted eitherto a host that shares the same physical network with the originating host or to a default gatewayfor further routing across the network.As such, the IPon a particular host is responsible for routing packets that originate on that host only, fulfilling local needsforrouting.Agateway,ontheotherhand,isresponsibleforroutingall trafficregardlessofitsoriginator(aslongas theTTLfieldis valid). A default gatewayis a router that a host is configured to trust for routing traffictoremotesystems across thenetwork.However,thetrustedroutermust be

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 138 Material attached to the same network as the trusting host.Arouter on a remote network cannotbeusedforprovidingthefunctionalityofthedefault gateway. Bridgingandroutingaredifferentinadistinctway.Whilebridgingoccursat the data link layer or Layer 2 of the OSIreference model, routing takes place at thenetwork layeror Layer 3 ofthe OSIreference model.Routingalgorithmsare usedto determinetheoptimal routingpathsalonganetwork. Characteristics of Routers Primarily,thepacketswitchingnetworkintendstodeliverdatapacketstransmitted from one host to another over a network. The routing protocols and algorithm tendtoprovideoptimal routes overthe network forcommunicatinghosts sothat the network could be used effectively and efficiently. In order to guide a data packettoarriveto itsintendeddestination,thepacketswitchingnetworkattempts to provideabest path as well as alternatepaththroughitselfto suchdatapackets. To deliver the packets from source host to destination host, there exist few key design issues for such networks so that the network could select a route across thenetworkbetween end nodes withthefollowingcharacteristics: ? Correctness: It is the responsibility of the routers along with routing protocolsandtheassociatedroutingalgorithminapacket-switchednetwork, thattheroutersrunamongthemselvestoprovidethecorrectroutingdecisions tothenextrouterinthewayofthedestinationend.Thecorrectnessfunction of a routershould provide a valid route, visible path andsafe links. Route validityensuresthatifarouteexistsforadestination,ausablerouteshould alsoexist forthat routein thenetwork. Ifthis condition is not satisfied,the users will experience a failure of end-to-end connectivityas data packets are forwarded alongnon-existent paths. The visible pathor path visibility ensures that the details of an existing path between two nodes should be propagatedbytheroutingprotocol.Alackofpathvisibilitywillpreventtwo connected nodes from learning routes between them.Link safetyensures routeavailabilitywithouttakingintoconsiderationtheorderinwhichrouting messagesare exchanged. Briefly,theobjectiveof'correctness'isto ensurecorrectroutingsothatthe packets reach their end points. ? Simplicity: It implies the routing protocol's ability to reduce the path computationcomplexity.Inotherwords,theroutingshouldprovidesimple methods to computepaths to thedestinationssothat theoverheadis aslow as possible. As the complexity of the routing algorithms increases, the overhead also increases. ? Robustness: It is the propertyof a network whichdefines the expectancy ofanetworktoruncontinuouslyformanyyearsadheringwellwithchanges in physicaltopologyand trafficpattern. Duetothe changeintopologyand traffic pattern,there maybe somelocal failureoroverloadin thenetwork. Robustness is,therefore, the capabilityofthe networktoroutethepackets to the destination through some routes in case of hardware and software failures.

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 139 ? Stability: It describes the abilityto tackle the changingconditions of the networkwithoutinfluencingnetworkperformance.Atthetimeofthechange innetworkconditions,thenetwork shouldnotbetoolethargicnorshouldit becomeunstableoroscillatory.Briefly,theroutingalgorithmsshouldprovide stabilityunderallpossiblecircumstances. ? Fairness: Fairness and optimality are correlated. If you try to improve one, theother will deteriorate. Fairness refers to equal prioritygiven to all nodes orhosts on the network for transmittingtheir packets; for example, to increase the performance of a network in terms of throughput, the performance criteriaareset in suchamannerthat networkpolicyprovides higher priorityto the transfer of packets between nearbyhosts compared to transfer between remote hosts. Hence, this appears to be unfair to the host that wants to transfer information to remote hosts. This is generally done on afirst-come first-serve basis. ? Optimality:Theroutingalgorithmsshouldprovideoptimalthroughputand least mean packet delays. ? Efficiency: The routing algorithm keeps on adding some processing overhead at each node including transmission overhead. Such overhead tends to deterioratenetwork efficiency. Performance Criteria Primarily, a network is designed to share information among remote hosts over thenetworkefficientlywithleastcost.Therefore,networkdesigncallsformeeting someperformancecriteria. Theseare: (i) Selectionofroute (ii) Distance(minimumnumberofhops) (iii) Least cost (iv) Throughput The selection of a route to the destination is determined differently. The simplest way is to choose the route which passes through the least number of nodes.Such routes arecalledminimumhoproutes.Theadvantageofaminimum hoprouteisthatitinvolvesleastnetworkresources.Anotherperformancecriterion is the leastcost routing in which each route orlinkis associated withacost and a leastcostpathischosenfordeliveryofthepackets.Betweentheminimumnumber of hops and least cost routing, the algorithm used fordeterminingthe minimum path is straightforward and takes almost the same processing time as least cost. However,theleastcostroutingis moreflexiblethanminimum hop;theleastcost algorithm is therefore used for determining the route. Another important performance criterion is the throughput. It defines the abilityof the network to clear the number of packets per second from the network. 3.8.1 Strategies for Routing It is one of the simplest routing techniques in which a permanent path from one nodetoanothernodeisdeterminedwiththehelpoftheleastcostalgorithm.Inthis
Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 140 Material
algorithm,aleastcostrouteisconfiguredpermanently.Thefixedrouteischanged onlywhen there is some change in the topologyof the network. Obviously, the link costs are not calculated based on the dynamic variables, such as the traffic pattern. However, the link maybedesigned based on the expected traffic. Figure 3.24 shows the implementation of fixed routing.At the network operation center, a central matrix showing a least cost path from one to node to the other nodes is created and stored. Table 3.5 illustrates destination pair of nodes foreverysource, theidentityofthenext nodeonthenetwork.Itis foundto bequitecumbersometo identifyall nodesforeachpairofnodes.Therefore,only the next hop or node for each pair of node is identified. In Figure 10.1, let us consider a link X-Aand the remainingnetworking fromAtoYas R 1 . Inthe next step, the least cost value ofA-Ylink is determined and defined as R 2 . If R 1 < R 2 thentheX-Yroutecanbeimproved byusingR 2 .IfR 1 >R 2, thenR 2 isnot theleast cost valueofthe networkfromAtoY.Therefore, R 1 = R 2 .This providesa wayto identifythe nextnode, not theentire networkalongthe network. InFigure3.24,inreachingnode6fromnode1,apackethastopassthrough either node 2, 3 or 4.Again, the route to node 6 from node 2 goes via node 5. Similarly, the route to node 6 from node 3 goes via node 4.The complete route from X toYis either through node 1, 2, 5 and 6 or 1, 4 and 6. Out of these two routes, theleast cost route is determined.Accordingto the performance criteria, theleast costrouteis consideredbetterthantheminimum hoproute.Therefore,it maynot be true that aroute through node 1,4 and 6 will be the least cost route as compared to aroutethrough nodes 1, 2, 5.An intuitive conclusionsays that links emanating from node 4 will havemuch more weight thanlinks emanating from othernodes. Therefore,theroutepassingthroughnode1,2,5and6is considered the optimal path from X toY. 2 A 5 1 X B 3 6 Y 4 Fig. 3.24 Implementation of the Fixed Routing
FromFigure3.24,thematrixateachnodeandtheoverallmatrixmaybedetermined and stored. Table 3.5 shows these matrices. Table 3.5 Destination Nodes for Source Nodes Node 1 Directory Desti- nation Next node 2 2 3 3 4 4 5 2 6 2 Node 2 Directory Desti- nation Next node 1 1 3 1 4 1 5 5 6 5 Node 3 Directory Desti- nation Next node 1 1 2 1 4 4 5 1 6 4 Node 4 Directory Desti- nation Next node 1 1 2 1 3 3 5 6 6 6 Node 5 Directory Desti- nation Next node 1 2 2 2 3 2 4 6 6 6 Node 6 Directory Desti- nation Next node 1 5 2 5 3 4 4 4 5 5

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 141 Central Routing Directory from Node 1 2 3 4 5 6 - 1 1 1 2 5 2 - 1 1 2 5 3 1 - 3 2 4 4 1 4 - 6 4 2 5 1 6 - 5 1 To node 2 3 4 5 6 2 5 4 6 6 - Fixed routing does not differentiate between datagram and virtual circuits.All packets between two end-points follow thesame route. The majoradvantage of fixedroutingisthesimplicitythatperformswellinabalancedstableload.Itsmajor drawback is its rigid structure and lack of flexibility. In case of link failure or congestion, its responseis abysmallypoor. Random Routing Random routing offers the same simplicityand robustness as provided bythe floodingalgorithm.However,itsmajoradvantageisthatitprovidesfarlesstraffic loadthanflooding.Inrandomflooding,anodechoosesoneoutgoingpathrandomly for retransmissionof the incoming packet.Theincominglinkthroughwhich the incomingpacket arrives is excluded for retransmission.Second,selection of the outgoing link from a particular node can be random or round robin. Random algorithm is refined with probabilitycalculation in which a probabilityto each outgoinglinkforselectingthelinkiscalculatedbasedondatarate,oronfixedlink costs. Similarto the flooding algorithm, random algorithm also does not require network details because route selection is random. It does not take into consideration theminimum hop orleast-costfactors.Thisenables thenetworkto carryahigherthanoptimumtrafficload,althoughnotnearlyashighasforflooding. The major advantage of this routing is found when a network is highly interconnected because this algorithm uses alternative routes excellently. The probability calculation enables the packet to opt for the least queued link for retransmission. Adaptive routing Almostallpacketswitchingnetworksusesomesortofadaptiveroutingtechnique. Theadaptiveroutingalgorithm iscapableofchangingroutingdecisionstoreflect changes in network conditions, such as topology and traffic pattern. Routers automaticallyupdateroutinginformation whenchanges aremadetothenetwork configuration. Therouting details are obtainedfrom adjacent routers orfrom all routers. It uses the distance, number of hops and estimated transit time as optimizationparameters.Itisconvenient,asitdoesnotinvolvehumanintervention incaseofchanges to thenetwork configuration.Its disadvantage,however,isthat the overhead required to send configurationchange information can be a heavy burden.Thisis alsoknown asdynamicrouting.Inadaptiverouting,thefollowing conditionsinfluenceroutingdecisions: (i) Failure:Ifanodeorlinkbreaksuporfails,itisimmediatelytakenoutfrom theroute.
Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 142 Material (ii) Congestion: Ifa part of thenetwork is heavilycongested,the data packet should be avoided to choose such congested links. It should take a path around the congested area rather than through thearea of congestion. Someof thedisadvantages of adaptive routingareas follows: (i) Theroutingdecision is morecomplexandtendstoincreasetheprocessing burden on the network nodes. (ii) An adaptive strategy proactiveness may cause congestion-producing oscillation. Theadaptivealgorithmcanbefurtherclassifiedasfollows: (i) Centralized:Acentral nodein thenetworkcollects all details concerning the network topology, traffic pattern and other nodes. Subsequently, the details areforwardedto therouters inthenetwork.Theadvantageofthis is thatonlyonenodekeepsthedetails ofthenetworkwithout engagingmuch resource. However, failure of the central node leads to the failure of the entirenetwork. (ii) Isolated: This refers to the node that decides theroutingdecisionwithout seeking details from other nodes. Isolation maylead to the selection of a congestedrouteresultingindelay.Popularexamplesofthisroutingalgorithm are hot potato and backward learning. (iii) Distributed:Thenodetakesdecisionsafterreceivingtheinformationfrom itsneighboringnodes. 3.8.2 Shortest Path Routing Shortestpathrouting(SPR)isaformofroutingwhichattemptstosendpacketsof data overanetwork in sucha waythat thepath taken from thesendingcomputer totherecipientcomputerisminimized.Thepathcanbemeasuredineitherphysical distanceorinthenumberofhops.Thisformofroutingusesanon-adaptiverouting algorithm. Tosolvesingle-source shortest path routingproblem,Dijkstra's algorithm is used. Dijkstra's algorithm is a graph search algorithm that solves the shortest path problem fora graph with nonnegativeedge path costs toproduce a shortest path tree. For a given source vertex (node) in the graph, the algorithm finds the path with the lowest cost, i.e., the shortest path between the vertex and every othervertex. It is also used tofind costs of shortestpaths from asinglevertex toa single destination vertex by ending the algorithm once the shortest path to the destinationvertexisdetermined.Dijkstra'salgorithmcanbeusedtofindtheshortest routebetween onecityand all othercities. Consequently, theshortest path first is widelyused innetwork routingprotocols. TheDijkstraalgorithmusesthefollowingsteps: 1. A network graph is built to identify source and destination nodes. Thereafter,amatrix,knownasthe'adjacencymatrix'iscreatedinwhich a coordinateis used to indicateweight. If no directlink exists between twonodes,theweightbecomesinfinity.

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 143 2. Astatus recordincludingthepredecessorfield(indicatingtheprevious node),lengthfield(givingthesumoftheweightsfromthesourcetothat node)andlabelfield(indicatingthestatusofnodewhetheritissettledor tentative) foreach node on thenetwork is constructed inthe router. 3. The parameters of the status record for all nodes are initialized to set theirlabeltotentativeandtheirlengthtoinfinity. 4. In the next step, a T-node is created. If T-node is a source node, the router changes source node label to permanent which never changes again. 5. Thestatus record forall tentativenodes directlylinked tothesourceT- node are updated. 6. The router selects a tentative node whose weight is lowest. That node becomes thedestination T-node. 7. If thenewT-node is not the intended destination, therouter repeats the step 5 above. If this node is the intended node, the router extracts its previous nodefromthestatus record and does this until itarrives at the destinationnode. Let us find the best route between routersAand E. It maynot always be as easy as it sounds. In certain complicated cases, the best route can onlybefound using algorithms. 1. Thesourcenode(A)hasbeenselectedtobetheT-node.Itslabelistherefore permanent (permanent nodes are shown with filled circles and T-nodes with the-< symbol). Let usconsiderasimpleexampletounderstandtheDijkstraalgorithm toidentify the best path with least cost. Figure 3.25 is asimple example to illustrate how to reachpoint Bfrom pointAin aweighted graphusingtheDijkstraalgorithm.The weighted graph has 5 nodes and 6 links with their weights. The weight maybe accordingto the distance, time, cost or anytype ofappropriate weight. A C 5 D 4 7 9 3 B E 11 Fig. 3.25 An Example of Dijkstra Algorithm Asperttheserulesoftheoijkstraalgorithm,Figure3.25isconstructedasanetwork graph with eachlink having weight.Thereafter,a status table is structured with a row for each node in which the number of columns depends on the map and represents an iteration of the algorithm. Each column will contain the distance fromthestartinglocationduringthatiteration.A*isputineachcolumnwhenitis assumed that the distance is definite. There exist four possible routes between node A and node B. They are ACDB, AEB, ACDEB and AEDB. Obviously, among these routes,ACDB with weight 12 is the best route due to the smallest

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weight.Table3.6illustratesthissimpleexample.Theactualdistancesfromnode A aregiveninthecolumnsontheextremeright. Table 3.6 An Iteration of the Dijkstra Algorithm (Figure 3.25) Nodes Values A 0* C 5* 5* E 7 7* 7* D ? 9 9* 9* B ? ? 18 12* 12* Thefollowingsteps are used to buildTable 3.6: 1. Chooseaninitiallocationandobtainalldistancestoadjacentnodestofillin theappropriatebox ofthetable. Incaseofnodeswhichcannot bereached, filltheboxwithinfinity.IntheFigure3.25,thebeginningofthemapistaken as nodeAand the adjacent nodes are C and E. In this example,the source nodeAis theT-node with apermanent label.The permanent nodes andT-nodes aredepicted with filled circles and withthe-<symbol respectively. 2. Mark the lowest number in the box with *.Anode marked with a * in its row is called the T-node. The initial location itself is always settled or permanent with a distance 0*. InTable 3.6, the nodeC with adistance6 is the shortest route because other routes to node C will takea route through E, which has larger distance than direct route to C. The status record of tentative nodes C and E that are directly attached to T-node has been changed. The node C has been selected as T-node because C has less weight and its label has changed to permanent. Figure 3.26 shows this situation. A C (5,A) 5 D 4 7 9 3 B E 11 Fig. 3.26 An Example of Dijkstra Algorithm 3. Thenext column is filled byobtainingtheadjacent nodes totheT-node C. So far nodesAand C are permanent. Node D is adjacent to node C and nodeEisadjacent toA.Nowtheirdistancesarecomputedfromthestarting pointthroughthepermanentnode(s)towhichtheyareadjacent.Theirvalues are filled in the appropriate box ofthe table. The distance of node E from nodeAis7whichisfilledinthebox.ThedistancefromnodeAtoCis5and from node C to D is 4. This provides a value of9 for node Din the second column. In case, a permanent node is found to be adjacent to more than one permanent node, the least distance is filledin the table.

Alternatively,Figure3.27illustratesthestatusrecordsofthetentativenode that is directlylinked toT-nodeD with a valueof 9 and thereforethe node is selected as T-node and its label has been changed to permanent.

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 145 A C (5,A) 5 (9,C) D 4 7 9 3 B E 11 Fig. 3.27 An Example of Dijkstra Algorithm 4. Step 2 and 3 is repeated unless all nodes are covered. Now nodes A, C and E are considered permanent. Nodes adjacent to E are B and D and their distances are 18 and 12 which are filled in therespective columns of the table.As node B has 18 in the next column but it has changed to 12 in thenext box.Therefore, from locationAtolocation Btheshortest value is 12, thereforeACDB is chosen as the shortest path. Alternatively, thereexist no tentativenodes,thenext nodeBis determined as T-node because node B has the least weight. Now a route is identified. The previous node of B is node D and the previous node of D is node C, whileC'spreviousnodeis nodeA.Therefore,thebest routeisACDBwith total weight 12 which is 5+4+3. The Dijkstra algorithm works well but it is quite a complicated algorithm and requiresasubstantiallylongtimeforrouterstoprocessitatthecostoftheefficiency ofthenetwork. Secondly, ifoneroutercomputes wronginformationandpassesit ontootherrouters,allroutingdecisionswill becomeineffective. 3.8.3 Flooding in Hop Flooding is yet another static algorithm wherein each packet that comes in is forwardedtoeveryoutgoinglineexceptttheonefromwhereit cameontherouter. Thus,it generates an infinitenumberof duplicatepackets.Tocontrol thenumber ofpacketssogenerated, ameasurenamelyhopcounteris applied.Inthismethod, theheader ofeach packet is decremented at each hop andthepacket isdiscarded till thecounter reaches zero. Ifthe source host knows thepathfrom thesource to the destination, it initializes the hop counter to the length of the path from the sourcetothedestination. Ifthesenderdoes not haveanideaofthepathlength,he initializesthecountertothefulldiameterofthesubnet. Alternatively,atrackofthepacketsfloodingthecommunicationlinkisstored so that they cannot be sent out a second time. The source router attaches a sequencenumbertoeachpacketreceivedfromitshosts.Eachrouterthenrequires alistpersourcerouterindicatingwhichsequencenumbersoriginatingatthatsource havebeenavoidinganyincomingpacket onthelist.Eachlist isincrementedbya counter,k.Thisis indicative ofthefact that all sequencenumbersthrough khave beenlooked at.This prevents thelistfrom growingunnecessarily.

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 146 Material Figure3.28 explainstheconcept offloodinginwhichapacketis sent from anodetoalllinksemanatingfromthatparticularnodeexcepttheincominglinkto that node from which the data packet arrives to the node.Adata packet is to be transmitted from node 1 to node6. Thedata packetis transmitted from node1 to all outgoing links to node 2, node5, node 3 andnode 4. The packet from node 2 is transmitted to node 5. Node 5 transmits the packet to node 6 and node 1. Similarly, thesame packet will also reach from node 4to node 6.Thepackets so deliveredhaveuniqueidentifierslikesourcenodeandsequencenumber(orvirtual circuit numberand sequencenumber).Accordingtotheuniqueidentifier,node6 knows how to discard all packets except the first packet. 2 A 5 1 X B 3 6 Y 4 Fig. 3.28 Implementation of the Fixed Routing If Figure 3.28 is observed carefullythe retransmission of the packets from one nodetoothernodesgrows incessantly.To preventthis exponentialgrowthofdata packets due to retransmission, each node is enabled to remember the identityof thosewhich havealreadybeen retransmitted. Thefloodingalgorithmhasthreesignificantcharacteristics: (i) Because all possibleroutes between two end-pointsare attempted, a data packet will always arrive at the destination irrespective of any breakage in the network, provided a valid path exists between the two end-points. Thisexhibits therobustness of thisalgorithm and its applicationsespeciallyinmilitary-relatednetworks. (ii) Due to the reason that all paths are attempted, at least a copyof the packetfollowsaminimumhoppathwhich maybeutilizedforsetting uparouteto virtual circuit. (iii) Each and every node directly or indirectly connected to the source node is visited. This helps in disseminatingor broadcasting routing informationtoallnodes.
Selective Flooding: Selective flooding, which is slightly more practical, is a variationoffflooding.Everyincomingpacketisnotforwardedtoeachline.Instead, incoming packets are forwarded onlyto those lines going approximatelyin the rightdirection. Floodingisabroadcastprotocol.Thisprotocolisusedtodeliverthemessage to all nodes in a network. It is considered as the basic mechanism to propagate control messages. Flooding is primarily used in routing. It is based on the performanceofpathdiscoveryinon-demandroutingprotocolsthatarecommonly usedinmulti-hopwirelessnetworks. Inmobilead-hocnetworks,thesmallerend-
Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 147 to-enddelaysofshorterroutesrarelycompensatesfortheirreducedroutelifetime, and hop-count is a lousy metric. The flooding schemes are classified into three categories based on thefollowing conditions retainedbyeachnode: ? Thereisno needofsendinginformation toneighbors ? One-hop knowledge ofneighbors is necessary ? Two-hop or morehop knowledge of neighbors is also necessary Floodingmost oftenoccurs when alargenumberofpackets (dropletsina stream ofdata)areflowingthrough thenetworkthatregulardatacannot sendatanormal speed. Generally, it is a packet of SYN-ACK (synpackets).The initialization of connections between two hosts settled in TCP/IP requires a set ofback and forth responses, for example, 'Hi, are you there?'and the reply comes as 'Yes, I am here.'Andthenext question isasked as 'Are youreadytoreceive data?'which is replied as 'Yes, Ican.'The theoryfollows as 'the faster the flood, the slower the network'.Theygetcontrolusuallybymalwarevirusesortrojansandoftencannot be traced. Innocent flooding can occur when a router is given a circular route to some ofthe hosts on the network, in which therouter asks for the response from a certain host and another router and passes the request to router 1, which then passes it again to router2, which is sent to router1.Therouter2uses protocolsto test forandcloseinternal loopsinanetwork,whichwillmostoftenstopflooding. Floodingcomesunderthe categoryofnonadaptiveroutingalgorithm. Thisis the simplest way of routing and requires each node in the network to broadcast a packet upon receiving it for the first time. Flooding is widelyused in Wireless Sensor Network (WSN) by many applications. The algorithms used for WSN needtobedistributedanddependonlocalizedinformation.Thefloodingalgorithms need to be simple in both computation and communication process. To get efficiencyin Internetworking services, floodingalgorithmsreduce unnecessary redundanttransmissionsandsaveenergy.Whenarouterreceivesamulticastpacket foragroup,it determinesthepacketstatusandthenitisforwardedtoallinterfaces except theincoming interface. Routers onlyneed to store recentlyseen packets. The simplest technique for delivering multicast datagrams to all routers in an internetworkistoimplementafloodingalgorithm.Thefloodingprocedurebegins whena routerreceives apacket that is addressed to amulticast group. The router employsaprotocolmechanismtodeterminewhetherthisisthefirsttimethatithas seenthisparticularpacket orwhetherit has seenthepacket before.Ifitis the first reception of the packet, the packet is forwarded on all interfaces except the one onwhichitarrived,guaranteeingthatthemulticastpacketreachesallroutersinthe internetwork. If the router has seen the packet before, it is simplydiscarded.A flooding algorithm is verysimple to implement, since a router does not have to maintain a routing table and only needs to keep track of the most recentlyseen packets.However, floodingdoes not scaleforInternet-wideapplications since it generates alargenumber of duplicatepackets anduses all available pathsacross theinternetwork instead. This determines that packets havebeenflooded. The basic function of flooding is to spread queries across a network, by forwardingqueriestoallneighboringpeers.Thissimplesttypeoffloodingisknown as pure flooding. Let take an example, in which a network is composed by 7

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 148 Material peers (Peer 0, Peer 1, Peer 2, Peer 3, Peer 4, Peer 5, Peer 6 and Peer 7). Peer 0 sendsaqueryto itsadjacent neighborinstep1.Peer5isconstitutestherelevant resource. Peer 2 and Peer 3 receive the queryin Step 2 and forward the queryto the neighbors except Peer 0, where the queryis comingfrom. Peer 2 and Peer 3 againreceivethequeryastheydidinStep3.Thesetwopeersgetanerrormessage so that the queryis not being processed. Peer 1, Peer 4 and Peer 6 to process the querysameasPeer2 and Peer3 did in thelast step.Peer5 hasonlyoneneighbor, i.e., Peer 2 and it is the only peer that sends a query therefore Peer 5 has no optionbutto send thequery.Thus, it sends asuccessful queryhit message.It then forwards the result message to Peer 2 which is the last peer in the trail of the query. In Step 4, three events take place. The first event reveals that Peer 2 transfers the queryresult of Peer 5 to the queryissuer, Peer 0.The second event reveals thatpeer1 and Peer6 send theerrormessage. Thethirdeventreveals that both do not forward queries. Flooding is a simple blind routingmethodthat uses queryforwarding to make all peers accessible to the query.The produced query resultisthentransferredtothequeryissueraccordingtothemessagetrail.However, this wholemethod exploits a lot of bandwidth to ensurethe robustness. Abroadcastingmethodisusedforadatapacketthatisdestinedformultiple hosts. Broadcasts can occur at the data link layer and the network layer. Data- link broadcasts are sent to all hosts attached to a particular physical network. Network layer broadcasts are sent to all hosts attached to a particular logical network.TheTransmissionControlProtocol/InternetProtocol(TCP/IP)supports thefollowing types of broadcast packets: AllOnes:Bysettingthe broadcast address toall ones (255.255.255.255), all hosts on the network receive the broadcast. Network: Bysetting the broadcast address to a specific network number in thenetwork portion oftheIP address andsettingall ones inthehost portion of the broadcast address, all hosts on the specified network receive the broadcast. For example, when a broadcast packet is sent with the broadcast address of 131.108.255.255, all hosts on network number 131.108 receive the broadcast. Subnet: By setting the broadcast address to a specific network number andaspecificsubnetnumber,allhostsonthespecifiedsubnetreceivethebroadcast. For example, when a broadcast packet is set with the broadcast address of 131.108.4.255, all hosts on subnet 4 of network 131.108 will receive the broadcast. 3.9 CONGESTION CONTROL Congestionisaglobalissue,involvingthebehaviourofallthehosts,alltherouters, the store-and-forward processingwithin the routers, etc. Congestionis caused if the input trafficrate exceeds the capacityof the output lines, which occurs if the routers are too slow to perform bookkeeping tasks, such as queuing buffers, updating tables, etc., and if the routers' buffer is too limited. When excessive packets are rushed to the node or a partial part of the network, the performance of the network marketedlydecreases and this process istermed as congestion.If thenumberofpackets is dumped intothe subnet thetrafficincreases thenetwork performance.At this stage, the network is also no longer able to cope with the high rate at which the losing packets are last, resulting in a complete collapse in

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 149 performance.As a result, no packets are delivered. To overcome this problem, congestioncontrol algorithmswereintroduced.Congestioncontrolis theprocess ofmaintainingthenumberofarranged packetsinanetwork belowacertainlevel atwhichnetworkperformanceisdegraded.Congestioncontrolmakesthatsubnet capableofcarryingtheoffered traffic.Summingtherelativedelaymeasurements overaperiodofdataflowgivesanindicationofthelevelofqueuingatthebottleneck. If the sum of relative delays over an interval is 0, no additional congestion or queuing is present in the network at the end of the interval with respect to the beginning.Similarly,ifthesuccessfuldatapacketsaresummedupfromthebeginning of a session, then anypoint of summation is equal to zero, since, the entire data contained in the links are not in the network queues. The congestion control algorithminvolvesasrelativedelaysfromthebeginningofasessionandthenupdating themeasurementsatintervalsequaltotheamountoftimetotransmitawindowof data and receive the corresponding ACKs. The sum of relative delay is then translated into the equivalent number of packets queued at the bottleneck represented bythe sum of relativedelays. In otherwords,the algorithm attempts tomaintainthefollowingcondition: i t N n where –1 –1 i i i t t W N N M In the above equation, N ti is the total number of packets queued at the bottleneckfromthebeginningoftheconnectionuntilt i ;nisthedesirednumberof packets sent and received as per session, to be queued at the bottleneck. M Wi-1 is theadditional amount ofqueuingintroducedover theprevious windowW i-1 ;and N t1 = M W0 . Applicationswhich performcongestioncontrolmakemoreefficientuseof thenetworkandshouldgenerallyseebetterperformancebecauseofit.Congestion control algorithms prevent the network from entering congestive collapse. Congestive collapse is a situation where the network links are heavilyutilized, adverselyaffectingproductivity.Thenetworkwillsoonbegintorequireapplications to perform congestion control and those applications which do not perform congestion controlwill beharshlypenalizedbythenetwork,probablyintheform ofpreferentiallydroppingtheirpacketsduringtimesofcongestion.Theassumption inwhichstatisticalmultiplexingcanbeusedtoimprovethelinkutilizationisthatthe usersdonotreachtheirpeakratevaluessimultaneously,butifthetrafficdemands arestochasticandcannotbepredicted,thencongestionisunavoidable.Whenever the total input rate is greater than the output link capacity, congestion occurs. When the network becomes congested, the queue lengths might become very largeinashorttime,resultinginbufferoverflows. Congestion is caused bythe shortageof buffer space. Theproblem can be solved when the cost of memorybecomes cheap enough toallowlarge memory. Larger buffers are useful only for very short term congestions and will cause undesirable long delays. The long queue and long delay introduced by a large memoryisundesirableformanyapplications. Congestion is caused by slow links. This problem can be solved by introducinghigh-speedlinks. However, this is not always thecaseas sometimes

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 150 Material increasein linkbandwidth can aggravatethecongestionproblem becausehigher speedlinks maymake thenetwork unbalanced.Iftwo sources beginto senddata to the destination at their peak rate, congestion will occur at the switch. Higher speed linkscan make thecongestionconditionin theswitcheven worse. Another reason for congestion is slow processors. However, faster processorswilltransmitmoredataperunittime.Ifseveralnodesbegintotransmit to one destination simultaneously at their peak rate, the target will soon be overwhelmed. Congestionis adynamic problem andanystatic solutions are not sufficienttosolvetheproblem.Allotherissues,suchasbuffershortage,slowlink, slow processors are symptoms and are not caused by congestion. Proper congestionmanagementmechanisms aremoreimportantthanever. Adding more memorymayhelp till a point, but if routershave an infinite amount of memory, congestion gets worse. Flow control relates tothe point-to-pointtrafficbetweenagivensenderandagivenreceiver.Asituationrequiringflow control refers to the

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fiber optic network with a capacityof 1000 gigabits/sec on which a supercomputer was trying to transfer a file to a personal computer at 1Gbps.

Asituation requiring congestion control is to store-and-forwardnetwork with1-Mbpslinesand1000largeminicomputers,inwhichhalfoftheparttriesto transfer files at 100 kbps to the other half. Figure 3.29 describes flowchart in whichthebasicalgorithm isusedforcongestioncontrol. Receive congestion control trigger Check reported congestion condition Resource is currently under loaded Resource is currently overloaded Increase congestion level by one Decrease congestion level by one if non zero Resource is optimally loaded Maintain current congestion level Send new congestion level to front-end processors if a level change has been made Fig. 3.29 Flowchart of Congestion Control Algorithm Figure3.29showsthatthecongestioncontroltaskreceives acongestiontriggerif anyoftheresourcesbeingmonitoredcrossesacongestionthreshold,i.e.,congestion has either risen abovea threshold orfallen belowa threshold.New congestion is
Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 151 sent to the front-end processor, if a level change has been made. On the basis of thereportedcongestioncondition,thecongestioncontroltaskappliesacongestion levelinthefollowingway: ? Resourceoverloaded:Ifthemonitoredresource isoverloaded,thetraffic inthesystemneedstobereduced.Thus,thecongestioncontroltaskincreases thethrottlingoftrafficbyincreasingthecongestionlevel byone. ? Resourceoptimallyloaded:Ifthemonitoredresourceisloadedjust right, i.e., to its optimum usage, the congestion level needs to be maintained. Therefore, no change is made to the congestion control level. Hence, no congestion control action is taken. ? Resource underloaded: If the monitored resource is underloaded, the system can handle more traffic than is being currentlyoffered. Thus, the congestion control taskdecreases thethrottlingoftrafficbydecreasingthe congestion levelbyone. Ifthecongestionlevelhaschangedinthepreviousstep,thetaskneedstoimplement thelevelchangebyaskingthefront-end processors toincreaseordecreasetraffic blocking. The front-endprocessors takethe appropriate action,whichwill result inchangeintrafficload.Changesinloadhandledbythesystemwillfinallyresultin furthercongestion triggers,thus bringingus backtothestartingpoint. 3.9.1 General Principles of Congestion Control
Growingdemandofcomputerusagerequiresefficientwaysofmanagingnetwork traffic to avoid or limit congestion in cases where increases in bandwidth is not desirable or possible. It is generally accepted that network congestion control problemremainsacriticalissueandahighpriority,giventhegrowingsize,demand and speed (bandwidth)of increasinglyintegrated services network.ATM is also influencedwiththeperformanceofavastmajorityofcongestioncontrol schemes proposed for the solution of the available bit rate (ABR) problem that not has been proven analytically. In part, due to lack of a structured approach and a strong theoretical foundation in stabilizing controlled systems. The proposed schemes are developed using intuition and simple non-linear designs. Using simulation, these simple schemes are demonstrated to be robust in variety of scenarios.Sincethesearedesignedwithsignificantnon-linearity,basedmostlyon intuition, for example, two-phase slow start andcongestion avoidance dynamic windows, binaryfeedback, etc., refers to the analysis ofaclosed loopbehaviour, whichisdifficult,ifpossible,evenforsinglecontrolloopnetworks.Fromacontrol theorypointofview,allsolutionstoproblemsincomplexsystems,suchascomputer networks,canbedivided intothefollowinggroups: ? Openloop:Thesolutionssolvetheproblembygooddesign,inessence,to make sure the problem does not occur in the first place. Tools include factors such as when to accept new traffic, when to discard packets and whichpacketsto discard, and howto schedulepacketsat various pointsin thenetwork.It is helpful inmakingdecisions without regardtothecurrent state of the network. ? Closed loop: The

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solutions are based on the concept of a feedback loop

whichconsistsofvariousparts.In thefirst part,thesystem isusedtodetect whenandwherecongestionoccurs.Thesecondpartpassestheinformation

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 152 Material to places where actions can be taken and the third part adjusts the system operation to correct the problem. Perfect Desirable Congested Maximum carrying Capacity of subnet Packets sent P acke ts delive red Fig. 3.30 Congestion Graph Figure 3.30 shows that if too much traffic is offered, congestion sets in and the performance degrades sharply. Onlyperfect data packets are transmitted across the network. In Figure 3.30 congested data packets are tilted,which implies that thesedatapacketsarenotgoingtobetransmitted.Thechiefmetricsformonitoring thesubnet forcongestion can beofthe followingtypes: ?

Themonitoredcongestioninformationispropagatedinthefollowingway: ? Therouterdetecting thecongestion sendsaseparate warningpackettothe trafficsource. ? A bit or field can be reserved in each packet. When a router detects a congested state, it fills in the field in all outgoing packets to warn the neighbours. ? Hosts orrouters send probepacketsout periodicallytoexplicitlyaskabout congestion and to route traffic around problem areas. When congestion takes places, buffers get full, so packets arediscarded leading to more retransmissions and less packets delivered totheir destinations.Adding memorymighthelp,but then thequeuesget longerleadingtomoretime-outsand retransmissions. Congestion thus tends to feed upon itself and become worse, leading to collapse of the system. Congestion control involves insuringthat

that involves the behaviourof allhosts and routers. Incontrast,flowcontrol isrelatedtothepoint- to-point traffic between a sender and a receiver, ensuring that the sender is not overloading the receiver. There are manypolicies on different layers that affect
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congestion.Animportantissuehereisthesettingfortimers,iftheyaresettoolow extraretransmissionsoccurs.Forthisadaptivesettingoftimersisrequired.Sliding window protocols usingselective repeat giveless retransmissionsthanusing the 'Go-Back-N' control. Using piggybacking for ACKs reduces the number of packets,butaddsanextratimerinvolvingachanceofextraretransmissions.Using asmallerwindowsizereducesthedatarateandthushelpsfightcongestion.When virtual circuits are used it is easyto denynew connections in case congestion is near.Arouting algorithm can help avoid congestion byspreadingtraffic over all possible routes, insteadofselecting the best one.Asequence ofvirtual circuits is set up from the source through one or more gateways to the destination. Each gatewaymaintainstables tellingwhichvirtualcircuits pass throughit,wherethey are to be routed, and what the new virtual circuit number is. Once data packets beginflowing,eachgatewayrelaysincomingpackets,convertingbetweenpacket formatsandvirtualcircuit(VC)numbersasneeded.Asallpacketsmusttransverse the same sequence of gateways, theyarrive in order. Multiprotocol router ATM Router Host End-10-end concatenated virtual circuits OSI M X.23 M SNA 1 2 M M Fig. 3.31 Concatenating Virtual Circuit This schemeworks best when allthenetworks haveroughlythesameproperties. It can not be used if one of the subnets does not offer VCs but onlydatagrams. CheckYourProgress 16. What is the purpose of a router? 17. Namethedifferenttypes ofroutingalgorithms. 18. Giveonecharacteristicoffloodingalgorithm. 3.10 DEADLOCKS A deadlock is a situation in which some processes wait for each other's actions indefinitely. In real life deadlocks can arise when two processes wait for phone calls from one another or when persons crossing a narrow bridge in opposite directionsmeetinthemiddleofthebridge.Deadlockismoreseriousthanindefinite postponement or starvation because it affects more than one job. Because resources are tied up in deadlocks, the entire system is affected.
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Processesinvolvedinadeadlockremainblockedpermanentlywhichaffects thethroughput, resourceefficiencyand theperformanceoftheoperatingsystem. Adeadlock can bringthesystem to standstill. Operating system handles onlydeadlocks caused bysharing of resources in the system. Such deadlocks arise when someconditions concerningresource requests and resourceallocations areheld simultaneously. Deadlock detection mechanism detects a deadlock bychecking whether all conditions necessary for a deadlock hold simultaneously. The deadlock prevention and deadlock avoidance ensure that deadlocks cannot occur, bynot allowingtheconditionsfordeadlockstoholdsimultaneously. The most common example for deadlock is a traffic jam. In the example (refer Figure 3.32) shown below, there is no proper solution to a deadlock; no onecanmoveforward until someonemoves out oftheway, but noonecanmove out ofthewayuntil eithersomeoneadvancesorarearofalinemoves back.Only then can the deadlock be resolved. Fig. 3.32 A Classic Case of Traffic Deadlock Thus, we can say that a deadlock refers to a situation in which two or more competingactionsarewaitingfortheothertofinishandthusneithereverdoesthis. Forexample, consider about thetwo trains approachingeachotherat a crossing. Inthissituation,boththetrainsstopandnoneofthemcanrestartuntiltheotherhas gone. In computer science, deadlock refers to a specific condition when two or more processes are each waiting for another to release a resource or more than two processes arewaiting for resources in a circular chain. Followingaretheexamples ofdeadlock: ? The occurrence of deadlocks is common in the multiprocessing system. Thereasonfor this is thatin themultiprocessingsystem,several processes have to share a specific type of mutually exclusive resource known as a

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 155 software, or soft, lock. There often exists a hardware lock (or hard lock) in computers that intend for the time sharing and/or real time markets. This lockprovides an exclusive access toprocesses. This leads toaforced serialization.Deadlockscreatetroublesas welackageneralsolutiontothis problem. ? Think oftwo people drawing diagrams with onlyonepencil and oneruler between them. If one person possesses the pencil and the other possesses theruler,thiswouldleadtoadeadlockifthepersonhavingthepencilneeds the ruler and vice versa.As it is not possible to satisfyboth the requests, a deadlockisinevitable. ? In case of telecommunications, deadlock is a little more complex. Here, deadlock occurs when neither of the processes meets the condition for moving to another state and each communication channel is empty. The secondconditionisignoredincaseofothersystemsbutisveryimportantin thecontextoftelecommunications. ? We mayconsider an example of a deadlock in database products. Client applications usingthedatabasemayneedanexclusiveaccess toatable.To acquiresuchanaccess, alockmaybedemandedbytheapplications.Think ofaclientapplication holdingalockonatableandattemptingtoobtainthe lockon asecond tablewhich isalreadyheldbyasecondclient application. This mayleadto deadlock if thesecond applicationtries toobtainthe lock possessedbythefirstapplication.However,thisparticulartypeofdeadlock iseasilyprevented,forexamplebyusinganall-or-noneresourceallocation algorithm. When a Deadlock Occurs? Adeadlock occurswhen thefollowingfourconditions aremet: ? MutualExclusion: Each resourceis allocated to onlyoneprocess at any givenpointoftime. ? Hold and Wait: The previously granted resources are not released by processes. ? No Preemption: The previously granted resources are not taken away from theprocesseswhich hold them. ? Circular Wait: There exists a chain of two or more processes. These processes should exist in such a waythat each process in thechain holds a resource requested bythe next process in the chain; there must exist a set (P0, P1, P2,P3, ……., Pn)ofwaitingprocesses such that P0is waitingfor aresourcethat is held byP1,P1 is waiting foraresourcethat isheldbyP2, ...Pn–1iswaitingfor aresourcethat is held byPn,and Pniswaitingfor the a resource that is held byP0 (refer Figure 3.33).

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 156 Material R1 R3 R2 R4 P0 P2 P3 P1 Fig. 3.33 Circular Wait Basics of Resource Allocation Graph or RAG Three events concerning resource allocation canoccur in a system: request for a resource, allocation of a resource and release of a resource. A request can occur when some process Pi makes a request for a resource Ri. If ri is currentlyallocated to some process Pk, process Pi gets blocked on an allocation event ri. In effect, Pi waits for process Pk so that ri is released. A release event does the task to free ri by Pk. Table 3.7 shows the function of request allocation and release of resources. Table 3.7 Request Allocation and Release of Resources Request A process requests a resource through a system call. If the resource is free, the kernel allocates it to the process immediately; otherwise, it changes the state of the process to block. Allocation The process becomes the holder of the resource allocated to it. The resource state information gets updated and the process state changes to ready. Release A process releases a resource through a system call. If some processesare blocked onthe allocation event for the resource, thekernelusessometie-breakingrule,forexampleFCFSallocation, to decide which process should be allocated the resource Symbols used in RAG 1. Process 2. Resource typewith fourinstances 3. Pi requests instances of Rj Pi request edge

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 157 4. Process Pi is holding an instanceof Rj Pi assignment edge Basic Facts 1. If a graph contains no cycles, there will be no deadlock. 2. If a graph contains a cycle ? Ifonlyoneinstanceperresourcetype,thenadeadlockwilloccers. ? If several instances per resource type, possibilityof a deadlock. Possibility 1 for a Deadlock The possibility1 for a deadlock is shown in Figure 3.34. R1 R3 P2 P3 P1 R2 R4 Fig. 3.34 Possibility1 for a Deadlock E = {P1 ? R1, P2 ? R3, R1 ? P2, R2 ? P2, R2 ? P1, R3 ? P3} Two possibility for cycles are as follows: ? P1 ? R1 ? P2 ? R3 ? P3 ? R2 ? P1 ? P2 ? R3 ? P3 ? R2 ? P2 Possibility 2 Cycles but No Deadlock Two possibilitycycles but for no deadlock is shown inFigure 3.35. R1 P2 P3 P4 P1 R2 Fig. 3.35 Possibility 2 for a Deadlock Cycle is P1 ? R1 ? P3 ? R2 ?P1.

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 158 Material No deadlock, observe that process P4 mayrelease its instanceof resource type R2. That resource can then be allocated to P3 breaking this cycle. 3.10.1 Deadlock Conditions Two processes,Aand B (applications) needthe samefileresources F1andF2 to completetheirtask. Initially, fileF1 is allocatedtoprocessA,andF2 is allocated to process B. Suppose each of the processes starts execution in this state of resource allocation. Now, during the execution, suppose processArequests file F2 whichis in use byB, and process Brequests fileF1whichis in usebyA.That is, now processAis waiting forfile F2 that is heldbyprocess B, andprocess B is also waiting for file F1 that is held byprocessA. The processes are in a circular wait state. The chances that such a circular wait will occur can be negated by adopting the strategy of allocating all or none of the resources to each of the processes. That is, if all of the resources neededfor a process areavailable, they areallallocatedbeforethestartofexecution;otherwise,noresourcesareallocated and the process has to wait. This negates the hold and wait condition and hence prevents circularwait. Finish Print Send Image Files Image Processing Image Printing Fig. 3.36 Cicular Wait May Occur between Image Processing and Printing System Forexample: Considerthephotoprocessingandprintingsystemgiveninfigure3.36.Theimage processing system sends images in lots of ten for printing to the image printing system and waits for Finish-Print message from the image printer.The image printingsystemaccepts images send bythe imageprocessingsystem onebyone, and when it receives ten images, it prints them all in a single sheet of paper to minimizethewasteofprinterstationery.TheimageprintingsystemsendstheFinish-Printmessagebacktotheimageprocessingsystemafterprintingeverytenimages. Suppose the image processing system had only nine images to be printed in a single sheet and it sends them all and waits for the Finish-Print message. The image printer receives the nine images and then waits for the tenth one before starting printing. The image processing system also waits for the Finish-Print message for it to send the next lot of images forprinting. This is anexample of a circularwait(deadlockedstate)inwhichtheimageprinteris waitingfortheevent (ofsendingthetenth image)fromtheimageprocessorandtheimageprocessoris waitingfortheFinish-Print messagefromtheimageprintertosendthenextlotof images. Suppose the image processor sends thelast image indicator of a lot. Then theimageprintercanstartprintingwithwhatevernumberofimagesithasreceived. In this waythecauseofcircularwait is eliminated.

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 159 3.11 QUEUEING THEORY: BASIC DESIGN TECHNIQUES Queueingtheoryisthemathematical studyofwaitinglinesorqueues.Aqueueing model is constructed so that queue lengths and waiting time can be predicted. QueueingtheorywasfirstdefinedbyAgnerKrarupErlangwhenhecreatedmodels to describe the system of CopenhagenTelephone Exchangecompany, a Danish company.The standard approach and applications include telecommunication, trafficengineering, computernetworks, routingandcongestion,etc. Inaddition, thequeueingtheoryhasbeenspecificallyusedinindustrialengineeringandproject management. Queuingtheorydealswithproblems whichinvolvequeuingorwaiting,for examplein computersit refers to waitingfor a response. Fundamentally,allqueuingsystemscan becategorisedintoindividualsub- systemsconsistingofentitiesqueuingforsomeactivity,asshowninthefollowing Figure 3.36. Fig. 3.36 Sub-System of Queuing Anotherexampleincludesthetheoryoftrafficsignalswhichtypicallyfocuses on the estimation of delays and queue lengths that result from the adoption of a signal control strategy at individual intersections, as well as on a sequence of intersections. In the physical layer and DLL (Data Link Layer) analysis, the simplifiedassumptions ofqueuing theorycan beusedforconductingsignificant analysis,sincerealisticassumptionsincludethetheoreticalanalysis. ComputerScientistsandMathematicianshaveresearchedandstudiedqueues basedoncomputernetworkingtechnologyandformulatedtheirfirst applications for telephone exchanges, known as theErlang's loss formula. It was recognised that singlequeues and networks ofqueues could beusedas performance models ofcomputersystems.Inrecenttimes,developmentsandadvancementsinmostof the computer systems typicallystructured as the queueing networks. However, variousperformanceanalysisissynonymouswithqueueingtheory. Queueing theory was first used in the late 1960s to model time sharing computersystems.Specifically,singlequeues wereusedtoexamineandevaluate theallocationstrategiesforthecomputerCPUs(CentralProcessingUnits).Analysis ofthesinglequeuesdefineaqualitativeaswellasquantitativeabilityofsomeaspects of the operating system and disk management system design. Though, in the beginning, these single queue models were not capable to represent systems of interacting computing devices. Subsequent developments in queueing theory

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consequentlystudiedtheinteractionbetweenservicecentresorqueues—queueing networks. Recent computer systems are defined as a set of loosely coupled hardwarecomponentsthroughwhichroutingpacketsortransactionsgetcirculated. The success ofqueueing theoryas a performance modelling paradigm depends onthedatacommunication systems ofcomputers. Aqueueingsystem can be completelydescribed by: (i) Theinput(arrivalpattern). (ii) Theservicemechanism(servicepattern). (iii) Thequeuediscipline. (iv) Customer's behaviour. The Input (Arrival Pattern) Input describes the way in which the customers arrive and join the system. Generally, customers arrive in a more or less random fashion, which is not possible to predict. Thus, the arrival pattern can be described in terms of probabilities,andconsequently,theprobabilitydistributionforinter-arrivaltimes (the timebetween two successive arrivals)must be defined.We deal with those queueing systems in which the customers arrive in Poisson fashion. The mean arrival rate is denoted by?. The Service Mechanism This means, thearrangement of service facilityto serve customers. Ifthere is an infinite number of servers, then all the customers are servedinstantaneouslyon arrival and therewill beno queue. Ifthenumberofserversis finitethen thecustomersareservedaccordingto a specificorder, with servicetimeas a constant orrandom variable. Distribution ofservicetimethatisimportantinpracticeisthenegativeexponentialdistribution. The mean service rate is denoted bym. The Queue Discipline Itisaruleaccordingtowhichthecustomers areselectedforservicewhenaqueue has beenformed. Themost commondisciplines are: ? First Come First Served (FCFS). ? First In First Out (FIFO). ? Last In First Out (LIFO). ? Selection for Service In Random Order (SIRO). Therearevariousotherdisciplinesaccordingtowhichacustomerisserved inpreferenceovertheothers. Underpriioritydiscipline,theserviceisoftwotypes, namelypreemptiveandnon-preemptive.Inpre-emptivesystem,thehighpriority customers are givenservice over the lowprioritycustomers; innon-pre-emptive system, a customerof low priorityis serviced before a customerof high priority. In the caseof parallel channels 'fastest serverrule' is adopted.

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 161 Customer's Behaviour Thecustomersgenerallybehaveinthefollowingfourways: (i) Balking: Acustomer who leaves the queue because the queue is too long and he has no time to wait or does not havesufficient waitingspace. (ii) Reneging: This occurs when a waiting customer leaves the queue due to impatience. (iii) Priorities:Incertainapplicationssomecustomersareservedbeforeothers, regardless of theirarrival. These customers haveprirityoverothers. (iv) Jockeying: Customers mayjockeyfrom one waitinglineto another.This is most commonin a supermarket. Transient and Steady States: Asystem is said to be in a transient state when its operating characteristicsaredependent on time. A steadystate system is the one in which the behaviour of the system is independent oftime. Let P n (t)denotetheprobabilitythat therearen customersin the system, at time t. Then in steadystate, lim ( ) n t p t = p n (Independent of t) ? ( ) n dp t dt = n dp dt ? lim ( ) n t p t = 0 Traffic Intensity (or Utilization Factor): An important measure of a simple queueisitstrafficintensitygivenby, TrafficIntensity? = Mean arrival rate Mean service rate = Theunit oftrafficintensityisErlang. Kendall's notation for representing Queueing Models Generally,queueingmodel maybecompletelyspecifiedinthesymbolform (a/b/ c): (d/e) where, a = Probabilitylawforthearrival(inter-arrival)time. b = Probabilitylaw accordingto which the customers arebeingserved. c = Number ofchannels(orservicestations). d = Capacityofthesystem,i.e.,themaximumnumberallowedinthesystem (inserviceandwaiting). e = Queuediscipline. 3.11.1 Classification of Queueing models Thequeueingmodelsareclassifiedasfollows: Modell: (M/M/1): (?/FCFS):This denotes Poissonarrival (exponentialinter- arrival),Poissondeparture(exponentialservicetime),Singleserver,Infinitecapacity

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 162 Material andFirstcomefirstservedservicediscipline.TheletterMisuseddueto Markovian propertyofexponential process. Model II: (M/M/1): (N/FCFS): In this model, the capacity of the system is limited(finite),sayN.Obviously,thenumberofarrivalswillnotexceedthenumber N in anycase. Model III: Multiservice Model (M/M/S):(?/FCFS): This model takes the numberofservicechannelsasS. Model IV: (M/M/S): (N/FCFS): This model is essentiallythe sameas model II,exceptthemaximumnumberofcustomersinthesystemislimitedtoN,where, (N < S). CheckYourProgress 19. Whatiscongestion? 20. Whatistheuseofcongestioncontrolalgorithms? 21. What type of deadlock does an operatingsystem handle? 22. What are thecomponents of queuingsystem? 23. What arethemost common queuediscipline? 3.12 ANSWERS TO 'CHECK YOUR PROGRESS' 1. Therearetwo types ofdatatransmissionmethods that areusedtotransmit datafromits origin to theinformation processing.Theseareas follows: a. Offline:Computersarenotconnectedbycommunicationcircuits.Data istransmittedbetweenaterminalandinformationprocessingunitthrough a magnetic tapeand magnetic disk packs. b. Online:Computersareconnectedbycommunicationcircuits.Datacan beinstantlytransmittedbetweenaterminalandinformationprocessing unit. 2. Thedatacommunicationsystemconsistsofthefollowing: a. TransmitterorSenderofData:These maybe terminals, computers andmainframes,etc. b. Medium: The medium, through which the data is transmitted, can be cables,RadioFrequency(RF)wave,microwave,fibreoptics,infrared, etc. c. Receiver:Asthenameimplies, itis thedevice,whichreceivesthedata transmitted.Theseareprinters, terminals,mainframes,computers,cell phone, etc. 3. DCEistheequipment that interfacesthesourcewiththemedium andvice versa.DCEincludesmodems, DSUs and CSUs andFront EndProcessors (FEPs). 4. The earliestelectronicnetwork is thetelephonesystem.

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 163 5. Thetelephonenetworkconsists ofthesubscriber'sline,switchboards,and trunklines. 6. PSTNis theglobal compilationofinterconnectsmadeforassistingcircuit- switched voice communication. The conventional Plain Old Telephone Service(POTS)isprovidedbyPSTNtodwellersandtovariousenterprises. 7. There are two forms of ISDN service:narrow band and broad band. 8. The World Wide Web is also known as the Web, WWW or W3. It is a globalsystemofhypertextandmultimediaservices. 9. Electronicmail,ore-mail, allowscomputerusers locallyandworldwideto exchange messages. E-mail users have an electronic mailbox into which incomingmailisdropped. 10. Telnetisavirtualterminalemulationfacilitythatallowsausertoconnectto a remote system as if the user's terminal was hard wired to that remote system. 11. Archive is aprogram that searches all the FTP sites onthe Internet, which areavailableonitsmasterlist,andstoresthefilenamesinacentraldatabase. This databaseis available for users to search. 12. TCP/IPstandsforTransmission Control Protocol/InternetProtocol.It was developed with the objective to specify a suite of protocols capable of providingtransparentcommunicationsinteroperabilityservices. 13. TheInternationalOrganizationforStandardization(ISO)tooktheinitiative in settingup OSI. 14. Thephysicallayerdeterminesthetypeofnetworkdesignexclusivelydesigned for the physical layer and connected to higher levels such as data link, network, session, transport, presentation and application layers. 15. PhysicalLayeristhefirst layerofthemodel whichdefinesthephysical and electricalimplementationofthebus.Inotherwords,itdefinesthehardware andsignal-levelimplementationofthebus. 16. Arouterisusedtomanagenetworktrafficandfindthebestrouteforsending packets. 17. There are two types of routing algorithm known as adaptive and non- adaptive. 18. Animportantcharacteristicofthefloodingalgorithmisthateachandevery node, directlyor indirectly connected to the source node, is visited. This helpsindisseminatingorbroadcastingroutinginformationtoallnode. 19. Congestion is aglobal issue, involving thebehavior ofall thehosts, all the routers, thestore-and-forward processing within the routers, etc. 20. Congestioncontrolalgorithmspreventthenetworkfromenteringcongestive collapse. 21. Operating system handles onlydeadlocks caused bysharing of resources inthesystem.

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 164 Material 22. Aqueueingsystem can be completelydescribed by: (i) Theinput(arrivalpattern). (ii) Theservicemechanism(servicepattern). (iii) Thequeuediscipline. (iv) Customer's behaviour. 23. Themostcommonqueuedisciplienare: (i) FCFS (ii) FIFO (iii) LIFO (iv) SIRO 3.13 SUMMARY ? Adatacommunicationsystemisacomputersystem thatcollectsdatafrom remotelocationsthroughdatatransmissioncircuits,thenoutputsprocessed data toremote locations. ? Adatacommunicationsystemisacomputersystem thatcollectsdatafrom remotelocationsthroughdatatransmissioncircuits,thenoutputsprocessed data toremote locations. ? Datacircuit terminatingequipmentis alsoknownasDataCommunication Equipment (DCE). DCE is the equipment that interfaces the source with themediumand viceversa. ? DCE is a device that communicates with a DTE device in RS-232C communications. ? Communicationssoftwareisgenerallyembeddedinthecomputeroperating system. ? The earliestelectronicnetwork is thetelephonesystem. ? Thetelephonenetworkconsistsofthesubscriber'sline,switchboards,and trunklines. ? A computer can be connected permanently to the Internet using leased lines. ? PSTN or Public Switched Telephone Network relates to the public telephonenetwork. ? PSTNrequire64kbps channel as thevital digital circuit whichalsoknown asdigitalsignaling0/DS0. ? Public Switched Data Network (PSDN) is a network that is accessible to the public. It assists packet-switched data as well as PSTN. ? ISDN which is short for Integrated Services Digital Network is a set of CCITT/ITUstandardsusedfordigitaltransmissionoverordinarytelephone copper wire and other media. ? ISDNisanetworkarchitectureinwhichdigitaltechnologyisusedtoconvey informationfrommultiplenetworkstotheend-user.Thisinformationisend- to-enddigital.

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 165 ? Broadband ISDN Service is a digital service in excess of 1.544 Mbps. This digital service can be in the form of Frame Relay, SMDS, orATM. Broadband ISDN is the service of the future. ? Products for ISDN technologyfrom different vendors even with similar features andoptions maycreatesomecompatibilityissues. ? Internet Service Provider(ISP) is a companythat access internet services. This service provider provides a software package in which you get registrationwiththeprovidingservices. ? CommercialISPseasilyaccessandcommunicatewithindividualorvarious organizations across net. ? WideArea Networks (WANs) connect larger geographic areas, such as New Delhi, India, or the world. ? TheInternet,WWWandInformationSuperHighwayaretermswhichhave deepimpactin thelives ofmillions ofpeoplealloverthe world. ? The word Internet is an acronym of the word 'internetwork' or 'interconnected network'.Therefore, it canbesaidthat theInternetis not a singlenetwork, but acollection of networks. ? ARPAnetwasbuiltbyDARPAasdescribedearlier.Thisinitiatedthepacket switchingtechnologyintheworldofnetworkingandthereforeissometimes referred to as the 'grand-daddyof packet networks'. ? The Internet is becoming a necessarytool rather than a convenient tool in society.Ithasproveditsutilityinallwalksoflife,suchaseducation,economy, andsocio-political arenas. ? Electronicmail,ore-mail,allowscomputerusers locallyandworldwideto exchangemessages. ? Telnetisavirtualterminalemulationfacilitythatallowsausertoconnectto a remote system as if the user's terminal was hard wired to that remote system.Thefiletransferfacilities areusuallyprovidedforbyamechanism known as theFileTransfer Protocol (FTP). ? SMTP is a defined standard for e-mail over the TCP/IP protocol and therefore is widelyused on the Internet. ? Routingreferstotheprocessofselectingtheshortestandmostreliablepath intelligentlyoverwhichtosenddatatoitsultimatedestination. ? Network architecturedefines the communications products and services, which ensure thatvarious components worktogether. ? OSI reference model divides the required functions of the network architectureinto several layers and defines thefunctionofeach layer. ? Data communications processes allocate memoryresources, commonly knownascommunicationbuffers,forthesakeoftransmissionandreception of data. ? Thephysicallayerdeterminesthetypeofnetworkdesignexclusivelydesigned for the physical layer and connected to higher levels such as data link, network, session, transport, presentation and application layers.
Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 166 Material ? Asession layernetwork is designedto occasionallymergethesession and transport layers. Therefore, network designers design the hierarchical topologyforthis layer. ? The OSI model of data communication was developed in 1984 by the InternationalStandardizationOrganization(ISO). ? It is the responsibility of the routers along with routingprotocols and the associated routingalgorithmin apacket-switchednetworkthat therouters run amongthemselves to provide thecorrect routingdecisions tothe next router inthe wayofthedestination end. ? Congestionisaglobalissue, involvingthebehaviourofallthehosts,allthe routers, thestore-and-forward processing within the routers, etc. ? Congestion is caused bythe shortage of buffer space. ?

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Flow control relates to the point-to-point traffic between a given sender and

agiven receiver. ? When congestion takes places, buffers get full, so packets are discarded leading to more retransmissions and less packets delivered to their destinations. ? Adeadlock is a situation in which some processes wait for each other's actionsindefinitely. ? Processesinvolvedinadeadlockremainblockedpermanentlywhichaffects the throughput, resourceefficiencyand the performance of the operating system. ? In computer science, deadlock refers to a specific condition when two or more processes are each waiting foranother to release aresource or more than two processes are waiting for resources ina circular chain. ? Queueingtheoryisthemathematical studyofwaitinglines orqueues. ? Queueing theoryis the mathematical studyof waiting lines or queues.A queueingmodelis constructed so thatqueuelengths and waitingtimecan be predicted. ? Aqueueingsystem can be completelydescribed by: (i) Theinput(arrivalpattern). (ii) Theservicemechanism(servicepattern). (iii) Thequeuediscipline. (iv) Customer's behaviour. ? Themostcommondisciplinesare: o First Come First Served (FCFS). o First In First Out (FIFO). o Last In First Out (LIFO). o Selection for Service In Random Order (SIRO).

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning Material 167 3.14 KEY TERMS ? Receiver:Itis thedevice, which receivesthedata transmitted.Theseare printers, terminals,mainframes,computers,cellphone,etc. ? PublicSwitchedTelephoneNetwork(PSTN):Itistheglobalcompilation ofinterconnectsmadeforassistingcircuit-switchedvoicecommunication. ? PublicSwitchedDataNetwork(PSDN): Itis anetwork thatis accessible to the public. It assists packet-switched data as well as PSTN. ? ISDN: It is a network architecture in which digital technologyis used to conveyinformationfrommultiplenetworkstotheend-user.Thisinformation is end-to-end digital. ? Wide Area Networks WAN: It is defined as a data communications network covering a relativelybroad geographical areato connect LANs together. ? World Wide Web (WWW): It is a global system of hypertext and multimedia services. WWW is a client-server model based on TCP/IP protocols and consists ofbrowsers as clients andWebserversas servers. ? Telnet:Itisavirtualterminalemulationfacilitythatallowsausertoconnect to aremotesystem as iftheuser's terminal was hard wiredtothat remote system. ? Routing:Itrefers to theprocess of selectingthe shortestandmost reliable pathintelligentlyoverwhichtosenddatatoitsultimatedestination. ? Deadlock: It is a situation in which some processes wait for each other's actionsindefinitely. ? Queueingtheory: It isthemathematical studyof waitinglines orqueues. ? Processing Delay: It refers to the time from the packet's arrival at the networklayerofthenodeuntilitisassignedtoanoutgoingqueue(ifrouted at the IP layer). ? QueuingDelay:Itrefers to thespecifictimefrom whenthepacket arrives tothequeueuntilitistransmitted. ? PropagationDelay:Itreferstothetimefromwhenthelastbitistransmitted until thelastbit is received atthedestinationnode. 3.15 SELF ASSESSMENT QUESTIONS AND EXERCISES Short-Answer Questions 1. Discusstheprocessofdigital datatransmission. 2. What are the objective of Internet2 project? 3. Whatistheutilityofinternet? 4. What are the advantages of telephone networks?

Data Transmission Network, TCP/IP and OSI Model NOTES Self - Learning 168 Material 5. List the various layers of OSI. 6. State the main advantages of TCP/IP? 7. What is the purpose of a gateway? 8. What arethedesigngoals ofroutingalgorithms? 9. WritethefeaturesofRAGalgorithm. 10. Whatarethecommon queuediscipline? 11. Discussthevariusqueuingmodel. Long- Answer Questions 1. Explain the conceptofnetwork architecture. 2. Write adetailed note on datacommunicationsystem. 3. Describe thevarious advantages achieved bythe layered approach. 4. Brieflydescribethe various layers ofthe OSImodel. 5. Explaintheresponsibilitiesofthesevenlayers. 6. What arethegeneral principles ofcongestioncontrol? 7. Elaboratethevariouspolicies that effect congestion. 8. Illustrateallthemethodsused forhandlingdeadlocks. 9. What doyou understand byqueuingtheory? Explain. 3.16 FURTHER READING Forouzan, Behrouz A. Data Communications and Networking. New Delhi: Tata McGraw-Hill, 2004. Stallings,Williamand RichardVanSlyke.BusinessDataCommunications.New Jersey: PrenticeHall, 1998. Black, Uyless. Computer Networks. New Jersey: Prentice Hall, 1993. Stallings,William. Data and Computer Communications. NewJersey: Prentice Hall, 1996. Tanenbaum,Andrew S. Computer Networks. New Jersey: Prentice Hall PTR, 2002. Stallings, William. Data and Computer Communications. NJ: Prentice-rHal, 1996.

WideArea Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 169 UNIT 4 WIDEAREANETWORK,TCP/IP AND DATALINK LAYER ADDRESSING Structure 4.0 Introduction 4.1 Unit Objectives 4.2 Wide Area Network 4.2.1 Network Using WAN and Network Services 4.3 Transmission TCP/IP or Communication Protocol over WAN 4.4 IPAddressing 4.4.1 Characteristics of IP Addresses 4.4.2 Subnetting 4.4.3 Supernetting 4.5 Other Network Layer Protocols 4.5.1 Address Resolution Protocol (ARP) 4.5.2 Reverse Address Resolution Protocol (RARP) 4.5.3 Encapsulation 4.5.4 Ethernet 4.6 Routing Protocols 4.6.1 Routing Protocols 4.6.2 Types of IP Routing and IP Routing Algorithms 4.7 TCP Services andApplications 4.7.1 TCP Features 4.7.2 TCP Segment 4.7.3 A TCP Connection 4.7.4 State Transition Diagram 4.7.5 FlowControl 4.7.6 Error Control 4.8 Domain Name System (DNS) 4.9 Answers to 'Check Your Progress' 4.10 Summary 4.11 Key Terms 4.12 Self Assessment Questions and Exercises 4.13 Further Reading 4.0 INTRODUCTION Awideareanetwork(WAN) isa telecommunications network thatextends over a large geographic area for the primarypurpose of computer networking. Wide areanetworks areoften established with leasedtelecommunication circuits.The textbookdefinitionofaWANisacomputernetworkspanningregions,countries, oreventheworld.However,intermsoftheapplicationofcommunicationprotocols andconcepts,it maybebesttoviewWANsascomputernetworkingtechnologies used to transmit data over long distances, andbetween different networks. The Internet protocol suite, commonly known as TCP/IP, is the

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set of communications protocols used in the Internet and similar computer networks.

ThecurrentfoundationalprotocolsinthesuitearetheTransmissionControlProtocol (TCP) and the Internet Protocol (IP).

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 170 Material The Internet protocol suite provides end-to-end data communication specifying how data should be packetized, addressed, transmitted, routed, and received.Thisfunctionalityisorganizedintofourabstractionlayers,whichclassify all related protocols according to each protocol's scope of networking. From lowesttohighest,thelayersarethelinklayer,containingcommunicationmethods for data that remains within a single network segment (link); the internet layer, providing internetworking between independent networks; the transport layer, handlinghost-to-hostcommunication;andtheapplicationlayer,providingprocess- to-process dataexchange for applications. Thenetworklayeranddatalinklayerareresponsiblefordeliveringthedata from thesource device or sender, to the destination deviceor receiver. Protocols at bothlayers contain source and destination addresses, but theiraddresses have different purposes.The network layer, or Layer 3, logical address contains informationrequiredtodeliverthelPpacketfromthesourcedevicetothedestination device.ALayer 3 IPaddress has two parts, the network prefix and the host part. Thenetworkprefixisusedbyrouterstoforwardthepackettothepropernetwork. The host part is used by the last router in the path to deliver the packet to the destinationdevice. In this unit you will learn about WideArea NetworkWAN,Transmission Control Protocol/Internet Protocol (TCP/IP) data transmission by TCP and Ethernet, dataencapsulation, data routing, andIPAddressing. 4.1 UNIT OBJECTIVES Aftergoingthroughthisunit,you willbeableto: ? DefineWideArea Network ? Explain transmissioncontrolprotocol/Internet protocol(TCP/IP) ? Understand data transmission byTCP andEthernet ? Discuss dataencapsulation and datarouting ? Explain TCP/IP servicesand applicationprotocols ? Understand andexplain IP addressing ? Discuss network layeraddresses and subnetting ? UnderstandAddress Resolution Protocol (ARP) ? Elaborate on Domain Name System (DNS). 4.2 WIDE AREA NETWORK This technologyconnects sites that arein diverse locations.Widearea networks (WANs) connect largergeographicareas, suchas New Delhi, Indiaor the world. WAN hasnogeographicallimits.Dedicatedtransoceaniccablingorsatelliteuplinks maybe used to connect this type of network. Hence, aWAN maybe defined as adatacommunications network that coversa relativelybroadgeographicareato connect LANs together between different cities with the help of transmission
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 171

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facilities provided by common carriers, such as telephone companies. WAN technologies

functionat thelowerthreelayers oftheOSIreferencemodel.These are thephysical layer, the datalink layer and the network layer. Figure 4.1 illustrates the system of WAN, which connects many LANs together. It also uses switching technologyprovided bylocal exchangeand long distancecarrier. Fig. 4.1 Wide Area Network Packetswitchingtechnologiessuchasasynchronoustransfermode(ATM), frame relay, switched multimegabit data service (SMDS), and X.25 are used to implementWANalongwithstatisticalmultiplexingtoenabledevicestosharethese circuits. Thedifferencebetween MANandWANmaybeunderstoodonlyfrom the services being used bythem. WAN uses both the local and long distance carrier whileMAN usesonlyalocal carrier. Hardwareand protocols aresameas in case of MAN. The answerto the confusion between LAN andWAN technologies lies in how data is switched. It is the integration of LAN and WAN that makes the network work. After all, people and machines not only need to be accessible locally,butfromdifferent sites aswell. Anetworkis accomplished usingthreebasiccomponents: ? Hardware ? Protocols (software) ? Applications(usefulsoftware) Each ofthese comprises several layers. In the domain ofcomputer design and networking the concept of layers is important. Each layer protects the layer belowfromthelayerabovesothateachlayerchangeswithminimalimpactonthe upper layers. This protection, in some cases, is so proficient that an application maynotcometoknowthatitisrunningonadifferenthardware.TheOSInetwork model definesseven layers. Theroleofcomputernetworksindevelopmentismulti-faceted.Acomputer, along with the necessarynetworking infrastructure, is required to be connected with either LAN or WAN or Internet or all, so as to play a greater role in

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 172 Material e-governance, telemedicine, e-education, e-business, etc. The Internet (internetworking) has become a potent tool for education, productivity and enlightenment. It can improve the quality of life at a relatively low cost. The Government ofIndia had set up ERNET in 1986 toprovideTCP/IP connections for education and research communities in India. ERNET established the first TCP/IPcomputernetworkinIndiaandofferedserviceslikee-mail,Internetsurfing, FTP,Telnet. Subsequently, the government liberalized thepolicies relatingwith Internetanditsbackbone.Theliberalizedpoliciesencouragedmanyprivateplayers likeDISHNET,Mantraonline,JAINTV,etc.andothergovernmentorganizations likeNIC,VSNLandMTNLtoenterthisfieldtobringtheInternettocommonpeople. The majornetwork infrastructureavailableinthe countryhas twotypesof WAN: 1. TerrestrialWAN 2. VSATWAN Followingaredifferentoptions forsettinguptheIntranet,educationportal or e-commerce, etc. 1. Leasedline 2. DialUpconnection 3. VSAT 4. RadioLink The role ofInternet in development can be seen in the areas of education, economic productivity, health care, democracyand human rights and qualityof life besides several others. In education, this contribution is bywayof shared databases, organization of conferences, circulation of papers and discussion, collaborative research and writing.Web-basedregistration,onlinedigital library privileges,otheronlinelearningfacilitieslikevirtualclassroomsandinformation regardingcoursesandsoforth.Economicproductivitymaybeincreasedas Internet runsovertelephoneinfrastructureatrelativelymarginalcosts,providingincreased economic benefit. Internet enables global communication with suppliers and customersetc.Thiscan help to openglobal marketsindevelopingnations.Inthis manner, Internet has facilitated the opening of e-commerce. Internet is being effectivelyutilized in the health sector.The rapid growth of Internet and related areas like switched leased lines, terrestrial and satellite packet radio and videoconferencing, etchasled to thedevelopment oftelemedicine.Byproviding peopleliving underdictatorships with outsideinformation andideas the Internet encourages democracy.The Internet also enables people to share theirideas and coordinatepolitical activitieswithintheirnations.Internetcanforcetransparency in the administration and therefore maybe considered a catalyst to encourage human rights in a wider sense. The environment is understress everywhere, in termsofpollutionandlimitedresourcesforenergy.Internetenablesustosubstitute communication for transportation and therebyreduce pollutionand save energy andtimein thelargerinterestsofmankind. WAN is theacronym forWideAreaNetwork and refers toa network used to connect different equipment from remote areas. Normally, network services areprovided bya Common Carrierof, for example,atelephone company. Users

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 173

canuseservicesonrentbasis.Availableservicesincludetelephonenetwork,leased line, packet switched network, X.25, ISDN, frame relayand cell relay. LANs canbeextended to awiderareabut it cannotbeextendedarbitrarily far orto handle arbitrarilymanycomputers. There is a distance limitations even with extensions. Therefore, other technologies for larger networks are needed. Thenetworks can be broadlydivided intothreecategories namely: ? LANforasinglebuilding ? MetropolitanArea Network (MAN)— single cityand ? WAN—country,continent and planet WAN is composedanumberofautonomous computerthat aredistributed over a large geographical area as shown in Figure 4.1. LAN can be extended across large distances using Satellite Bridge but still this can not accommodate arbitrarilymanycomputers.WAN must be scalable to longdistancesand many computers.Therefore,networkmustreplacesharedmediumwithpacketswitches to span long distances or manycomputers. Each switch moves an entire packet fromoneconnectiontoanother.Thismechanismiscalledpacketswitching.These switches arenothing but a small computerwith network interfaces,memoryand program dedicated to packet switching function. These packet switches may connect to computers and to other packet switches, typically high-speed connections to other packet switches, lower speed to computers as shown in Figure 4.2.These packet switches can be linked together toformWANs.WANs neednotbesymmetricorhaveregularconnections,i.e.,eachswitchmayconnect to one or more other switches and one or more computers. High Speed Connections Switch At Site1 Switch At Site 2 Switch at Site 3 Switch at Site 4 Computers connected to network Fig. 4.2 Packet Switches as Building Blocks to Make a WAN

Datadeliveryfromonecomputertoanotherisaccomplishedthroughstore- and-forward technology. Packet switch storesincomingpacket andforwardsthe packettoanotherswitchorcomputerthathasinternal memory.Thereforethiscan holdpacketin queueifoutgoingconnectionis busy. Difference between WAN and LAN ? With LAN additional expanses are rarelyrequired once it is installed. WithWAN, users must continue to paya communication cost to their contracted common carrier.

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 174 Material ? WAN is generallyslower in transmission speed. Requestingthe same level of speed as with LAN leads to a substantial increase in communicationcosts. ? The Satellite Bridge can extend LAN across large distances while in case of theWAN, it spans over a wide geographical area. ? LANstillcannotaccommodatearbitrarilymanycomputers,WANmust be scalableto long distancesand manycomputers. Network Using WAN and Network Services The major objective of network design is to select the network service and to determinethetransmissionspeedforthesystem.Followingarethetypicalexamples of network usingWAN and network services: Host to Terminal Connection The host to terminal connection is a conventional type ofconnection between a mainframeanddumbterminals.Thisconnectionis widelyusedforroutinework. Fixedmessagelength,forexample,makesestimationoftrafficeasy.Asterminals are relativelyslow, telephone network, low speed leased line, packet switching network, ISDN and so on are mainly used.Aterminal controller (TC) may be usedtointegratetwoormoreterminalsforconnectionwithahigh-speedline.The TCshownintheFigure4.3isusedtointegratetwoormoreterminalsforconnection withasingleWANline. Mainframe TC WAN Fig. 4.3 Host to Terminal Connection LAN to LAN Connection The configuration shown in Figure 4.4 is used to connect LANs that are remote from one another. There is a large difference in transmission speed between LAN andWAN. In addition, using a high-speed line can become substantially expensive. Therefore, properarrangements must oftenbe madeto reduce traffic within the WAN. Leased line, ISDN, and frame relay are mainly used for this connection.

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 175 Ethernet 10 Mbps Router WAN 1200 600 Mbps WAN 1200 600 Mbps Router Token-ring 4Mbps, 16Mbps Router Ethernet 10Mbps Fig. 4.4 LAN to LAN Connection Remote LAN connection The configuration shown in Figure 4.5 is mainlyused to connect a remote LAN and PC.Due to the limited number of terminals to be connected and alsodue to restrictions on allowable expense, the types of WAN that can be used are also limited.IngeneralISDNisfrequentlyused.Someserversareexclusivelydesigned for the access purpose. WAN Access Server Fig. 4.5 Remote LAN Connection Router Concepts Arouterhastwo functionsas follows: ? Forwarding Function— It is a function that allows selection of the appropriate route based on IP header information and sends packets throughthisroute. ? Filtering Function— It is a function that allows dumping of invalid packets fora specific network instead of forwarding. Forwarding Function Themostimportantprocessinginforwardingistodeterminetheroute.Ingeneral, routing refers to the processing used for determiningthe next hop (IP address of next router). Here,weconsiderthattheprocessingforsendingpacketstothehost inthesamenetworkisalsoperformedasanintegralpartofrouting.Routinginthe same network maybe termed as local routing.

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 176 Material The routing is simple if the destination address of the host is in the same subnet.However, ifit is not inthesamesubnet thepacket must first besent tothe boundaryrouter. The boundaryrouter references the routingtable to determine thenexthop.Routingtablevariesinconfigurationdependingontheroutingmethod used. Inthis section wewill understand thetypical hop-by-hoproutingtable. Theroutingtablepossessedbyarouterincludescombinationofdestination address and the next hop that corresponds to that address. Figure4.6shows theroutingtableforrouterA(address138.25.10.1).This tablelistsdestinationaddressesforeachlocalnetwork,andnotforeachdestination host.Thistablealso includes asthenexthop(theaddressofnext router)towhich the packet must be transferred. If no hops are included, this means that the destination network is directlyconnected tothe router. WhenrouterAreceives apacket, ittracksthis tabletoperform routing.For example,ifthe packets addressed to thehost ofnetwork138.25.40.0,thenrouter A sends the packet to router C (138.25.30.1). Router C has a similar routing table so thatit can perform routing. 138.25.40.0 138.25.10.0 10.2 10.1 Router B 20.1 Router A 30.2 Routing Table A 138.25.30.0 40.1 30.1 Router C 138.25.20.0 Destination Network 138.25.10.0 135.25.20.0 138.25.30.0 138.25.40.0 Next hop ------ 138.25.10.2 ------ 138.25.30.1 Fig. 4.6 Forwarding Function Filtering Function Thesecondfunctionavailablewitharouteristhatitcanfilterpacketstodetermine whethertheycanpassthroughit.Forexample,considerthattherearetwonetworks connected via router as shown in Figure 4.7. Now, we impose the following conditions: (1) HostsAand C cannot communicateusing UDPpackets (2) Host Bcannot useFTP forcommunicationwithhost D (3) Host Dcannotcommunicatewith hostA (4) HostDcancommunicatewith host BonlyusingTELNET In thiscase the network administratorset the router as given below: ExclusionList: (Source host =A, Destination host = C, Protocol = UDP) (Source host = C, Destination host =A, Protocol = UDP)

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 177 (Source host = B, Destination host = D, Port = FTP) (Source host = D, Destination host =A) InclusionList: (Source host =D, Destination host = B,Protocol = TELNET) Network Network A B C D Router Fig. 4.7 Filtering Function Hierarchical Routing Because of the global nature of Internet system, it becomes more difficult to centralize the system management and operation. For this reason, the system mustbehierarchicalsuchthatitisorganizedintomultiplelevels,withseveralgroup loops connectedwithoneanotherateachlevel. Therefore,hierarchical routingis commonlyused for such a system as shown in theFigure 4.8. Backbone Domain Domain Domain Domain Domain Domain Inter-domain routing Intra-domain routing Inter-domain router Intera-domain router Fig. 4.8 Hierarchical Routing ? Asetofnetworks interconnected byrouterswithinaspecificareausing thesameroutingprotocol is called domain. ? Two ormoredomains maybefurthercombined toformahigher-order domain. ? Arouterwithinaspecificdomainiscalledintra-domainrouter. Arouter connectingdomainsiscalled inter-domainrouter. ? A network composed of inter-domain routers is called backbone.

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 178 Material Each domain, which is also called operation domain, is a point where the systemoperationisdividedintopluralorganizationsinchargeofoperation. Domains are determined accordingto the territoryoccupiedbyeach organization. Routing protocol in such an Internet system can be broadlydivided into twotypes: ? Intra-domainrouting ? Inter-domainrouting.
Eachoftheseprotocolsishierarchicallyorganized.Forcommunicationwithin a domain, only the former routing is used. However, both of them are used for communicationbetweentwoormoredomains.
Onthepagesthatfollow,wewilllookatdescriptionofRoutinginformation Protocol (RIP), Open Shortest Path First (OSPF), and IS-IS, that are intra- domain protocols. RIP and OSPFwill be covered later in detail. Two algorithms, Distance-Vector Protocol and Link-State Protocol, are available to updatecontents ofroutingtables. Distance-Vector Protocol
DistancevectorprotocolsareRIPandInteriorGatewayRoutingProtocol(IGPR). Algorithm where each router exchanges its routing table with eachof its neighbors. Each router will then merge the received routingtables with its own table,andthen transmitthemergedtabletoitsneighbors. This is showninFigure 4.9.Thisoccurs dynamicallyafter afixed timeinterval bydefault,thus requiring significantlinkoverhead. Routing Table A Network A Network A Network B Routing Table B Network A Network B Router A Router B Network A Routing Information B to C Routing Information A to B Network A Network B Router C Network C Routing Table C Network A Network B Network C Routing Information A to B Routing Information B to C Fig. 4.9 Routing Method-Distance—Vector Type There are problems, however, such as: (1) If exchanging data among routers every90 seconds for example, it takes 90 x 10 seconds that a router detects a problem in router 10 items ahead and the route cannot be changedduringthis period.
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 179 (2) Trafficincreasessinceroutinginformationiscontinuallyexchanged. (3) Thereisalimittothemaximumamountofroutinginformation(15for RIP), and routing is not possible on networks where the number of hopsexceedsthismaximum. (4) Cost dataisonlythe numberofhops, andsoselectingthebest pathis difficult. However,routingprocessingissimple,anditisusedinsmall-scalenetworks in which thepoints mentioned abovearenot a problem. RIP (Routing Information Protocol) RIPis the most widelyused routing protocol of distance-vector type today. RIP has been originallydesigned based on the routing protocol applied to XNS and PUP protocol systems of Xerox (RFC1058).The RIP packet format is shown in Figure 4.10. Command Version All 0s Address family All 0s IP Address All 0s All 0s Cost 0 8 16 31 Command: Request or response Address family: Represents address types (protocols). For example, “2” for IP address Address: Represents destination address. Any of the following types can be included: ? Host address ? Subnet address ? Network address ? Default route Cost: Expressed by an integer between 1 and 5 to represent the cost of a route to reach the destination address R e p e a t Fig. 4.10 RIP Packet Format ? RIP request isused, forexample, byarouterupon startup,to inquireof itsneighborrouteraboutrouteinformationtoobtainroutinginformation. ? RIP response includes a destination host addressand cost information in the address part. Response is sent to the neighbor router in case of thefollowing: (1) Receipt ofRIP request (2) Regularly Response is sent every 30 seconds even if no RIP request is issued.All routers delete route information from their routing tableifnorouteinformationisreceivedwithinaspecifiedperiod of time.This is intended to allow detection of fault ofneighbor router. (3) In caseof changes made to routing table contents If changes are madeto therouting table because changes to the networkconfiguration havebeen detected, informationrelating to thesechanges is sent to the neighbor router.
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 180 Material Link-State Protocol
ThesearеOSPF,IS-IS(IntermediateSystemtoIntermediateSystemIntra-Domain RoutingExchangeProtocol). Algorithm where

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each router in the network learns the network topology then creates a routing table based on

this topology. Each router will send an informationofitslinks (Link-State)toitsneighborwhowillinturnpropagatethe informationtoitsneighbors,etc. Thisoccursuntilallroutershavebuiltatopology of the network. Each router will then prune thetopology, with itself as the root, choosingtheleast-cost-pathtoeachrouter, thenbuildaroutingtablebasedonthe pruned topologyas shown in Figure 4.11. In link-state protocols, there are no restrictions in number of hops as in distance-vector protocols, and these are aimed at relativelylarge networks such asInternetbackbones.Theloadonrouterswillbelargehowever,sinceprocessing iscomplex. Router B Link-State Router B (1) Receive Router B’s Link State Router A (2) Build Topology Database (3) Build Routing Table Net Cost Fig. 4.11 Routing method – Link State type OSPF (Open Shortest Path First) OSPF (details in RFC1247) is a link-state type routing protocol developed for use in alarge-scale network byeliminatingthe disadvantages of RIP.This is the onlystandardized inter-domain protocol for the Internet as of today, and offers the following features. The common part of OSPF packet format is shown in Figure 4.12. ? Compatiblewith hierarchical topologyfornetwork ? Allowsuseofsubnet mask ofvariablelength. ? Allows load distribution when two ormoreroutesare available. ? Supports authorizationmethodforimprovedsecurity. In OSPF,eachdomain isdivided intoseveralareas.Detailedconfiguration of eachareacan behidden fromother areas. Therefore, routers that belongtothe sameareahavethesamenetworkconfigurationinformationwhileroutersbelonging to other areas have different configuration information. Because one area is composedofsubnetswith seriallyassignedaddresses,externalinterventionisnot

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 181 necessarytomanagetheroutetoreacheachaddressinthatarea.Itisonlynecessary to managethe route to thatarea as an integral route to a series of those addresses. Version Packet type Packet Length Router ID Area ID Check sum Authentication type Authentication Data Individual Information Part 0 8 16 31 Version: OSPF Version Packet Type: The OSPF packet types 1. Hello 2. Database description 3. Link state request 4. Link state update 5. Link state acknowledgement Packet length: The length of the protocol packet in bytes Router ID: IP address of the router that has sent this packet Area ID: Area ID of the router that has sent this packet Authentication type: Authorized or not Authentication Data: Password etc. Fig. 4.12 OSPF Packet Format Network Model for OSPF Routers can beclassified into threetypes as follows. Onerouter mayplaytwo or moreroles. Also, routinginformation exchangedbetweentheseroutersis called LSP (linkstate packet). ? Domainborderrouter—Thisrouterexchangesrouteinformationwith routers in other domains. Information thus obtained is included in an OSPF message and transferred to other routers in the same domain (domaintowhichdomainborderrouterbelongs).Thisallowsallrouters in the same domain to know which domain border router can provide routeinformationtoaspecificdomain. ? Internal router— Internal router is a router having its links directly connected to a network within a specific area. That is, internal router does not have anydirect links to a network in another area. ? Area border router — This router belongs to two or more areas and notifiesthebackboneoftheoutlineofitsownconfigurationinformation sothatthisoutlineinformationcanbetransferredtootherareaboundary routers. The backbone consists of those networks not contained in anyarea, their attached routers, and those routers that belongto multiple areas. To recapitulate what has been described above, OSPF is a hierarchical routing composedof intra-area routing, inter-arearouting, inter-domainrouting, andsoon.This means that ifa messageneeds tobe sent from onearea toanother, this messagewill sequentiallypass asshown inFigure4.13andalso below: Source host ? Internal router?Area border routerin thesamearea?Domain border router in the same domain ? Destination domain border router ? Destination area border router ? — ? ? Destination internal router ? Destinationhost

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 182 Material Domain Area Area border router Area border router Internal router Area Area border router Area Domain Domain border router Domain Domain border router Fig. 4.13 Network Model for OSPF CheckYourProgress 1. What are the two types ofnetwork in frastructure inthe country? 2. DefineWAN. 3. What do you understand byRIP? 4. Whatisinternalrouter? 4.3 TCP/IP OR COMMUNICATION PROTOCOL OVER WAN The

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TCP/IP reference model is anetwork model used inInternet architecture. It has its beginnings back in the 1960s.The

various design goalsof TCP/IP are: ? Abilitytoconnectmultiplenetworkstogethereffortlessly. ? Creation of a standardized concept of the communication mechanisms provided byeach type of network. ? Ability for the connections to remain intact as long as the source and destinationmachinesarefunctioning. ? Aflexiblearchitecture. The TCP/IP protocol suite is so called because it specifies

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two of its most important protocols:Transmission Control Protocol (TCP)andInternet Protocol (IP).

TCP/IP Protocol Layers Likemostnetworkingsoftware,TCP/IPismodeledinconceptuallayers.Bydividing the communication software

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into layers, the protocol stack permits division of labor, ease of execution and code testing, and the

abilityto develop alternative layer implementations. Layers communicate with those above and below via concise interfaces. The TCP/IP protocol suite has five layers (Figures 4.14 and 4.15). The layers are as follows: physical, data link, network, transport and application.

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 183 Fig. 4.14 TCP/IP Five-Layer Reference Model Fig. 4.15 Another Depiction of the TCP/IP Five-Layer Reference Model Theselayersinclude: ?

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Application layer: The application layer is provided bythe program that uses TCP/IP for communication. An application

layer

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is a user process cooperating with another process, usuallyon a different host.

Somecommonexamplesofstandardnetworkingservicesinclude Telnet andFileTransferProtocol(FTP).Theinterfacebetweentheapplication and transport layers is defined byport numbers and sockets. ? Transportlayer:Thetransportlayermanagesend-to-enddatatransfer

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by delivering data from an application to its distant peer. Multiple applications

canbesupportedsimultaneously.Inotherwords,thislayer manages datatransferbetween networked applications.Themost-used

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transport layer protocol is theTransmission Control Protocol (TCP), whichprovidesconnection-orientedreliabledatadelivery,duplicatedata suppression, congestion control, and flow control.Another transport layer protocol is the User Datagram Protocol which provides connectionless,unreliable,best-

effortservice. ? Internetworklayer:The internetworklayer is alsocalledtheinternet layer or the network layer. It provides the "virtual network" image of an internet. Internet Protocol (IP)isthe

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most important protocol inthis layer. It is a connectionless protocol. IP does not provide reliability, flow control or error handling. These functions must be provided at a higher level.

IP provides a routing function that attempts to deliver transmittedmessages totheirdestination.Thebasicunit ofinformation Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 184 Material transmitted across an IP network is called an IP datagram. Other internetwork-layer protocols are IP, ICMP, IGMP,ARP, and RARP. ? Network interface layer: The network interface layer is

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also called the link layer or the data-link layer.

It

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is the interface to the actual network hardware. This interface may or may not provide reliable delivery, and may be packet or stream oriented. In fact, TCP/

IPdoes not specifyanyprotocolhere, butcan usealmost anynetworkinterface

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available, which illustrates the flexibilityof theIPlayer.Examples are IEEE 802.2, X.25 (which is reliable in itself),ATM, FDDI, and even SNA 2.

TCP/IP Protocol Flow Figure 4.16 provides the structure ofTCP/IPprotocol flow. Fig. 4.16 TCP/IP Protocol Flow Internet Protocol The Internet Protocol (IP) is one of the most dominant protocols of the TCP/IP protocolsuiteanditsmainprotocolislocatedatthenetworklayer.Thefundamental jobofnetwork layer is concernedwith thedeliveryofdata,from thesourcetothe destination, between devices that may be on different networks. They are interconnectedin anarbitrarymanner: aninternetwork.IP isthemechanism used for sending and communicating data from one device to another on TCP/IP networks. TheprimaryjobofIPprotocolistodeliverdatagramsacrossaninternetwork of connected networks.

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 185 Characteristics Internet Protocol has proved to be aboon in incalculable ways. Ofcourse, it has served the industry in manifold ways to accomplish the task because of it's unsurpassedcharacteristics.Let'stakealookatthedistinguishingattributesofthe Internet Protocol which are as follows. ? Universally-addressed: In order to send datafrom pointAtopoint B, IP first needs devicesto set up aconnection on how to sendand receive data. Itisalsoofparamountimportancetoconfirmthatdevicesareabletoidentify which device is 'point B'. Essentially, IP states preciselythe addressing mechanism for the network and uses these addresses for data delivery purposes. ? Underlying-protocol independent: IP is designed to permit the transmissionofdataacrossanytypeofunderlyingnetworkthatisconducive to work with a TCP/IP stack irrespective of which of them instigates the proceedings. Itincludesprovisions to allowit toadjust totherequirements of various lower-level protocols such as Ethernet or IEEE 802.11. IPcan alsorunonthespecialdatalinkprotocolsSLIPandPPPthatwerespecially designed for it.An important exampleis IP's capabilityto fragment large blocksofdataintosmalleronestomatchthesizelimitsofphysicalnetworks, and then havethe recipient rebuild the piecesagain as needed. ? Deliveredconnectionlessly: IPis a connectionless protocol.This means that whenAwants to send data to B, it doesn't first set up a connection to B and then send the data—it just makes the datagram and sends it. ? Delivered unreliably: IP is said to be an 'unreliable protocol'. It means that when datagrams are sent from deviceA to device B, device Ajust sends each one and then moves on to the next.IP doesn't keeptrackofthe ones it has already sent . It does not provide reliabilityor service quality capabilities such as error protection for the data it sends, flow control or retransmissionoflostdatagrams. It is because of this reason that IP is called a best-effort protocol. It does what it can to get data to where it needs to go, but 'makes no guarantees' that thedata will actuallybedelivered there. ? Delivered withoutacknowledgments: Because of its fallible nature, IP does not acknowledge for the deliveryof data to the source. When device B receives a datagram from device A, it does not send back an acknowledgementtotellAthatthedatagramwasreceived.Thereisalways a questionmark in the sender's mind regardingthe deliveryof data. IP Functions The primaryjob of IPfunctions is to add and manage IPaddresses.With this as foundation, let us takea closelook at fourofits major functions. Addressing: To deliver datagrams, IP includes a mechanism for host addressing. SinceIP operates over internetworks,its system is designedto allow uniqueaddressingofdevices across largenetworks.It alsocontainsastructureto facilitatetheroutingofdatagrams to distant networks ifthat isrequired.
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 186 Material Data encapsulation and formatting/packaging:As the TCP/IP network layer protocol,

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IP accepts data from the transport layer protocols UDP andTCP.Itthen encapsulates this datainto an IPdatagram usingaspecial format priortotransmission. Fragmentation and reassembly: IP

datagrams are passed down tothedatalinklayerfortransmissiononthelocalnetwork.However,themaximum frame sizeofeach physical/data-link networkusingIP maybedifferent. For this reason, IP fragments IP datagrams into pieces so theycan each becarried on the local network. The receiving device reassembles and restructures the whole IP datagramagain. Routing/indirectdelivery: When an IP datagram is sent to a destination onthesamelocalnetwork,it iscalled direct delivery.Thistypeofdeliveryis easy to perform using the network's underlying LAN/WLAN/WAN protocol.

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If the final destination is on a distant network not directlyattached to the source,

it is called indirect delivery. This is achieved by routing the datagram through intermediate devices called routers. IPaccomplishes this with the support of the other protocols, includingICMP and TCP/IP gateway/routingprotocols such as RIPand BGP. Version 4 of the Internet Protocol is, in fact, the first version that was widelydeployed andis the one in current widespread use. IP Datagram IP datagram is therudimentaryunit ofinformationcarriedintheformofapacket in the IPlayer, containing a source and destination address.This information is communicated across thenetwork using Internet Protocol. It is avariable-length packet which comprises two parts: header and data (Figure 4.17). The header is 20–60bytesin lengthandcontainsinformationcriticaltoroutinganddelivery. Fig. 4.17 IP Datagram Version(VER):Identifies theversion ofIPusedtogeneratethedatagram. For IPv4, this is 4. This field ensures compatibilitybetween devicesthat maybe
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 187
runningdifferentversionsofIP.AdevicerunninganolderversionofIPwilldiscard datagrams created bynewer implementations, assuming that the older version maynot beable to understand thenewer datagram correctly. Headerlength (HLEN): Specifies the length of the IPheader, in 32-bit words. This includes the length of anyoptions fields and padding. The normal value of this field when no options are used is 5 (5 32-bit words = 5 × 4 = 20 bytes). Differentiated services(DS): Carries information to provide qualityof service features, such as prioritized delivery,etc., forIPdatagrams(Figure 4.18). Fig. 4.18 Differentiated Services Fig. 4.19 Types of Service Fig. 4.20 Default Types of Service

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 188 Material Fig. 4.21 Codepoint Values Total length (TL): Specifies the total length of an IPdatagram, in bytes. Since this field is 16 bits wide, the maximum length of an IP datagram is 65,535 bytes. Identification:Contains a16-bit value common to eachof the fragments belongingtoaparticularmessage;fordatagramsoriginallysentunfragmenteditis still filled in, so it can be used if the datagram must be fragmented by a router duringdelivery.Recipientscanusethisfieldtoreassemblemessageswithoutmixing fragments from differentmessages. This is needed becausefragments mayreach the destination from multiple messages mixedtogether and IP datagrams can be received out of order from anydevice. Flags:Threecontrol flags,two ofwhichareusedtomanagefragmentation and one that is reserved (Figure 4.22). Fig. 4.22 Flags Fragmentoffset: In afragmented message, this fieldspecifies the offset, orposition,intheoverallmessagewherethedatainthisfragmentgoes.Itisspecified in units of8 bytes (64 bits). The first fragment has anoffset of 0. Timetolive(TTL):Thisfield specifies howlongthedatagramis allowed to 'live'on thenetwork, interms of router hops.Eachrouterreducesthevalue of the TTL field by one prior to transmitting it. If the TTL field drops to zero, it is assumed that the datagram has taken too long a route and is discarded. Protocols: Figure4.23 provides the structure for protocols. Fig. 4.23 Protocol Structure Headerchecksum:Achecksum is computed over the header to provide basicprotectionagainstcorruptioninthetransmission.Itiscalculatedbydividing
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 189 the headerbytes into words (a word is two bytes) and thenaddingthem together. Eachdevicereceivingthedatagramdoesthesamechecksumcalculationandona mismatch, discards thedatagram as damaged. Sourceaddress: Thesourceaddress ofthedatagram isa 32-bitIP address . Intermediate devices, such as routers, handling the datagram do not put their address into this field. It is always the device that originallysent the datagram whose address comes here. Destination address: The destination address is 32-bit IP address of the intendedrecipientofthedatagram.Devicessuchasroutersmaybetheintermediate targetsofthedatagram.Thisfieldalwayshastheaddressoftheultimatedestination. Options: One or more options may be incorporated after the standard headers in certain IP datagrams. The header of the IP datagram constitutes two parts:afixed partandavariablepart. Thevariablepart consistsoftheoptions that can be amaximum of 40 bytes. Optionformat: Figure4.24 provides the optionformat structure. Fig. 4.24 Option Format Categories of options: Figure 4.25 provides the categories of options structure. Fig. 4.25 Categories of Options
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 190 Material 4.4 IPADDRESSING The Internetaddress or IP address is a uniqueidentifierusedin theIPlayerof the TCP/IP protocol suiteto identifyeach device connectedto the Internet. IP addresses are used by the IP protocol to uniquelyidentifya device on theInternet.IP datagrams are transmittedoveraphysical networkattachedto

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the host. Each IP datagram has a source, IP address and a destination IP address.

To send a datagram to a certain IP destination, the destination IPaddress must be mapped to a physical address. 4.4.1 Characteristics of IP Addresses ? AnIPaddressisa32-bitaddressthatuniquelyanduniversallyidentifiesthe host or a router connected to the Internet. ? EachIP addressis unique. No twodevices ontheInternetcan havesimilar addresses. ? Each IP address comprises two elements: the prefix, which identifies the physicalnetwork,andthesuffix,whichidentifiesacomputeronthenetwork (Figure 4.26). IP address = >network number<>host number< Fig. 4.26 Two Level IP Address (i) Each IP address is 32-bit number represented in a dotted decimal form. For example, 128.11.3.31 is an IPaddress with 128.11 being the network number and 3.31 beingthe host number. (ii) TomakeInternet address easierforpeopletocomprehendandwrite, it is often
expressed as four decimal numbers, each separated by a dot.Thisformat is called '

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dotted-decimal notation.'Dotted-decimal notation divides the32-bit Internet address into four8-bit fields and specifies the valueof each field independentlyas a decimal number with

thefields separated bydots (Figure 4.27). Fig. 4.27 The Dotted-decimal Notation of the IP Address 128.11.3.31 Classful Addressing IP addresses, when started a few decades ago, were based on the concept of classes. Each class fixed a

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boundary between the network prefix and the host number at adifferent point withinthe32-bit address.

There are five classes of IP addresses as shown in Figure 4.28.
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 191 Fig. 4.28 Five Classes of IP Addresses ClassAaddresses: These addresses use 7 bits for the >network<

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and 24 bits for the >host< portion of the IP address. This permits 2 7 –2 (126) networks each with 2 24 –2 (16777214) hosts—a total of more than 2 billion addresses. Class B addresses: These addresses use 14 bits for the >

network<

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and 16 bits for the >host< portion of the IP address. This allows for 2 14 –2 (16382) networkseach with2 16 –2(65534)hosts—atotalofmorethan 1billionaddresses. Class C addresses: These addresses use 21 bits for the >

network<

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and 8 bits for the >host< portion of the IP address. That allows for 2 21 –2 (2097150) networkseachwith2 8 –2(254)hosts—atotalofmorethanhalfabillionaddresses. Class Daddresses: These addresses are reservedfor multicasting(a sort of broadcasting, but in a limited area, and onlyto hosts using the same Class D address). Class E addresses: These addresses are reserved for future

use. Addresses perclass: The ClassAaddress is more suitable for networks with an excessivelycolossal number of hosts (Figure 4.29). Class C addresses are apt for networks with a small number of hosts. This clearly indicates that medium-sized networks (those with more than 254 hosts or where there is an expectation of more than 254 hosts) must use Class B addresses. Fig. 4.29 Addresses per Class Findingtheclassin binarynotation is showninFigure4.30.
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 192 Material Fig. 4.30 Finding the Class in Binary Notation Findingtheclassin decimalnotation isshowninFigure4.31. Fig. 4.31 Finding the Class in Decimal Notation

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Find the class of each address: ? 00000001 00001011 00001011 11101111 ? 11000001 10000011 00011011 11111111 ? 227.12.14.87 ? 193.14.56.22 Solution: ? The first bit is 0. This is a ClassAaddress. ? The first 2 bits are 1; the third bit is 0. This is a Class C address ? The first byte is 227 (between 224 and 239); the Class is D. ? The first byte is 193 (between 192 and 223); the Class is

C.
Figures 4.32, 4.33 and 4.34 depict blocks in classesA, B and C. Fig. 4.32 Blocks in Class A
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 193 Fig. 4.33 Blocks in Class B Fig. 4.34 Blocks in Class C Inclassfuladdressing,thenetworkaddress(thefirstaddressintheblock)is assignedtotheorganization.Therangeofaddressescanautomaticallybeconcluded from thenetwork address. Given the network address 17.0.0.0, find the class, the block, and the range of the addresses. Solution: The class is Abecause the first byte is between 0 and 127. The block has a netid of 17. The addresses range from17.0.0.0 to 17.255.255.255.
Limitationsofclassfuladdressing:Therearecertainlimitationsofclassful addressingwhicharementioned below. 1. Lack of internal address flexibility: Massive organizations are assignedlarge, 'monolithic'blocks ofaddresses thatdonotmatchwell

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 194 Material
withthestructureoftheirunderlyinginternalnetworks. 2. Inefficient use of address space: LimitedIP address space is wasted due to the existence of only three block sizes (classes A, B and C, repectively). 3. Proliferation of router table entries: With the growth of Internet, routers require more and more entries to handle the routing of IP datagrams, whichcauses performance problems forrouters ultimately affectingtheexecutionlevelofthetask.Attemptingtoreduceinefficient address space allocation leads to even more router table entries. Thesedifficultieswereaddressedpartiallythroughsubnetaddressing,which providesmoreflexibilityfortheadministratorsofindividualnetworksonaninternet.
Subnetting,however,doesn'treallytackletheproblemsingeneralterms.Someof these issues remain due to theuse of classes even with subnets. Classless Addressing Classfuladdressingresultedinefficient useofaddressspace.TheClassBaddress block contains a very large number of addresses (65,534) but a Class C block hasonlyarelativelysmallnumber(254). Therearemanythousandsof'medium-sized'organizationswhoneedmorethan254IPaddresses,butasmallpercentage oftheseneed65,534 oranythingevenclosetoit.Whensettingup theirnetworks, these companies and groups would tend to request Class B address blocks and not Class C blocks because theyneed more than 254, without considering how many of the 65,000-odd addresses they reallywould use and how may will go waste. The onlysolution to this would be to convince – or force – companies to use many smaller Class C blocks instead of 'wasting' the bulk of a Class B assignment.Manyorganizationsresistedthisduetothedifficultyinvolved,andthis causedtheothermainproblemthatsubnettingdidn'tsolve:thegrowthofInternet routing tables. ReplacingoneClass Bnetworkwith10 Class Cswouldmean ten times as manyentries for routers to keep the track of. It wasquiteobvious that aslongas therewereonlythreesizes ofnetworks, the allocation efficiency problem could never be properly rectified as it was permanent.Theonlysolutionleftwastoget ridoftheclassescompletely,infavor ofaclasslessaddressingscheme.Thissystemwouldsolveboththemainproblems of'classful'addressingnamelyinefficientuseofaddressspace,andtheexponential growthofroutingtables. This system of classless addressing was developed in the early1990s and formalized in 1993. The technologywas calledClassless Inter-Domain Routing (CIDR). In classless addressing, when a host orrouter needs to beconnected to the Internet, it is granted a block or range of addresses.Variable-length blocks are assignedthat belongto no class. Inthisarchitecture,theentireaddress space(232 addresses) is divided into blocks ofdifferent sizes (Figure 4.35).
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 195 Fig. 4.35 Address Space Conditions: 1. The addresses in the

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block must be contiguous. 2. The number of addresses in a block must be a power of 2. 3. Thefirst address must

beevenlydivisible bythe numberof addresses. A classless address is specified in CIDR or slash notation(Figure 4.36) Fig. 4.36 CIDR Notation wherex.y.z: IPaddress; n, integer that tells us how manybits are used for the network ID For example, consider the network specification 184.13.152.0/22. The '22' means this network has 22 bits for the network ID and 10 bits for the host ID. This is equivalent to specifying a network with an address of 184.13.152.0 and a subnet mask of 255.255.252.0 (Figure 4.37) Fig. 4.37 Subnet Mask
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 196 Material Fig. 4.38 Prefix Lengths ?

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First address: The first address of the block can be found bysetting the 32–nrightmost bits in

binarynotation to zero ? Lastaddress: Thelast address of theblockcanbefoundbysettingthe 32–n right most bits in binarynotation to one ? Number of addresses: 2 32–n Example: What is the first, last and number of addresses in the block if one of the addresses is 205.16.37.39/28? Solution: FirstAddress The prefix length is 28, which means that we must keep the first 28 bits as it is and change the remaining bits (4) to 0s. The following shows the process: Addressinbinary:1100110100010000 0010010100100111 Keeptheleft 28 bits:1010011111000111 1010101000100000 Result inCIDR notation: 205.16.37.32/28 LastAddress The prefix length is 28, which means that we must keep the first 28 bits as it is and change the remaining bits (4) to 1s. The following shows the process: Addressinbinary:1100110100010000 0010010100100111 Keeptheleft 28 bits:1010011111000111 1010101000101111 Result inCIDR notation: 205.16.37.47/28 Number of Addresses : 2 32-28 = 16 Under CIDR, all internet blocks can be of random size. Instead of having all networks use 8 (Class A), 16 (Class B) or 24 (Class C) bits for the network ID, we can have large networks with, say, 13 bits for the network ID (leaving 19 bits for the host ID), or very small ones that use 28 bits for the network ID (only 4 bits for the host ID). ? Benefits of classless addressing CIDR provides manyadvantages over the 'classful' addressing scheme, whether ornot subnetting is used:With this as foundation, the benefits of classless addressingareas follows. o Efficient address space allocation: Under CIDR, addresses are allocatedin sizes ofanybinarymultipleinstead offixed-sizeblocks of lowgranularity.Thisensuresinminimumwastageofaddressspace.So,

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 197 a company that needs 5,000 addresses can be assigned a block of 8,190 instead of 65,534 as shown in Figure 4.39. In other words, the equivalent of a single Class B network can be shared amongst eight companies that each need 8,190 or fewer IP addresses. Fig. 4.39 Efficient Address Space Allocation o Elimination of class imbalances: Under CIDR, the classes (A, B and C) do not exist anymore , so there is no problem of imbalances in the use of addresses with some portions of the address space being widelyused whileothers are neglected. o Efficientroutingentries:CIDR'smultiple-levelhierarchicalstructure allows asmall numberofroutingentries to represent alargenumberof networks. Network descriptions can be 'aggregated' and represented byasingle entry. Since CIDR is hierarchical, the detail of lower-level, smallernetworkscanbehiddenfrom routers thatmovetrafficbetween large groups of networks. o No separatesubnetting method: CIDR implements the concepts of subnettingwithintheinternetitself.Thereisnoseparatesubnettingmethod used.Anorganization can use thesamemethod used ontheInternet to subdivideitsinternalnetworkintosubnetsofarbitrarycomplexitywithout the need fora separatesubnettingmechanism. 4.4.2 Subnetting DuetotheexponentialgrowthoftheInternet,theprincipleofassignedIPaddresses became too rigid to allow easychanges to local network configurations. Those changesmightoccurwhen: ? a new typeof physical network is installedat a location. ? thereisagrowthofthenumberofhoststhatrequiresplittingthelocalnetwork into two or more separate networks.
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 198 Material ? growing distances requiresplittinga network intosmaller networks, with gateways between them. Adding an extra hierarchical level in the way IP addresses are currently interpreted formsthebasicideaofsubnetting.The concept ofanetwork remains unchanged, but instead of having just 'hosts' within a network,a new two-level hierarchyis created: subnets and hosts.Athree-level hierarchyis also created— there is a network, within the network is a subnet and there are hosts within the subnet. Each subnetis a subnetwork, and functions muchthe waya full network doesinconventionalclassfuladdressing. Thus, instead of an organization having to group all its hosts under that network inan unstructured manner, itcan organize hosts intosubnets that reflect the wayinternal networks are structured. These subnets fit within the network identifierassignedto theorganization, justas all the'unorganized'hosts usedto. Subnettingaddsanadditional leveltothehierarchyofstructuresusedinIP addressing.Athree-level hierarchyis createdforIPaddresses (Figure4.40).Now IP addresses mustbebroken into threeelements instead of two.This is achieved by leaving the network ID alone. The host number part of the IP address is subdividedintoasecondnetworknumberandahostnumber.Thissecondnetwork is termed a subnetwork ID or subnet ID. The main network now consists of a number of subnets. These subnet ID bits are used to identifyeach subnet within the network. Hosts are assigned to the subnets in a manner that makes the most sense for that network. The IP address is interpreted as: >network number<>subnet number<>host number< Fig. 4.40 Three-Level Subnet Hierarchy Fig. 4.41 Addresses with and without Subnetting The combination of subnet number and host number is often termed the local address or the local portion of the IP address.
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 199 In orderto do subnetting, thehost ID is split into subnet ID andhost ID. In doing this, the size of the host ID part of the address gets reduced. In short, bits from the host ID are being 'stolen'to use for the subnet ID. ClassAnetworks have 24 bits to split between the subnet ID and host ID: Class B networks have 16, and Class C networks only8 (Figure 4.42). Fig. 4.42 A Subnetted Network The division of the host ID that is a part ofthe IP address is used to define asubnetnumberandhost numberischosenbythelocal administrator.Any number of bits in the host IDcan be used to form the subnet. Thenumberofsubnetsistwotothepowerofthesizeofthesubnet IDfield. Similarly,thenumberof hosts persubnet is two tothe powerofthesize of the host IDfield (Figure 4.43). Fig. 4.43 Division of Host-Id Bits into Subnet-Id and Host-Id In Class B network 154.71.0.0 16 bits are for the network ID (154.71) and16 forthehost ID. Inregular'classful'addressingtherearenosubnets and 65,534 total hosts. In order to subnet this network, the local administrator can decide to split these 16 bits. However, it is upon his discretionwhatsuitsbesttotheneedsofthenetwork.Anycombinationwill work, as long as the total is 16: 1 bit for the subnet ID and 15 for the host ID, or 2 and 14, 3 and 13, and so on. The more the bits 'stolen' from the
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 200 Material host IDforthe subnet ID, moresubnets arepossible—but the fewer hosts will beavailableforeach subnet. Subnettingisassigned to an organizationorat themostfeworganizations. Eachorganization is assigned onenetwork numberfrom the IPv4address space.Theorganizationisthenfreetoassignaseparatesubnetworknumber for eachof its internal networks. This allows the organizationto organize additionalsubnetswithoutobtainingnewnetworknumberfromtheInternet. ? Subnet mask In subnetting,it is necessarytocommunicate,whichbits areforthesubnet ID and which for the host ID, to devices that interpret IPaddresses.A32- bit binarynumberwhich provides this information todevices handlingIP addresses is called a subnet mask. The subnet mask is a 32-bit binarynumberthat comes with anIP address. Like IP addresses, theyare usuallyconverted to dotted decimal notation for convenience. It is created in a way that it has a one bit for each corresponding bit ofthe IP address that is part of its network ID or subnet ID, and a zero for each bit of the IPaddress's host ID. The mask informs theTCP/IP devicesaboutthebits inaIPaddress thatbelongtothenetwork ID and subnet ID, and which are a part of the host ID. Fig. 4.44 Determining the Subnet Mask of a Subnetted Network Suppose there is a Class B network 154.71.0.0. It is decidedto subnet this using 5 bits for the subnet ID and 11 bits for the host ID. In this case, the subnet mask will have 16 ones forthe network portion (sincethis is Class B) followed by 5 ones for the subnet ID, and 11 zeroes for the host ID. That's '11111111 11111111 11111000 00000000'in binary, with the bits corresponding to thesubnet IDhighlighted.Convertingtodotteddecimal, the subnet mask would be 255.255.248.0. ? Applying thesubnet mask A mask is used to find out what subnet an IP address belongs to. Suppose there is ahost on this network with an IPof 154.71.150.42.Arouter needs to find out which subnet this addressis on. This is donebyperformingthe masking operation as shown in Figures 4.45 and 4.46.

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 201 Determining the Subnet ID of an IP Address Through Subnet Masking Component Octet 1 Octet 1 Octet 2 Octet 3 Octet 4 IP Address 10011010(154) 10011010(154) 01000111 (71) 10010110 (150) 00101010 (42) Subnet Mask 11111111(255) 11111111(255) 11111111 (255) 11111000 (248) 00000000 (0) Result of AND Masking 10011010(154) 10011010(154) 01000111 (71) 10010000 (144) 00000000 (0) Fig. 4.45 Applying the Subnet Mask Fig. 4.46 Using a Subnet Mask Touseasubnetmask,adeviceperformsabooleanANDoperationbetween each bit of the subnet mask and each corresponding bit of an IP address. Theresulting32-bit numbercontainsonlythenetworkIDandsubnetIDof the address, with the host ID cleared to zero. This result, 154.71.144.0, is the IP address of the subnet to which 154.71.150.42 belongs.
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 202 Material Default subnet masks for ClassA, Class B and Class C networks IP Address Class Total # Of Bits For Network ID / Host ID Default Subnet Mask First Octet Second Octet Third Octet Fourth Octet Class A 8 / 24 11111111 (255) 00000000 (0) 00000000 (0) 00000000 (0) Class B 16 / 16 11111111 (255) 11111111 (255) 00000000 (0) 00000000 (0) Class C 24 / 8 11111111 (255) 11111111 (255) 11111111 (255) 00000000 (0) Fig. 4.47 Default Subnet Masks for Class A, Class B and Class C Networks Since the local network administrator is able to customize his choice of dividingpoints between subnet ID and host ID tosatisfytherequirements ofthenetwork, thisis sometimes calledcustomizedsubnetting.Thesubnet mask that is used to create a customized subnet is called a custom subnet mask. Thecustom subnet mask is used bynetwork hardwaretodetermine how the local network administrator has decided to divide the subnet ID from the host ID in the network. ? Deciding how many subnet bits to use The crucial determining factor in customized subnettingis how to divide network ID into subnet ID and host ID. The local administrator has to decide on the number of bits to take from the host ID, portion of the IP address and put into the subnet ID.As mentioned earlier, the number of subnets possible on the network is two to the power of thenumber of bits
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 203 usedtoexpress the subnet ID, andthenumberof hosts possiblepersubnet is two to the power ofthe number of bits left in the host ID minus two. Thus, the decision of how many bits to use for subnet ID and host ID representsafundamentaltrade-offin subnet addressing: o Eachbit takenfromthehost IDforthesubnetIDdoublesthenumberof subnets that arepossible in the network. o EachbittakenfromthehostIDforthesubnetID(approximately)reduces byhalf thenumber of hosts that are possible within eachsubnet on the network. ? Subnetting bitallocation options The above conceptcan beillustrated bythefollowingexample. Imagine that we begin with a Class B network with the network address 154.71.0.0. Since this is Class B, 16 bits are for the network ID (154.71) and16areforthehostID.Inthedefaultcase,therearenosubnetsand65,534 hoststotal.Tosubnettheabovenetwork,thereareanumberofchoices. o We can decideto use 1 bit for the subnet IDand15 bits forthe host ID. If wedothis, then the total number ofsubnets is 2 1 or2: thefirst subnet is 0 andthe second is 1. The number of hosts availablefor each subnet is 2 15 –2 or 32,766. o We can use2 bits for the subnet ID and 14 for the host ID. In this case, wedoublethenumberofsubnets: wenow have2 2 or4subnets:00, 01, 10 and11 (subnets 0, 1, 2 and 3). But the number of hosts is now only 2 14 –2 or 16,382. o We can use anyother combination of bits that add up to 16, as long as theyallow us at least 2 hosts per subnet: 4 and12, 5 and 11, and so on. To divide the 'classful'host ID into subnet ID and host ID, bits is the key design decision in subnetting. The decision is primarilymade keeping in mind the requirements of the network as foreseen by the network administrator. The network administrator must choose, based on the requirements forthe numberof subnetsin thenetwork,andthe maximum number of hosts that need to be assigned to each subnet in the network. For example, suppose we have 10 total subnets for our Class B network. We need 4 bits to represent this, because 2 4 is 16 while 2 3 is only 8. This leaves 12 bits for the host ID, for a maximum of 4,094 hosts per subnet. However, suppose we have 20 subnets. If so, 4 bits for subnet ID won't suffice. Hence, we need 5 bits (2 5 =32). This means in turn that we now haveonly11bits forthehost ID, foramaximum of2,046hostspersubnet. ? Practical exampleof subnetting 1. Step1:Forsuccessfulsubnetting, thenetworkadministratormust start by taking cognizance of the present and future requirements of the network. The most important parameter to establish is the number of subnets required and the maximum number of hosts needed for each subnet.It is of paramount importance to keep in mind that numbers should be based not just on present needs but on the requirements in thenearfuture.
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 204 Material 2. Step2:DecidingHowManyBitstoUsefortheSubnetIDandHostID. EachbittakenfromthehostIDforthesubnet IDdoublesthenumberof subnets that arepossible in the network. EachbittakenfromthehostIDforthesubnetID(approximately)halves thenumberofhoststhatarepossiblewithineachsubnetonthenetwork. There are six possible ways this decision can be made for a Class C network,as illustratedin Figure 4.48. Fig. 4.48 Six ways of Deciding How many Bits to use for the Subnet ID and Host ID Therelationship between thebits andthe numberofsubnets and hosts isasfollows: o Thenumberofsubnets allowed in thenetworkis twotothepowerof the number ofsubnet ID bits. o The number of hosts allowed per subnet is two to the power of the numberof hostID bits, minus two. Suppose there is a Class C network, base address 211.77.20.0, with a total of7subnets. Themaximumnumber ofhosts persubnet is 25. Fig. 4.49 Deciding How many Bits to use for the Subnet ID and Host ID

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 205 If there is more than one combination of subnet ID and host ID sizes that meet requirements, the administrator shouldchoosea 'middle-of- the-road' option that best foresees future growth requirements. If no combination meetstherequirements, therequirementshavetochange. 3. Step 3: Determiningthe Custom Subnet Mask(Figure 4.50) Continuingwiththeaboveexample Fig. 4.50 Determining the Custom Subnet Mask 4. Step4:DeterminingSubnet Identifiers andSubnetAddresses The network ID assigned to the network applies to the entire network. This includes all subnets and all hosts in all subnets. There is a unique identifier for each subnet within a network called the subnet identifier orsubnetID.Thisistodifferentiatethesubnetfromtheothersubnetsin the network (Figure 4.51). RecallourClassCnetwork,211.77.20.0.Thenetworkaddressinbinaryis: 11010011 01001101 00010100 00000000 We are subnetting using 3 bits for the subnet ID, leaving 5 bits for the host ID.Nowlet's seethenetworkaddress withthesubnetbits inbold: 11010011 01001101 00010100 00000000 Subnet #2has a subnet IDof 2, or 010 in binary.To findits address we substitute "010"for the subnet IDbits, to give: 11010011 01001101 00010100 01000000, which is 211.77.20.64 in binary.
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 206 Material Fig. 4.51 Determining Subnet Identifiers and Subnet Addresses 5. Step 5: Determining HostAddresses for each Subnet Once the subnet addresses are known, these addresses can be used as thebasis for assigningIP addressestothe individual hostsin eachsubnet. TocontinuewiththeaboveClassCexample,211.77.20.0,thatwasdivided into 8 subnets using 3 subnet bits. The address appears as shown below with the subnet bits shown highlighted and the host ID bits shown highlightedandunderlined. 11010011010011010001010000000000 The first subnet is subnet #0, which has all zeroes for those subnet bits, and thus, the same address as the network, as a whole: 211.77.20.0. 1. The first host address has the number1 for the host ID,or '00001' in binary.So,it is: 11010011 01001101 00010100 00000001 In decimal, this is 211.77.20.1. 2. Thesecond hostaddress has thenumber2forthehostID,or'00010' inbinary.Itsbinaryvalueis: 11010011 01001101 00010100 00000010 In decimal, this is 211.77.20.2
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 207 Fig. 4.52 Determining Host Addresses for each Subnet ? Types of subnetting Therearetwotypes ofsubnetting: staticand variablelength. 1. Staticsubnetting:Staticsubnettingimpliesthatall subnetsobtainedfrom the same network use the same subnet mask. The advantage of static subnettingisthat it issimple toimplement andeasytomaintain.Theonly obviousdisadvantageisthatitmightwasteaddressspaceinsmallnetworks. Consider a network of four hosts using a subnet mask of 255.255.255.0. Thisallocationwastes250IPaddresses.Allhostsandroutersare required to support static subnetting. 2. Variable length subnetting: In variable length subnetting or Variable LengthSubnetMasks(VLSM),allocatedsubnetswithinthesamenetwork can use different subnet masks.Asmall subnet with onlya fewhosts can use a mask that accommodates this need. A subnet with many hosts requires a different subnet mask. The ability to assign subnet masks according to the needs of the individual subnets is useful in conserving networkaddresses.Variable length subnettingdividesthenetworksothat
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 208 Material each subnet contains sufficient addresses tosupport the requirednumber of hosts. Anexisting subnet can be split into two parts byaddinganother bit tothe subnet portion of the subnet mask. Other subnets in the network are not affected by the change. 4.4.3 Supernetting Supernetting allows the use of multiple IP networks on the same interface. Combination of multiple network addresses of the same Class into blocks is called Supernetting. If the IP networks are contiguous, you maybe able to use a supernet. If the IP networks are not contiguous, you would need to use sub- interfaces. Arequirementforsupernettingisthatthenetworkaddressesbeconsecutive and that theyfall on the correct boundaries.To combine two Class C networks, the first address' third octet must be evenlydivisible by2. If you would like to supernet 8 networks, the mask would be 255.255.248.0 and the first address' third octet needs to be evenly divisible by 8. For example, 198.41.15.0 and 198.41.16.0 could NOT be combined into a supernet, but you would be able to combine 198.41.18.0 and 198.41.19.0 into a supernet. An IP address is a 32-bit number (4 bytes, called 'octets', separated by periods, commonlycalled 'dots.') Supernetting is most often used to combine Class C addresses (the first octet has values from 192 through 223).Asingle Class C IP network has 24 bits for the network portion of the IP address, and 8 bits for the host portion of the IP address. This gives a possibility of 256 hosts within a Class C IP network (2 8 =256). The subnet mask for a Class C IP network is normally 255.255.255.0. To use a supernet, the number of bits used for the subnet mask is reduced. For example, by using a 23 bit mask (255.255.254.0—23 bits for the network portion of the IP network, and 9 bits for the host portion), you effectively create a single IP network with 512 addresses. Supernetting, or combining blocks of IP networks, is the basis for most routing protocols currently used on the Internet. For example: Consider two Class 'C' network numbers of 198.41.78.0 and 198.41.79.0. The addresses pass the prerequisites. Theyare consecutive and the third octet ofthefirst address isdivisibleby2 (78Mod2=0).Tofurtherillustratewhat is being done, let's look at the addresses in binary. The third octet of the first address (78) is 01001110. The second (79) is 01001111. The binaries are the same except forthe last bit ofthe address (the 24thbit of the IP address). The 78 network is supernet 0 and the 79 network is supernet 1. The subnet mask for this example supernet is 23 bits, or 255.255.254.0. All devices on the network MUSTbeusingthis subnet mask.Anydevice that is not usingthis subnet mask wouldbe unreachable.

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 209 CheckYourProgress 5. What isinternet protocol? 6. What do you understand bytheterm direct delivery? 7. DefineIPdatagram. 9. DefineIPaddressing. 9. Writetheprocess ofsubnetting. 10. Definesubnet mask. 4.5 OTHER NETWORK LAYER PROTOCOLS The third layer is the network layer, also called the internet layer in the TCP/IP model, where internetworkingprotocols are defined, the most notable beingthe Internet Protocol. The main job performed here is the address resolution, or providingmappings betweenlayertwo andlayerthreeaddresses.Thisresolution can be done in either direction, and is represented bythe two TCP/IP protocols namely, ARP(Address Resolution Protocol) and RARP(ReverseAddress Resolution Protocol). InTCP/IP, diagnostic, test and error-reportingfunctions at the network layer are performed bythe Internet ControlMessage Protocol (ICMP), which is like the Internet Protocol's 'administrative assistant'. The InternetGroup Management Protocol (IGMP) is a communication protocol used to manage the membership ofInternet Protocol multicast groups. IGMP is used by IP hosts and adjacent multicast routers to establish multicast group memberships.

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ARP is a network-specific standard protocol. It is used for convertingthe higher-level IP addresses to physical network addresses.

RARP is usedto find thelogical address for amachine that onlyknows its physical address. Fig. 4.53 ARP and RARP Figure4.54 showsthepositionofARPandRARPinTCP/IPprotocolsuite. Fig. 4.54 Position of ARP and RARP in TCP/IP Protocol Suite
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 210 Material 4.5.1 Address Resolution Protocol (ARP) On asinglephysical network, individual devices areidentifiedinthenetwork by theirphysicalhardwareaddress.Higher-levelprotocolsidentifydestinationhosts bytheir symbolicaddress known as IP address.When such ahigh level protocol wants to send a datagram to destination host with IPaddress w.x.y.z, the device driver does not understand this address.Thebasic functionofARPis totranslate the IPaddress to the physical address of the destination host.ARPuses a lookup table(sometimesreferredtoastheARPcache)tocarryoutthistranslation(Figure 4.55). In case the address is not found in theARPcache, anARPrequest is sent out in thenetwork.AnARPrequest is abroadcast message withaspecial format sent inthe network.AnARPreplyis generated byadeviceon thenetworkwhich recognizes its own IP address in the request. The reply contains the physical hardware address of the host and source route information (if the packet has crossed bridges on its path). TheARP cache of the requesting host is updated withthisnewinformation.Allsubsequentdatagramstothisdestination IPaddress can now be translated to a physical address by looking up the updated ARP cache,whichis used bythedevicedriverto sendout thedatagram inthenetwork. A4-6E-F4-59-83-AB Fig. 4.55 Address Resolution Protocol Working ofARP o

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ARP packet generation If an application wants to send data to a certain IP destination address, the IP routing mechanism first determinesthe IP address ofthe next hop of the packet (it can be the destination host itself, or a router) and the hardware device on which it should be

sent.
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 211 TheARPmodule tries to find the address inthisARPcache.Ifit finds the matchingpair,it givesa corresponding48-bitphysical addressbacktothe

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caller (the device driver), which then transmits the packet. If it does not find the pair in its table, it discards the packet (the assumption is that a higher-level protocol will retransmit) and generates a

networkbroadcast of anARP request. Fig. 4.56 ARP Packet Fig. 4.57 Encapsulation of ARP Packet ARP packet reception On receipt of an ARP packet (either a broadcast request or a point-to- point reply), the recipient device driver passes the packet to the ARP module which treats it as shown in Figure 4.58.
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 212 Material Swap source and target addresses in the ARP packet. Put my local addresses in the source address fields. Send back ARP packet as an ARP reply to the requesting host. Do I have the specified hardware type? No (discard) No (discard) No No No (discard) No (discard) Yes Yes Yes Yes Yes Yes End Do I speak the specified protocol? Is the pair > protocol type. sender protocol address< already in my table? Am I the target protocol address? Is flag = false? Is the opcode a request? Set flag = false. Update the table with the sender hardware address. Set flag=true. Add the triplet >protocol type, sender protocol and sender hardware< to table. Fig. 4.58 ARP Packet Reception The requestinghost will receive thisARPreply, andwill follow the same algorithm to treat it. As a result, its lookup table (ARP cache) will be updatedwith the hardwareaddress ofthe recipient device. Subsequently, when a higher-levelprotocol wants to senda packetto that host, theARP module will find the target hardware address and the packet will be sent to the correspondinghost (Figure 4.59). Example Ahost with IP address 130.23.43.20 and physical address B2-34-55-10- 22-10 has a packet to send to another host with IP address 130.23.43.25 andphysical addressA4-6E-F4-59-83-AB (which isunknowntothefirst host). The two hosts are on the same Ethernet network. Show theARP request and replypackets encapsulated in Ethernet frames. Solution:

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 213 Fig. 4.59 ARP Request and Reply Packets Encapsulated in Ethernet Frames ProxyARP Suppose there is an IP network that is divided into subnets and interconnected byrouters.Considering the 'old' IP routingalgorithm, no hostonthenetworkisawareoftheexistenceofmultiplephysicalnetworks. ConsiderhostsAand B, which are on different physical networks within the same IP network, and a router R between the two subnetworks as illustratedinFigure 4.60. Fig. 4.60 Hosts A and B and Router R When host A wants to send an IP datagram to host B, using the ARP protocol,it first has to determine the physical networkaddress of host B. Assuming, host B to be on the local physical network, hostAsends out a broadcastARPrequest to find out the physical address ofhost B. Host B does not receive this broadcast, but router R does. Router R is aware of subnets. It runs the subnet version of the IP routingalgorithm and is able to determine that the destination of the ARP request (from the target protocoladdressfield)isonanotherphysicalnetwork.TherouterRreplies to the request in lieu of host B. Router R will specify its own address in the replyand the datagram will be deliveredto Router R. The router will then forward such packets to the correct subnet.
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 214 Material HostAupdates its cache, and will send future IPpacketsfor host B tothe router R (Figure 4.61). Fig. 4.61 Proxy ARP Router 4.5.2 Reverse Address Resolution Protocol (RARP) Somenetwork hosts,such as diskless workstations,arenot awareoftheirownIP address when theyare booted. In order

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to determine their own IP address, they use a mechanism similar to ARP.

This mechanism is called ReverseAddress Resolution Protocol (RARP). The known parameter is

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the hardware address of the host and the IP address is the parameter

to be determined. It differs more fundamentallyfromARPinthefactthataRARPservermustexistinthenetwork (Figure4.62).Thisservermaintainsadatabaseofmappingsfromhardwareaddress to protocol address and is preconfigured. - - - - - Fig. 4.62 Reverse Address Resolution Protocol
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 215 4.5.3 Encapsulation TheIGMP messageis encapsulatedin anIP datagram,whichisencapsulatedina frame (Figure4.63). Fig. 4.63 Encapsulation of IGMP Message ? The IP packet that carries an IGMP packet has avalue of 2 in its protocol field. ? TheIPpacket that carries anIGMP packet has avalueof 1initsTTLfield. 4.5.4 Ethernet The IEEE 802.3 or CSMA/CD protocol was based on the specification called Ethernet, formallydeveloped byXerox andlater modified and acceptedbyIBM andDEC.Theprotocolisverysimple.Thestationwillingtotransmitinformation would listen to the cables before transmitting anything. If the cable is busy, the stationwaits untilit becomes idle.Iftwo ormorestationssimultaneouslystartthe transmission, the transmitted signals collide with each other. Under such circumstances, each transmitting station hears a collision message, waits for a random period, and repeats the transmissionprocess again. Dependingonthetypeofthetransmission mediaused, theEthernet canbe classifiedintothefollowingcategories.Theyare: Thick Ethernet or 10base5 A 10 Mbps cable is like a yellow hose. The maximum length of the cable is 2.5 meterswithdirectionmarkings.Thedirectionmarkingshelptofindoutwherethe cable goes. Thefollowingarethe characteristics ofthethickEthernet (10base5): ? Cable supportsa maximum distanceof500meters. ? It providesconnectivityto amaximumof 1024stations. ? Maximum distance covered by a network using thick Ethernet is 2.5 km. ? Maximum number ofstations supportedbytheEthernet is 1024. A medium-sized network based on Ethernet is shownin Figure 4.64.
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 216 Material Fig. 4.64 Baseband Ethernet All stationsareconnected to acoaxial cable.Agroupofstations connected to acable forms a segment.Adevice called repeater is used to link two network segments, whichare separated bylongdistance.Eachstation is connected to the Ethernet cable through a transceiver.Atransceiver is a transmitter-receiver pair, whichcan extractorinsert signals onacableinonedirection.Arepeaterconsists of twotransceivers. Hence, it is able to transmit andreceive both directions. Implementationof Ethernet GeneralimplementationofanEthernetisshowninFigure4.65.Thetwosignificant layers that are implemented are thephysical layer and thedata link layer. Thephysicallayerperformsthefollowingfunctions: (a) Encodingthedata:This processgenerates thesynchronization bits called preamblefor the data frameat the transmitter.At the receiver, it removes thepreamblefrom thereceived frame.Thephysical layer also performs the encoding and decodingof data. (b) Mediumaccess: The physical layer transmits and receives data by sensingtheidle channel. In theevent of a collisionthat has occurred onthechannelduringthetransmission,thephysicallayerrecognisesit andintimatesthis to thedatalink layer. Thedatalinklayerperformsthefollowingfunctions: (a) Dataencapsulation:Dataencapsulationincludesformationofframe, addressing, error detection. (b) Link management: This includes allocation of channels, collision avoidance, errordetectionresolvingcollision. Fig. 4.65 Ethernet Implementation The computer or station is connected to an Ethernet card. The Ethernet card consistsofa station interface, datapacket generator anda linkmanagement

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 217 unit.Thefirst two units formthedatalink layer.Theoutput oftheEthernet cardis connected to the data encoder/decoder, which in turn is connected to the transmissioncablethroughatransceiver.Thelinkmanagementunitoftheethernet card, data encoder/decoder, the transceiver and the transmission cable form the physicallayer. Ethernet frame format The IEEE 802.3 Ethernet frameformat is showninFigure 4.66. Fig. 4.66 Ethernet Frame Format Preamble:7-bytesynchronizationpattern,consistingofalternative0sand 1s is usedforreceiversynchronization. Start of frame: A 1-byte word similar to the preamble ends with two consecutive1 bits. Destination address:A6-bytes address specifies the station to which a packetisaddressed.Thisaddressmaybeanindividualaddressoragroupaddress. Sourceaddress:It isthe address ofthe packet-originatingstation. Its size is equivalent to thesizeofthedestination address. Length:Thisfieldgivesthelengthoftheactualdatabytestransmittedinthe informationfield.Sizeofthisfieldis2bytes. Informationfield:Thesizeoftheinformationfieldisavariable.Itmustbe a minimum of 46 bytes. In case it is less than 46 bytes, dummy frames (called 'pad')areincludedinplaceoftheinformationfieldtomakeuptheminimumlength. Theupperlimitfortheinformation fieldis 1500bytes. Frame check sequence: A 4-byte code used for the purpose of error- detection. It detects the presence of errors in the destination address, source address,lengthandinformationfields. Cheaper Net or Thin Net (10base2) Forlocal areanetworks that do notrequirethecapabilities ofacompleteEthernet system, the IEEE 802.3 standard committee has created a new standard called thinnet.ThedifferencesbetweentheEthernetandthecheapernetaregivenbelow. Thick Ethernet Cheaper netor Thin net Maximum segment length is 500 metres. Maximum length isupto 200 metres. Maximum number of nodes per segment is 100. Maximum number of nodes is 30. Maximum number of stations per network is 1024. Maximum stations per network is 1024. Node spacing is 2.5 metres. Node spacing is 0.5 metres. Network cable diameter is 0.4 inches. Cable diameter is 0.25 inches. Cable is connected through a vampire tap. BNC-T-connector is used to connect cables and N-series connector.

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 218 Material StarLAN (10BaseT) ThethirdvariationofIEEE802.3standardwasaStarLAN.Thisparticularstandard was originallyproposed byAT&T. Local area network switching, based on this standard operates at a data rate of 1 Mb per second. The twisted-pair cable alreadyusedintelephonelinescouldbeusedasatransmissionmedia.Treetopology is used to configure a StarLAN. Each group of stations is connected to a local hub. Hubs are connected in the form of a tree. The root of the tree is the header hub.Theconfigurationmaycontainupto5upwardlevelsofhubs.Thetransmitted message first reachesthelocal hub. Then it is transmittedupwarduntil it reaches theheaderhub.Fromthereitisbroadcasteddowntoallthestationsonthenetwork. Optical Fibre CSMA/CD LAN (10BaseF) Optical fibre version of CSMA/CD LAN has a number of advantages than the coaxialcableversionofEthernet.Theyhavegoodimmunitytotheelectromagnetic interference, low loss of power, high bandwidth and less weight, and high transmissionsecurity.HubsinanopticalfibreLANarewidelyseparated.However, it isexpensivewhileconsideringthecost ofcouplers andterminators. 4.6 ROUTING PROTOCOLS Internetworking involves connecting different physical networks. Providing connections between dissimilarnetworks is one of thebasic functions provided bytheIP.Asystem that performs this function iscalled an IProuter.AnIProuter isadevicethatattachestotwoormorephysical networksandtransfersdatagrams between the networks. A host sends data to a remote destination in the form of a datagram. The datagram travels from one router to another.The router forwards the datagram towards thefinal destination. Each routerchooses the next devicealongthe path to reach the destination. This next device is called the next hop device. The datagramtravelstillitreachesarouterconnectedtothedestination'sLANsegment. ThedestinationLANsegmentdiffersfromtheoneonwhichthesystemoriginally received the datagram, the intermediate host has forwarded (that is,routed) the IPdatagram from one physical network to another. To forward packets between network segments,it is theIProutingtable in each device that is used. The basic table contains information about a router's locallyconnected networks. The configuration ofthe device can be extended to containinformationdetailingremotenetworks.Thisinformationprovidesamore completeviewoftheoverallenvironment.Routingtablescanbestaticordynamic. InaStaticRoutingTable,informationisenteredmanually.Theadministrator enters theroutefor each destination into thetable.AstheInternet changes, static routing table is not automaticallyupdated.Astatic routingtable can beused in a small network that does not changeveryoften.

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 219 DynamicRoutingTableisupdatedperiodicallyandautomaticallyusingone of dynamic routingprotocols such as RIP, OSPF orBGP.All tablesin the routers areupdatedautomaticallybydynamicroutingprotocolswheneverthereisachange intheInternet. Commonfieldsinaroutingtable(Figure4.67): ? Mask: Defines mask applied for the entry ? Network address:Address of the destination host ? Next-hop address: Address of the next hop router to which packet is delivered ? Interface: Name of the interface ? Flag: This field defines five flags – U(up):Router is up and running – G(Gateway): Destination is in other network – H(Host specific):Entryin network address is ahost specific address – D(Addedbyredirection):Routinginformationforthisdestinationhas been added to the routing tablebya redirection messagefrom ICMP – M(Modifiedbyredirection):Routinginformationforthisdestination has been modified bya redirection message from ICMP ? Reference count: Number of users of the route at the moment ? Use: Shows the number of packets transmitted through this router for thecorrespondingdestination. Fig. 4.67 Routing Table A routing protocol is characterized as robust if it provides the ability to dynamicallybuildandmanagetheinformationintheIProutingtable.As changes occur in thenetwork topology, theroutingtables are updated withminimal or no manualintervention. Autonomous Systems AnAutonomousSystem(AS)isdefinedasalogicalportionofalargerIPnetwork (Figure4.68).AnASnormallyconsistsofaninternetworkwithinanorganization. Itisadministered byasinglemanagementauthority.

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 220 Material Router Router Router Router Router Router Router Router Router IGPs Autonomous System A Single Management Authority Autonomous System C IGPs EGP Internet Autonomous System B IGPs Fig. 4.68 Autonomous Systems 4.6.1 Routing Protocols Someroutingprotocols areused todetermineroutingpaths withinanAS.Others areusedtointerconnect different autonomous systems: ? InteriorGatewayProtocols(IGPs):ThesearereferredtoasIntraDomain Protocols.InteriorGatewayProtocolsallowrouterstotransmitinformation within an AS. Examples of these protocols are Open Short Path First (OSPF)and RoutingInformation Protocol (RIP). ? Exterior Gateway Protocols (EGPs): These are referred to as InterDomain Protocols. ExteriorGatewayProtocols interconnectdifferent autonomous systems. Theyallow the exchange of summaryinformation betweenautonomous systems.An exampleofthis typeofroutingprotocol is Border GatewayProtocol (BGP) (Figure 4.69). Fig. 4.69 Types of Routing Protocols Unicasting Communication between one source and one destination is known as unicast. There is aone to one relationship between source and destination. Inthis type of
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 221 communication, both thesource and destinationaddresses are unicast addresses (Figure 4.70). Fig. 4.70 Unicasting In unicasting, the router forwards thereceived packet through onlyone of itsinterfaces. 4.6.2 Types of IP Routing and IP Routing Algorithms Themainfunctionofroutingalgorithmsistobuildandmaintaintheiproutingtable on a device. There are two primarymethods used to build the routing table. ? Staticrouting:Staticroutingusesfixeddefinitionsrepresentingpathsthrough thenetwork. ? Dynamicrouting:Indynamicrouting,algorithmsrouterscanautomatically determineand maintainknowledgeof thepaths throughthenetwork.This automaticdiscoverycanuseanumberofcurrentlyavailabledynamicrouting protocols. The protocols are differentiated on the basis of the way they determine and compute new routes to destination networks. Theycan be classifiedintofourbroadcategories: (i) Distancevector protocols (ii) Link state protocols (iii) Path vector protocols (iv) Hybrid protocols 1. Static Routing Staticroutingis manuallyperformed bythenetworkadministrator.Itisthe responsibilityoftheadministratortodetermineandbroadcastroutesthrough the network. These definitions are, then, manuallyprogrammed in every routingdevicein thenetwork. The routers in the network do not communicate with each other about the changing topologyof the network.After a device has been configured, it simplyforwards packets to the predetermined ports. Static routing is relatively simple and easy to administer in a small non redundant network which does not change frequently.However, there are several disadvantages tothis approachformaintainingIP routingtables: ? Static routes require a considerable amount of co-ordination and maintenanceinnon-trivial networkenvironments.
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 222 Material ? In Static Routing,ifthe current operational state ofthe networkchanges, static routes cannot adapt to it. For example, ifa destination subnetwork becomes unreachable, the change is not reflected in the routing table. Thestaticroutespointingtotheinaccessiblenetworkremainintherouting table. Traffic continues to be forwarded towards that destination. The network administrator has to manually make the change. Unless the networkadministratorupdatesthestaticroutestoreflectthenewtopology, traffic is unable to use any alternate paths that may exist. Normally, static routes are used only in simple network topologies.
However,thereareadditionalcircumstanceswhenstaticroutingcanprove to be of greater use. For example, static routes canbe used: ? Todefineadefaultroutemanually.Whentheroutingtabledoesnotcontain a more specific route to the destination, a default route is usedto forward traffic. ? To define a route that is not automaticallyadvertised within a network. ? Whenitisundesirabletosendroutingadvertisementtraffictthroughlower- capacityWANconnections because ofutilization or line tariffs. ? To define complex routing policies. Static routing can be used to create predetermined paths to a certain host. For example, static routes can be used to forward traffic to a specific host through a designated network path. ? To provide a more secure network environment. Since automatic update is not possible, the administrator has more control over the network.The administrator is aware of all subnetworks defined in the network. The administrator has the final authority over all communication permitted between these subnetworks. ? To provide more efficient resource utilization. Static Routing is more efficient because this method of managing a routing table requires no networkbandwidth to advertise routes between neighbouringdevices. It also uses less processor memory and CPU cycles to calculate network paths. 2. Distance Vector Routing Asperdistancevectorrouting,theroutewiththeminimumdistancebetween two nodes is the route with the least cost. In this protocol, each node maintainsatableofminimumdistancesto everynode. Distance vectoralgorithmsareexamples ofdynamicroutingprotocols. In distance vector algorithms, each device in thenetwork can automatically construct andmaintain alocalIProutingtable. Thereisaverysimpleprinciplebehinddistancevectorrouting.Eachdevice in the network maintains a distance vector table. In the distance vector table, the device maintains the distance or cost from itself to a known destination. This value shows theattractivenessofthe path. Theleast cost path is more desirable than a path with a higher value. The least cost path becomes the chosen path to reach the destination.

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Thetableisperiodicallyadvertisedtoeachneighbouringrouter.Eachrouter processes these advertisements to establish the best paths through the networkandcontinuallyupdatetheirtables. Distancevectoralgorithmsareadvantageous becausetheyaresimple,easy toimplementanddebug.Theyareveryusefulinsmallnetworkswithlimited redundancy. However, there are several disadvantages with this type of protocol,someofwhich are mentioned below. ? During an unfavourable condition, the length of time for everydevice in the network to produce an exact routing table is called the convergence time. This time can be excessive in large, complex internetworks using distance vector algorithms. While the routing tables are converging, networksarevulnerableto inconsistent routingbehaviour.Thiscancause routingloops or other types of unstable packet forwarding. ? Inordertoreduceconvergencetime,alimitisoftenplacedonthemaximum numberofhopscontainedin asingleroute.Pathsthat arevalidbut exceed this limit ofhops cannot be used in distance vector networks. ? Devices periodically advertise their distance vector routing tables to neighbouring devices. Theyare sent even if no changes have been made to the contents of the table. This is not efficient because this can cause noticeableperiodsofincreasedutilizationinreducedcapacityenvironments. RIP is apopular example of a distancevector routingprotocol. 3. Link State Routing Link State Routing algorithms are based on the principle of a link state to establishnetworktopology.Alinkstateisthedescriptionofaninterfaceon a router, such as IP address, subnet mask, type of network and its relationshiptoneighbouringrouters.Thecollectionoftheselinkstatesforms a link state database.
Thefollowingistheprocessusedbylinkstatealgorithmstodeterminenetwork topology. (i) All other routing devices on the directly connected networks are identifiedbyeach router. (ii) Eachroutermaintainsinformationaboutalldirectlyconnectednetwork linksandtheassociatedcostofeachlink.Thisinformationisadvertised to neighboring devices. This is carried out through the exchange of linkstateadvertisements (LSAs)with otherrouters inthenetwork. (iii) Each router uses these advertisements to create a database detailing the current network topology. The topologydatabase in each router issimilar. (iv) Using the DijkstraAlgorithm and the information in the topology database each router computes the most desirable routes to each destinationnetwork.ThisinformationisusedtoupdatetheIP routing table.
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 224 Material Fig. 4.71 Link State Routing

nodeisunlikebecausethecalculationsarebasedondifferentinterpretations of the topology. 4. DijkstraAlgorithm(Shortest-PathFirst(SPF)Algorithm) The SPF algorithm is used to process the information in the topology database (Figure4.72). The SPF algorithm provides a tree-representation ofthenetwork.ThedevicerunningtheSPFalgorithmistherootofthetree. The output ofthe algorithm is thelist ofshortest-paths toeach destination network. Fig. 4.72 Dijkstra Algorithm
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 225 Figure 4.73 shows the process of the formation of a shortest path tree. Fig. 4.73 Example of Formation of Shortest Path Tree Figure 4.74 shows a routing table for nodeA. Fig. 4.74 Routing Table for Node A The OSPF protocol is a popular example of a linkstate routing protocol. 5. Path VectorRouting This type of routing is mainly used in routing traffic between different AutonomousSystems.EachAutonomousSystemcontainsatleastonenode called the speaker node. This speaker node creates a routing table and advertises it to the speaker nodes in neighbouring autonomous systems. Onlythepath is advertised, the metrics of the node are not advertised.
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 226 Material A route is defined as a pairing between a destination and the attributes of the path to that destination, thus the name, path vector routing, where the routers receive a vector that contains paths to a set of destinations. Thepathisexpressedintermsofthedomains(orconfederations)traversed so far.Aspecial path attribute that records the series of routing domains throughwhichthereachabilityinformationhaspassedcarriesthepath.The preferredpathtoreachthedestinationisthepathrepresentedbythesmallest numberofdomains. ? Initialization Fig. 4.75 Path Vector Routing At the beginning, each speaker node knows onlythe paths inside its own autonomous system. NodeA1 is the speaker node forAS1, B1 forAS2, C1 for AS3, and D1 for AS4. Each node creates an initial table that shows paths within the autonomous system. NodeA1 creates an initial table that showsA1 toA5 are located inAS1andcan be reached through it. Node B1 creates an initial table that shows B1 to B4 are located in AS2 and can be reached through it (Figure 4.75). ? Sharing Eachspeakernode sharesitsinitialtableswithotherspeakernodes.Node A1shares its tables with Node B1and C1. Node C1shares its tables with Node B1and D1 andA1. Node B1 shares its tables with NodeA1and C1. Node D1 shares its tables with Node C1. ? Updating A speaker node in the autonomous system updates its own routing table when it receives a two-column routing table from a neighbor on the different autonomous system. The table is updated by adding the nodes thatare not in itsroutingtable andaddingitsownautonomoussystemand autonomous system that sent the table. After completing the update process, each speaker node has a routing table that contains paths to

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 227 reach nodes within the autonomous system and between different autonomous systems (Figure 4.76). Fig. 4.76 Updation in Path Vector Routing IfrouterA1 receives apacketfornodeA3, itknows that thepathis inAS1; but if it receives a packet for D1, it knows the packet has to go fromAS1, toAS2 and then toAS3. If node D1 inAS4 receives a packet for nodeA2, it knows it should go throughAS4,AS3 andAS1. The major advantage of a path vector protocol is its flexibility.There are several otheradvantages of using apath vector protocol. ? PathVectorProtocol involveslesscomplexityincomputationthanthat of the Link State Protocol.To compute a path vector, a newlyarrived route is evaluated and compared to the existing one, while to compute a link state, it is necessary to execute an SPF algorithm. ? In Path vector routing, it is not essential for all routing domains to have homogeneous policies for route selection.Arouting domain maynot be aware ofthe route selection policies used byotherrouting domains.The supportforheterogeneousrouteselectionpolicieshasseriousimplications for computational complexity. In path vector protocol, each domain is allowed to select routes independently.This route selectionis basedonly onlocalpolicies.However,littleadditionalcostisincurredtoaccommodate heterogeneous route selection. ? It is more efficient because only the domains whose routes are affected by the changes have to recompute. ? Suppressionofroutingloopsis implementedthroughthepathattribute,in contrast to link state and distance vector, which use a globally-defined monotonically, thereby, increasing,metric forroute selection.Therefore, differentconfederation definitionsare accommodatedbecauseloopingis avoided bythe use offull path information. ? InPathvectorrouting,informationisdistributedaftercomputationofroute. Consequently,onlyroutinginformationassociatedwiththeroutesselected bya domainis distributed to adjacentdomains. ? In Path vector routing, information can be selectivelyhidden. The majordisadvantages ofpath vectorroutingare: 1. Whenthenetwork topologychanges, onlythose routeswhichareaffected by the changes are recomputed. This is more efficient than complete recomputation.However,becausefullpathinformationisincludedineach

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 228 Material distance vector, the effectofa changein networktopologycanpropagate fartherthan in traditional distancevector algorithms. 2. Unlessthenetworktopologyisfullymeshedorisabletoappearso,routing loops can become an issue. BGP is a popular example of a path vector routing protocol. 6. HybridRouting Thelastcategoryofroutingprotocolsis hybridprotocols.Inhybridrouting protocols, there is an attempt to combine the positive attributes of both distance vector and link state protocols. Hybrid protocols use metrics to assign a preference to a route as done in distance vector. However, the metrics are more precise than conventional distance vector protocols. In hybridprotocols,asinlinkstatealgorithms,routingupdatesarenotperiodic. Theroutesareupdatedonlywhenthenetworktopologychanges.Networks thatusehybridprotocolsarelikelytoconvergemorequicklythannetworks usingdistancevectorprotocols. Finally, theseprotocols potentiallyreduce the costs of link state updates and distance vector advertisements. Although open hybrid protocols exist, this categoryis almost exclusively associated with the proprietary EIGRP algorithm developed by Cisco Systems, Inc. 4.7 TCP SERVICES AND APPLICATIONS 1. Process-to-process communication TCP provides process-to-processcommunication usingport numbers. Table 4.1 Ports Commonly used by TCP

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 229 2. Stream delivery service TCP is a connection-oriented protocol that is accountable for realiable communication between end to end processes. It

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allows the sendingprocess to deliver data as a stream of bytes and allows the receiving process to obtain data as a stream of bytes. TCP creates an environment in which twoprocesses can be connected byan imaginary tube.

The sending process produces (writes to) the streamofbytesandthereceivingprocessconsumes(readsfrom)them.Thedelivery process of the data would fail if the connection is not made or the connection is terminatedontheeitherend(Figure4.77). Fig. 4.77 Stream Delivery Service SendingandreceivingbuffersThesendingandreceivingprocessesmayread orwritedataat varyingspeed.TocounterthisTCPneeds bufferforstorage,there aretwobuffers,thesendingbufferandhereceivingbuffer,oneforeachdirection. Onewaytoimplementabufferistouseacirculararrayof1-bytelocations(Figure 4.78). Fig. 4.78 Sending and Receiving Buffers 3. Segments The IPlayer, as a service provider forTCP, needs to send data in packets, not as stream of bytes.At the transport layer, TCPgroups a number of bytes together into a packet called a segment. TCP adds a header to eachsegment and delivers thesegment totheIP layerfortransmission.Thesegments areencapsulatedinIP datagrams and transmitted (Figure4.79).

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 230 Material Fig. 4.79 Segments 4. Fullduplexcommunication TCPprovidesforconcurrentdatastreamsinbothdirections.EachTCPhassending andreceivingbufferandsegmentsmovebi-directionally. 5. Connection-oriented service TCPis a connection-oriented protocol. When a process at siteAwants to send andreceivedatafromanotherprocessatsiteB,aconnectionisestablishedbetween thetwoandsubsequently,dataisexchangedinbothdirectionsandtheconnection isterminated. Thisis avirtualconnection notaphysicalconnection. 6. Reliable service TCP guarantees reliable services.

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TCP assigns a sequence number to each byte transmitted, and expects a positive acknowledgment (ACK) from the receiving TCP layer. If the ACK is not received within a timeout interval, the data is retransmitted. Becausethedataistransmittedinblocks (TCP segments),onlythe sequence number of the first data byte in the segment is sent to the destination host. 4.7.1

TCP Features Toacknowledgesafedeliveryofpackets,TCPprovideswell-organized,efficient and responsible mechanisms. It implements the followingfeatures to ensure the same. 1. Numbering system ? Byte number: TCP numbers the bytes of data being transferred to each connection. Numberingis independent in eachdirection. The numbering startswitharandomlygenerated number.Arandomnumberbetween0and 2 32. -1 is the number of the first byte. ? Sequence number:After the bytes have been numbered, TCPassigns a sequencenumbertoeachsegmentthatisbeingsent.Thevalueinthesequence numberfieldofasegmentdefinesthenumberofthefirstdatabytecontained inthatsegment. ? Acknowledgementnumber: Thevalue oftheacknowledgment fieldina segment definesthenumberofthenext bytearecipientexpectsto receive. Theacknowledgmentnumberiscumulative,whichimpliesthattherecipient
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 231 takes the number of last byte it has received, safe and sound. Then the value is changed by adding one to it, and announces this as the acknowledgementnumber. 2. Flowcontrol Flowcontrolisoneoftheimportantparaphernaliasthat TCPprovides.Thereceiver of the data controls the amount of data that is being sent by the sender. This is done to prevent the receiver from being overwhelmed with data. In this manner, thesenderrestricts the data transmission to the recipient. Thenumberingsystem allows TCP to use a byte-oriented flow control. 3. Errorcontrol To providereliableservice,TCPimplements errorcontrolmechanism.This also ensure the authenticity and integrityof the receiving data. Error-control is byte oriented. 4. Congestion control TCP takes into account congestion in network. The amount of data sent by a senderisnot onlycontrolled bythereceiver,but isalsodeterminedbythelevel of congestion inthenetwork. 4.7.2 TCP Segment A packet in a TCP is called asegment (Figure 4.80). Fig. 4.80 TCP Segment
Thevariousconstitutingtermsaredefinedasfollows: Sourceport The16-bitsourceportnumber,usedbythereceivertoreply. Destination port The 16-bitdestinationport number. Sequence number Thesequencenumberofthefirst databyteinthis segment. If the SYN control bit is set, the sequence number is the initial sequence number (n) and the first data byteis n+ 1. Acknowledgment IftheACKcontrol bit isset,this fieldcontains thevalueof the number next sequence number that the receiver is expecting to receive.
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 232 Material Data offset Thenumberof32-bit words intheTCPheader.It indicates where the data begins. Reserved The six bits reserved for future use; must be zero. URG This indicates that the urgent pointer field is significant in thissegment. ACK Thisindicatesthattheacknowledgmentfieldissignificantin thissegment. PSH Pushfunction. RST Resets theconnection. SYN Synchronizesthesequencenumbers. FIN No more data from the sender. Window Used in ACK segments. It specifies the number of data bytes, beginning with the one indicated in the acknowledgmentnumberfieldthat thereceiver(thesender ofthissegment)iswillingtoaccept. Checksum The16-bitone'scomplementoftheone'scomplementsum of all 16-bit words in a pseudo-header, the TCP header, and the TCP data. While computing the checksum, the checksum field itselfisconsideredzero. Urgentpointer Points to thefirst dataoctet followingtheurgent data.Only significantwhentheURGcontrolbitisset. Options Just as in the case of IP datagram options, options can be either: – asinglebytecontainingtheoptionnumber;avariablelength option. 4.7.3 A

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TCP Connection TCP stands for Transmission Control Protocol. It is connection-oriented.

A connection-orientedtransportprotocolestablishesavirtualpathbetweenthesource anddestination.Allofthesegmentsbelongingtoamessagearethensentoverthis virtualpath.Aconnection-orientedtransmissionrequiresthreephases:connection establishment,datatransferandconnectiontermination. 1. Connection establishment The connection establishment in TCP is called three-wayhandshaking (Figure 4.81). Theprocess startswith theserver.Theserverprogramtells itsTCPthatitis readytoacceptthe connection.This iscalledarequest forpassiveopen.Although theserver TCP is readyto accept anyconnection from anymachinein the world, itcannotmakethisconnection itself. The client programissues arequest foran active open.Aclient that wishes to connect to an open server tells its TCP that it needs to be connected to that particular server.TCPcan now start thethree-wayhandshaking process.
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 233 Fig. 4.81 Three-way Handshaking ? ASYNsegment cannot carrydata, but it consumes onesequence number. ? ASYN+ACKsegmentcannotcarrydata,but doesconsumeonesequence number. ? AnACK segment, if carrying no data, consumesno sequence number. 2. Data transfer

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After connection is established, bi-directional data transfer can take place. The client and server can both send data and

acknowledgements. The sending TCP uses a buffer to store the stream of data coming from the sending application program(Figure4.82).ThesendingTCPcanselectthesegmentsize.Thereceiving TCP also buffers the data when theyarrive and delivers them to the application program when theprogram is ready. Fig. 4.82 Data Transfer

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 234 Material 3. Connectiontermination Any of the two parties involved in exchanging data can close the connection, althoughtheclientinitiatesit(Figure4.83). Fig. 4.83 Connection Termination Closingtheconnection is done implicitlybysendinga TCPsegment with theFINbit (no moredata)set. Becausetheconnectionisfullduplex (thatis,there are two independent data streams, one in each direction), the FIN segment only closes the data transfer in one direction. The other process will now send the remainingdata,it still hastotransmitand alsoendwithaTCP segmentwherethe FIN bit is set. The connection is deleted (status information on both sides) after the datastream is closed in both directions. ? TheFINsegment consumes onesequencenumberifit doesnotcarrydata. ? The FIN +ACK segment consumes one sequence number if it does not carrydata. 4. Half close InTCP,oneendcan stopsendingdatawhilestillreceivingdata.Thisiscalledhalf close. InFigure4.84,theclienthalf-closestheconnectionbysendingaFINsegment inthemiddleofdatatransmission.Theserveracceptsthehalfclosebysendingthe ACKsegment.Thedatatransferfromservertoclient stops.Theserver,however, canstill send data. When theserver has sent alltheprocessed data, itsends aFIN segment, which isacknowledged byanACKfrom theclient.

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 235 Fig. 4.84 Half Close 4.7.4 State Transition Diagram Table 4.2 States of TCP

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 236 Material Fig. 4.85 State Transition Diagram The two transitions leading to the ESTABLISHEDstatecorrespondto the openingofaconnection,andthetwotransitionsleadingfromtheESTABLISHED state arefor the termination ofa connection.TheESTABLISHEDstate is where the data transfer can occur between the two ends in both the directions. If a connection is in the LISTEN state and a SYN segment arrives, the connection makes a transition to the SYN_RCVD state and takes the action of replyingwithanACK+SYNsegment.Theclientdoesanactiveopenwhichcauses its end ofthe connection to senda SYN segment tothe server and tomove to the SYN_SENT state. The arrival of the SYN+ACK segment causes the client to move to the ESTABLISHED state and to send an ack back to the server. When thisACKarrives the server finallymoves to the ESTABLISHED state. In other words, we have just traced theTHREE-WAYHANDSHAKE. In the process of terminating a connection, the important thingto bear in mind is that the application process on both sides of the connection must independently close its half of the connection. Thus, on anyone side, there are three combinations oftransition that get a connectionfrom the ESTABLISHED state to the CLOSED state: ? Thissideclosesfirst: ESTABLISHED ? FIN_WAIT_1 ? FIN_WAIT_2 ? TIME_WAIT ? CLOSED. ? Theothersidecloses first: ESTABLISHED ? CLOSE_WAIT ? LAST_ACK ? CLOSED. ? Both sides closeat the same time: ESTABLISHED ? FIN_WAIT_1 ? CLOSING ? TIME_WAIT ? CLOSED.

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 237 Themainthingtorecognizeaboutconnectionteardownisthataconnection in theTIME_WAITstate cannot move to the CLOSED state until it has waited fortwotimes,themaximumamountoftimeanIPdatagrammightliveintheInter net. The reason for this is that while the local side of the connection has sent an ACKinresponseto theotherside's FIN segment,itdoes not know thattheACK wassuccessfullydelivered.Asaconsequence,theothersidemightre-transmitits FIN segment, and this second FIN segment might be delayed in the network. If theconnectionwereallowed tomovedirectlytotheCLOSEDstate,thenanother pair of application processes might come along and open the same connection, andthedelayedFINsegmentfromtheearlierincarnationoftheconnectionwould immediatelyinitiatetheterminationofthelaterincarnationofthatconnection. 4.7.5 Flow Control TCP carefully keeps track of the data it sends and what happens to it. This managementofdataisrequiredtofacilitatetwokeyrequirementsoftheprotocol: ? Reliability:Ensuringthatdatathatissent,actuallyarrivesatitsdestination, and if it fails, diagnozing and detecting the discrepancyand re-sends the data tothe destination. ? Dataflow control: Managingthe rate at whichdata is sent, sothat it does notoverwhelmthereceivingdevice. To accomplish these tasks, the entire operation of the protocol is oriented around something called the sliding window acknowledgement system. Abasictechniqueforensuringreliabilityincommunicationsusesarulethat requires a device to send back an acknowledgement each time it successfully receives a transmission. If a transmission is not acknowledged after a period of time, the device is re-transmitted by its sender. This system is called positive acknowledgement with retransmission (PAR) (Figure 4.86). One drawback with this basicschemeis that thetransmitter cannot sendasecond message until the first has been acknowledged. Fig. 4.86 Positive Acknowledgement with Retransmission (PAR)

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 238 Material The basic PAR reliability scheme can be enhanced by identifying each message to be sent, so multiple messages can be in transit at once. The use of a send limit allows the mechanism to also provide flow control capabilities, by allowingeach device to control therate at which thedata is sent. TheTCPslidingwindowsystemisavariationontheenhancedPARsystem, with changes made to support TCP's stream orientation. Each device keeps a trackofthestatusofthebytestreamitneedstotransmitbydividingthemintofour conceptualcategories: 1. Bytessentandacknowledged: Theearliest bytes in the stream will have beensent andacknowledged. Thesearebasically'accomplished'from the standpoint of the device sending data. For example, let's suppose that 31 bytes of data have alreadybeen sent and acknowledged. Thesewould fall into Category#1. 2. Bytes sent but not yet acknowledged: These are certain bytes that the device has sent but for which it has not yet received an acknowledgment. The sender cannot consider these "accomplished" until they are acknowledged. Let's saythere are 14 bytes here, in Category#2. 3. Bytes not yet sent for which recipient is ready: These are bytes that have not yet been sent, but for which the recipient has room, based on its mostrecentcommunicationtothesenderofhowmanybytesitiswillingto handle at once. The sender will tryto send these immediately(subject to certain algorithmic restrictions that we shall explorelater). Suppose there are 6 bytes in Category #3. 4. Bytes not yet sent for which recipient is not ready: These are certain bytesfurther'downthestream'whichthesenderis not yetallowedtosend because the receiver is not ready.There are 44 bytes in Category#4. Fig. 4.87 TCP Sliding Window System Oncethedevicesareready,itisnowtimefordatatransmission.Thereceiving device uses a similar parameters to differentiate between data received and acknowledged, not yet received but readyto receive, and not yet received and not yet readyto receive. In fact, both devices maintain a separateset of variables bysegregating and keeping a track of the categories into which bytes fall in the stream; theyare sending as well as the one theyare receiving. The senderand receiver must mutuallyagree on the sequencenumbers to assign tothebytes in the stream.This is calledsynchronizationandis donewhen theTCPconnectionissuccessfullyestablished. In our example, the byte ranges for thefour categories are:

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 239 1. Bytes sent and acknowledged: Bytes 1–31. 2. Bytes sent but not yet acknowledged: Bytes 32–45. 3. Bytes not yet sent for which recipient is ready: Bytes 46–51. 4. Bytes not yet sent for which recipient is not ready: Bytes 52–95. ? The SendWindowand UsableWindow The key to the operation of the entire process is the number of bytes that therecipientisallowingthetransmittertohaveunacknowledgedatonetime.This is called the send window, or often, just the window. The window is what determines howmanybytes the sender is allowed to transmit, and is equal to the sum of the number of bytes in Category#2 and Category#3. Thus, the dividing line between thelast two categories (bytes not sent that recipient isreadyfor and ones it isnot readyfor)isdeterminedbyaddingthewindowtothebytenumberof the first unacknowledged byte in the stream. In our example above, the first unacknowledged byte is #32. The total windowsizeis 20. Fig. 4.88 The Send Window and Usable Window Theterm usablewindow is defined astheamount of datathe transmitteris stillallowedtosendgiventheamountofdatathatisoutstanding.Itis,thus,exactly equal to the size of Category#3. Let'ssupposethatinourexampleabove,thereisnothingstoppingthesender fromimmediatelytransmittingthe6bytesintheCategory#3(theusablewindow). Whenitdoes so, the6bytes will shift fromCategory#3 toCategory#2.The byte ranges willnowbeasfollows: 1. Bytes sent and acknowledged: Bytes 1–31. 2. Bytes sent but not yet acknowledged: Bytes 32–51. 3. Bytes not yet sent for which recipient is ready: None. 4. Bytes not yet sent for which recipient is not ready: Bytes 52–95.

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 240 Material Fig. 4.89 Sliding Window Sometimelater, thedestination devicesends back amessageto thesender providingan acknowledgment. It will not specificallylist out thebytes that have been acknowledged, because as we said before, doing this would be quite inefficient.Instead,itwillacknowledgearangeofbytesthatrepresentsthelongest contiguous sequence of bytes received since the ones it had previously acknowledged. For example, suppose the bytes alreadysent but not yet acknowledged at thestartoftheexample(32–45)weretransmittedinfourdifferentsegments.These segments carried bytes 32–34, 35–36, 37–41 and 42–45, respectively.The first, second and fourth segments arrived, but thethird did not. Thereceiver will send back an acknowledgement only forbytes 32–36 (32–34and 35–36). It will hold bytes42–45butnot acknowledgethem,becausethiswouldimplyreceiptofbytes 37–41, which have not shown up yet. This is necessary because TCP is a cumulative acknowledgement system, which can only use a single number to acknowledgedata,thenumberofthelastcontiguousbyteinthestreamsuccessfully received. Let's also say the destination keeps the window size the same, at 20 bytes. When thesending device receives this acknowledgment, it will be able to transfersomeofthebytes from Category#2to Category#1,sincetheyhave now been acknowledged. When it does so, something interestingwill happen. Since five bytes have been acknowledged, and the window size did not change, the sender is allowed to send five more bytes. In effect, the window shifts, or slides, overtothe right in thetimeline.At the sametime five bytes movefrom Category #2 to Category#1, five bytes move from Category#4 to Category#3, creating a new usable window for subsequent transmission. So, after receipt of the acknowledgement,thegroupswilllooklikethis 1. Bytes sent and acknowledged: Bytes 1–36. 2. Bytes sent but not yet acknowledged: Bytes 37–51. 3. Bytes not yet sent for which recipient is ready: Bytes 52–56. 4. Bytes not yet sent for which recipient is not ready: Bytes 57–95. For each time the data is transmitted, this process will take place as an acknowledgementisreceived,causingthewindowtoslideacrosstheentirestream to betransmitted. Thisis theTCP slidingwindow acknowledgementsystem.It is averypowerful technique, which allowsTCP toeasilyacknowledgean arbitrary numberofbytesusingasingleacknowledgementnumber,thusprovidingreliability

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 241 to the byte-oriented protocol without spending time on an excessive number of acknowledgements. For simplicity, the example above leaves the window size constant,butin reality, it can beadjusted toallowa recipient to control the rate at which the data is sent, to enable efficient flow control and congestion handling duringeachtransmission. Fig. 4.90 Send Window Sliding to the Right Whenadevicegetsanacknowledgementforarangeofbytes,it knowsthat theyhavebeensuccessfullyreceived bytheirdestination.It movesthem from the 'sent but unacknowledged'to the 'sent and acknowledged'category.This causes the send window to slide to the right, allowingthe device to sendmore data. TCP acknowledgements are cumulative, andtell a transmitter that all the bytes uptothesequencenumberindicatedintheacknowledgmentwerereceived successfully.Thus,ifbytesarereceivedoutoforder,theycannotbeacknowledged until all the preceding bytes are received. TCP includes a method for timing transmissionsandretransmittinglostsegments,ifnecessary. TheTCPslidingwindowsystemisusednotjustforensuringreliabilitythrough acknowledgmentsandretransmissions—itisalsothebasisforTCP'sflowcontrol mechanism.Byincreasingorreducingthesizeofit'sreceivewindow,adevicecan raise or lower the rate at which its connection partner sends it data. In the case where adevice becomes extremelybusy, it can even reducethe receive window tozero,closingit;thiswillhaltanyfurthertransmissionsofdatauntilthewindowis reopened. 4.7.6 Control TCP providesreliabilityusingerrorcontrol,whichdetectscorrupted,lost,out-of- order, and duplicated segments. Error control inTCPlets the receiver check the integrityof thereceived packet. This is preciselyachieved through theuse of the checksum, acknowledgment,and time-out. ? Checksum Each segment includes a checksum field for checkingthe corrupt segment each timethedatatransmissiontakes place. Ifthesegment iscorrupt,itis discardedby thedestination TCPand is considered aslost.TCP uses a16-bitchecksum that is mandatoryineverysegment.

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 242 Material ? Acknowledgement TCP issues acknowledgements to confirm the receipt ofdata segments. Control segments that carry no data but consume a sequence number are also acknowledged.ACK segments are never acknowledged. ? Retransmission When a segment gets lost, corrupted or delayed, it is re-transmitted to the destination.Asegmentistransmittedontwooccasions:whenatransmissionexpires or when the sender receives three duplicateACKs. No re-transmission timer is set for anACK segment. Retransmission after RTO: TCP maintains one re-transmission time-out (RTO)timerforalloutstanding(sent,butnotacknowledged)segments.Whenthe timer matures, the earliest outstanding segment is re-transmitted. The value of RTOisdynamicinTCPandisupdatedbasedonround-triptime(RTT)ofsegments. An RTT is the time needed for a segment to reach a destination and for an acknowledgement to bereceived bythe sender. ? Out-of-order segments Data mayarriveout of order and be temporarilystored bythereceivingTCP, but TCP guarantees that no out-of-order segment is delivered to the process. 1. Normaloperation Fig. 4.91 Normal Operation

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 243 2. Lost segment Fig. 4.92 Lost Segment Alostsegmentandcorruptedsegmentareregardedinthesameperspective bythereceiver.Alostsegmentisdiscardedsomewhereinthenetwork;acorrupted segment is discarded by the receiver. In the above example, the sender sends segments 1and 2, which areacknowledged immediatelybyanACK. Segment 3 is lost.Thereceiver receives segment 4,whichis out oforder.Thereceiverstores the data in the segment in its buffer but leaves a gap to indicate that there is no continuityinthedata.Thereceiverimmediatelysendsanacknowledgementtothe sender, displaying the next byte it expects to be received.There is a timerfor the earliest outstandingsegment.When this timermatures,thesendingTCP resends segment 3, whicharrives and is acknowledged. 3. Fast retransmission Fig. 4.93 Fast Retransmission

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 244 Material When the receiver receives the fourth, fifth and sixth segments, it triggers an acknowledgement. The sender receives four acknowledgements with the same value.Althoughthetimerforsegment 3hasnot maturedyet,thefast transmission requiresthatsegment3,thesegmentthatisexpectedbyalltheseacknowledgements, beresent immediatelyto all thedestinations. 4. Lost acknowledgement Fig. 4.94 Lost Acknowledgement Lost acknowledgement corrected byresendinga segment Fig. 4.95 Deadlock Lost acknowledgements may create deadlock if they are not properly handled (Figure4.95).

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 245 4.8 DOMAIN NAME SYSTEM (DNS) DNS is based on ahierarchical structurethat enables samehost namestobe used unambiguouslywithindifferentdomainstosimplifynamespacemanagement.The name space describes the architecture of the names including rules for name creation,interpretationandtheformofnames.TheDomainNameSystem(DNS) describes an architecture depending on domains or nodes. The domains are structured hierarchically according to their control of authority.The Internet is dividedintomorethan200Top-LevelDomains(TLDs).Thesedomainsarefurther partitioned into subdomains. The subdomains can be further partitioned and so on. Examples of TLD are countries like in, jp, us, ae, eg, etc. There are certain TLD, which comes under the category of generic TLD, and theyare com, net, org, edu, int, etc. The DNS hierarchical name architecture follows adirectorystructure and organizes names from most general types to most specific types.In this manner, the DNS name space allows names to be arranged into a hierarchy of domains looking as an inverted tree. In relation to computer terminology, it looks like the directorystructureofa filesystem. Everystandaloneinternetworkwilldefineits ownnamespacewithuniquehierarchicalstructure. Thedomain namecomponents arerepresentedinEnglishwords separated by dots, for example, www.hotmail.com, www.yahoo.co.in, etc. Each name separatedbydotsissubdomainsandaremanagedbyaseparateauthorizedserver, for example, ".com" authorized server or servers are happened to manage all domains'*.com'. The DNS name space defines an inverted tree type structures. Unlike real tree, theDNStreegrowsfromthetopdown.Therearecertainterminologiesinrelation to DNS tree that are defined below: Root: The DNS treegrows from top to down, therefore,root occupies thetopof theDNS namestructure. However, it doesnot defineanynameandis considered null.The rootdomain is theparentofall thedomainsinthehierarchy. Branch: It refers to any next closest part of DNS hierarchy and describes a domainwithsubdomainsandobjectswithinit.Likearealtree,allbranchesconnect themselves to the root. Leaf: Beneath the leaf, no object is defined and therefore it is an 'end object' in thestructure. Theyarealso referred as interiornodes,indicatingthat theyoccupy apositionin themiddleofthe structure. Top-Level Domains (TLDs):Theycomedirectlyunder theroot of thetree and thereforereferredasthehighest-leveldomains.Othernameisfirst-leveldomains. Similarly,thedomainsplaceddirectlybeneaththetop-leveldomainsarecalledthe second level domains and so on.TheTLDs are considered children domains.A peeratthesamelevelinthehierarchyisknownassiblingwhichdefinesthatallthe TLDs aresiblings with root domain as the parent. Subdomains: Theyarelocated directlybelow thesecond-level domains. Conclusively, it maybe understood that a domain is either a collection of objects, which represents a branch of the tree, or a specific leaf. Thus, a DNS
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 246 Material name space is organized as a true topological tree with one parent onlywithout anyloops.TheDNSnamespaceislogical structurewithouthavinganyrelevance withphysicallocationsofdevices. Naming in DNS It involves DNS labels and label syntax rules in which each domain or node is describedwithatextlabelsoasthedomainmaybeidentifiedwithinthestructure. Syntaxrulesare: Length:Thecharacterlengthmaybeof0-63characters.However,1-20character lengthiswidelyused. Symbols: Name can be described with letters,numbers and thedashsymbol ('– ')only. Case: They are not case-sensitive and lower and upper case for same label is equivalent.Everylabelneedstobeuniquewithinitsparentdomainbutneednotto be uniqueacross domains. Creating Domain Names Theindividualdomainwithinthedomainnamestructureisuniquelycreatedusing the sequence of labels beginning from the root of the tree to the target domain from right to left separated bydots to provide aformal name to thedomain. The rootofthenamespaceisdefinedwithazero-lengthor'null'namebydefault.The DNS Name length is limited to 255 characters to describe a complete domain name. TheDomainNamemaybeeitheraFullyQualifiedDomainName(FQDN) oraPartiallyQualifiedDomainName(PQDN).AFullyQualifiedDomainName (FQDN)assignsfullpath oflabelsbeginningfrom therootofthetreedowntothe targetnodetouniquelyidentifythatnodeintheDNSnamespace.UnlikeFQDN, the PQDNonlydescribes a part of a domain nameto provide arelativename for aparticularcontext.
ItisessentialtohaveanauthoritystructuretomanageuniqueTLDs.Erstwhile the Network InformationCenter, nowknown, as theInternetAssignedNumbers Authority(IANA) is the central DNS authorityfor the Internet to create TLDs name. In somecases, IANA delegates theirpower for some of theTLDs to other organizations.Thusmultipleauthoritiesworkinassigningandregistering Domain Name. The authorityfor lower level domain is entrusted with the organization, whichbelongsto thesecondleveldomain.Conclusively,theDNSnamespaceof theInternetismanagedbyseveralauthoritiesarrangedhierarchicallyinthesimilar manner as DNS name space. CheckYourProgress 11. What is an IP router? 12. Howwillyou defineanAutonomousSystem(AS)? 13. Whatisunicasting? 14. Whatisflowcontrol? 15. What isthesignificanceof DomainNameSystem (DNS)?

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 247 4.9 ANSWERS TO 'CHECK YOUR PROGRESS' 1. The majornetwork infrastructureavailableinthe countryhas twotypes of WAN: (i) TerrestrialWAN (ii) VSATWAN 2. WANis theacronym forWideAreaNetwork andrefers toanetwork used to connect different equipment from remote areas. Normally, network services are provided bya Common Carrier of, for example, a telephone company. 3. RIPisthemost widelyusedroutingprotocol ofdistance-vectortypetoday. RIP has been originallydesigned based on the routingprotocol applied to XNS and PUP protocol systems of Xerox (RFC1058). 4. Internal router is a router having its links directlyconnected to a network withinaspecificarea. That is, internalrouterdoes nothaveanydirectlinks to a network in another area. 5. The Internet Protocol (IP) is one of the most dominant protocols of the TCP/IPprotocolsuiteand its mainprotocol is locatedatthenetworklayer. The fundamental job of network layer is concerned with the deliveryof data, from the source to the destination, between devices that maybe on differentnetworks. 6. When an IP datagram is sent toa destination on the samelocal network, it is called direct delivery. 7. IP datagram is therudimentaryunit ofinformation carried in theform of a packet in the IPlayer, containing a source and destination address. This informationiscommunicated across thenetworkusingInternet Protocol. 8. TheInternet addressorIP address isauniqueidentifierusedintheIP layer oftheTCP/IPprotocolsuitetoidentifyeachdeviceconnectedtotheInternet. 9. In orderto do subnetting, thehost ID is splitintosubnet IDandhost ID. In doingthis, the sizeof thehost ID part ofthe address gets reduced.In short, bits from the host ID are being 'stolen'to use for the subnet ID. ClassA networks have 24 bits to split between the subnet ID and host ID: Class B networks have 16, and Class C networks only8 10. The subnet mask is a 32-bit binarynumberthat comes with anIP address. Like IP addresses, they are usually converted to dotted decimal notation for convenience. It is created in a way that it has a one bit for each corresponding bit ofthe IP address that is part of its network ID or subnet ID, and a zero for each bit of the IPaddress's host ID. 11. AnIP routeris adevicethatattaches to twoormorephysical networks and transfers datagrams between the networks.

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 248 Material 12. AnAutonomous System (AS) is defined as a logical portion ofa larger IP network(Figure4.68).AnAS normallyconsists ofaninternetworkwithin anorganization. Itis administered byasinglemanagementauthority. 13. Communicationbetweenonesourceandonedestinationisknownasunicast. There is a one to one relationship between source and destination. In this typeofcommunication,boththesourceanddestinationaddressesareunicast addresses. 14. FlowcontrolisoneoftheimportantparaphernaliasthatTCPprovides.The receiver of the data controls the amount of data that is being sent bythe sender.This is done to prevent thereceiver from beingoverwhelmedwith data. 15. DNS is based on a hierarchical structure that enables same host names to be used unambiguouslywithin different domains tosimplifyname space management. The name space describes the architecture of the names includingrules fornamecreation,interpretationandtheformofnames. 4.10 SUMMARY ? WideArea Networks (WANs) connect larger geographic areas, such as New Delhi, Indiaor the world. ? Packetswitchingtechnologiessuchasasynchronoustransfermode(ATM), frame relay, switched multimegabit data service (SMDS), and X.25 are usedtoimplementWANalongwithstatisticalmultiplexingtoenabledevices to sharethese circuits. ? WANis theacronym forWideAreaNetworkand refers toa networkused to connect differentequipment from remoteareas. ? LANs can beextended to awiderarea but it cannotbeextendedarbitrarily farortohandlearbitrarilymanycomputers. ? WANis composedanumberofautonomous computerthat aredistributed over alarge geographical area. ? Themajorobjectiveof network design is toselect thenetworkserviceand to determinethetransmission speed forthe system. ? The routing is simple if the destination address of the host is in the same subnet. ? If a packet sent from the source host is addressed to a host in the same subnet, the IPlayer ofthesourcehost must obtaintheMACaddress of the destinationhost. ? Default gatewayconsistsofmanuallyregisteringrouterIPaddresses inthe host. ? Asetofnetworks interconnected byrouterswithinaspecificareausingthe sameroutingprotocolis called domain. ? TheTCP/IPreferencemodelisanetworkmodelusedinInternetarchitecture. It has its beginnings back in the 1960s.

Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 249 ? The Internet Protocol (IP) is one of the most dominant protocols of the TCP/IPprotocolsuiteand its mainprotocol is locatedatthenetworklayer. ? The fundamental job of network layer is concerned with the deliveryof data, from the source to the destination, between devices that maybe on differentnetworks. ? The primary job of IPfunctions is to add and manage IPaddresses. With this as foundation, let us take aclose look at four ofits major functions. ? TheInternet addressorIP address isauniqueidentifierusedintheIP layer oftheTCP/IPprotocolsuitetoidentifyeachdeviceconnectedtotheInternet. ? IP addresses, when started a few decades ago, were based on the concept ofclasses.Each classfixed aboundarybetweenthenetworkprefix andthe

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host number at a different point within the32-bit address. ?

Classful addressingresulted in efficient useof address space. TheClass B address block contains a very large number of addresses (65,534) but a Class C block has onlya relativelysmall number(254). ? Insubnetting,it is necessarytocommunicate,which bits areforthesubnet ID and which for the host ID, to devices that interpret IPaddresses.A32- bit binarynumberwhich provides this information todevices handlingIP addresses is called a subnet mask. ?
Onasinglephysicalnetwork,individualdevicesareidentifiedinthenetwork bytheirphysical hardware address. ?
Internetworkinginvolvesconnectingdifferentphysicalnetworks.Providing connections between dissimilar networks is one of the basic functions provided by the IP. Asystem that performs this function is called an IP router.AnIProuterisadevicethatattachestotwoormorephysicalnetworks and transfers datagrams between the network ? In hybrid routing protocols, there is an attempt to combine the positive attributes ofboth distance vector and link state protocols. ?
Transmission Control Protocol (TCP) is a connection-oriented, reliable transport protocol for process-to-process delivery and end to end communication. ? Toprovidereliableservice,TCPimplementserrorcontrolmechanism.This alsoensuretheauthenticityandintegrityofthereceivingdata.Error-control is byte oriented. ? DNS is based on a hierarchical structure that enables same host names to be used unambiguouslywithin different domains tosimplifyname space management. ?
Thedomainnamecomponents arerepresentedinEnglishwordsseparated bydots,forexample, www.hotmail.com, www.yahoo.co.in,etc. ? Theindividualdomainwithinthedomainnamestructureisuniquelycreated usingthesequenceoflabelsbeginningfromtherootofthetreetothetarget domainfrom rightto left separated bydots toprovidea formalnametothe domain
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning 250 Material 4.11 KEY TERMS ? WAN: It is the acronym for WideArea Network and refers to a network usedtoconnect different equipment from remote areas. ?
DataRouting:Itreferstotheprocessofselectingtheshortestandthemost reliablepathintelligentlyoverwhichtosenddatatoitsultimatedestination. ?
StaticRouting:Thismethodusesfixeddefinitionsrepresentingpathsthrough thenetwork. ?
DynamicRouting:Indynamicrouting,algorithmsrouterscanautomatically determineand maintainknowledgeofthepathsthroughthenetwork. ? IPdatagram:Itistherudimentaryunitofinformationcarriedintheformof a packet in the IPlayer. ? InternetAddress: It is a unique identifier usedin the IPlayerof theTCP/ IP protocol suiteto identifyeach device connected to the Internet. ? SubnetMask: It is a 32-bit binarynumberthat comes withan IP address. Like IP addresses, theyare usuallyconverted to dotted decimal notation forconvenience 4.12 SELF ASSESSMENT QUESTIONS AND EXERCISES Short-Answer Questions 1. Write the difference between LAN andWAN. 2. What is distance vector protocol. What are theproblems with it? 3. Write the various goals ofTCP/IP. 4. State thecharacteristics of IP. 5. Whatisclassfuladdressing? 6. Whatarethelimitationsofclassfuladdressing? 7. Howwillyou decidethathowmanysubnetbitsarerequiredinsubnetting? Discuss with thehelpofan example. 8. Inwhichcircumstancesstaticroutingisuseful? 9. Write two keyrequirements ofTCP. 10. What is DNS tree? 11. Writethe process of naming in DNS. 12. How will you createa domain name? 13. Explain theconcept ofIP addresssing.
Wide Area Network, TCP/IP and Data Link Layer Addressing NOTES Self - Learning Material 251 Long-Answer Questions 1. Explain routerprotocols indetails. 2. Describe TCP/IPprotocols in detail. 3. Explain theconcept ofIP addressing. 4. How manyclasses of IP addresses are there? Explain eachclass in detail. 5. Describeclasslessaddressingindetail.Also,analysethebenefitsofclassless addressing. 6. ExplaintheworkingofARP. 7. ExplainthetypesofIProutingalgorithms. 8. Write adetailed note on Domain Name System (DNS). 4.13 FURTHER READING Forouzan, Behrouz A. Data Communications and Networking. New Delhi: Tata McGraw-Hill, 2004. Stallings,Williamand RichardVan Slyke.Business DataCommunications.New Jersey: PrenticeHall, 1998. Black, Uyless. Computer Networks. New Jersey: Prentice Hall, 1993. Stallings,William. Data and Computer Communications. NewJersey: Prentice Hall,1996. Tanenbaum,Andrew S. Computer Networks. New Jersey: Prentice Hall PTR, 2002. Stallings, William. Data and Computer Communications. NJ: Prentice-Hal, 1996.
Broadband Network and Internet Services NOTES Self - Learning Material 253 UNIT 5 BROADBAND NETWORKAND INTERNETSERVICES Structure 5.0 Introduction 5.1 Unit Objectives 5.2

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Broadband Network 5.3 Local Loop Technologies 5.3.1 Asymmetric Digital Subsriber Line (ADSL) 5.3.2 High Bit-Rate Digital Subscriber Line (HDSL) 5.3.3 Wireless Local Loop (WLL) 5.4 network Security 5.4.1 Basic Requirements of Network Security 5.4.2

Levels of Security 5.4.3 Data Security 5.4.4 Basic Techniques 5.5 Firewalls 5.6 Data Encryption 5.7 Authentication 5.8 Viruses 5.9 Internet Privacy and Security Attacks 5.9.1 Key Management 5.10. Electronic Mail and Internet Services 5.10.1 Sending E-Mails via Internet 5.11 Electronic Commerce 5.11.1 Internet:ATool for Electronic Commerce 5.12 Electronic Data Interchage (EDI) 5.12.1 EDI Implementation 5.13 electronic commerce user characteristic and issues 5.13.1 Advantages and Disadvantages of E-commerce 5.13.2 limitations of E-commerce 5.14 Answers to 'Check Your Progress' 5.15 Summary 5.16 Key Terms 5.17 Self Assessment Questions and Exercises 5.18 Further Reading 5.0 INTRODUCTION Broadbandisthetransmissionofhigh-qualitydataofawidebandwidth.Broadband connections include Wi-Fi, DSLS, fiber, and satellites. The term broadband commonlyrefers to high-speed Internet access that is always on and faster than thetraditionaldial-upaccess.Broadbandincludesvarioushigh-speedtransmission technologies.DSLisawirelinetransmissiontechnologythattransmitsdatafaster overtraditionalcoppertelephonelinesalreadyinstalledtohomesandbusinesses. DSL-basedbroadbandprovidestransmissionspeedsrangingfromseveralhundred Kbpstomillionsofbitspersecond(Mbps).AsymmetricalDigitalSubscriberLine (ADSL)isused primarilybyresidentialcustomers, suchas Internetsurfers,who receive a lot of data but do not send much.ADSLtypicallyprovides faster speed in the downstream direction than the upstream direction. Symmetrical Digital
Broadband Network and Internet Services NOTES Self - Learning 254 Material SubscriberLine(SDSL)isused typicallybybusinessesforservicessuchasvideo conferencing,whichneedsignificantbandwidthbothupstreamanddownstream. Electronicmail(emailore-mail)isamethodofexchangingmessages("mail") betweenpeople usingelectronicdevices. Electronicmail (e-mail)is acomputer- based application for the exchange of messages between users.Aworldwide e- mail networkallows peopleto exchangee-mail messages veryquickly.E-mail is theelectronicequivalentofaletter,butwithadvantagesintimelinessandflexibility. While a letter will take from one dayto a couple of weeks to be delivered, an e-mailisdeliveredtotheintendedrecipient'smailboxalmostinstantaneously,usually in themultiple-second to subminute range.Internet Services allows us to access huge amount of information such as text, graphics, sound andsoftware over the internet.FollowingdiagramshowsthefourdifferentcategoriesofInternetServices. E-commerce(ElectronicCommerce)istheactivityofelectronicallybuying or sellingof products on onlineservices orover theInternet. E-commerce draws ontechnologiessuchasmobilecommerce,electronicfundstransfer,supplychain management, Internet marketing, online transaction processing,electronic data interchange(EDI),inventorymanagementsystems,andautomateddatacollection systems. EDI (Electronic Data Interchange) is an electronic way of transferring businessdocumentsinanorganizationinternally,betweenitsvariousdepartments or externally with suppliers, customers, or any subsidiaries. In EDI, paper documents are replaced with electronic documents such as word documents, spreadsheets, etc.Many business documents can be exchanged using EDI, but the two most common are purchase orders and invoices.At a minimum, EDI replaces the mail preparation and handling associated with traditional business communication. However, the real power of EDI is that it standardizes the information communicated in business documents, which makes possible a "paperless"exchange. Inthisunit,youwilllearnaboutbroadbandnetwork,locallooptechnologies, AsymmetricDigital Subscriber Line (ADSL),HighBit-Rate Digital Subscriber Line (HDSL), network security, electronic mail and other internet services, like electronic commerceand EDI. 5.1 UNIT OBJECTIVES Aftergoingthroughthisunit,you willbeableto: ? Understand broadband network ? Analyzelocallooptechnologies ? ComprehendAsymmetricDigitalSubscriberLine(ADSL) ? ExplainHighBit-RateDigitalSubscriberLine(HDSL) ? Comprehendlinecodingtechniques ? DefineWirelessLocal Loop (WLL). ? Elaborate on networksecurityand securitylevels ? Discuss electronicmailandotherinternetservices
Broadband Network and Internet Services NOTES Self - Learning Material 255 ? Defineelectroniccommerce ? Analyzeinternet as a tool for electronic commerce ? ExplainElectronicDataInterchange(EDI) ? Understand theprocessofimplementingEDI 5.2 BROADBAND NETWORK Broadband LANs are multichannel, analog LANs. Theyare typicallybased on coaxial cableasthetransmissionmedium,althoughfibreopticcable is alsoused. Individualchannelsofferbandwidthof1to5Mbps,with20to30channelstypically supported.Aggregatebandwidth is as much as 500 MHz. Itscharacteristics are: ? Stations connected via RF modems, i.e., radio modems accomplish the digital-to-analog conversion process, providing the transmitting device access toan analog channel. ? Digitalsignal modulatedonto RFcarrier(analog). ? Channel allocation based on FDM. ? Head-Endforbidirectionaltransmission. Advantages ? Greaterbandwidth ? Data, voice and video can be accommodated on broadband channel ? Greaterdistances Disadvantages ? Highcost,requires modems ? Lack of well-developed standards ? Cabledesign ? Alignmentandmaintenance Somebroadband LANsarereferred to as10Broadband36where10stands for 10 Mbps, Broadband for multichannel and 36 for 3600 metres maximum separation between devices. 5.3 LOCAL LOOP TECHNOLOGIES Local Loop(LL)is referred as anelectroniccircuit linefromasubscriber's phone to the local exchange office termed as Local Central Office (LCO). The implementationofwiresinthelocallooptechnologyisverytoughfortheoperators, especiallyintheruralareasandalsotheremoteareasduetolessernumberofusers whichincreasesthecostofinstallation.Hence,theWirelessLocalLoop(WLL)is used which is based on wireless links rather than the wired links made of copper wires forconnecting the subscribers to the local central office.Public Switched TelephoneNetwork(PSTN),AsymmetricDigital SubscriberLine(ADSL),High bit-rate Digital SubscriberLine (HDSL),Wireless Local Loop(WLL),Wireless Access Network Unit (WANU), etc. are examples ofWLL.

Broadband Network and Internet Services NOTES Self - Learning 256 Material Definition:ALocal Loop (LL) is aphysical connection from the end user sitetoaprovidersPointofPresence(POP).Thelocalloopisprovidedinanumber of ways depending on the type of provider. Local loops can be made of copper, fiber,coax, or wireless, and is installed to the demarcationpoint (Demarc). Mostly,thelocalloop is installedbytheLocalTelephoneCompany(LTC), suchas Incumbent Local ExchangeCarrier(ILEC),but it isspecificallyinstalled byCompetitiveLocalExchangeCarriersorCLEC's,fiberproviders,oranyother 3rd partyproviders. Local loops are also termed as the circuits, subscriber line, orphysicallink. AnIncumbentLocalExchangeCarrier(ILEC)isalocaltelephonecompany, andaCompetitiveLocal Exchange Carrier(CLEC) is a telephonecompanythat competes with the alreadyestablished local telephone business byproviding its ownnetworkandswitching. Line Coding Techniques
Linecodingistheprocessofconvertingdigitaldatatodigitalsignals.Withthehelp ofthistechniqueasequenceofbitscanbeconvertedtoadigitalsignal.Atthesender sidedigitaldataareencodedintoadigitalsignalandatthereceiversidethedigital data arerecreated bydecoding thedigital signal. Basically,the'LineCoding',alsocalleddigitalbasebandmodulationordigital basebandtransmission,isaprocesscarriedoutbyatransmitterthat convertsdata, in the form of binarydigits, into a baseband digital signal that will represent the dataonatransmissionline.Thetransmissionlineinquestioncouldbealinkbetween two devices in a computer network, or it could form part of a much larger telecommunicationsnetwork.Thereceiverisresponsibleforconvertingtheincoming line coded signal back into binarydata. Thereare different types of line coding techniques,rangingin complexity fromverybasicunipolarschemes in whichthepresenceorabsenceofavoltageis used to represent a binaryone or a binaryzero, to highlysophisticate multilevel schemesinwhichdifferentsignalamplitudesareused,eachrepresentingaunique groupingofbinarydigits. 5.3.1 Asymmetric Digital Subsriber Line (ADSL) InADSLtechnology, there has been a new progress which intends to use two copper loops at a data rate of 1.544Mbps. This data rate is developed towards the user direction in the network and data rates upto 600Kbps from the user to network. ADSL is widely used to connect most of the homes and small business subscribers totheInternet.ADSLdividestheavailablefrequencies inatelephone linebyassumimgthatmostoftheInternetsubscribersaremoreinclinedtodownload informationfromtheInternetthanupload.ADSL,therefore,providestheconnection speed from the Internet to the subscribers three to four times faster than the connection from the subscribers back to the Internet.ADSLis considered as a distance-sensitivetechnologyinwhichthequalityofsignaldiminishesasthedistance of the connection increases from home to the location of the service providers.
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ADSLtechnologyiscapableofprovidingmaximumdownloadspeedupto8Mbps at a distance of about 1.8 Km and upload speed of up to 640 Kbps.ADSLoffers download speed in the range of 1-2 Mbps and uploadspeed in the range of 64- 640 Kbps. Other versions ofADSLlikeASDL2 andASDL2+ are also availabe for higher downloadand upload speeds 12-24 Mbps and1-3 Mbps respectively. Thedistanceisnotalimitingfactorfortelephonelinesbecausetelephonelinesuse repeaters to amplifyvoice signals whilethese repeaters are not compatible with DSL. 5.3.2 High Bit-Rate Digital Subscriber Line (HDSL) Highbit-rateDigitalSubscriberLine(HDSL)isdefinedas atelecommunications protocol whichwas standardized in 1994.It was thefirst Digital SubscriberLine (DSL)technologywhichusedahigherfrequencyspectrumovercopperandtwisted pair cables. HDSLwas developed fortransportingDS1 services at 1.544 Mbit/s or Mbps and 2.048 Mbit/s orMbps over telephone localloops without requiring repeaters.Successortechnologyto HDSLincludes HDSL2(Highbit-rateDigital SubscriberLine2)andHDSL4(Highbit-rateDigitalSubscriberLine4),proprietary SDSL(SymmetricDigitalSubscriberLine),andG. High bit-rate Digital Subscriber Line 2 (HDSL2) is a standard developed bytheAmerican National Standards Institute (ANSI) Committee T1E1.4 and published in 2000 as ANSI T1.418-2000. Identical to its predecessor HDSL, HDSL2 provides a symmetric data rate of 1,544 Kbit/s or Kbps in both the upstream and downstream directions at a noise margin of 5-6dB (deciBel). The modulationtechniqueusedinHDSL2isTC-PAM(Trellis-CodedPulse-Amplitude Modulation), which is also used in G. SHDSL. Spectral shaping is applied to increase compatibility withADSLand HDSL2 on the same bundle of packet being transmitted. HDSL4 provides the similar bitrate as HDSL2, but uses four wires instead oftwo, in orderto increase robustness.Ona local loop,thereachof HDSL2isapproximately9,000feet(2.7km),whilethatofHDSL4isapproximately 11,000 feet (3.4 km). A Symmetric Digital Subscriber Line (SDSL) is referred as a Digital Subscriber Line (DSL) that transmits digital data over the copper wires of the telephone network, wherethe bandwidth in the downstream direction, from the networktothesubscriber, is identicalto thebandwidthintheupstream direction, from the subscriber to the network. This symmetric bandwidth is considered as theoppositeoftheasymmetricbandwidth recommended byAsymmetric Digital Subscriber Line (ADSL) technologies, where the upstream bandwidth is lower thanthedownstream bandwidth. Single-pair High-speed Digital Subscriber Line (SHDSL) is referred as a specific type of Symmetric Digital Subscriber Line (SDSL), it is a data communications technologyforeven transmits andreceives,i.e.,symmetricdata rate over copper telephone lines, which is faster than a conventional voiceband modemcanprovide.As opposedtootherDSLtechnologies,SHDSLusesTrellis- Coded Pulse-Amplitude Modulation (TC-PAM).As a baseband transmission scheme,TC-PAM operates at frequencies that include those used bythe analog

Broadband Network and Internet Services NOTES Self - Learning 258 Material voice Plain Old Telephone Service (POTS). Support of symmetric data rates made SHDSL a popular network for data transmission for Private Branch eXchange (PBX), Virtual Private Network (VPN), web hosting and other data services. SHDSL features symmetrical data rates in both the upstream and downstream directions, from 192 Kbit/s Kbps to 2,312 Kbit/s Kbps of payload in 8 Kbit/s or Kbps increments for one pair and 384 Kbit/s Kbps to 4,624 Kbit/ s Kbps in 16 Kbit/s Kbps increments for two pairs of wires. The reach varies accordingto theloop rate and noiseconditions (more noise orhigherratemeans decreased reach) and may be up to 3,000 meters. An optional extended SHDSL mode allows symmetric data rates up to 5,696 Kbit/s or Kbps on one pair, using the 32-TC-PAM modulation scheme specifiedinAnnexesFand G.TheSHDSLpayloadmaybeeither'ClearChannel' (unstructured), T1 (Transmission System 1) or E1 (E-Carrier 1), full rate or fractional, multiple ISDN (Integrated Services Digital Network) Basic Rate Interface (BRI),AsynchronousTransfer Mode (ATM) cellsor Ethernet packets. HDSL was developed for T1 service at 1.544 Mbit/s by the American NationalStandardsInstitute(ANSI)CommitteeT1E1.4andpublishedinFebruary 1994 asANSI Technical Report TR-28. ThisAmerican variant uses two wire pairs at a rate of 784 kbit/s each, using the 2B1Qline code, which is also used in theAmerican variant of the ISDN U interface. First products were developed in 1993.AEuropean version of the standard for E1 service at 2.048 Mbit/s was published in February 1995 by the European Telecommunications Standards Institute(ETSI)asETSIETR 152. Thefirst editionofETR152specifiedtheline code 2B1Q on either three pairs at 784 kbit/s each or two pairs at 1,168 kbit/s each.Secondedition ofETR 152,publishedinJune 1995,specifiedtrellis coded carrierlessamplitude/phasemodulation(CAP)asanalternativemodulationscheme, runningon twopairs at1,168kbit/seach. ThirdversionofETR152,publishedin december 1996, added the possibilityof using a single CAP-modulated pair at 2,320kbit/s.Later,aninternationalHDSLstandardwaspublishedbyStudyGroup 15 of the Telecommunication Standardization Sector of the International Telecommunication Union (ITU-T) on 26 August 1998 and adopted as recommendation ITU-T G.991.1 on 13 October 1998. 5.3.3 Wireless Local Loop (WLL) Wireless Local Loop (WLL) is the useof a wireless communications link as the LastMile/FirstMileconnectionfordeliveringPlainOldTelephoneService(POTS) or Internet access (marketed under the term Broadband) to telecommunications users.Varioustypes ofWLLsystems and technologies exist. Inaddition,thevarioustermsusedforthistypeofaccessincludeBroadband WirelessAccess(BWA),RadioInTheLoop(RITL),Fixed-RadioAccess(FRA), FixedWirelessAccess (FWA) and MetroWireless (MW). FixedWirelessTerminal(FWT)unitsdifferfromconventionalmobileterminal unitsoperatingwithincellularnetworks,suchasGSM(GlobalSystemforMobile

Communications)inthatafixedwirelessterminalordeskphonewillbelimitedto analmostpermanentlocationwithalmostnoroamingabilities.WLLandFWTare genericermsforradiobasedtelecommunicationstechnologiesandtherespective deviceswhichcanbeimplementedusinganumberofdifferentwirelessand radio technologies. CheckYourProgress 1. What is a broadband network? 2. What do you understand bythe term line coding? 3. Write theuse ofADSL. 4. Howwill youdefineHighbit-rateDigitalSubscriberLine(HDSL)? 5. What is theuse of WLL? 5.4 NETWORK SECURITY Network security is a broad topic with a multi-layered approach. It can be addressedatthedatalink,networkandtheapplicationlayers.Theissuesconcerned arepacketintrusionandencryption,IPpacketsandroutingtableswiththeirupdate versions,andhost-levelbugsthatoccuratthedatalink,networkandtheapplication layersrespectively. TCP/IP protocols are used globally irrespective of the nature of the organizations,whethertheyaregeneralcategoryorganizationsorsecurity-specific sensitive organizations. The news or information about hackingof websites or portalsbyundesiredpeopleisverycommonnowadays.This showsthat theTCP/ IP protocols are susceptible to interception. This generates a needto ensure all round security for the network in an organization. The tasks of the network administrator haveto be widened to include the overall securityof the network. He has to ensure that all parts of this network are adequately protected and adequatemeasures ofsecurityhavebeen implementedwithinaTCP/IPnetwork. He should be aware of an effective security policy. He should also be able to pinpointthemainareasofriskthatthenetworkmayface.Thesemainareasofrisk varyfromnetworktonetworkdependinguponthefunctioningoftheorganization. Thereare,therefore,varioussecurity-relatedaspectswhichhavedirectimplications for the network administrator alongwith the means to monitor the implemented measures ofsecurityeffectivelyand to tackletheproblem ofbreachofsecurityif it happens. 5.4.1 Basic Requirements of Network Security Themainobjectiveofthenetworkistoshareinformationamongstitusers situated locally or remotely. Therefore, it is possible that undesired users can hack the network and prove to be harmful for the health of the network or the user. The network administrator must follow the followingpoints to provide the network adequatesecurityotherthannetwork-specificsecurityasinthecaseofe-commerce, etc. ? Networks are designed to shareinformation.Therefore,the network must beclearlyconfiguredtoidentifytheshareableinformationandnon-shareable information.

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Thenetworkshouldalsoclearlyspecifywithwhomtheshareableinformation could be shared. ? An increase in the system securitymeans a corresponding increase in the coststothemanagement.Thereforeacompromisinglevelbetweensecurity and prices should be established as per the requirements of the network securitysystem policy.This will largelydepend upon the level of security neededforthenetwork, theoverall securityrequirementsandtheeffective implementa-tionofthechosen levelofsecurity. ? Division of theresponsibilities concerningthenetwork's securitymust be clearlydefined between theusers and thesystem administrator. ? The requirements forsecuritymust be detailed within a network security policyoftheorganizationthatindicatesthevaluabledataandtheirassociated cost to the business. ? After definingthedetailed network securitypolicyandclearlyidentifying his responsibilities intheorganization, thesystemadministratorshouldbe maderesponsibleforensuringthat thesecuritypolicyiseffectivelyapplied tothecompanyenvironment,includingtheexistingnetworkinginfrastructure. 5.4.2 Levels of Security
TheUSDepartmentofDefensehaslisteddifferentstepsintheevolutionofsecurity levels.Thefirst step in thisdirection was thetrustedcomputersystem evaluation criteriainDecember1985, popularlytermedastheOrangeBook.Incontinuation withthislevel, anothersecuritylevelknownasthetrustednetworkinterpretation ofthetrustedcomputersystem evaluationcriteriaortheRedBookwasdescribed in July1987. These security levels contain the security-related problems in the componentorthemodularform.Eachlevelcontainsthespecificsecurityproblem whichisbrokendownintodifferentdivisions.Eachofthedivisionsorclassifications represents asecuritylevel defined interms ofthefollowinggeneral categories: ? Useridentificationandauthentication. ? Thecapabilitytomonitorand auditsystem activity. ? Provision ofdiscretionaryaccess. ? Control of the reuse of resources. ? Identifyingspecificareasofpossibleattack. ? Provision ofsuitablecountermeasures. ? The level of system trusts, including systems architecture, design, implementation, transport, andtrust ofotherhosts. 5.4.3 Data Security Datasecurityis concerned with the protectionof data contained inafileormany files in a computer either as a standalone or on a network, from unauthorized interception. In caseof a postal system, a postcard as acarrier of information isopen to all. It does not have anysort of security measures.An envelope is used to hide
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informationfromotherpeople.Anenvelopeactsasameansforsecurity.Therefore, postcard and envelope have different purposes with respect to security. These twoparticularcases initiated similaractionstosolvethesecurity-relatedissues in case of datacommunication. E-mails are opento all as post cards. Followingthe envelopeexampleinthepostal system willenableuserstosecureatleast someof theirdata. The access protection provided by log on passwords is not a foolproof system and thesemayeasilybe bypassed. The bypassingcan bedone bybooting from a disketteor connecting the stolen hard drive as a secondaryone to another computer. In this manner, anyvital data might easilybeaccessed. Consequently, encryption of the information seems to be the onlyeffective wayto protect data frombeinginterceptedbyunauthorizedpersons.Theencryptionmustbedeveloped to ensure reliable data security and that data is not decrypted without the right passwordortheright user.Themain drawbackofthepassword-basedencryption includes the loss of password or registration of wrong passwords due to wrong spelling or some other human mistakes. In this case, it becomes impossible to restore thedata. There are other rules to avoid insuch situations. The invalid access to the host can be prevented to a certain extent in the case of conventional host-to-terminal as the number of terminals connected is limited. The situation is entirelydifferent in the case of Internet where access is allowedfromanyterminalconnectingonanetwork.Therefore,thisrequiresproper securitymeasures. Thefollowingare thethreetypes ofsecuritymeasures: ? Invalidaccess/Possibilityofeavesdropping ? Firewallsecurity ? Encryption(VPNFunction) 5.4.4 Basic Techniques Figure 5.1 shows a LAN connected to the Internet to allow access to the outside world. The terminals connected to the Internet have access to manyservers to obtain a varietyof information bases. But it also provides an opportunityto the undesirable person to execute commands on the servers and other computers. Thus,allowingusers orterminals toaccess theserverorothercomputersthrough websites to obtain desired information maycreate a number ofproblems. These problems canbe as follows: ? Hackers may access someone else's computer and servers without valid authentication to steal the information not meant forgeneral purpose.The confidentialinformationmayreachwronghands.Hackingshowsthatthere is a security lapse in the particular system or network and the system or network is unstableand proneto tampering. ? Hackingmayalsoleadtointerceptionoftheinformationfromthenetwork, whichislackinginsecuritymeasures.Theinformationmaybetamperedor alteredfromtheactual contents.
Broadband Network and Internet Services NOTES Self - Learning 262 Material Authentication Function Included Fi rew all R R R R Encryption User User Hacker Fig. 5.1 Unauthorized Access to LAN and Eavesdropping 5.5 FIREWALLS The Internet provides a two-wayflow oftraffic that maybeundesirable in many organizations wheresomeinformation isneededexclusivelyfortheorganization or for the Intranet. The Intranet is a TCP/IP network that is modelled after the Internetthat onlyworkswithintheorganization.Inordertodelineateinformation meant onlyforthebenefit of the organizationor its Intranet andtheother open to all ormeant forthe Internet, somesort ofsecuritymeasures areneededtocontrol thetwo-wayflowoftraffic.Ameasureknownasfirewallis usedforthispurpose. A firewall is a combination of software and hardware components that controls the traffic between a secure network (usually an office LAN) and an insecure network (usually the Internet), using rules defined by the system administrator.Thefirewallsits at thegatewayofanetworkor sitsat aconnection between thetwo networks, and theentire traffic between twoor more networks has to traverse the firewall. The firewall stops or allows the traffic based on the securitypolicyasdefinedin rules'table. Thesecuretrusted network is said to be 'inside' thefirewall. Theinsecure untrusted network is said to be'outside'the firewall.The firewall's architecture has to be such that it would permit a certain amount of traffic to get through, otherwiseit wouldbemore of a'stonewall', preventingaccess totheInternet, or sendingof e-mails or anyother informationfrom either side ofthe firewall, thus turningintoaself-defeatingexercise. The fact that it allows some traffic through provides a channel that could potentiallybeexploited,and could carryviruses. However,principally,thephilosophybehindfirewallis: ? It existsto block traffic. ? It existsto permit traffic.

Broadband Network and Internet Services NOTES Self - Learning Material 263 In brief,thebasicaimoffirewall isto provideonlyoneentranceandexit to thenetwork.Therearetwofirewalls.Oneblockstheundesirabletraffic,whilethe otherallowstraffic. Network Architecture of a Firewall Themostimportantaspectofafirewallisthatitisattheentrypointofthenetworked system it protects. This means that the firewall is the first program that receives andhandles incomingnetworktraffic,and itisthelasttohandleoutgoingtraffic. Thelogicissimple–afirewallmustbepositionedinanetworktocontrolall incomingand outgoing traffic. The internal network also needs tobe structured andconfiguredinsuchawayastoimplementsecuritypolicyoffirewalltoprotect specific services running on the systems. The following are some examples of networkstructureto protect it fromexternal threats usingafirewall. 1. Arouteron dedicated connections totheInternet canbepluggedinto thefirewallsystem as shown inFigure5.2. Thiscanalsobeprovided with the help of a hub for full access servers outside the firewall as showninFigure 5.3. Internet Router Switch DMZ Switch Internal Clients Firewall System Mail Server Router Database Server Fig. 5.2 Router Connected to Firewalls on a Dedicated Connection Internet Firewall System LAN Hub DMZ Hub Internal Clients Fig. 5.3 LAN Hub Connected to Firewalls Broadband Network and Internet Services NOTES Self - Learning 264 Material 2. Therouter can beconfigured withsomefilteringrules.However,this router may be owned by ISP, therefore, ISPmaybe asked to put all desired control. 3. In a dial-up service like an ISDNline, a third network cardis used to provideafilteredDMZ.Thisgivesfullcontroloverthe Internetservices and still separates them from theregularnetwork. 4. A proxyservercan be used to monitor the traffic onthenetworkand allowtheusersalimitednumberofservicesorsomeunwantedservices maybeblocked. This can beintegrated withthefirewall as shown in Figure 5.4. Internet Proxy Firewall LAN Hub Internal Clients Fig. 5.4 Proxy Server Connected with Firewall 5. Aproxyserveronanorganization's LANconnectedwiththefirewall should have rules to only allow the proxy server to connect to the Internet for theservices it is providing. This waythe users can get to theInternet onlythrough the proxyasshown in Figure 5.5. Internet Firewall System LAN Hub Internal Workstations Proxy Server Fig. 5.5 LAN Connected to the Internet via Proxy CheckYourProgress 6. What is data security? 7. Write the threetypes of securitymeasures. 8. Definethetermfirewall. 9. What is thebasicaimoffirewall? 5.6 DATAENCRYPTION Encryption hides yourdatafrom curious eyes. Thisis a method ofencodingdata topreventunauthorized persons from viewingormodifyingit.Themainfeatures of dataencryption are: ? Prevents unwanted access to documents ande-mail messages. ? Even thestrongest levels ofencryption areverydifficult tobreak.
Broadband Network and Internet Services NOTES Self - Learning Material 265 Processes and Types of Encryption The process of data encryption consists of certain steps.Thedatapasses through amathematicalformulacalledanalgorithm,whichconvertsitintoencrypteddata calledciphertext.Thesealgorithmscreateakeyandthenencapsulatethemessage withthiskey. There are two types of encryptions – asymmetric andsymmetric. Asymmetric Encryption In publickey(asymmetric)encryption,twomathematically-relatedkeysareused – oneto encrypt themessageand theothertodecrypt it.Thesetwokeys combine to form a key pair.Asymmetric encryption provides both data encryption and validationofthecommunicatingparties'identities andisconsideredmoresecure thansymmetricencryption,butiscomputationallyslower. Apublickeyencryption schemehas followingsix majorparts: (i) Plaintext:This is thetext messageto whichanalgorithm is applied. (ii) EncryptionAlgorithm: It performs mathematical operations to conduct substitutionsandtransformationstotheplaintext. (iii) PublicandPrivateKeys: These are a pair of keys where one is used for encryption and theother for decryption. (iv) Ciphertext: This is the encrypted or scrambled message produced by applyingthealgorithmtotheplaintextmessageusingkeys. (v) DecryptionAlgorithm: This algorithm generates the ciphertext and the matchingkeytoproducethe plaintext. Encryption Process Theasymmetricdataencryption process hasthe followingsteps: ? Theprocessofencryptionbeginsbyconvertingthetexttoapre-hashcode. Thiscodeisgeneratedusingamathematicalformula. ? This pre-hash code is encrypted bythe software usingthesender's private key. ? Theprivatekeyis generated usingthe algorithm used bythesoftware. ? The encrypted pre-hash code and the message are encrypted again using the sender's private key. ? The next step is for thesender of the message to retrieve the publickeyof thepersonforwhomthisinformationisintended. ? The sender encrypts the secret keywith the recipient's public key, so that onlytherecipientcandecryptitwithhis/herprivatekey,thusconcludingthe encryption process. Decryption Process The asymmetricdatadecryption process hasthefollowingsteps: ? The recipient uses his/her private keyto decrypt the secret key. ? Therecipient uses his/herprivatekeyalongwiththesecretkeytodecipher the encrypted pre-hash code and the encrypted message.

Broadband Network and Internet Services NOTES Self - Learning 266 Material ? Therecipientthen retrieves thesender'spublickey.This publickeyis used to decrypt the pre-hash code and to verifythe sender's identity. ? The recipient generates a post-hash code from the message. If the post- hashcodeequals the pre-hash code, then this verifies thatthe message has not been changed enroute. Symmetric Encryption Private keyencryption (symmetric) – also known as conventional or single-key encryption – is founded on a secret keyshared bytwocommunicatingparties. It requiresallpartiesthat arecommunicatingtoshareacommonkey.Thesecretkey is usedbythe sendingpartyto convert simpletextto encryptedtext, i.e.,text that is encipheredusingthe secret keyas thesecuritycomponentof themathematical process. The receiving party then proceeds to decipher the encrypted material, usingthesamesecretkeythatitshares.Examplesofsymmetricencryptionsystems wouldincludetheRSARC4algorithm(thatfurnishesthebasisforMicrosoftPoint- to-PointEncryption(MPPE),DataEncryptionStandard(DES),InternationalData EncryptionAlgorithm (IDEA), and the procedure now put forward bythe US Governmentcalled'Skipjack'EncryptionTechnologyalreadyutilizedintheclipper chip. Anencryption schemehas fivemajorparts: (i) Plaintext:This is thetext messageto whichanalgorithm is applied. (ii) Encryption Algorithm: It performs mathematical operations to conductsubstitutionsandtransformationstotheplaintext. (iii) SecretKey:This istheinput forthealgorithm as thekeydictates the encrypted outcome. (iv) Ciphertext: This is the encrypted or scrambled message produced byapplying the algorithm to the plaintext message using the secret key. (v) DecryptionAlgorithm: This is theencryption algorithm inreverse. Itusestheciphertextandthesecretkeytoderivetheplaintextmessage. When using this form of encryption, it is essential that the sender and the receiver have a way to exchange secret keys in a secure manner. If someone knows the secret keyand can figure out the algorithm, communications will be insecure.Thereisalsotheneedforastrongencryptionalgorithm.Whatthismeans isthatifsomeoneweretohaveaciphertextandacorrespondingplaintextmessage, theywouldbeunabletodeterminetheencryptionalgorithm.Therearetwomethods ofattackingconventionalencryption – bruteforceandcryptanalysis.Brute force is just asit sounds; using amethod (computer) to findall possible combinations andeventuallydeterminingtheplaintextmessage.Cryptanalysisisaformofattack thatstrikesthecharacteristicsofthealgorithmtodeduceaspecificplaintextorthe keyused.Onewould then beableto figureouttheplaintext forallpast andfuture messages thatcontinue to usethiscompromisedsetup.

Broadband Network and Internet Services NOTES Self - Learning Material 267 Encryption Encryption Digital signature is not forged byother person. Oncesigner signs the document or message, it can not be forged. Signer can not replace the sign once message is signed. The two types of encryption are essentiallyused known as privatekeyencryptionand publickeyencryption. PrivateKey Encryption: The private keyencryptioncontains a secret keythat is taken as code. This mechanism encrypts a packet of information if it passed across network to theother computer.Theprivate keyrequires installingthe key whichis essentiallythe sameas secretcode.Thecodeprovides thekeytodecode the message. For example, a coded message A is substituted by C and B is substituted byD.Therefore,AbecomesC and Bbecomes D.Ifaclueis givenfor the message that code is shifted by 2. The message can be decoded by your friend.Aperson wants to see the message, can not get the message, until and unlessheknowsthesecretkey.Thefinancial,legal,ecommercebusinesstransaction hindrancecan be solved in thepresenceorabsence ofan authorized handwritten signature. PublicKeyEncryption:Thepublickeyencryptionusesprivateandpublickeys. Theprivatekeyisrestricted fortheindividualsystems,whereas publickeycanbe accessed byanysystem where message would be communicated securelywith theindividualsystem.Decodingforencryptedmessageispossiblewithpublickey thatisprovidedbytheindividualsystemanditsownprivatekey.Basically,thekey is based on hash value. The mechanisms are interrelated with each other that increase its popularityin transaction ofdigital cash, e-moneytransferacross net etc. The worst kind of software failure you can have is when your computer refuses to start up because your operating system (Windows) refuses to work. Theothertypeoffailureyoumightexperienceisthatanapplicationrefusestorun. Both ofthesetypes offailurescan reallystopyouinyourtracksandruinyourday. Internet hit bycable breakdown is to be considered as a majorcause of irregular Internet accessing. Recently, Internet access inIndiaandlarge partsofWestAsia has been hit following breakdown of two undersea cables inthe Mediterranean Sea. Internet access in India and large parts of WestAsia including the UAE, Kuwait, and SaudiArabia has been hit following breakdown of two undersea cables intheMediterranean Sea. Thedisruptionwas causedbyananchoringship thataccidentallydamagedIndian-ownedFlagcableandSEA-ME-WEafterbeing diverted from the Egyptian port ofAlexandria due to badweather. Repair teams have alreadyset sail for the location to troubleshoot the problem and hence this target was termed as breakthrough process to breakdown the Internet. The followingfactorsareresponsibleInternet breakdowntobreakthroughlist: Registry Problems Windows has a built-in database and control system to keep track of all of the softwareandcriticalinformationthatlivesonyourPC.Usuallytheymakecomments under their breath.Your PC might not start up or animportant program installed on your PC might not work.

Broadband Network and Internet Services NOTES Self - Learning 268 Material ? ImproperInstallations: If you are having problems with software, you canusuallyfix thembysimplyreinstallingyoursoftware.Thisissomething we often put off doing because it is a pain, but it does work better than anythingelse. ? Recent Software Installation: When you install new software or hardware, internal changes are made to your operatingsystem, and these changes can affect the balance of power on your computer. When you suspectproblemslikethisthenyoucanseeandsuggestfortroubleshooting process if you can work through thelist to tryto findwhat went wrong. ? ExpiredSoftware:ManyprogramsthatusersinstallontheirPCsareoften downloaded from theInternet. Manyare trial versions.Programs like this runfineandofferallofthefeaturesofthecommercialversionuntiloneday whentheysimplystoprunning. Softwarethat needstobeactivatedmaybe fullyfunctionalfora fewdaysand then maycompletelyceasetofunctions until youactivateit. Finally,subscription-basedsoftware,suchasantivirus software might continue to work after it expires typically one year. The expiredsoftwarecreates problem to those system whichare installedwith therecent operatingsystem. 5.7 AUTHENTICATION Authentication Authentication is any process by which one verifies that someone is who they claimtheyare.Basically,itinvolvesausernameandapassword.Itcanalsoinclude any other method of demonstrating identity, such as a smart card, retina scan, voice recognition, or fingerprints. Basic authenticationis the most basicform of authentication to Web applications. Both server and client authentication are requiredinWindows security. ServerAuthentication: The server authentication is a part of client-server computing.Basically, SSL/TLSisusedforauthentication.AWebserveracquires digitalcertificatefromavailableserverusingCertificationAuthority(CA).CAis thirdpartyauthoritythat issues digital certificates forauthentication. TheDigital Certificate(DC)authenticatesthesignaturethatisinfactdigitallysignedmessage. The DC uses SSL/TLS (Secured Socket Layer/ Transport Layer Security) in X.509publickeyinfrastructurethatwasdefinedbyInternationalTelecommunication Standardization Sector(ITU-T).Ifclient connects toserverusingSSL/TLS both client and serverfollows strong cryptographic algorithm. Then the server sends X.509certificatethat contains theserver'spublickey.Theclientthengenerates a 48-byterandomnumber, apremastersecretkeyafterencryptingthenumberused by the server's public key. The encrypted premaster secret key is sent to the serverbyclient.Aftergettingpremastersecretkey,theserverdecryptsthemessage using theprivate keys. Then both client-server shares the same premaster secret keywhichisbasicallysymmetrickeyusedtoencryptthemessage.Thentheystart communicatingviageneratedkeys.Inthismechanism,onlyserverknowstheprivate keywhich decrypts the encrypted premaster secret keyand then clients knows

Broadband Network and Internet Services NOTES Self - Learning Material 269 themessageaftersendingthedecrypted messagebyserver.It provesthat client is talkingwithcorrectserver.Thiswholemechanismrepresentsthecompletescenario ofauthenticatingtheserver. ClientAuthentication:InSSL/TSL,client authenticationisnotrequiredinstead it isoptional.Aclient stays anonymous communicatingbetweenWebserver and browser in B2B business transaction. Therefore, theyuse HTTP authentication methods. The HTTP authentication known as RFC 2617 represents the HTTP protocol inwhich client and servercommunicates betweeneachotherviaHTTP protocol.Itbasicallyconsiderstwo factorsas useridandpasswordtoauthenticate theusers/clients.Sometimes,useridmightbeuser'semail-idalso.Bothvaluesare senttoauthenticatewithoutencryptionandhencetheyarenotconsideredassecure methodofauthenticationincryptography.Inthismechanism,clientsendsBase64- encodeduserid andpassword in HTTPheader. If dataissent throughSSL/TLS connectiontherefore,it isnotalteredorstolenduringtransmission.Themalicious servercannotdisguiseitselfasgenuineWebserverandalsonotstealthepassword ofuser.Forclientauthentication,SSL/TLScertificateisusedtoobtainanappropriate digital certificate before connecting to the server.Aclient generates the private key/publickeypairtoobtaintheclientcertificate.Theprivatekeyiskeptassecret keyandprotected bypassphrase. Thepassphrase works as passwordwithadded security. It is a sequence of word to control access to thesystem.Theapplication does not maintain the database ofuserid and password. It verifies the certificate that is signed bytrusted CA. Fig. 5.6 Uses of Client Certificates Figure 5.6shows the complete scenario of usingthe clientcertificates. Let takeanexample,thecustomermanagestenpasswordsinwhichcompany'XXX' usesspecificpasswordtoaccessthesystemandcompany'YYY'usestheservice. Once certificate-based authentications are used byapplications 'A','B'and 'C', the company issues CAwhere company trusts on legitimate user. In this way, client certificatesareused to authenticatethemessage.

Broadband Network and Internet Services NOTES Self - Learning 270 Material Authenticationattachesdateandtimealongwithauthorofthesignatureand scrutinizesthecontentswhensignaturewasbeingcompleted.Itensuresthatmessage is not altered. The message can beelectronicdocuments,such asemail, text file, spreadsheet etc.Aperson or information is authenticated on the computer by using various techniques. User name and password provides authentication. If userlogsonthesystem unitorapplication,usernameandpasswordwill beasked forcheckingauthentication.Generallypasswordauthenticationisprovidedtouser in which two prime fields, such as 'User Nameand Password' arerequired to access thesystem. Ifthe two requirements are not matched usersarenot allowed to access thesystem. If two requirements are not matched, users are not allowed to access the system. ThesecuritysettingforInternetusercan beconfiguredwith'SecuritySettings– Internet Zone' tab. 5.8 VIRUSES Viruses are frequently transmitted through e-mail attachments, peer--to--peer downloads,phishingandinstantmessages.Phishingreferstoafraudulentprocess in which user'scredentials are easilygrabbed.Amongthese,e-mail attachments carryandspreadvirusfastinanaddressbookorarandomcombinationofaddress

Broadband Network and Internet Services NOTES Self - Learning Material 271 book.Ifthesevirusesarenot controlledquickly,theserverscandisrupt thee-mail servicesforall systems. Thefunctionsofcomputervirusesareasfollows: ? Itdeletes registryattaches,systemfiles andlogfiles.ItalsodestroystheOS ofsystemunits. ? Manyviruses slowdown thecomputerperformance. ? Viruses declinesuddenlyin speed and in loss of filesordata. ? Theycausetodisplayunknownanduncommonmessagesorevenplayinga tune. ? Theyare responsiblefor the loss ofhard disk partition. ? Theyreleaseoffilesnormallyviae-mail. Toknowtheworkingand spreadingofviruses onPCorevenontheInternet,you mustknowthelifecycleofcomputerviruses. Thelifecycleofcomputervirusisas follows: ? Coding ? In this phase, the virus program is coded and developed. ? Releasing? Oncethecodeisready,itisspreadtothesystemandnetwork. ? Spreading ? It is out forwarded through asimple e-mail. ? Quarantining? Inthisphase,thevirusgetsquarantined.Thisphaseoften happenswhenitvalidatesthesignatureofthevirusanddevelopsanantivirus update. Virusesspreadfrommachinetomachineandacrossnetworkinanumberofways. The viruses are always trying to trigger and execute themalicious programs that intentlyspread the computer system. For example, a macro virus is booted with infected disk and spread the viruses to boot sector. Then it started to share the network drive or other media that exchanges infected files across Internet by downloading files and attachments form Internet. Thetransmissionof viruses is possiblebyfollowingways: ? Ifsystemunitis bootedfrominfected files. ? If programs are executed with an infectedprograms. ? The virus infiltration includes common routes, floppy disks and e-mail attachments. ? If pirated software and shareware are used inthe system files. Viruses are malicious and smart. Manya times, users are not able to realizethat theirsystem unithas gotinfected withviruses.Thepropertyofvirusesisthat they hide themselves among regular system files or as attachments and camouflage themselves as standard files. The followingsteps are usuallytakenif the system getsinfectedwiththeviruses: ? The Internet facilityand LAN utilities must be disconnected forthe some time. ? The OS mustbeinstalled within thesystem unit ifthesystem has not been booted properly. If the system does not recognize the hard drive it means that itis infected with virus.It is bettertoboot fromWindowstorescuethe disk. The partition table ofscandisk must berecoveredusingscandisk for a standardWindows program.

Broadband Network and Internet Services NOTES Self - Learning 272 Material ? Aback-upofallimportantandcriticaldatamustbetakenatregularintervals by using external devices, such as CD, USB, floppy disks or even flash memoryetc. ? Antivirus softwaremust be installed in thesystem and shouldbe made to rweekend or at the end of the month.Agood qualityantivirus disinfects infected objects, quarantines infected objects and is abletodeleteTrojans and worms. ? The latest updates must be taken to remove the antivirus database. The infected computeris not included to download these updates. ? Scans disinfect the mails of a client's database and ensure the maliciousograms arenotreactivatedifmessagesaresentfrom oneaddress to another across the network. ? Firewallsecurityfeaturesmustbeinstalledinthesystemthatpreventattacks frommaliciousandforeignprograms. ? Delete and clean the corrupted applications and files. Tryto reinstall the required applications in your system but be sure that the corresponding software is not pirated. Antivirus Software(s) Now you know the concept of worms, spyware and viruses.You need to install and run the antivirus programs to clean the virus and provides the securityfor Windows. It helps in protectingWindows from crashing.The antivirus software available inthemarket to dealwith virus-relatedissues areas follows: ? SymantecAntivirus that is used to check the securityofforeign programs andapplications. ? WindowsVistaAntivirusSpyware,AntivirusNortonAntivirusthat is used to catch worms, rootkits, spywares, viruses, etc.. ? AvastAntivirus. ? KasperskyAntivirusthatisusedforHTTPtraffic-checkingandforproviding asecuritywizard. These antiviruses are useful for thosetypes of viruses that are downloaded from thenetorfrom email attachments.Themost popularantivirusprogramsareData Fellows F-Prot, EliaShim ViruSafe, ESaSS ThunderBYTE, IBM Antivirus, McAfee Scan, MicrosoftAnti Virus, Symantec NortonAntivirus and S&S Dr Solomon'sAVTK. The hard disks and drives must be scanned on a daily basis. Everyweek, hackers and malicious programmers release their virus programs acrosstheInternetsoitisbettertokeepthesystemupdatedwiththelatestantivirus softwareandprograms.Theupdated usermanualandhelpfilesmustbeprovided to the users during the installation of expensive applications and the operating system.Infact,automaticupdatestothelistofantivirusandmultithreaddetection are thestandard features of an antivirus program. Windows XP Firewall AsecurityauditloggingfeatureisprovidedwiththeWindowsXPFirewall.Windows securityis protected with firewall installation.Firewall provides asecure barrier forWindows securitythat protects your PC from outside and foreignworld. It is

Broadband Network and Internet Services NOTES Self - Learning Material 273 configured with full-timeInternet connection.Firewall softwareis consideredas aneffectivemeanstoprotecttheInternetfrommalfunctionsandnetworked-based security threats. Information and services are essentially required for the organizations. Internet connectivityuses dialup capabilityandinstalled with the systemunittotheInternetserviceprovider.Connectionsnetworkrequiresvarious typesofsoftwareaswellasoperatingsystem. FirewallisinsertedbetweenInternet and Internet-based attacks that provide a single choke point in which all other malfunctions aretracked.Thecharacteristics offirewallareas follows: ? All Internet traffic must be passed via firewall. It the foreign accessing approaches to the local network. ? Onlyauthorized trafficis to beallowed to pass. ? It itselfis to beimmuneto be permutation. ? It filters traffic with the help of allotted IP address and also takes help of TCPport number. ? It hosts the server software, such as Web or mail service. ? It monitorssecurity-related events. ? ItprovidesaplatformfortheInternetProtocolSecurity(IPSec)thatincludes a network address translator, audits and alarms. Thelimitationsoffirewallareasfollows: ? Some of the complex types of attacks are not protected byfirewalls. ? Itcannotprotectvirus-infectedprogramsandnotabletoscantheincoming files,messagesforviruses, emails, etc. ? It does not protect against threats. The firewall is consisted of two systems, known as a bastion-host and a packet filteringrouter.Bastion-hostisworkedforauthenticatingservicesandperforming theproxyfunctions.Theconfigurationoffirewallisassembledbetweentwopacket-filteringrouters.Inthissetting,oneapproachcomesbetweenthebastion-host and the Internet work. This configuration is set with an isolated subnetwork, which provides threelevels of defenseto thwart intruders.

Broadband Network and Internet Services NOTES Self - Learning 274 Material Youneedtoselect theOnradiobuttoninWindows Firewalltab,becauseitblocks all outsideandforeignsources from connectingto thiscomputer. 5.9 INTERNET PRIVACYAND SECURITY ATTACKS Each individual has his or her own personal space. Breaching that privacy is considered to be unacceptable.This rule applies to the Internet orWeb as well. ThereareinnumerableInternetusersalloverthe worldwhoareconstantlyaccessing data and uploading data. So the Internet privacy is to regulate what a person revealsabouthimselforherselfandwhocangainaccesstoit.TheInternetprivacy isthedesireormandateofpersonalprivacyconcerningtransactionsortransmission ofdataviatheInternet.Itinvolvestheexerciseofcontroloverthetypeandamount ofinformationapersonrevealsabouthimselfontheInternetandwhomayaccess suchinformation.Thetermisoftenunderstoodtomeanuniversal Internetprivacy, i.e., everyuser ofthe Internet possessing Internet privacy.Internet privacyforms a subset of computer privacy. People with only a casual concern for Internet privacyneednotachievetotal anonymity. Aspeopleusecomputersforavarietyofpurposes,confidentialinformation, confidential communications, andpersonal choicescanbe registeredina variety of ways. The Internet privacy is a broad term referring to the various concerns, technologies,andstrategiesforprotectinginformation,communications,andchoices that are meant to be private. In general, usingthe Internet oftenmeans givingup somemeasureofprivacy.Forpeoplewhowishtoremaincompletelyanonymous, the best approach is to use a public computer, such as those available at public libraries.Otherstepstotakewhenanonymityisthegoalincludeclearingthecache and browsinghistorybefore leaving thecomputer.This is donein different ways depending on the browser used and refraining from entering any personal information orcreating anyusernamesorpasswords. For example, if you want to shop online, use social networkingsites, play onlinegames, orparticipate in forums, Internet privacycanbecome anissue in a numberofways. Ifyourpasswordsareexposed,youridentitycanbefraudulently used or even stolen. If your words, photographs or products you have created arepostedwithoutyourpermission, yourreputationandincomecanbedamaged. Ifyourcontactinformation is passed around,youmaybesubject tospam.If your browsinghistorybecomes public, peoplewill knowwhat you havebeenlooking at online.Fortunately, takingcertain precautionscanreducetheprivacyrisks that you face. Strongpasswordsthatarekeptsecretareonewaytosafeguardyour Internet privacy.Browserprivacysettings,whichcontrolelementslikestorageofyourbrowsing and download historyand the acceptance ofcookies, are there for youto alter to meetyourpreferences.Theoptionsdifferwithdifferentbrowsers.Similarly,social networkingsiteshavesettingstoallowyoutocontrolthelevelofprivacyofvarious postings you maymake. The default settings maybe skewedtowards the public exposureofinformationratherthantowardsInternetprivacy.Forsitessuchasforums, makesureyoureadtheprivacytermsbeforesigningup.

Broadband Network and Internet Services NOTES Self - Learning Material 275 Internet users obtain Internet access through anInternet Service Provider (ISP).All datatransmitted to and from users must pass through theISP.Thus, an ISPhasthepotentialtoobserveusers'activitiesontheInternet.Inaddition,search engines have the abilityto track a user's searches. Personal information can be revealedthroughsearches includingsearch itemsused,thetimeofthesearch,etc. Search engines have claimed a necessityto retain such information in order to providebetterservices,protectagainstsecuritypressureandprotectagainstfraud. Security Attacks and Counter Measures ITU-T(InternationalTelecommunicationUnion)RecommendationX.800,Security ArchitectureforOSI(Open Systems Interconnections)definessystematicwayto definetherequirementsforsecurityand characterizetheapproaches tosatisfying those requirements. It effectivelyassesses the securityneeds of an organization andevaluates,andchoosesvarioussecurityproductsandpolicies.TheOSIsecurity architecture is a wayof organizing the task of providing security. Furthermore, because this architecture was developed as aninternational standard, computer andcommunications vendorshavedevelopedsecurityfeaturesfortheirproducts and services that relate to this structured definition of services and mechanisms. TheOSIsecurityarchitecturefocusesonsecurityattacks,mechanismsandservices asfollows: ? SecurityAttack: It refers to anyaction that compromises the securityof informationownedbyanorganization. ? Security Mechanism: It is a process (or a device incorporating such a process)thatisdesignedtodetect,preventorrecoverfromasecurityattack. ? Security Service: It refers to processing or communication service that enhances the securityof the data processing systems and the information transfers of an organization. The services are intendedto counter security attacks,andtheymakeuse ofoneor moresecuritymechanisms toprovide theservice. Threat is a potential for violation of security, which exists whenthere is a circumstance, capability, action, or event that could breach securityand cause harm.Thatis, athreatisapossibledangerthatmightexploit vulnerability. Attackisanassaultonsystemsecuritythatderivesfromanintelligentthreat; that is, an intelligent act that is a deliberate attempt (especiallyin the sense of a method ortechnique)to evade securityservices andviolatethesecuritypolicyof a system. SecurityAttacks A securitypolicycan be defined as the frameworkwithinwhich an organization establishesneededlevelsofinformationsecuritytoachievethedesiredconfidentiality goals.Apolicyisastatementofinformationvalues,protectionresponsibilitiesand organizationcommitmentforasystem.Priortoevaluatingattacksagainstasystem and decidingon appropriate mechanisms torepulse these threats, it is necessary to specifya securitypolicy.Asecuritypolicythat is sufficient for the dataof one organizationmaynotbesufficientforanotherorganization.

Broadband Network and Internet Services NOTES Self - Learning 276 Material SecurityAttacks Agraphicalrepresentation ofthecommunicationprocessandsomeoftheattacks isgiveninFigure5.7. Communication Information Source Information Destination Fig. 5.7 Information Flow Interruption Aninterruptioncanbedefinedasastatewheretheassetofasystemgetsdestroyed orbecomesunavailable.Thistypeofattacktargetsthesourceorthecommunication channelandpreventstheinformationfromreachingitsintendedtarget,forexample, anattackermaycut thephysicalwireto prevent theinformationfrom reachingits destination.Anothercommonlyused techniquebytheattackeris tooverload the carryingmediawherebytheinformation gets droppedduetocongestion.Attacks inthiscategoryattemptto performakind ofDenialofService(DoS).Agraphical representationofinterruption isgiveninFigure5.8. Interruption Information Source Information Destination Fig. 5.8 Interruption Interception Interception happens when an unauthorized partygets access to the information byeavesdroppingintothecommunicationchannel.Wiretappingisagoodexample ofinterception.Agraphical representation ofinterceptionis giveninFigure5.9. Interception Information Destination Information Source Fig. 5.9 Interception
Broadband Network and Internet Services NOTES Self - Learning Material 277 Modification Inmodification,theinformationisnotonlyinterceptedbutmodifiedbyanunauthorized partywhileintransitfromthesourcetothedestination(e.g.bymodifyingthemessage content).Agraphical representation ofmodification is given in Figure5.10. Modification Source Destination Fig. 5.10 Modification Fabrication Fabricationoccurswhenanattackerinsertsforgedobjectsintothesystemwithout thesender'sknowledgeorinvolvement.Fabricationcanbecategorizedasfollows: ? Replaying: When apreviouslyintercepted entityisinserted, this process iscalledreplaying. Forexample,replayinganauthenticationmessage. ? Masquerading: When the attacker pretends to be the legitimate source andinserts his/herdesired information, theattackis called masquerading. For example, addingnew records to a file or database. Agraphical representationoffabricationis giveninFigure5.11. Fabrication Source Destination Fig. 5.11 Fabrication
Broadband Network and Internet Services NOTES Self - Learning 278 Material Network Security and Counter Measures Securitymanagementfornetworks is differentforall kinds ofsituations.Asmall home or an office would onlyrequire basic securitywhile large businesses will require high maintenance and advanced software and hardware to prevent maliciousattacksfrom hacking and spamming. Small Homes ? Useabasic firewall ora unifiedthreatmanagement system. ? ForWindows users, abasicAntivirus software.Ananti-spyware program wouldalso bea good idea. Therearemanyothertypes ofantivirus oranti- spyware programs out there to be considered. ? When usinga wireless connection, use a robust password.Alsotryto use the strongest securitysupported byyour wireless devices, such asWPA2 withAESencryption. ? IfusingWirelesschangethedefaultSSIDnetworkname,alsodisableSSID Broadcast; as this function is unnecessaryfor homeuse. ? Enable MACAddress filtering to keep track of all home network MAC devices connectingto yourrouter. ? Assign STATIC IPaddresses to network devices. ? Disable ICMPping on router. ? Reviewrouterorfirewalllogstohelpidentifyabnormalnetworkconnections or trafficto the Internet. ? Use passwords for all accounts. ? Havemultipleaccountsperfamilymember,usingnon-administrativeaccounts for day-to-day activities. Disable the guest account (Control Panel ? AdministrativeTools? ComputerManagement?Users). ? Raiseawareness aboutinformation securitytochildren. Medium Businesses ? Useafairlystrong firewall or UnifiedThreatManagement System ? Strong Antivirus software andInternetSecuritySoftware. ? For authentication, use strong passwords and change it on a bi-weekly/ monthlybasis. ? When usinga wireless connection, usea robust password. ? Raise awarenessabout physical security toemployees. ? Use anoptional network analyser ornetwork monitor. ? Anenlightenedadministratorormanager. Large Businesses ? Astrong firewall and proxy to keepunwanted people out. ? A strong Antivirus software package and Internet Security Software package.
Broadband Network and Internet Services NOTES Self - Learning Material 279 ? For authentication, use strong passwords and change it on a weekly/bi- weeklybasis. ? When usinga wireless connection, usea robust password. ? Exercise physical security precautionstoemployees. ? Prepare a network analyser ornetwork monitor and use it when needed. ? Implement physicalsecuritymanagementlikeclosedcircuittelevisionforentry areas and restricted zones. ? Securityfencing to markthecompany's perimeter. ? Fire extinguishers for fire-sensitive areas like server rooms and security rooms. ? Securityguards canhelptomaximizesecurity. School ? Anadjustable firewall and proxy toallowauthorizedusersaccessfromthe outsideand inside. ? Strong Antivirus software and Internet SecuritySoftwarepackages. ? Wirelessconnectionsthatleadto firewalls. ? Children'sInternetProtectionAct compliance. ? Supervisionofnetworktoguaranteeupdatesandchangesbasedonpopular siteusage. ? Constantsupervisionbyteachers,librarians,andadministratorstoguarantee protection againstattacks byboth internet and sneakernet sources. LargeGovernment ? Astrong firewall and proxy to keepunwanted people out. ? Strong Antivirus software andInternetSecuritySoftwaresuites. ? Strong encryption. ? Whitelistauthorizedwirelessconnection,blockallelse. ? All network hardwareis in securezones. ? All host shouldbeon a privatenetwork that is invisiblefrom theoutside. ? Put Web servers in a DMZ, or a firewall from the outside and from the inside. ? Securityfencing to mark perimeterand set wireless range tothis. 5.9.1 Key Management Themanagementofkeysisthechiefproblemareaforallencryptionsystems.The keysarethemostvaluableinformation.Ifanyonecangetakey,anyonecandecrypt everything that has been encrypted bythat key. In some cases, one mayalso be able to get succeeding keys. The management of keys is not just about securing them while in use. It is also about creating strongkeys, securelydistributingthe keys to correct users, and revoking the keys, if theyhave been compromised or expired.

Broadband Network and Internet Services NOTES Self - Learning 280 Material Key Creation Obviously, all keys must be created with care. Certain keys have poor security performance with certain algorithms. For example, when creating keys for use with RSA, care must be used to choose a and b from the set of prime numbers. Likewise, a keyof all 0's when used with DES does not provide strongsecurity. Most encryptionsystems havesomemethodforgeneratingkeys.Incertaincases, people areallowed to choose thekeybycreatingapassword. In this case,it may be a good idea to instruct the users on how to choose strong passwords, ideally, which should include numbers and special characters. Otherwise,the total key space issignificantlyreduced (this allows quickerbrute-force keysearches). Somekeysarechosenfromrandomnumbers.Unfortunately,therearevery few trulyrandom number generators. Most are pseudo-random.If the generator isnottrulyrandom,it maybepossibleto predictthenext number.Ifanyonebases the keys on the output of the random number generator and you can predict the output, you maybe able to predict the key. Thelengthofthekeymayalso need tobechosen.Somealgorithmsusefixedkey lengths (such as RSA with 512-bit key). For example, a 1,024-bit RSA key is stronger than a 512-bit RSAkey.You cannot, however, comparethe strength of the DES key to a RSA key in a similar manner. Table 5.1 shows the relative strengthsofkeys fordifferenttypesofalgorithms. Table 5.1 Relative Key Strengths for Different Types of Algorithms Private Key Encryption (DES, RC5) Public Key Encryption (RSA, Diffie-Hellman) Elliptic Curve Encryption 40 bits – – 56 bits 400 bits – 64 bits 512 bits – 80 bits 768 bits – 90 bits 1,024 bits 160 bits 120 bits 2,048 bits 210 bits 128 bits 2,304 bits 256 bits Key Distribution Once the keys have been generated, theymust get to various locations and to be equipment to be used. If the keyis not secure during transit, it maybe copied or stolenandtheentireencryptionsystemisnowinsecure.Therefore,thedistribution channel mustitself besecure. Keyscould be moved out-of-band.In otherwords, the keys could be transported by administrators by hand. This may work successfullyif the remote sites are short distances apart. But what if the remote sites are continents apart? The problem becomes much harder. There is a partial solution to this problem, however. It maybe possible to usetheDiffie–HellmanKeyExchangeinordertocreateanddistributemanysession keys (short-term keysused fora singlesessionor asmall amountoftraffic).This mayreducetheneed to travel to remote locations. Longer-term keys (RSA keys, for example) require more care. It is not appropriate to use the Diffie-Hellman KeyExchangealgorithm to distribute the RSAkeypairs. InthecaseofRSAkey
Broadband Network and Internet Services NOTES Self - Learning Material 281 pairs, one key must be kept secret and one can be published. The key that is publishedmust bepublished in such awayas toprecludebeingtamperedwith.If thepairsaretobegeneratedbyacentralauthority,theprivatekeymustbesecurely transmitted to the pair owner. If the owner will generate the keypair, the public keymayneed to be transmitted to the central authorityin a secure manner. Key Certification If keys are transmitted to a remote destination by some means, they must be checkedoncetheyarriveto besurethat theyhavenot beentamperedwithduring transit. This can be a manual process or it can be done via some type of digital signature.Publickeysareintended tobepublishedorgivenouttootherusersand must alsobe certified as belongingto theowner ofthekeypair.This can be done throughacentral authority(normallycalledacertificateauthority,orCA).In this case, the CAprovides a digital signature on the public keyand this certifies that theCAbelieves thepublic keybelongs to the ownerofthekeypair(ReferFigure 5.12).Withoutpropercertification, an attackercouldintroduceherownkeys into the system and thus compromise the security of all information transmitted or authenticated. Fig. 5.12 Key Protection Key Protection The publickeysof akeypairdo not require confidentialityprotection.Theyonly requiretheintegrityprotectionwhichisprovidedbytheircertification.Theprivate keyof apublic keypair must be protected at all times. If an attackerwere to gain a copyof the private key, he could read all confidential traffic addressed to the keypairownerandalso digitallysign informationas ifhewasthekeyowner.The
Broadband Network and Internet Services NOTES Self - Learning 282 Material protectionoftheprivatekeyincludes allcopies ofit.Therefore,thefilethat holds the key must be protected just like any backup tape that may include the file. Most systems protect the private keywith a password. This will protect the key from casual snooping but not from a concerted attack. The password used to protect the keymust be well chosento resist brute- force attacks. However, the best wayto protect the keyis to prevent an attacker from gainingaccess to the file in the first place.All keys to a private keysystem must beprotected. Ifthe keyis kept in afile,this file mustbeprotected wherever it mayreside. If the keywill reside in memory, care must be taken to protect the memoryspace from examination bya useror process. Likewise, in thecase of a core dump, the core file must be protected since it mayinclude the key. Key Revocation Keys donothaveinfinitelives. Sessionkeys onlyexist foragivensession.There is no needto revokethekeyas it becomes invalidat theendofthesession.Some keys maybecertified fora givenperiod oftime. Generallyspeaking, publickeys pairs are certified for one or two years. The certified public keywill recognize if the date has expired. Systems that read the certificate will not consider it valid afterthatdatesoitbecomesunnecessarytorevokeanexpiredcertificate.However, keys can also be lost orcompromised. If this happens,the owner ofthekeymust inform otherusers ofthefact that the keyis nolonger validand thus it should not be used. In the case of a private keyencryption system, if a keyis compromised (andiftheusers ofthesystem knowit)theycancommunicatethis informationto eachotherandbegin usingafreshkey.Thecaseofpublickeyencryptionsystems isalittledifferent. If a key pair is compromised and revoked, there is no obvious way to inform all of the potential users about the public keywhich is no longervalid. In some cases, public keys are published to key servers. Someone wishing to communicate with the owner of thekeymaygo tothe server once toretrieve the certified public key. If the keyis compromised and revoked, how does another person find out? The solution is that onemust periodicallyvisit thekeyserver to see if there is a revocation of the key and the owner of the key must post the revocation to all of the potential keyservers. The keyservers must also hold this revocationinformationatleastuntiltheoriginalcertificateexpires. 5.10 ELECTRONIC MAILAND INTERNET SERVICES OfthevariousapplicationsofTCP/IPthemostimportantoneistheinternetworking equivalent of thereal-world postal deliverysystem,commonlycalled electronic mail or e-mail. The historyof e-mail goes backto the veryearliest days of TCP/ IP's development. Today millions of people every day send both simple and complexmessagesaroundtheworldthroughe-mail.TCP/IPe-mailisnotanyone application.Itisimplementedasacompletesystemcomprisingseveralprotocols, software elements and components.All theseelements perform one or the other part ofthecompletecommunication process of e-mail. These includea standard messageformat, aspecific syntax forrecipient addressing, andprotocolsto both

Broadband Network and Internet Services NOTES Self - Learning Material 283
delivermailandallowaccesstomailboxesfromintermittentlyconnectedTCP/IP clients. Mail Communication Process Steps ThemodernTCP/IPe-mailcommunicationprocess consistsofthefollowingfive basic steps. 1. Mail Composition E-mailjourneybeginswiththecreationofamessage,thatis,electronicmailmessage. There aretwo parts of a message: the header and the body. the header contains data that describes the message and controls how it is delivered and processed, thebodyofthemessageistheactual informationthatis tobecommunicated.The messagemustbecreatedasperthestandardmessageformatforthee-mailsystem sothatitcanbeprocessed.Itmustalsospecifythee-mailaddressesoftheintended recipients forthemessage. Bywayof analogyto real mail, thebodyofthe messageis likealetter,and the headeris like the envelopeinto which the letteris placed. 2. Mail Submission Therearevariousotherinternetworkingapplicationsbesidese-mail.But,electronic mail is different from manyotherinternetworkingapplications in thatthesender andreceiverofa messagedo notnecessarilyneedtobeconnectedtothenetwork simultaneously, nor even continuously, to use it.The system is so designed that aftercomposingthemessage, theuserdecideswhentosubmit themessagetothe electronicmail systemso it can bedelivered. Themail is transferredbyusingthe SimpleMailTransferProtocol (SMTP). This is analogous to dropping off an envelope at the post office, or to a postal workerpickingup an envelope froma mailbox and carryingit to thelocal post officeto insert intothemaildeliverystream. 3. Mail Delivery Once the user has submitted the electronic mail message, it is accepted bythe sender'slocalSMTPsystemfordeliverythroughthemailsystemtothedestination user.Today,this is accomplished byperformingaDomain NameSystem (DNS) lookupoftheintendedrecipient'shostsystemandestablishinganSMTPconnection with that system.SMTP also supports theabilitytospecifyasequence of SMTP servers throughwhich amessagemustbepassedtoreachthedesireddestination. Onewayortheother,eventuallythemessagearrivesattherecipient'slocalSMTP system. This is like the transportation of the envelope through thepostal system's internal 'internetwork' of trucks, airplanes and other equipment to the intended recipient'slocalpost office. 4. Mail Receipt and Processing Now,thelocal SMTPserveracceptsthee-mail messageforfurtherprocessing.It placesthemailintotheintendedrecipient'smailbox,whereitwaitsfortheuserto retrieveit.
Broadband Network and Internet Services NOTES Self - Learning 284 Material In our physical analogy, this is the step where the recipient's local post officesorts mailcomingin from thepostal deliverysystem andputsthemail into individual postofficeboxes orbinsfordelivery. 5. Mail Access and Retrieval The intended recipient periodically checks with its local SMTP server to see if there is anymail forhim/her.Ifso, the recipient can retrievethe mail,openit and readitscontent. This is donebyaspecial mail accessprotocol ormethodand not bySMTP.Theaccess protocol and client e-mail software mayallow the user to scan the headers of received mail (such as the subject and sender's identity) to decide which mail messages to download. This saves quite a lot of time as user neednot actuallyopen up everymail. This is the step where mail is physically picked up at the post office or delivered to the home. Electronic Mail Message Communication Model, Devices and Protocol Roles Oneofthecriticalrequirementsofanelectronicmailsystemisthatthesenderand receiver of a message need not be online at the time when mail is sent. TCP/IP thereforeusesacommunication model withseveral devices thatallowthesender and recipient to be decoupled.Thesender's client device spoolsmail and moves it to thesender's local SMTPserverwhen it is readyfortransmission.Thee-mail is thentransmitted to the receiver's SMTPserver using SMTPwhere it remains for an indefinite period of time. When the recipient is readyto read it, he or she retrieves it using one or more of a set of mail access protocols and methods, the two most popular of which are POP and IMAP (Refer Figure 5.13). Fig. 5.13 Electronic Mail Communication Model
Broadband Network and Internet Services NOTES Self - Learning Material 285 ? Sender's Client Host: The sender of the mail composes an electronic mailmessage,generallyusingamailclientprogramonhisorherlocalmachine. Themail,oncecomposed,isnotimmediatelysentoutovertheInternet;itis held in a buffer area called a spool. This allows the user to be "detached" fortheentiretimewhen anumberofoutgoingmessagesarecreated.When the user is done, all of the messages can be sent at once. ? Sender's LocalSMTPServer:When the user's mail is readyto be sent, heorsheconnectstotheinternetwork.Themessagesarethencommunicated to the user's designated local SMTP server, normally run by the user's InternetServiceProvider(ISP). Themailissentfromtheclient machineto the local SMTPserver using SMTP. (It is possible in some cases for the sender to be working directly on a device with a local SMTP server, in whichcasesendingissimplified.) ? Recipient's Local SMTPServer:The sender's SMTPserver sends the e-mail using SMTP to the recipient's local SMTP server over the Internetwork.There,thee-mailisplacedintotherecipient'sincomingmailbox (inbox).Thisiscomparabletotheoutgoingspoolthatexistedonthesender's clientmachine.Itallowstherecipienttoaccumulatemailfrommanysources over aperiod oftime, andretrieve them when it is convenient. ? Recipient's Client Host: In certain cases the recipient mayaccess his or her mailboxes directlyon the local SMTPserver. More often, however, a mail access and retrieval protocol, such as POP3 or IMAP, is used to read themailfromtheSMTPserveranddisplayitontherecipient'slocalmachine. There,it is displayed usingan e-mailclient program,similartotheone the sender used to compose the message in the first place. Some form of addressing is required for all network communications. Since electronic mail is user-oriented, e-mail addresses are based on users as well. In modernTCP/IPe-mail,standardaddressesconsistofausername,whichspecifies whotherecipient is, andadomainname, whichspecifiestheDNSdomainwhere the user is located.Aspecial DNS mail exchange (MX)record is set up for each domainthatacceptse-mail,soasendingSMTPservercandeterminewhatSMTP serverit should use to send mail to aparticular recipient. User Agent The user agent (UA) makes the sending and receiving anymessage easier and provides serviceto the user. Someexamples of command-driven useragents are mail, pine, and elm. Some examples of GUI-based user agents are Eudora, Outlook, and Netscape (Refer Figure 5.14). Fig. 5.14 Functions of User Agent

Broadband Network and Internet Services NOTES Self - Learning 286 Material Simple Mail Transfer Protocol ThemostimportantcomponentoftheTCP/IPelectronicmailsystemistheSimple Mail Transfer Protocol (SMTP). Derived from Mail Transfer Protocol (MTP), SMTP is the mechanism used for the deliveryof mail between TCP/IP systems and users. The onlypart of the e-mail system for which SMTP is not used is the final retrievalstepbyan e-mailrecipient. IntheearlydaysofSMTP,mailwasdeliveredusingtherelativelyinefficient process ofrelayingfrom servertoserveracross theinternetwork.Today,whenan SMTPserverhas mailtodelivertoauser,itdetermines theserverthathandles the user's mail using the Domain Name System (DNS) and sends the mail to that serverdirectly. SMTP servers both send and receivee-mail; the device sendingmail acts as aclient for that transaction; the one receivingit acts as a server (Refer Figure 5.15).Toavoid confusion, it is easier to refer tothe device sending e-mail as the SMTPsender and the one receiving as the SMTPreceiver; these were the terms used when SMTPwas originallycreated. Fig. 5.15 Simple Mail Transfer Protocol (SMTP) SMTP Connection and Session Establishment and Termination ThedeliveryofelectronicmailusingtheSimpleMailTransferProtocol involves theregular exchangeof e-mail messages between SMTP servers. SMTP servers areresponsibleforsendinge-mailthatuserssubmitfordelivery.Theyalsoreceive e-mail either intended for local recipients, or in some cases for forwarding or relayingto otherservers. An SMTP session consists of three basic phases (Refer Figure 5.16): 1. First, thesession isestablished throughthe creation of aTCP connection and the exchange of identityinformation between the SMTP sender and receiverusingtheHELOcommand. 2. Once the session is established, mail transactions can be performed. 3. Finally, when the SMTPsender is done with the session, it terminates it usingtheQUIT command. If SMTP extensions are supported, theSMTP sender uses the EHLO (extended hello) command instead of HELO, and the SMTP receiver replies with a list of extensions itwill allow theSMTPsendertouse.

Broadband Network and Internet Services NOTES Self - Learning Material 287 SMTP mail transaction process Thedeliveryofe-mailmessagebeginswiththeestablishmentofanSMTPsession betweenthedevicessendingandreceivingthemessage.TheSMTPsenderinitiates a TCP connection to the SMTP receiver, and then sends a HELO or EHLO command, to which the receiver responds.Assuming there are no problems, the sessionis thenestablished and readyforactual e-mail message transactions. Fig. 5.16 SMTP Session SMTPMail Transaction Overview TheSMTP mail transaction process consistsof threesteps: 1. Transactioninitiationandsenderidentification:TheSMTPsendertells the SMTP receiver that it wants to start sending a message, and gives the receiver thee-mail address of themessage's originator. 2. Recipient identification: The sender tells the receiver the e-mail address(es) ofthe intended recipients ofthe message. 3. Mail transfer: The sender transfers the e-mail message to the receiver. Thisisacompletee-mailmessagemeetingtheRFC822specification(which maybe in MIME format as well)(Refer Figure 5.16). SMTP Security Issues The base protocol does not include anysecuritymechanism as Internet security was not an issue in the times when SMTP was designed. But with the change in current scenario, e-mail is so often abused today, most modern SMTPservers incorporate one ormore securityfeatures toavoid anyproblem.

Broadband Network and Internet Services NOTES Self - Learning 288 Material SMTP Commands The SMTP sender performs operations using a set of SMTP commands. Each commandisidentifiedusingafour-lettercode.SinceSMTPonlysupportsalimited numberoffunctions, it has asmall commandset (ReferFigure5.17). abc@xyz.com efg@xyz.com efg abc efg abc Fig. 5.17 SMTP Mail Transaction Fig. 5.18 SMTP Commands and Responses ? Commandformat Fig. 5.19 Command Format

Broadband Network and Internet Services NOTES Self - Learning Material 289 ? Commands Fig. 5.20 Commands SMTP responses EachtimetheSMTPsenderissuesacommand,itreceivesareplyfromtheSMTP receiver (Refer Figure 5.21). These replies are similar to FTP replies, and uses bothathree-digitreplycodeand adescriptivetextline.Aspecialenhancedstatus codes SMTP extension is also defined; when enabled, this causes the SMTP receiverto returnmoredetailed result informationafterprocessingacommand.

Broadband Network and Internet Services NOTES Self - Learning 290 Material Fig. 5.21 SMTP Responses Mail Access Protocols For flexibility,TCP/IPuses a varietyof mailbox access and retrieval protocols and methods to allow users toread e-mail. Threedifferent models describe how thesedifferentmethods work: ? The online model, in which e-mail is accessed and read onthe server. ? The offline model, in which mail is transferred to the client device and used there. ? The disconnected model, where mail is retrieved and read offline but remains ontheserverwithchangessynchronizedforconsistency. Fig. 5.22 POP and IMAP TCP/IP Post Office Protocol (POP/POP3) The Post Office Protocol (POP) is currently the most popularTCP/IP e-mail access and retrieval protocol. It implements the offlineaccess model, allowing users to retrieve mail from their SMTP server and use it on their local client computers. It is specificallydesigned to bea verysimple protocol and has only small number of commands. The current revision of POP is version 3, and the protocol is usuallyabbreviated POP3 for that reason (ReferFigure 5.22).

Broadband Network and Internet Services NOTES Self - Learning Material 291 ? POP3GeneralOperation,Client/ServerCommunicationandSessionStates POP3 isaregularTCP/IPclient/serverprotocol.Toprovideaccess tomailboxes, POP3 server software must be installed and continuouslyrunning on the server where the mailboxes are located. POP3 uses theTransmission Control Protocol (TCP)forcommunication,toensurethereliabletransferofcommands,responses and message data. POP3 servers 'listen'on well-known port number 110 for incoming connection requests from POP3 clients.After a TCP connection is established, the POP3 session is activated. The client sends commands to the server,whichreplieswithresponsesand/ore-mailmessagecontents(Figure5.23). POP3 is a client/server protocol that is described using a simple linear sequence of states. 1. AuthorizationState:Theserverprovidesagreetingtotheclienttoindicate that it is ready for commands. The client then provides authentication information to allow access to the user's mailbox. Bydefault, POP3 uses onlyasimpleusername/passwordauthenticationmethod. 2. TransactionState:Theclientis allowedtoperformvarious operations on the mailbox. Theseinclude listing and retrievingmessages, and marking retrievedmessagesfordeletion.Theclientnormallybeginsbyfirstretrieving statistics about the mailbox from the server, and obtaining a list of the messages in the mailbox. The client then retrieves each message one at a time, marks each retrieved message for deletionon the server. 3. Update State:When the client is done with all of its tasks and issues the QUITcommand,thesessionentersthisstateautomatically,wheretheserver actuallydeletes themessages marked fordeletion intheTransactionstate. This concludes the session and the TCP connection between the two is terminated. Fig. 5.23 POP General Operation

Broadband Network and Internet Services NOTES Self - Learning 292 Material TCP/IP Internet Mail Access Protocol (IMAP/IMAP4) ThePost OfficeProtocol is popularbecauseofits simplicityandlonghistory,but POP has few features and normallyonlysupports therather limited offline mail access method.To provide more flexibilityfor users in howtheyaccess,retrieve and work with e-mail messages, the Internet MessageAccess Protocol (IMAP) was developed. IMAP is primarily used in the online and disconnected access models;itallowsuserstoaccessmailfrommanydifferentdevices,managemultiple mailboxes,selectonlycertainmessagesfordownloading,andmuchmore.Dueto itsmanycapabilities,itisgrowinginpopularity. IMAP general operation, client/server communication and session states IMAP is a client/server application, and an IMAP session begins with the client makinga TCP connection to theserver (Figure 5.23). Thesessionbetween an IMAP4 clientand serveris describedintheIMAP standards. The following are the IMAP states, in the usual sequence in which they occur fora session: 1. NotAuthenticated State:The session normallybegins in this state after a TCPconnectionis established; unless thespecialIMAPpreauthentication featurehas beenused (we will get to this featureshortly). Theclient at this pointcannotreallydomuchasidefromprovidingauthenticationinformation so it can move to the next state. 2. Authenticated State: The client has completed authentication, either through an authentication process in the prior state or through preauthentication.Theclientisnowallowedtoperformoperationsonwhole mailboxes. The client must select a mailbox before individual message operations are permitted. 3. Selected State:After a mailbox has been chosen, the client is allowed to accessand manipulateindividual messages within themailbox.When the client is done with the current mailbox it can close it and return to the Authenticated stateto select a newone to work with,or can log out to end thesession. 4. Logout State: The client mayissue a Logout command from anyof the other states to request that the IMAP session be ended. The session may alsoenterthisstateifthesessioninactivitytimerexpires.Theserversendsa responseand theconnection is terminated. 5.10.1 Sending E-Mails via Internet E-mail, short for electronic mail, enables you to send your correspondence instantaneouslyanywhereintheworldviatheInternet.E-mailhasmadetheworld a'smallerplace'. The popularityofe-mailingis becauseof its capabilitytosend and receive messagesanytime,anywherewithout anycost.An e-mail allows youto sendand receive avarietyof file types such as text, image,video, sound and graphics to a

Broadband Network and Internet Services NOTES Self - Learning Material 293 singlerecipientormultiplerecipientsusingbroadcasting.Tousethee-mailfeature, you just need to create an e-mail account for yourself using awebsite that offers such services. Various sites provide the e-mail facility. Some of them such as Yahoo.com,Rediff.com, hotmail.com and lycos.comprovideitfreeofcostwhile others chargefor it. Since bynow you would be quite keen to usethe e-mail facility, let us run through theprocess of creating and using an e-mail account onYahoo.com. Creating a User ID Type the URL 'http://www.yahoo.com'in the address bar of a Web browser such as Internet Explorerto visittheYahoohomepage. Mail The pagethat is now displayed is the 'Sign in'page. If you arean existing user, you need to type in your user id and password to log on to your account. If you are a first time user, you need to first create an account for yourself. New User Existing User Click 'Sign Up' to create a new user ID. The page that is displayed is a registrationformthat requiresyou to fillinyourdetailsalongwiththeuserIDand password for yournew e-mail account.

Broadband Network and Internet Services NOTES Self - Learning 294 Material User Id and Password Once you have registered yourself on a website, you become a member and can simplylog on to your mail account to start sendingandreceivinge-mails. Forall future access, you would haveto remember your user ID and password because that is thekeyto your login. Checking Your E-Mail You can access your e-mail anytime bylogging on to your mail. To do so, carry outthefollowingsteps: – TypetheURL'http://www.yahoo.com'intheaddressbarofaWebbrowser. – Enter your user ID and password. User Id and Password Sign In Onceyouhavesigned in successfully, you canaccess youre-mail account. You can access your 'Inbox'to view any incoming mail, or write a new mail through the ComposeMail option. ClickingtheInbox button displaysall thereceivedmessages ormails. Clickingthe e-mail subject displays thecontents of the e-mail that can be read to take necessary action.

Broadband Network and Internet Services NOTES Self - Learning Material 295 Compose Inbox Changing the Password Ane-mail passwordis used forsecurityreasons.Apasswordisthepersonal code ofauserandshould not bedisclosedto anyone. Hence,nevergiveyourpassword to anyone and do not write it down where someone else may find it. You can changeyourpasswordinthefollowingmanner: Click on Options on the top menu bar. ClickonPassword underYourInformation. The ChangeMail Password windowshould appear: In theOld Password box, type in your current password. In both the New Password and Re-enter New Password boxes, enter what you want your new password to be. Click on theSave Options button. A password should be at least eightcharacters in length. This willonlychangeyoure-mailaccount password,notthepasswordyou use to logon to the computer. Composing and Sending E-mails The Compose option on the left corner of your screen allows you to write an e-mail message.You can also attach documents to your mail.Whenyou select the Compose option, thefollowing screen appears. You can use the following option while composing or writing an e-mail message. – To: Specifies the e-mail address of a recipient such as recipient@domain.comanduser@abcdomain.com.Thisshouldbea validemailidforthedeliveryofyourmessage.Youcanspecifymultiple recipients' addresses separated bycommas. – Cc: Specifies theaddress of the recipient to whom you want to send the carbon copy (cc) of your message. You can specify multiple

Broadband Network and Internet Services NOTES Self - Learning 296 Material recipients' addresses separated bycommas. – Subject: Refers to the subject of the e-mail message. It provides a fair ideatotherecipient about what themail contains. – Message Box: Provides a text area for composing e-mail content. Send Attachments Message Box E-Mailing with Google ? Open the web browser and type the name of the e-mail site on which you wouldliketo create an account. For example, gmail.com. ? TypeinthefollowingURL:http://mail.google.com/mail/signupintheaddressbar. ? Followthesteps mentioned in theweb pagein ordertosuccessfullycreate youre-mailaccount.Thefollowingpagewill bedisplayed.

Broadband Network and Internet Services NOTES Self - Learning Material 297 Sending and Receiving E-Mails ? Click on Compose Mail to create a new message. ? You can select addresses from your Contacts list or type theaddress in the To:,Cc:, orBcc: fields.When you begin totype an address inthesefields, a complete address will be suggested from yourContacts list. ? SelecttheAttachafilelinkinordertoattachanyfilewiththee-mailmessage. (The figureshowsAttach a file.Attach another file is displayed onlyafter the first filehas been attached). ? Select the fileyou want to attach. Then click onOpen.

Broadband Network and Internet Services NOTES Self - Learning 298 Material ? Yourfilewillnowbe attached toyoure-mail message. ? Now click on the Send button to send the e-mail. ? You can now see that the message has been sent. Receiving E-Mails You can check the received mails byclickingon theInboxtab. Some Popular Websites Given below arethe names of some popularfree e-mail websites. 1. www.gmail.com 2. www.mail.yahoo.com 3. www.hotmail.com

Broadband Network and Internet Services NOTES Self - Learning Material 299 4. www.rediffmail.com 5. www.indiatimes.com Popular Networking Sites Someofthenetworkingandcommunitywebsitesinclude: 1. www.orkut.com 2. www.fropper.com 5.10.2

100%	MATCHING BLOCK 106/106	SA	Networking All.pdf (D144208908)

Some Important Features of E-Mail Services Available on The Internet

Followingaresomeofthesignificantfeatures ofe-mailservicesthatareavailable on the Internet for theWeb e-mail users: ? Automaticreplytomessages ? Auto-forward and redirection ofmessages ? Facilityto send copies of a message to manypeople ? Automaticfilingandretrievalofmessages ? Addresses can be stored in an address book and retrieved instantly ? Notification ifamessagecannot bedelivered ? E-mails areautomaticallydateandtimestamped ? Signatures can be attached ? Files, graphics or sound can be sent as attachments, often in compressed formats ? Webmailandmobileemailcanbeusedtoreceiveandsendmessageswhile onthe move CheckYourProgress 10. Write themainfeatureofdataencryption. 11. Whatisauthentication? 13. Defineinternetprivacy. 13. What are the two parts of a message? 14. Whyan E-mail password is used?

Broadband Network and Internet Services NOTES Self - Learning 300 Material 5.11 ELECTRONIC COMMERCE Thesedays,e-commerceuseselectronictechnologyforitshighgrowth;thusthere isahighdemandforthelatter.Itiswell-knownthatcomputerincreasesourcapacity tostore,searchandretrieveinformation.Withthetremendousgrowthincomputer usageforcommunicationandotherpurposes,peoplefromvariousfieldsareforming virtual societyon the Internet. Theconcept is quite simple; if one has access to a personal computer (PC) and can connect it to the Internet witha browser he/she can doan online business.You have to just get on theWeb, openan online store, and watchyour business grow.This wired world of business,where technology, human talent, and a new method of doing business, make up today's growing worldwide economy. Thebackbone of this electronic commerceis the Internet. E-commerceisnot onlyabout technology; it is alsoaboutinformation,decision- making and communication. Use of e-commerce refers to purchase, or sale, advertisingandservicingofgoods orservicesovertheInternet.Currentlythough not bigenough as compared totraditional peermarkets,E-commerceisexpected to growinthe nearfuture. According to a survey, the e-commerce industry in India is expected to grow very quickly. The total number of Internet users are rising very rapidly. Worldwide,thegrowthofe-commercehasgainedpopularityduetoonlineshopping but this has not happened in the case of the Indian market. Here, it is mainly concentrated on online travel and thebankingsector. However,growth ofthe industryis expectedtogoup veryhighinthe near futurethat willincludeboththeInternetandmobilebankingusers. 5.11.1 Internet: A Tool for Electronic Commerce E-businessdealswiththebuyingandsellingofinformation,productsandservices through the computer network. E-business is also defined as a business activity which uses an electronic medium. It also refers to the buying orsellingof goods and services without visiting a store. E-business involves activities, such as the deliveryof information, products, services and payment through the electronic medium. In addition, e-business refers to paperers business activities, such as supplychain management, enterprise resource planning,customer relationship management,andknowledgemanagement. In the 1950s, computers were used by organizations to process and store recordsofinternaltransactions.However,informationbetweenvariousbusinesses continued to be exchanged on paper, like purchase orders, invoices, cheques, remittance devices and other standard forms, which were used to document transactions. IBM was the first company which used the term 'e-business' internationally. In 1972, IBM used theterm 'e-business'and the first successful transaction wasexecuted between theUSandtheEuropeanUnionin 1993,with theinventionofpersonal computers. History of the Internet 1969 : The US Department of Defense started the first network among major research centres in the US. 1971 : Major connections or nodes were established. E-mail was introduced.

Broadband Network and Internet Services NOTES Self - Learning Material 301 1973 : DefenseDepartmentstarteddevelopingvariousformsoffiletransfer. 1984 : Domain Name Service(DNS) was introduced. 1986 : The US National Service Foundation created Internet-based telephonelines. 1987 : The number of hosts (computers on the Internet) reached 10,000. 1988 : The number of hosts on the Internet crossed over 60,000. 1989 : Over 100,000 hosts on the Internet were registered. 1991 : The World Wide Web (WWW) was created by CERN in Switzerland. (Conseil European pourla RecherchéNuclearire) 1992 : Onemillion hosts werefoundontheInternet. 1995 : Therewereatotalof6.6millionhostsorcomputersontheInternet. July1997 : 1.3 milliondomainnameswereregistered. Dec. 1997 : 22 millionservers, 40 millionusersontheWWW. 2000 : 110millionusersand72milliondomainnames. 2003 : 802.2 million users and 233 hosts. Table 5.2 Growth of the Internet in India 3 Years Internet Subscribers Internet Users 1997 25 45000 1998 250 200000 1999 359 1000000 2000 650 2000000 2001 1130 6668000 2002 1763 10684000 2003 3661 29000000 2004 4403 31723000 2005 6674 52875000 0 10000 20000 30000 40000 50000 60000 1999 2000 2001 2002 2003 2004 2005 Subscribers User Fig. 5.24 Internet Usage in India 1

Broadband Network and Internet Services NOTES Self - Learning 302 Material Table 5.3 Growth in the Number of Hosts Over the Years 2 Year Number of hostsadvertisedin theDNS 1993 1,313,000crore 1994 2,217,000crore 1995 4,852,000crore 1996 9,472,000crore 1997 1,6146,000crore 1998 2,967,0000crore 1999 4,323,0000crore 2000 72,398,092crore 2001 109,574,429crore 2002 147,344,723crore 2003 171,638,297crore 2004 233,101,481crore E-business opportunities for businesses Manybusinesses need e-business software services to help take advantage of e-business areas. 1. Tourism and travel sector: This sector has updated its system with E-business services. Consumers can make online reservation of hotels, motels, air tickets, railwaytickets, etc. 2. Bankingsector:Most bankshavechangedtheirworkingstylebymaking theirservicesavailableonlinethrough theirrespectivewebsites. 3. Health care sector: This sector is a large one and uses a major part of governmentexpenses.So,mostofthehealthcarecompaniescommunicate or exchangetheirservices with each other. 4. Stock sector: In the stock exchange sector, e-business services provide DematAccountfacilitiesforcustomerswhocanconductanoverallanalysis of the status of the stock areas and carryout their respective transactions. 5. Financial sector: In India, this sector has adopted E-business services and the users make full useof the same. Working of e-business To understand the operation of e-business, consider a customer who wants to make an online purchase. He is moved to the online transaction server where entiretheinformation is encrypted. Oncehehas placedhisorder,theinformation moves through aprivategatewaytoa processingnetwork, wheretheissuingand acquiring banks complete or deny the transaction. This process takes onlyfew seconds.

Broadband Network and Internet Services NOTES Self - Learning Material 303 Online Customer Merchant Website Online Transaction Server Internet Acquiring Merchant Bank Issuing Consumer Bank Processing Network Fig. 5.25 An Online Transaction Difference between e-business and traditional business mechanisms S. No. Basis E-business Traditional 1 Reduction of data error The buyer and the seller create purchase orders on their systems, print them or e-mail them to the receiver. The receiver then re-enters the same information on the computer. This creates the error. 2 Reduction of cost Initial cost of e-business is very high as compared to the paper process. However, over a period of time, it is very effective. As time is money, time is directly linked to saving money. There is a repetition of the same work at every level. So it involves a lot of time and if there is an error, it may lead to wastage of money. 3 Reduction of paper work 4 Reduction of process cycle time E-business reduces the processing cycle time of complete cycles as the data is entered into the system. It is a simulating process. E-business data in the electronic form is easy to share across the organization.

Broadband Network and Internet Services NOTES Self - Learning 304 Material Advantages of e-business 1. All-timeprocessing:Customers canusethemarketplaceatall times with the useofE-business services. 2. Better service: Customers are fullysatisfied and receive better service. 3. Removing mediators: Customers can directlycontact the suppliers and removeall mediators. 4. Dataonconsumerperformance:Usingthee-business services,one can understandconsumerbehaviour,forexample,websites,products,schemes and modes ofpayment which are preferredbythe customer. 5. Timesaving:Customerscansavetimebecausetheycanpurchaseanything throughthemerchant websites. 6. Improved customer services: These days, consumers want better services. Therefore, E-business services offer ameans of communication between the consumer and the company. The consumer can even make onlinecomplaintstoacompany. 7. Origin of new business opportunity: The biggest network between consumers and companies can lead to the origin of new business opportunities,likeinfinitepossibilitiesforbusinessestodevelopandincrease their consumer base. 8. Enhanced speed and accuracy of a product: The usage of e-business services reduces human errors and other problems like duplication of proceedings. This perfection in speed and accuracy, plus easy access to documentsandinformation affecttheincreaseinproduction. 9. Product cost saving: Despite the fact that you can reduce the cost of a product bytheuse of e-business services, it also reduces theerrors andthe cost ofsendingtheinformation to partners. Other advantages ? It reduces the cost of the product. ? It reduces paperwork as the entire work is done electronically. ? The product is directly supplied to the customer because all orders and enquiries are processed online. This eliminates the need for wholesellers and retailers and brings down the cost. ? Improvedcustomerrelationshipisachievedbyfastdissipationofinformation. ? E-businessminimizesthetimetaken fromordertodelivery. ? Provides better,fasterand effectivelinkagewithclients. ? Enhances the organization's product and also does a market analysis, as the organization getsfeedback from thecustomer. ? E-business helps to create knowledge markets. Small groups inside big firms can befunded with seed moneyto develop new ideas. ? E-business helps people work together. ? E-business is a 24 × 7 operation and has a global reach.

Broadband Network and Internet Services NOTES Self - Learning Material 305 Disadvantages of e-business 1. Lack of customer awareness: Mostlypeople have no knowledge about electroniccommunicationliketheInternet, computers,etc.Therefore,they are not ableto transact electronically. 2. Not for small businesses: Small businessmen do not want to take any extraburden becausetheyhaveno knowledgeof e-businessfunctions. 3. Does not support all types of businesses: Some types of businesses are not fitfor e-business services. 4. Legalformalities:Ifyou wantto usee-business servicesinyourbusiness, you have to complete certain legal formalities like authorization and authentication. Other disadvantages ? HighriskforInternetstartuporganization ? E-business is not free ? Securityproblems ? Customerrelationproblems ? Dataintegrityproblems ? Customersatisfactionproblems Goals of E-business The main goals ofe-business areto understand how the: 1. Needs of aconsumer, merchant and organizationcan be met 2. Qualityand quantityof goods can be improved 3. Speed of services can be increased Prerequisites for E-business procedure In orderto conduct e-business, you will require: 1. Acommercialwebsite,forexample, www.futurebazaar.com. 2. The product or services you want to sell through therespective websites. 3. Shopping carts or purchase order forms. 4. Current credit card account that will be accepted on e-payment. 5. Anonlinepaymentgateway,ifyouplantoprocesscredit cardsinrealtime, over the Internet. 6. Asecure socket layer (SSL) which will secure the gateway. Functions of E-business E-business applications enablevarious business functions andtransactionsto be conducted electronically. Someofthefunctions arediscussedas follows: E-Advertising: Advertisingofinformation is currentlythelargest commercial activityon theWeb. For example: (a) Acompany's website contains its profile and all the information on its products and services.

Broadband Network and Internet Services NOTES Self - Learning 306 Material (b) It displays banners that can be clicked. (c) E-business portalslikewww.yahoo.com, are usedfor advertising. (d) Newsgroups alsoprovidepublicity. E-Catalogue: Web pages that the information on products or services that a company offers are available on an e-catalogue. An e-catalogue provides informationon: (a) Packaging (b) Product attributes and characteristics (c) Availability (d) Payment modes (e) Cost, etc. E-Publishing: Thissectorwasamongthefirsttospendonthisnoveltechnology, especiallyontheInternet. E-publishinghasledtoseveral successful e-commerce endeavours,suchasanindependentpublicationthroughtheInternetandelectronic newspapers. Onlinepublicationsofferservices,suchas: (a) Onlinereading/browsing (b) Onlinesearch (c) Customizedinformationservices E-Banking: Thisfacilityoffersremotebankingelectronically.Electronicbanking isalsoreferredtoasonlinebanking,cyberbanking,homebankingorvirtualbanking. It enables Web users to make online purchases and pay for the same, using an online-banking facility. It is cost effective, simple andavailable roundthe clock. The customers have access to several services, such as: (a) Billpayment (b) Electronicchequewriting (c) Record keeping (d) Tracking of bank account, credit cards 5.12 ELECTRONIC DATA INTERCHAGE (EDI) ElectronicDataInterchange(EDI)relatedwithexchangeofdocumentswhichare used in business electronically. In other words exchange of business document fromcomputetocomputeris known asEDI.Documents areinstandardform and used to share among business partner. EDI brings many advantages like high processingspeed,lowcost, less errors,andimproverelationshipamongbusiness partners. EDIisfaster than emails, fax and postal mails. EDIdocuments reach to receiver's computer and start processing immediately. EDI is programmed documents andhandledbycomputerandthus theprocessingspeedwill increase. If peopleinvolvedthen theprocess is gettingslow and changes oferrors are also increased. Business entities conducting business electronically are called trading partners.AlltheonlineshoppingsitesusesEDItoplaceorderandinformbusiness partner.

Broadband Network and Internet Services NOTES Self - Learning Material 307 5.9.1 EDI Implementation EDIScopeincludessometypical steps towardasuccessfulEDIimplementation. Followingarethe steps required: ? Define the need that EDI is going to fulfil: Any stakeholder who is interested in starting EDI exchanges of a given type in the process of identifyingthebestsolutiontofulfiltheneedexpressedbytheusers.Business experts provide up-to-date input regarding the requirements to be considered whiledevelopingacertain exchange(Forexample,whichdata elementsneedtobeimplementedtosuccessfullyprovideReturnsServices, tocomplywithairlinesecurityregulations,orprovidedespatchaccounting information). ? Provide information about specific industry group requirements: Throughouttheimplementationprocess,businessexpertsprovideadditional documentation and support to ensure compliance with the business requirements of specificindustrygroups, which canexceed the technical requirementsin theEDImessagingstandards. ? Plan the different steps required to implement EDI:Assisting posts, airlinesandotherindustrystakeholderswhoareplanningtoimplementEDI formanyyears,providingstandardandcustomiseddeploymentplans with thekeymilestonesandimplementationschedulingbasedontherequirements andlimitationsoftheimplementingparty.Describethetechnicalrequirements andthenecessaryconfigurationsfortheinvolvedsystems:aHelpDeskand SystemsTechnologyteam provide detailed documentation regardingthe setupofanEDIexchangesystem,informationonavailablesystemproviders, and thekeysettings to beconsidered whenconfiguringanEDIsystem. ? Prepare the technical infrastructure to support the exchanges: The Help Desk is the central point that puts in place the required technical infrastructure for the exchanges, mainlybythe setupand management of EDImailboxes andtheexchanges between them. ? Test and validate the EDI messages during the preparation phase: Prior torelease in production, users can provide test EDImessages to the Help Desk, which uses developed tools to test them and validate their compliancewiththedefinedrequirements. ? Communicate with the receiving parties to confirm readiness and activation of EDI message exchanges: Once the EDI exchanges are readyto betriggered, the Help Desk communicates through its extensive global technical contact network to coordinate andannounce the start-up dates, and providesthenecessaryinformationfora successful exchange. ? Monitorand supportthenew exchanges:To ensuresuccess duringthe initial period, the new exchanges arecloselymonitoredbytheHelp Desk, assistingas needed. ? Provide continuous technicaladvice and the rightreporting tools to helptheusersmonitortheirown EDImessagequality:Theapplicable tools and reports to support permanent and proactive monitoring of the

Broadband Network and Internet Services NOTES Self - Learning 308 Material quality,availability,and timeliness ofEDImessages,supportingseamless day-to-day operations and facilitating the generation of value-adding, business relevantdatafrom EDI. E-Commerceprovidesthefollowingneeds: ? Non-Cash Payment: E-Commerce enables the use of credit cards, debit cards, smart cards, electronic fund transfer via bank's website, and other modes ofelectronics payment. ? 24x7 Service Availability: E-Commerce automates the business of enterprisesandthewaytheyprovideservicestotheircustomers.Itisavailable anytime,anywhere. ? Advertising/Marketing:E-Commerceincreasesthereachofadvertising of products and services of businesses. It helps in better marketing managementofproducts/services. ? Improved Sales: Using E-Commerce, orders for the products can be generatedanytime,anywherewithoutanyhumanintervention.Itgivesabig boosttoexistingsales volumes. ? Support: E-Commerce provides various ways to provide pre-sales and post-sales assistance to provide better services to customers. ? InventoryManagement:E-Commerceautomatesinventorymanagement. Reports get generated instantly when required. Product inventory managementbecomesveryefficientandeasytomaintain. ? Communication Improvement: E-Commerce provides ways for faster, efficient,reliablecommunicationwithcustomersandpartners. Advantages of an Electronic Data Interchange (EDI) System Followingaretheadvantages ofhavingan EDIsystem: ? Shorter Processing Life Cycle: Orders can be processed as soon as theyareenteredintothesystem.Itreducestheprocessingtimeofthetransfer documents. EDI saves our time of processing and generate automatic softwaregenerated purchase order, invoiceandorder detail immediately. ? Electronic Formof Data: It is quite easyto transfer or share the data, as it ispresentinelectronicformat. ? Reduction inDataEntryErrors: Chances of errors aremuchless while usingacomputerfordataentry.Datarepetitionanddocumentrepetitionis reducedto someextent.All thedocuments are centrallylocatedand easily accessible bybusiness partner. ? Maintain detail Customer Information in Database: Customer informationisstoredindatabaseandprovideimprovedclientservice.Help in maintaining detail information of customer in database. Many large manufacturers and retailersare ordering their suppliers toinstituteanEDI programformaintainingandgeneratingEDI. ? Improve Client Service: The fast transfer of enterprise documents and assesseddeclineinmistakesallowyoutodobusinessfasterandmoreefficient.

Broadband Network and Internet Services NOTES Self - Learning Material 309 ? Reduction in Paperwork:As alot of paper documents are replaced with electronic documents,there is a hugereductionin paperwork. ? CostEffective:As timeis saved and orders areprocessed veryeffectively, EDIproves tobehighlycost effective.Thecost ofpaperprocessingis very high as compared to EDI. It saves our moneyand expenses. ? Standard Means of Communication: EDI enforces standards on the content of dataand its format which leadstoclearercommunication. Disadvantages of Electronic Data Interchange (EDI) 1. TooManyMeasures:Therearetoonumerousmeasuresbodiesdeveloping standard documents formats for EDI. Developing EDI is difficult for programmers. 2. Changing Standards: Each year, most measures bodies publish modificationstothemeasures.This impersonatesadifficultytoEDIusers. 3. Limit yourSellingPartners: Some large companies are inclined to halt doingenterprisewith enterprises who don'tcomplywithEDI. 4. Intranet:AnIntranet is a typeofprivateInternet.Intranet uses IPprotocol tosharinginformation.Itisusedtoshareinformation,computationservices andoperational system within an organisation. Intranet isalsoanexample of WAN. It is a type of private network is not open for public. The informationislimitedwithinanorganisation.Itcanbeorganisationinternal website, which is spread over the multiple LAN on different locations. Intranet may be private website, internal communication tool used to communicateinternallyinanorganisationforimportantinformationexchange andfocuson important decisions. Overview of the Technology Involved in EDI ElectronicDataInterchange (EDI) can be transmitted usinganymethodology agreed to bythe sender and recipient, but as more trading partners began using the Internetfor transmission, standardized protocolshave emerged. Thisincludesavarietyoftechnologies,including: ? Modem (Asynchronousand Synchronous) ? FTP(FileTransferProtocol), SFTP(Secure FileTransferProtocol) and FTPS(FileTransferProtocol Secure) ? E-mail ? HTTP(HyperTextTransfer Protocol) ? AS1 ? AS2 ? AS4 ? Odette File Transfer Protocol [OFTP(and OFTP2)] ? MobileEDI ? Andmoretechnologies

Broadband Network and Internet Services NOTES Self - Learning 310 Material When some people compared the synchronous protocol 2400 bit/s modems, CLEO devices, and value-added networks used to transmit EDI documentstotransmittingviatheInternet,theyequatedthenon-Internettechnologies withEDIand predicted erroneouslythat EDIitself wouldbereplacedalongwith the non-Internet technologies. In most cases, these non-internet transmission methodsaresimplybeingreplacedby Internetprotocols,suchasFTP,HTTP, telnet, ande-mail,but theEDIdocumentsthemselvesstill remain. In 2002, the IETF published RFC 3335, offering a standardized, secure method of transferringEDIdata via e-mail.On July12, 2005, an IETF working group ratified RFC4130 for MIME-based HTTP EDIINT (AS2) transfers, and the IETF has prepared a similar RFC for FTP transfers (AS3). EDI via web services (AS4) has also been standardised bythe OASIS standards body.While someEDItransmissionhasmovedtothesenewerprotocols,theprovidersof value- addednetworks remain active. 5.13 ELECTRONIC COMMERCE USER CHARACTERISTIC AND ISSUES E-commerce is a form of commerce or business through which consumers are able to buy or sell products or merchandise electronicallyover the Internet. E-commercetakesplacebetweenorganizationsandbetweenorganizationsandtheir customers. It includes transaction of goods and other materials, and includes accessing information, tradinggoodsandelectronicmaterials. E-commerce Definitions (from various perspectives) 1. Fromaninterfaceperspective:E-commerceincludesvariousinformation and businessexchanges between aconsumerandan organization. 2. From communications perspective: E-commerce is a waybywhich a usercansupplyitems, information ortransactionsvianetworks. 3. From an online perspective: E-commerce provides an electronic environment that makes it possible forthepurchasingand sellingofitems on the Internet,such as furniture, books and electronic items. 4. As a market: E-commerce is a global set of connections. Inanutshell,e-Commerceisaformofcommerceorbusinessthroughwhichusers are able to buyor sell items electronicallyover the Internet. E-commerce, E-business and E-transaction E-commerce E-commerce can be: ? Business-to-businesssellingandpurchasing ? Thesecurityofbusinesstransactions ? E-retailingwithonlinecatalogues ? The assemblyand use of demographic datathrough theWeb

Broadband Network and Internet Services NOTES Self - Learning Material 311 ? Business-to-businessexchangeofdatathroughelectronicdatainterchange (EDI) ? E-mail andfax (e.g., with thehelp of newsletters) E-business E-business refers to business with customers, vendors and suppliers—via the Internet. E-business provides an environment to enhance businesses and also provides an interface between businesses and customers. E-business conducts business on theInternet,notonlybysellingandpurchasing,butalsobyproviding servicestocustomers and collaboratingwithbusiness partners. E-transaction E-transactionmeanscommercialtransactionswithanyone,anywhereandanytime. Itprovidesnewbusinessopportunitiesthatresultingreaterefficiencyandeffective transactions between customers and businesspartners. Scale of E-Commerce In E-commerce, the scale of work consists of communication and information exchangeasfollows: ? Exchangeof securedocuments, contents andvalues ? Platformsfore-commercecommunications ? Navigation,advertisingandexchangeofcatalogue ? Negotiationandcontractmakingprotocolsininteractionsamongconsumers, businessesandpublicadministration ? Mobiletechnology-based applications ? Devices and protocolswhichsupport mobility Drivers of E-Commerce The drivers of e-commerce are: 1. Anytime, anywhere,anyone Today, any user can access information any time. E-commerce binds organization,businessandothersectorswiththehelpofvideo,multimedia, text andothertechnologies. 2. Digital revolution With the help of digital revolution it is possible for digital devices to communicatewitheachanother. 3. Increase in access Due totremendous increase in thenumber of computers worldwideit has greatlyincreasedthedemandforinformationandcommunicationforbusiness as well as pleasure. 4. Organizationalchanges E-commercemakesitpossibletochangetheapproachofanyorganization. There is a tendency of owners and managers within the departments to developachainofrelationshipswithintheorganization.

Broadband Network and Internet Services NOTES Self - Learning 312 Material Basics of E-Commerce The basics features of e-commerce are: ? Business processthathelpsbuyingand sellingitemsontheInternet – Supplier,inventory,distribution,paymentmanagement – Financialmanagement,purchasingproductsandinformation ? Customerpurchasingon theInternet ? Transactions conducted between businesses onthe Internet Myths about e-Commerce Thefollowingaresomeofthecommonlynoticedmyths: 1. E-commerce is innovative Unfortunately, manyInternet retailers spendadisproportionateamount on theinnovativetasksofwebsiteconstructionandmarketingandconcentrate littleoncustomersupportandfulfilmentoftheirrequirements. 2. Creation of website is easy Thisistruetosomeextent;however,ensuringavailabilityandperformance of the site is not an easy task. There is technology and networking infrastructuretoconsiderforeffectiveuseof awebsite. 4. Customers can be lured All companies know that customers can be lured with price promotions andgiveaways.Thereararelyloyalcustomers.Themomentacompetitor lowers theprice,theyclick overtothesite. Thebest customercanbe lured onlywithqualityservice oncean item has been purchased. 5. Everyone is doing it It is true, but a Web presence is not commerce. Features of E-Commerce The features ofe-commerce are: ? The facilityto retrieveorders fromthe Internet. ? Thecapacityto permit users toaccesses accountingdatasecurelyoverthe Internet. ? The web page catalogue in several cases is actuallyassociated directlyto the software data based on accounting. The main advantage is that the buyerobserves real-timeinformation related to cost,qualityandmeasure. ? The abilityto send computerized information and datato users/groups of users. ? To get printouts of all reports in web page (HTML) formats. ? Web-enabledaccountingsoftware'shelpmenuisconnecteddirectlytopages on theInternet through the WWW. E-Commerce Framework Ane-commerceframeworksupposes that e-commerce applicationswill be built on theexisting technologyinfrastructure—groupofcomputers,communication networksandcommunicationsoftwaretodeveloptheinformationsuperhighway.
Broadband Network and Internet Services NOTES Self - Learning Material 313 E-commerce architectural framework (i) Main platforms TherisktotheInternetisthroughdigitaldisorder,closedmarketsthatcannot use eachother's services, incompatible applicationsand frameworks that interoperateorbuild upon each other,andan arrayofsecurityandpayment options thatconfusetheconsumers. Onesolutiontotheseproblemsisanobject-orientedarchitecturalframework for Internet commerce. Several vendors of e-commerce solutions have declared descriptions ofsuch aframework.Themost important platforms are: ? IBM commerce point ? Microsoft Internetcommerceframework ? Netscape ONE (Open Network Environment) ? Oracle NCA(Network ComputingArchitecture) ? Sun/Javasoft JECF(Java e-commerce Framework) (ii) General model Recently,fourofthesecompanieshavesettledtoholdacommondistributed object model based on Common Object Request Broker Architecture Internet Inter-ORB Protocol (CORBA IIOP). For the commerce on the Internet tobesuccessful, such systemsmust alsointeroperateat abusiness applicationlevel.Aconsumerorbusinessusingoneframeworkissupposed to be able to shop for, buyand make payments for products and services offered on dissimilarframeworks. This is not possibleat present. (iii) CommerceNet CommerceNetisanon-profitsocietythathasbeenformedtohelpbusinesses and customers to utilize the Internet for buying and selling. It is a cross- industry effort to build a framework of frameworks, involving both e- commercemerchantsand clients. The victory of this development certainlydepends on market leaders in eachareawhoparticipatevigorouslyintheirrespectivetaskforces.Allusersshould use similar software because no single companycan control what platform its customerswilluse. Mechanics of E-Commerce 1. The business aspect of E-commerce There are two bases and interactive business dimensions to e-commerce, and these are: (i) The customer aspect. This refers to placing refined goods with the finalclients. (ii) The enterprise aspect. This is primarilyan intercorporate or inter- organizationalsupplychainmanagement,etc.
Broadband Network and Internet Services NOTES Self - Learning 314 Material 2. The technological aspect of E-commerce It can be classified according to the three basic functions of anymarket environment. (i) Access environment. It makes use of private and public network technologies, such as the Internet, LAN andWAN. (ii) Transaction aspects. These are EDI, point of scale device, credit, debitandsmartcard, automated tellermachine(ATM)andelectronic fundtransfer(EFT). (iii) Support aspects. Thesearesupport services, such ascardvalidation technologies, bar codingdevice, amongothers. 3. The configuration of E-commerce E-commerce to become operational requires threethings to happen. (i) The organizational configuration. Integrating business process electronically. (ii) Thenetwork configuration. Providingabackbonefore-commerce. (iii) The media configuration. Getting access to the electronic marketplace. E-commerceApplications Byusingonline business one can place goods or products online.Awell-made application in e-commerceprovides all theinformation tosatisfythe customers' needs.Thisprovidesasensibleamountofproduct withthepurchaseabilitytothe customers. It is important to note that a website must be product specific and it must alsosupports thetransaction processwhenbusinessisbeingdone.Someof theseconsist of: A. 1. Search capability for the product. It provides a way through which a consumer can search products of their interest and switch directlyto the interested product over the Internet. 2. Data sheets can be downloaded. Consumers can download products andothersupportinginformation and maketheirpurchasedecision. 3. Supportforcustomersonline. It allows staff to focus moreon customer servicesissuedonline. 4. FAQ based on products. Once the customer buys the product then they expect that their problems be sorted out directly without having to communicatethroughtheuseofqualitysites. 5. Message board to support customers. Message board provides customers access to information anytime theyneed.New customers can benefit from thequestions and solutions provided bythemessage board. 6. Productnewsletters.Theseallowcustomerstobeuptodatewithproduct information.Userscaneasilysubscribemailinglistsforproductinformation in whichtheyareinterested. 7. Support sales process. E-commerce sites support the sales process through purchase and also provides the necessary information to the customer.

Broadband Network and Internet Services NOTES Self - Learning Material 315 B.E-commercecommunication mechanism Nowadays,theInternetisthefinestmeansofcommunicationbetweenbusinessmen and clients. Due to various advance technology-oriented concepts, purchasing and selling of goods through websites has become popular. Online business is growingspeedilythrough a varietyofsoftware that helps consumers to learn the tricksofbuyingand selling. Onlinebusinessworksbythefollowingmethods: ? Shopping cart software ? Onlinee-telephony Shopping cart software is the means of online presentation of goods for sale. It provides the idea of goods to choose from, online payment facility, joint selectionofgoodsintheformoflist,etc.Byputingallthechosengoodsinthecart and paying for all the selected items, shopping cart software has become the simplestwayofshoppingonline.Therearemanyfeaturesprovidedbythissoftware, suchas: ? Credit card adequacy ? Simplenavigationsystemfortheconsumers ? Consumeraccountability ? Ordermanagementability ? Web-basedadministrationability ? Flexibleshippingandtax options ? Built-insiteoptimizationtools ? Inventorymanagementability Oneofthefinestwaystocommunicateregardingbusinessisonlinetelephony. It is thetechnologyused to convertvoice signals intodatapacketswhich arethen are transported to a data network runs on the Internet Protocol (IP). It allows the consumer to call through the same phone line which he uses for the Internet connection.Itischeaperthanmakingcallsonthebasictelephoneline.Thisonline communication technologyis known in thewebworld as voiceover IP. C. OnlineE-telephony benefits ? Auserisabletodistinguishcallsasbusinesscalls,personalcallsorconsumer service calls even as theyareon same line. ? A user can direct the calls to a particular department and take automated orders. ? Ausercanscreen thecallers without anyinformationtocaller. ? A user can get forwarded calls from all over the world. ? Therewill beno busylineproblems. ? Voice mails can be received on the computer. In addition tothese, therearemanyotherfacilities whichcanbeavailedby usinge-telephony.Thus,communicationontheInternetprovidesnumerousfacilities to easebusiness complexities and raiseprofits.

Broadband Network and Internet Services NOTES Self - Learning 316 Material 5.13.1 Advantages and Disadvantages of E-commerce Advantages of E-Commerce to Organizations Thevarious advantagesofE-commercetobusinessorganizationsareasfollows: ? Usersandfirmscandotheirbusinessonlinethroughwiredorwirelessdevices and will beable to increase their salebyusinge-commerce. ? Companies will be able to offertheir products or services at lower prices. ? It increases the business both at the local and global level markets. ? The costofmanufacturingproducts, processingitems, distributinggoods, storing data or information and accessing information canbe reduced. E- commerce brings the universal access of the Internet to the core business processes of buying and selling goods and services. It helps to generate demand for products and services and improves order management, payment, and other support functions. Theoverall goal is to cut expenses byreducing transaction costs and streamlining all kinds of processes. E-commercehelpsthe process manufacturingcompaniesbyreplacingpaper catalogs,phonesales,and faxes. It alsohelps inthereductioninthecost of obtainingcommodityproductsandtheabilitytosometimesgetbetterprices for the products. E-commerce uses Internet technologies to enable better and faster collaboration between buyers and sellers. It is the practice of buying and selling varied good and services on the World Wide Web (Internet)overwired communicationlinesconnectedthroughouttheglobe where theWorld Wide Web serves as the central medium for all trading transactions.It alsoenables sell and purchaseofcommodities andservices right from yourhome thus reducingthe related cost expenses.Because, to purchasethevirtual productsand servicesonline,onehas tosimplyorderit and the products and services will be sent once your payment is acknowledged. Contribution to digital goods and services help the manufacturers to reduce operating cost andincrease profit. Thus, e-commerceis verycost efficient and economical.General costs of runningabusinessotherwisearefarhigherthanthatoperatedwiththehelp oftechnologyand e-commerce. Staffing, middlemen,overhead costs, etc. can be reduced drastically. Most of the transaction procedures can be automatedwithoutanyhumanintervention. ? The seller's websitegives greater accessibilityon the products available. Reviews onthe products bought on the websiteare convenientand useful for other prospectivebuyers. Costs such as rent, employment, marketing and other similar expenses are little.Also, the cost of advertising on the Internetisminimaland thereachismuch widerthantraditional business. ? Thebusinessorganization will be ableto reduce paperwork. ? Dropdownprocessingpermitscustomizationofproductsandserviceswhich providescompetitiveadvantagetoitsimplementers. ? It decreases the time between thecost of funds; andbetween the products and services. ? It supports the efforts for business process re-engineering(BPR).

Broadband Network and Internet Services NOTES Self - Learning Material 317 ? Itdecreasestheproduct costovertheInternet,whichismuchmorecheaper than value-added networks (VANs). It enables to build more collaborative and stronger relationships with suppliers.Thisincludesstreamliningandautomatingtheunderlyingbusiness processes, enablingareas such as: o Directmarketingselling o Customerservices(call centres) o Fulfilment o Procurement o Replenishmentandinformationmanagement Advantages of E-Commerce to Consumers Thefollowingaretheadvantages ofE-commerceto consumers: ? Itallowscustomerstoshoporperformanytransactionatanytimefromany locationintheworld. ? It provides customers with better selection ofproducts and services. ? Consumers maymakequick comparisonsamongexpensiveproducts. ? Consumers can interact with othercustomers,share theirideas, views and experiences. ? Significantdiscountsondifferentproductsoritemsareavailableduetohigh competition. ? It allows fast deliveryof products and services. ? Consumerscangetinformationinthis seconds. ? It ispossibleto participateinvirtual auctions. ? Consumers can get additional information about the goods, and make a moreinformeddecision.Thishelpsinthefollowingways: ? Better information opens the way to more assurances and to make a better choice. ? Additional information also leads to improved consumer fulfilment because consumers havea better idea ofusingthe goods. Advantages of E-Commerce to Society The followingarethe advantages of E-commerceto the society: ? It permits persons to work from home, due to whichthere is less traffic on roads,andthis in turn reducesair pollution. ? It helps products to be sold at competitive prices. ? It allows people in remote areas to connect through theInternet and enjoy products,goodsandothersserviceswhicharegenerallynoteasilyavailable tothem. ? Deliveryof services at reduced cost. ? It improves thequalityof products.

Broadband Network and Internet Services NOTES Self - Learning 318 Material ? More people can work offsite. o This decreases HRcosts forcompanies,becausetheycanhavesmaller office buildings,less parkingspaces, fewerITservices,etc. ? It facilitates thedeliveryofwith thehelpofpostal services ? Higher standard ofliving:Somegoodscanbesoldat low prices,allowing less affluentpeople to buymoreand increasetheir standardofliving. Disadvantages of E-Commerce Somedisadvantages ofE-commerce are as follows: ? Customerswillnotbesatisfieduntiltheyseetheproductsorgoodsphysically. ? Securityproblemsmightarisewhendoingbusinessonline. ? Lack ofsecuritymeasures ? Somelegalissues 5.13.2 limitations of E-commerce Technical Limitations of E-Commerce Therearevarioustechnicallimitations ofE-commerce,suchasthefollowing: ? There is lack of security, consistency, standards and other protocols. ? Thebandwidthisinsufficientfortelecommunication. ? Development tools forsoftwarearechangingspeedily. ? TherearesometechnicaldifficultiestointegratetheinternetandE-commerce software. ? There is a requirement for web servers and other infrastructureinstead of network servers which causes additional cost. ? There are some problems related to software that does not fit with some hardware, operating systems or other components. Non-Technical Limitations of E-Commerce Someofthenon-technical limitations ofE-commerceareas follows: ? Costandjustification o Thecostofdevelopingane-commerceapplicationathomecanbevery high. o There maybesecurityand privacyproblems. ? Online business provides lack of touch andfeel to customers ? Lackofbargaining,trust and userconflict ? Controlconflict

Broadband Network and Internet Services NOTES Self - Learning Material 319 CheckYourProgress 15. What is E- commerce? 16. What are the goals of e-business? 17. DefineEDI. 18. What do you understand byE-Commerce? 5.14 ANSWERS TO 'CHECK YOUR PROGRESS' 1. BroadbandLANsaremultichannel,analogLANs.Theyaretypicallybased oncoaxialcableas the transmissionmedium,althoughfibreopticcable is also used. Individual channels offer bandwidth of 1 to 5 Mbps,with 20 to 30channelstypicallysupported. 2. The 'Line Coding', also called digital baseband modulation or digital basebandtransmission,isaprocesscarriedoutbyatransmitterthatconverts data, in the form of binary digits, into a baseband digital signal that will represent thedataon a transmission line. 3. ADSL is widely used to connect most of the homes and small business subscribers to the Internet.ADSLdivides the available frequencies in a telephonelinebyassumimg that mostofthe Internet subscribers are more inclinedtodownload informationfrom theInternetthanupload. 4. High bit-rate Digital Subscriber Line (HDSL) is defined as a telecommunications protocol which was standardized in 1994. It was the firstDigitalSubscriberLine(DSL)technologywhichusedahigherfrequency spectrum over copper and twisted pair cables. 5. WirelessLocalLoop(WLL)istheuseofawirelesscommunicationslinkas the 'Last Mile / First Mile' connection for delivering PlainOld Telephone Service (POTS) orInternet access (marketed underthe term 'Broadband') totelecommunicationsusers. 6. Data securityisconcerned with the protectionof datacontained inafileor many files in a computer either as a standalone or on a network, from unauthorizedinterception. 7. Thefollowingarethethree typesofsecuritymeasures: (i) Invalidaccess/Possibilityofeavesdropping (ii) Firewallsecurity (iii) Encryption(VPNFunction) 8. A firewall is a combination of software and hardware components that controls thetraffic between a securenetwork (usuallyan officeLAN) and aninsecurenetwork(usuallytheInternet),usingrulesdefinedbythesystem administrator. 9. The basic aim of firewall is to provide only one entrance and exit to the network.Therearetwo firewalls. Oneblocks theundesirabletraffic,while theotherallowstraffic.

Broadband Network and Internet Services NOTES Self - Learning 320 Material 10. The main features ofdataencryption are: (i) Prevents unwanted access to documents ande-mail messages. (ii) Even thestrongest levels ofencryption areverydifficult tobreak. 11. Authentication is anyprocess bywhichone verifies that someone is who theyclaimtheyare.Basically,itinvolvesausernameandapassword.Itcan also include any other method of demonstrating identity, such as a smart card,retinascan,voicerecognition, orfingerprints. 12. The Internet privacy is a broad term referring to the various concerns, technologies,andstrategiesforprotectinginformation,communications,and choices that are meant to be private. In general, using the Internet often meansgivingupsomemeasureofprivacy. 13. There are two parts of a message: the header and the body. the header contains data that describes the message and controls how it is delivered and processed, thebodyof the messageis the actual informationthat is to becommunicated. 14. Ane-mailpasswordisusedforsecurityreasons.Apasswordisthepersonal code of a user and should not be disclosed to anyone. Hence, never give your password to anyone and do not write it down where someone else mayfindit. 15. E-commercereferstopurchase, orsale,advertisingandservicingofgoods orservicesovertheInternet. Currentlythoughnotbigenoughascompared to traditional peer markets, E-commerce is expected to grow in the near future. 16. The main goals ofe-business areto understand how the: (i) Needs of aconsumer, merchant and organizationcan be met (ii) Qualityand quantityof goods can be improved (iii) Speed of services can be increased 17. Electronic Data Interchange (EDI) related with exchange of documents which are used in business electronically. In other words exchange of business document from compute to computer is known as EDI. 18. E-commerceis aform ofcommerceorbusinessthroughwhichconsumers are able to buy or sell products or merchandise electronically over the Internet. 5.15 SUMMARY ? Broadband LANs aremultichannel, analog LANs andtypicallybased on coaxialcableasthetransmissionmedium,althoughfibreopticcableisalso used. ? Local Loop(LL)isreferredasan electroniccircuit linefrom asubscriber's phone to thelocal exchange officetermed as Local Central Office(LCO). ? A Local Loop (LL) is a physical connection from the end user site to a providers Point of Presence (POP).

Broadband Network and Internet Services NOTES Self - Learning Material 321 ? InADSLtechnology, there has been a new progress which intends to use two copper loops at a data rate of 1.544Mbps. ? ADSLoffers download speed in the range of 1-2 Mbps and upload speed in the range of 64-640 Kbps. ? Linecodingis theprocess ofconvertingdigitaldatatodigital signals.With the help of this technique a sequence of bits can be converted to a digital signal. ? TCP/IP protocols are used globally irrespective of the nature of the organizations, whethertheyaregeneral categoryorganizationsorsecurity- specificsensitiveorganizations. ? Networks are designed to shareinformation.Therefore,the network must beclearlyconfiguredtoidentifytheshareableinformationandnon-shareable information. ? Data securityisconcerned with the protectionof datacontained inafileor many files in a computer either as a standalone or on a network, from unauthorizedinterception. ? The intranet is a TCP/IP network that is modelled after the Internet that onlyworkswithintheorganization. ? In public key(asymmetric) encryption, two mathematically-related keys are used, one to encrypt the message and the other to decrypt it. ? PrivateKeyencryption(symmetric)isalsoknownasconventionalorsingle-keyencryption. ? A user remotelylocated must be first authenticatedbefore accessing the networkorIntranet ofan organization. ? ManagingWindowssecurityisrequiredtomanagethecompletesystemfor runningthe applications, downloading the updatefeatures forWindows, runtimeprograms, etc. ? The private key encryption contains a secret keythat is taken as code. ? Windows has abuilt-in databaseand control system tokeep trackof all of thesoftwareandcritical information that livesonyourPC. ? Virusesarefrequentlytransmitted throughe-mailattachments,peertopeer downloads,phishingandinstantmessages. ? The Internet privacy is a broad term referring to the various concerns, technologies,andstrategiesforprotectinginformation,communications,and choices that are meant to be private. ? An interruption can be defined as a state where the asset of a system gets destroyed orbecomes unavailable. ? A security policy can be defined as the framework within which an organizationestablishesneededlevelsofinformationsecuritytoachievethe desiredconfidentialitygoals. ? Fabrication occurs whenan attacker inserts forged objects intothesystem without thesender'sknowledgeorinvolvement.

Broadband Network and Internet Services NOTES Self - Learning 322 Material ? Themanagementofkeysisthechiefproblemareaforallencryptionsystems. Thekeysarethemostvaluableinformation.Ifanyonecangetakey,anyone can decrypt everything that has been encrypted bythat key. ? The public keys of a key pair do not require confidentiality protection. They only require the integrity protection which is provided by their certification. ? One of the critical requirements of an electronic mail system is that the senderand receiverof a message need not be online at thetime when mail issent. ? E-business deals withthe buying and sellingofinformation, products and servicesthroughthecomputernetwork. ? E-businessapplicationsenablevariousbusinessfunctionsandtransactions to beconducted electronically. ? Electronic DataInterchange(EDI)is related withexchangeofdocuments whichareusedin businesselectronically. ? ElectronicDataInterchange(EDI)canbetransmittedusinganymethodology agreed to bythe sender and recipient, but as more trading partners began usingtheInternet fortransmission, standardizedprotocols haveemerged. ? E-commerceis aform ofcommerceorbusinessthroughwhichconsumers are able to buy or sell products or merchandise electronically over the Internet. 5.16 KEY TERMS ? LocalLoop(LL):It refers toan electronic circuit linefrom asubscriber's phone to the local exchange officetermed as Local Central Office (LCO) ? LineCoding:It is the process ofconvertingdigital datatodigital signals. ? Intranet: It is a TCP/IP network that is modelled after the Internet that onlyworkswithintheorganization. ? Ciphertext: This is the encrypted or scrambled message produced by applyingthealgorithmtotheplaintextmessageusingkeys. ? Authentication: It is any process bywhich one verifies that someone is whotheyclaim theyare. Basically,it involves ausernameandapassword. ? Private Key Encryption: The private keyencryption contains a secret keythatis taken ascode.This mechanism encryptsapacket ofinformation if it passed across network to the other computer. ? SecurityAttack: It refers to anyaction that compromises the securityof informationownedbyanorganization. ? Interruption: It can bedefined as a statewhere the asset ofa system gets destroyed orbecomes unavailable. ? Electronic Data Interchange (EDI): It is the Exchange of business document from computerto computeroverinternet.

Broadband Network and Internet Services NOTES Self - Learning Material 323 ? E-commerce:Itisaformofcommerceorbusinessthroughwhichconsumers are able to buy or sell products or merchandise electronically over the Internet. ? E-business: E-business refers to business with customers, vendors and suppliers—viatheInternet.E-businessprovidesanenvironmenttoenhance businesses and also provides an interface between businesses and customers. 5.17 SELF ASSESSMENT QUESTIONS AND EXERCISES Short-Answer Questions 1. State theadvantage and disadvantages of broadband network? 2. What arelinecodingtechniques? 3. State the basictechniques of data security. 4. Write the procedures to validate remote login. 5. Whatiskeycertification? 6. Writethestepsofmailcommunication process. 7. What do you understand bySMTP? 8. WritesomeE-businessopportunitiesforexpandingbusiness. 9. What are differences between E-business and traditional business mechanisms? 10. What arethe advantages of E-commerce? 11. How theE-advertisingis proven veryusefulinpresent days? 12. What are thedisadvantages of EDI? 13. Write thefeatures of e-commerce. 14. What are the myths related to e-commerce? 15. Discuss the advantages and disadvantages of E-Commerce. Long-Answer Questions 1. Elaborate onlocal loop technologies. 2. Brieflydescribethebasicrequirements ofnetworksecurity. 3. Explainthenetwork architectureofafirewallindetail. 4. What arethevarious types ofsecurityattacks? Explain. 5. Discuss keymanagement(SMTP)in detail. 6. Explainsimplemailtransferprotocolindetail. 7. Elaborate on theworkingofE-business. 8. BrieflydescribethevariousstepsinvolvedinEDIimplementation.

Broadband Network and Internet Services NOTES Self - Learning 324 Material 5.18 FURTHER READING Forouzan, Behrouz A. Data Communications and Networking. New Delhi: Tata McGraw-Hill, 2004. Stallings,Williamand RichardVanSlyke.BusinessDataCommunications.New Jersey: PrenticeHall, 1998. Black, Uyless. Computer Networks. New Jersey: Prentice Hall, 1993. Stallings,William. Data andComputer Communications. NewJersey: Prentice Hall,1996. Tanenbaum,Andrew S. Computer Networks. New Jersey: Prentice Hall PTR, 2002. Stallings, William. Data and Computer Communications. NJ: Prentice-Hal, 1996.

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1/106 **SUBMITTED TEXT** 22 WORDS **47%** **MATCHING TEXT** 22 WORDS

Digital Subscriber Line (ADSL) High Bit-Rate Digital Subscriber Line (HDSL), Line Coding Techniques Wireless Local Loop (WLL). Security : Basic Requirements of Network Security,

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Broadband Network 5.3 Local Loop Technologies 5.3.1 Asymmetric DigitalSubsriber Line (ADSL) 5.3.2 High Bit-Rate Digital Subscriber Line (HDSL) 5.3.3 Wireless Local Loop (WLL) 5.4 network Security 5.4.1 Basic Requirements of Network Security 5.4.2

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3/106 **SUBMITTED TEXT** 14 WORDS **84%** **MATCHING TEXT** 14 WORDS

the data in the form of bits from the sender to the receiver

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native information stream are translated, in an analog electrical network, into

native information stream are translated in an analog electrical network into

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the carrier signal is modulated (varied) in order to create an analog of the original informationstream. TheelectromagneticsinusoidalwaveformorsinewaveasshowninFigure 1.5canbevaried in amplitudeat afixed frequency,usingAmplitudeModulation (AM).Alternatively, the frequency of the sine wave can be varied at constant amplitude,

the carrier signal is modulated (varied) in order to create an analog of the original information stream. Carrier can be varied in amplitude at a fixed frequency, using Amplitude Modulation (AM). Alternatively, the frequency of the sine wave can be varied at constant amplitude,

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the bit rate is the number of bit intervals per second

The bit rate is the number of bit intervals per second.

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one symbol). The relation between bit rate and baud is that bit rate

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8/106	SUBMITTED TEXT	16 WORDS	87%	MATCHING TEXT	16 WORDS

required to transmit the signal. The signal maybe in the form of pieces or block that

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9/106	SUBMITTED TEXT	28 WORDS	65%	MATCHING TEXT	28 WORDS

required to move these signal units withlargebitsfor an efficient system.To understandthe relationbetweenbit and baud rate, we consider an analogy of car, passengers and highway with signal units,bitsandbandwidth respectively. A car has

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10/106	SUBMITTED TEXT	29 WORDS	60%	MATCHING TEXT	29 WORDS

of five passengers at a time. Supposeahighwaymaysupport only1000cars perunittimewithoutcongestion, when each car on the highway carries five passengers, it is considered that the highwayis capable of providing services without congestion. Thus,

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these 5000 passengers wish to go in separate cars, they require 5000 cars

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12/106	SUBMITTED TEXT	32 WORDS	86%	MATCHING TEXT	32 WORDS

highway's capacityis meant onlyfor 1000 cars. It does not bother as to whether these 1000 cars are carrying 1000 passengers or 5000 passengers or more. To support more cars, the highway needs to

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13/106	SUBMITTED TEXT	20 WORDS	54%	MATCHING TEXT	20 WORDS

Short haul modems canalso be used onan end-to-end length ofthedirect connection longer than 15 km, when bothends of the line

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called local loops are servedbythesameexchangeinthetelephonesystem.Theyaredistance-sensitive, because signal attenuation happens as the signal travels through the line. The

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in large-volume telephone line multiplexing dedicated forcomputer-to-computer links. Theyprovidehigh data rates. 1.4.3 Modems Based on Line (

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a pair of two-wire lines for transmittingand receiving. In this case, the signals inthe two directions are kept

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17/106 **SUBMITTED TEXT** 11 WORDS **100%** **MATCHING TEXT** 11 WORDS

Modems that provide a low-speed reverse channel are sometimes called split-speed or

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18/106 **SUBMITTED TEXT** 16 WORDS **52%** **MATCHING TEXT** 16 WORDS

slow and moderate rates, up to 1800 bps, are asynchronous.Asynchronousmodems operateinFSK(FrequencyShift Keying) modulation.Two frequencies for transmission and

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19/106 **SUBMITTED TEXT** 15 WORDS **90%** **MATCHING TEXT** 15 WORDS

Synchronous Modems Synchronous modems operate in the audio range, at rates up to 28.8 kbps in

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offset the signal according to the average of the known attenuation in each frequency.

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used to operate at low rates ina dial-up line. Manually adjusted

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22/106	SUBMITTED TEXT	35 WORDS	65%	MATCHING TEXT	35 WORDS

bands spaced bythe modulation frequency, f m that is not in case ofAM. There- fore,AM considered a linear process whereas FM as a nonlinear process. It is necessaryto transmit all side bands to reproduce a distortionfree signal. Ideally,

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23/106	SUBMITTED TEXT	21 WORDS	56%	MATCHING TEXT	21 WORDS

complicated,but when^2 is small,thebandwidth oftheFM signal is 2f m . Onthe other hand when^2 is large, the bandwidth is determined (empirically) as 2

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For example, twisted pair and coaxial cable systems conduct electrical energy,

For example, twisted pair and coaxial cable systems conduct electrical energy,

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the carrier wave as in FM, the phase of the carrier wave is varied. In PM,theinstantaneous amplitudeofthemodulatingsignal varies thephase ofthe carrier proportionately. Modulating index for PM is given as ^{2} = “?, where “?is the peak phase deviation in radians.As in the case of angular modulation argu- ment of sinusoidal is varied and thereforewe will have thesame resultant signal properties for frequencyand phase modulation.Adistinction in this case can be made onlybydirect comparison of the signal with the modulating signal wave,

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26/106	SUBMITTED TEXT	18 WORDS	82%	MATCHING TEXT	18 WORDS

There are two types of coaxial cables: (i) Baseband: It transmits a single signal at a time at

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Propagation Delay Propagation delayrefers to the length oftime required for a signal to travel from

Propagation delay refers to the length of time required for a signal to travel from

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28/106 **SUBMITTED TEXT** 20 WORDS **69%** **MATCHING TEXT** 20 WORDS

Coaxial cable is not so limited as UTP, although amplifiers or other intermediate devices must be used to extend high frequency

SA CMP506 Computer Networks.pdf (D164861258)

29/106 **SUBMITTED TEXT** 10 WORDS **MATCHING TEXT** 10 WORDS

can tolerate as well as the amount of weight or

100% can tolerate, as well as the amount of weight or

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30/106 **SUBMITTED TEXT** 14 WORDS **76%** **MATCHING TEXT** 14 WORDS

Coaxial cable'ssuperiorperformance characteristics make it the favoured medium in many short hauls, bandwidth-intensive data applications.

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31/106 **SUBMITTED TEXT** 12 WORDS **100%** **MATCHING TEXT** 12 WORDS

refers to the length of time required for a signal to travel

refers to the length of time required for a signal to travel

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32/106 **SUBMITTED TEXT** 18 WORDS **82%** **MATCHING TEXT** 18 WORDS

There are two types of coaxial cables: (i) Baseband: It transmits a single signal at a time at

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33/106 **SUBMITTED TEXT** 13 WORDS **88%** **MATCHING TEXT** 13 WORDS

Network (LAN) is a network that is restricted to a relatively small area

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VLF: Very low frequency LF: Low frequency MF : Medium frequency VHF: Very high Frequency HF: High frequency UHF: Ultra high frequency SHF: Super high frequency EHF: Eextremely high frequency 10

VLF: Very Low Frequency LF: Low Frequency MF: Medium Frequency HF: High Frequency VHF: Very High Frequency UHF: Ultra High Frequency SHF: Super High Frequency EHF: Extremely High Frequency

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35/106	SUBMITTED TEXT	12 WORDS	100%	MATCHING TEXT	12 WORDS

A LAN is a form of local (limited-distance), shared packet network for

SA DCAP453.docx (D142461319)

36/106	SUBMITTED TEXT	30 WORDS	87%	MATCHING TEXT	30 WORDS

Apart from the components needed bythe conventional wired LAN, a wireless LAN needs additional components. Theyare the transmitters and receivers at Radio Frequency(RF) or InfraRed (IR). The RF transmitter and receivers need

SA BCAP-51 DCN.pdf (D161530873)

37/106	SUBMITTED TEXT	21 WORDS	85%	MATCHING TEXT	21 WORDS

Palmtops or Personal Digital Assistants (PDAs) with communication capability ? Portable FAX ? Cellularphones Special Units For network management and efficient communication, a wireless LAN needs

SA BCAP-51 DCN.pdf (D161530873)

38/106	SUBMITTED TEXT	41 WORDS	71%	MATCHING TEXT	41 WORDS

out before theactual implementation. Hubs, bridges,networkoperatingsystem, servers, and other components are function exactlyas on awired LAN. Mobile Clients Mobile clients are portable computing devices that act as clients. The following are some ofthe portable mobile systems. ? Laptop computers: Laptop PCs with two-way communication facility (transceiver)

SA BCAP-51 DCN.pdf (D161530873)

39/106 **SUBMITTED TEXT** 37 WORDS **76%** **MATCHING TEXT** 37 WORDS

These units collect data from other systems. Security units: These units take care of thenetwork security. Transceivers: A transceiver is a half-duplex device. It performs transmission and reception of data within awireless LAN. It cantransmit in one directionata time. Portable bridges:

SA BCAP-51 DCN.pdf (D161530873)

40/106 **SUBMITTED TEXT** 14 WORDS **88%** **MATCHING TEXT** 14 WORDS

provides a bridgeservice. Working of Wireless LANs Wireless LANs use electromagnetic waves (radio or infrared technology) to

SA BCAP-51 DCN.pdf (D161530873)

41/106 **SUBMITTED TEXT** 13 WORDS **70%** **MATCHING TEXT** 13 WORDS

as radio carriers because they simplyperform the function of deliveringenergyto a remote receiver.The data

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42/106 **SUBMITTED TEXT** 35 WORDS **86%** **MATCHING TEXT** 35 WORDS

extracted at the receiving end. This is generallyreferred to as modulation of the carrier by the information being transmitted. Once the data is superimposed (modulated) onto the radio carrier, the radio signal occupies more than a single frequency,

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43/106 **SUBMITTED TEXT** 13 WORDS **100%** **MATCHING TEXT** 13 WORDS

interfering with each other if the radio waves are transmitted on different radio frequencies.

SA BCAP-51 DCN.pdf (D161530873)

44/106 **SUBMITTED TEXT** 37 WORDS **95%** **MATCHING TEXT** 37 WORDS

buffers, and retransmits data between the wireless LAN and the wired network infrastructure.Asingle access point can support a small group of users and can function within a range of less than one hundred to several hundred feet. The access point (

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45/106 **SUBMITTED TEXT** 31 WORDS **70%** **MATCHING TEXT** 31 WORDS

that is practical as longas the desired radio coverageis obtained. End-users access thewireless LANthroughwirelessLANadapters,which areimplemented as add-on cards in notebook or palmtop computers,as cards in desktop computers, or integrated within hand-held computers. Wireless LAN

SA BCAP-51 DCN.pdf (D161530873)

46/106 **SUBMITTED TEXT** 19 WORDS **MATCHING TEXT** 19 WORDS

IR systems are simple in design and therefore inexpensive. Theyuse the same signal frequencies used on fibre optic links. IR

82%

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47/106 **SUBMITTED TEXT** 12 WORDS **100%** **MATCHING TEXT** 12 WORDS

of radio or light waves that are transmitted and received across space,

of radio or light waves that are transmitted and received across space,

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48/106 **SUBMITTED TEXT** 17 WORDS **88%** **MATCHING TEXT** 17 WORDS

the other systems. Infrared transmission operates inthe light spectrum and does not require a license from the

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49/106 **SUBMITTED TEXT** 28 WORDS **67%** **MATCHING TEXT** 28 WORDS

e., at thespeed of light which is equal to 3 x 10 8 metre per seconds. In anyme- dium this speed gets reduced and also becomes frequencydependent. In case of

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50/106 **SUBMITTED TEXT** 30 WORDS **68%** **MATCHING TEXT** 30 WORDS

pass through ob- stacles. However, the power falls offsharplywith distance from the source because power is inversely proportional to cube of the distance from the source.At HF theytravel in straight lines and

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51/106 **SUBMITTED TEXT** 12 WORDS **100%** **MATCHING TEXT** 12 WORDS

a circular geographical area that handles cellular phones within its defined physical boundary.

SA DCAP453.docx (D142461319)

52/106 **SUBMITTED TEXT** 13 WORDS **88%** **MATCHING TEXT** 13 WORDS

A Local Area Network (LAN) is a network that is restricted to a

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53/106 **SUBMITTED TEXT** 12 WORDS **100%** **MATCHING TEXT** 12 WORDS

A LAN is a form of local (limited-distance), shared packet network for

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54/106 **SUBMITTED TEXT** 13 WORDS **82%** **MATCHING TEXT** 13 WORDS

Archive A computer site stores a large amount of public domaininformation, shareware software and

SA DCAP453.docx (D142461319)

55/106 **SUBMITTED TEXT** 24 WORDS **87%** **MATCHING TEXT** 24 WORDS

an Internet draft document. This should take no shorter than two weeks and no longer than six months. Once the IESGreaches a positive conclusion,it issues a last-

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56/106 **SUBMITTED TEXT** 11 WORDS **100%** **MATCHING TEXT** 11 WORDS

for inclusion into the standards track and for publication as a

SA Networking All.pdf (D144208908)

57/106 **SUBMITTED TEXT** 25 WORDS **44%** **MATCHING TEXT** 25 WORDS

TCP/IP stands for Transmission Control Protocol/Internet Protocol. It was developed with the objective to specifya suite of protocolscapable of providing transparent communications interoperabilityservices between computers of

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58/106 **SUBMITTED TEXT** 16 WORDS **65%** **MATCHING TEXT** 16 WORDS

The physical layer and data link layer of OSI is similar to the network layer of

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59/106 **SUBMITTED TEXT** 45 WORDS **36%** **MATCHING TEXT** 45 WORDS

Layer ?Application Layer ? Application Layer Presentation Layer ? Presentation Layer ? Presentation Layer Session Layer ? Session Layer ? Session Layer Transport Layer ? Transport Layer ? Transport Layer Network Layer ? Network Layer ? Network Layer Data Link Layer ? Data Link Layer ? Data Link Layer Physical Layer ?

Layer 7 Application Layer Application Layer 6 Presentation Layer Not present in the TCP/IP model 5 Session Layer 4 Transport Layer Transport Layer 3 Network Layer Network Layer 2 Data Link Layer Host-to-Network Layer 1 Physical Layer

W https://slideplayer.com/slide/2495933/

60/106 **SUBMITTED TEXT** 19 WORDS **100%** **MATCHING TEXT** 19 WORDS

specific to the platform in question) to a common one for the purpose of data exchange. For example, it performs

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61/106 **SUBMITTED TEXT** 55 WORDS **67%** **MATCHING TEXT** 55 WORDS

Layer 7) The application layer provides support servicesfor user and application tasks. It determines how the user is using the data network. It allows the user to use the network. For example, it provides network-based services to the end user. Examplesofnetworkservicesaredistributeddatabases,electronic mail,resource sharing, file transfers, remote file access and network management. This layer defines the nature of the task to be performed.

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62/106 **SUBMITTED TEXT** 16 WORDS **62%** **MATCHING TEXT** 16 WORDS

service requests received from the Application Layer and also sends service requests to the fifth layer

service requests from the Application layer and issues service requests to the Session layer.

W http://personal.psu.edu/faculty////m/e/mes121/Comms_Class02_Slides.ppt

63/106 **SUBMITTED TEXT** 13 WORDS **75%** **MATCHING TEXT** 13 WORDS

the Presentation Layer relieves the layer above it of concern regarding syntactical differences in

The Presentation layer relieves the Application layer of concern regarding syntactical differences in

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64/106	SUBMITTED TEXT	22 WORDS	85%	MATCHING TEXT	22 WORDS

fiber optic network with a capacityof 1000 gigabits/sec on which a supercomputer was trying to transfer a file to a personal computer at 1Gbps.

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65/106	SUBMITTED TEXT	14 WORDS	78%	MATCHING TEXT	14 WORDS

the subnet is able to carry the offered load. This is a global issue

the subnet is able to carry the offered traffic. It is a global issue,

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66/106	SUBMITTED TEXT	12 WORDS	92%	MATCHING TEXT	12 WORDS

Flow control relates to the point-to-point traffic between a given sender and

Flow control, in contrast, relates to the point-to-point traffic between a given sender and

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67/106	SUBMITTED TEXT	10 WORDS	100%	MATCHING TEXT	10 WORDS

solutions are based on the concept of a feedback loop

SA BCAP-51 DCN.pdf (D161530873)

68/106	SUBMITTED TEXT	31 WORDS	82%	MATCHING TEXT	31 WORDS

The percentage of all packets discarded for lack of buffer space ? Theaveragequeuelengths ? The number ofpackets that time out and are retransmitted ? The average packet delay ? The standard deviation of packet delay

SA BCAP-51 DCN.pdf (D161530873)

69/106	SUBMITTED TEXT	11 WORDS	83%	MATCHING TEXT	11 WORDS

set of communications protocols used in the Internet and similar computer networks.

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70/106	SUBMITTED TEXT	11 WORDS	100%	MATCHING TEXT	11 WORDS

facilities provided by common carriers, such as telephone companies. WAN technologies

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71/106	SUBMITTED TEXT	17 WORDS	63%	MATCHING TEXT	17 WORDS

TCP/IP reference model is anetwork model used inInternet architecture. It has its beginnings back in the 1960s.The

TCP/IP reference model is the network model used in the current Internet architecture. It has its origins back in the 1960's with the

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72/106	SUBMITTED TEXT	16 WORDS	68%	MATCHING TEXT	16 WORDS

each router in the network learns the network topology then creates a routing table based on

SA DCAP453.docx (D142461319)

73/106	SUBMITTED TEXT	9 WORDS	84%	MATCHING TEXT	9 WORDS

two of its most important protocols:Transmission Control Protocol (TCP)andInternet Protocol (IP).

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74/106	SUBMITTED TEXT	17 WORDS	64%	MATCHING TEXT	17 WORDS

into layers, the protocol stack permits division of labor, ease of execution and code testing, and the

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75/106	SUBMITTED TEXT	16 WORDS	88%	MATCHING TEXT	16 WORDS

Application layer: The application layer is provided bythe program that uses TCP/IP for communication. An application

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76/106	SUBMITTED TEXT	12 WORDS	87%	MATCHING TEXT	12 WORDS

by delivering data from an application to its distant peer. Multiple applications

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77/106	SUBMITTED TEXT	11 WORDS	83%	MATCHING TEXT	11 WORDS

is a user process cooperating with another process, usuallyon a different host.

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78/106 **SUBMITTED TEXT** 22 WORDS **62%** **MATCHING TEXT** 22 WORDS

transport layer protocol is theTransmission Control Protocol (TCP), whichprovidesconnection-orientedreliabledatadelivery,duplicatedata suppression, congestion control, and flow control.Another transport layer protocol is the User Datagram Protocol which provides connectionless,unreliable,best-

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79/106 **SUBMITTED TEXT** 9 WORDS **100%** **MATCHING TEXT** 9 WORDS

also called the link layer or the data-link layer.

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80/106 **SUBMITTED TEXT** 27 WORDS **63%** **MATCHING TEXT** 27 WORDS

most important protocol inthis layer. It is a connectionless protocol. IP does not provide reliability, flow control or error handling. These functions must be provided at a higher level.

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81/106 **SUBMITTED TEXT** 25 WORDS **94%** **MATCHING TEXT** 25 WORDS

is the interface to the actual network hardware. This interface may or may not provide reliable delivery, and may be packet or stream oriented. In fact, TCP/

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82/106 **SUBMITTED TEXT** 19 WORDS **82%** **MATCHING TEXT** 19 WORDS

dotted-decimal notation.'Dotted-decimal notation divides the32-bit Internet address into four8-bit fields and specifies the valueof each field independentlyas a decimal number with

Dotted-Decimal Notation Dotted-decimal notation divides the 32-bit Internet address into four 8-bit (byte) fields and specifies the value of each field independently as a decimal number with

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83/106 **SUBMITTED TEXT** 13 WORDS **73%** **MATCHING TEXT** 13 WORDS

boundary between the network prefix and the host number at adifferent point withinthe32-bit address.

boundary between the network-prefix and the host-number at a different point within the 32-bit address.

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84/106 **SUBMITTED TEXT** 20 WORDS **43%** **MATCHING TEXT** 20 WORDS

IP accepts data from the transport layer protocols UDP andTCP.Itthen encapsulates this datainto an IPdatagram usingaspecial format priortotransmission. Fragmentation and reassembly: IP

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85/106 **SUBMITTED TEXT** 18 WORDS **77%** **MATCHING TEXT** 18 WORDS

available, which illustrates the flexibilityof theIPlayer.Examples are IEEE 802.2, X.25 (which is reliable in itself),ATM, FDDI, and even SNA 2.

SA Fundamental of Computer Networking.pdf (D143474045)

86/106 **SUBMITTED TEXT** 14 WORDS **85%** **MATCHING TEXT** 14 WORDS

If the final destination is on a distant network not directlyattached to the source,

SA CMP506 Computer Networks.pdf (D164861258)

87/106 **SUBMITTED TEXT** 14 WORDS **80%** **MATCHING TEXT** 14 WORDS

the host. Each IP datagram has a source, IP address and a destination IP address.

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88/106 **SUBMITTED TEXT** 40 WORDS **89%** **MATCHING TEXT** 40 WORDS

and 24 bits for the >host< portion of the IP address. This permits 2 7 –2 (126) networks each with 2 24 –2 (16777214) hosts—a total of more than 2 billion addresses. Class B addresses: These addresses use 14 bits for the >

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89/106 **SUBMITTED TEXT** 31 WORDS **66%** **MATCHING TEXT** 31 WORDS

and 16 bits for the >host< portion of the IP address. This allows for 2 14 –2 (16382) networkseach with2 16 – 2(65534)hosts—atotalofmorethan 1billionaddresses. Class C addresses: These addresses use 21 bits for the >

SA Fundamental of Computer Networking.pdf (D143474045)

90/106	SUBMITTED TEXT	49 WORDS	69%	MATCHING TEXT	49 WORDS

and 8 bits for the >host< portion of the IP address. That allows for 2 21 –2 (2097150) networkseachwith2 8 – 2(254)hosts—atotalofmorethanhalfabillionaddresses. Class Daddresses: These addresses are reservedfor multicasting(a sort of broadcasting, but in a limited area, and onlyto hosts using the same Class D address). Class E addresses: These addresses are reserved for future

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91/106	SUBMITTED TEXT	68 WORDS	84%	MATCHING TEXT	68 WORDS

Find the class of each address: ? 00000001 00001011 00001011 11101111 ? 11000001 10000011 00011011 11111111 ? 227.12.14.87 ? 193.14.56.22 Solution: ? The first bit is 0. This is a ClassAaddress. ? The first 2 bits are 1; the third bit is 0. This is a Class C address ? The first byte is 227 (between 224 and 239); the Class is D. ? The first byte is 193 (between 192 and 223); the Class is

Find the class of each address. a. 00000001 00001011 00001011 11101111 b. 11000001 10000011 00011011 11111111 c. 14.23.120.8 d. 252.5.15.111 Solution The first bit is O. This is a class A address. The first 2 bits are 1; the third bit is O. This is a class C address. The first byte is 14 (between 0 and 127); the class is A. d. The first byte is 252 (between 240 and 255); the class is

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92/106	SUBMITTED TEXT	21 WORDS	81%	MATCHING TEXT	21 WORDS

block must be contiguous. 2. The number of addresses in a block must be a power of 2. 3. Thefirst address must

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93/106	SUBMITTED TEXT	16 WORDS	65%	MATCHING TEXT	16 WORDS

First address: The first address of the block can be found bysetting the 32–nrightmost bits in

First Address The first address in the block can be found by setting the 32 - n rightmost bits in

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94/106	SUBMITTED TEXT	17 WORDS	62%	MATCHING TEXT	17 WORDS

ARP is a network-specific standard protocol. It is used for convertingthe higher-level IP addresses to physical network addresses.

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95/106	SUBMITTED TEXT	34 WORDS	79%	MATCHING TEXT	34 WORDS

caller (the device driver), which then transmits the packet. If it does not find the pair in its table, it discards the packet (the assumption is that a higher-level protocol will retransmit) and generates a

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96/106 **SUBMITTED TEXT** 24 WORDS **85%** **MATCHING TEXT** 24 WORDS

Figure 4.71 shows a simple domain with five nodes. Each node uses the same topologyfor creating a routing table, but the routing table for each

figure shows a simple domain with five nodes. Each node uses the same topology to create a routing table, but the routing table for each

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97/106 **SUBMITTED TEXT** 35 WORDS **77%** **MATCHING TEXT** 35 WORDS

allows the sendingprocess to deliver data as a stream of bytes and allows the receiving process to obtain data as a stream of bytes. TCP creates an environment in which twoprocesses can be connected byan imaginary tube.

allows the sending process to deliver data as a stream of bytes and allows the receiving process to obtain data as a stream of bytes. • TCP creates an environment in which the two processes seem to be connected by an imaginary "tube"

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98/106 **SUBMITTED TEXT** 13 WORDS **100%** **MATCHING TEXT** 13 WORDS

to determine their own IP address, they use a mechanism similar to ARP.

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99/106 **SUBMITTED TEXT** 46 WORDS **73%** **MATCHING TEXT** 46 WORDS

ARP packet generation If an application wants to send data to a certain IP destination address, the IP routing mechanism first determinesthe IP address ofthe next hop of the packet (it can be the destination host itself, or a router) and the hardware device on which it should be

SA MCSDSE-2.7- Computer networks.pdf (D157336521)

100/106 **SUBMITTED TEXT** 13 WORDS **80%** **MATCHING TEXT** 13 WORDS

the hardware address of the host and the IP address is the parameter

SA MCSDSE-2.7- Computer networks.pdf (D157336521)

101/106 **SUBMITTED TEXT** 19 WORDS **85%** **MATCHING TEXT** 19 WORDS

After connection is established, bi-directional data transfer can take place. The client and server can both send data and

After connection is established, bidirectional data transfer can take place. The client and server can both send data and

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TCP assigns a sequence number to each byte transmitted, and expects a positive acknowledgment (ACK) from the receiving TCP layer. If the ACK is not received within a timeout interval, the data is retransmitted. Becausethedataistransmittedinblocks (TCP segments),onlythe sequence number of the first data byte in the segment is sent to the destination host. 4.7.1

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103/106	SUBMITTED TEXT	11 WORDS	83%	MATCHING TEXT	11 WORDS

TCP Connection TCP stands for Transmission Control Protocol. It is connection-oriented.

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104/106	SUBMITTED TEXT	10 WORDS	100%	MATCHING TEXT	10 WORDS

host number at a different point within the32-bit address. ?

host-number at a different point within the 32-bit address.

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105/106	SUBMITTED TEXT	28 WORDS	41%	MATCHING TEXT	28 WORDS

Broadband Network 5.3 Local Loop Technologies 5.3.1 Asymmetric Digital Subsriber Line (ADSL) 5.3.2 High Bit-Rate Digital Subscriber Line (HDSL) 5.3.3 Wireless Local Loop (WLL) 5.4 network Security 5.4.1 Basic Requirements of Network Security 5.4.2

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106/106	SUBMITTED TEXT	9 WORDS	100%	MATCHING TEXT	9 WORDS

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