Computer Network

B.Tech Computer & Software Engineering

Delhi Technological University

Module 1: Introduction

Instructor: Divyashikha Sethia

Course Content

- **UNIT I:**
- Introduction Concepts: Goals and Applications of Networks, Network structure and architecture, The OSI reference model, services, Network Topology Design - Delay Analysis, Physical Layer Transmission Media, Switching methods, ISDN.

- **UNIT II**
- Medium Access sub layer: Medium Access sub layer - Channel Allocations, LAN protocols -ALOHA protocols - Overview of IEEE standards - FDDI. Data Link Layer - Elementary Data Link Protocols, Sliding Window protocols, Error Handling.
-

UNIT III

- Network Layer: Network Layer - Point - to Pont Networks, routing, Congestion control, Internetworking -TCP / IP, IP packet, IP address, IPv6.

Course Content

UNIT IV

- Transport Layer: Transport Layer - Design issues, connection management, session Layer-Design issues, remote procedure call.
-

UNIT V

- Presentation Layer- Data compression techniques, cryptography.
-

UNIT VI

- Application Layer: Application Layer: File Transfer, Access and Management, Electronic mail, Virtual Terminals, Internet and Public Networks.

Books:

Computer Networks – Tanenbaum

Data Communication & networking - Forouzan

Marks

Component	Minor	Class Tests/ Tutorial and Interaction	Attendance	Major
Marks	20	5	5	70

Rules

- Discipline
- Punctuality
- Attendance !
- Q/A – Tutorials
- Protocol of Communication - Transparency

Roadmap

- What is a computer network?
- Evolution of computer networks
- Applications of computer networks
- Reference models

Introduction to computer networks

- "interconnected collection of autonomous computers connected by a *single* technology" [Tanenbaum]
- What is the Internet?
  - "network of networks"
  - "collection of networks interconnected by routers"
  - "a communication medium used by millions"
  - Email, chat, Web "surfing", streaming media

Evolution of computer network

- Mid 1960s standalone mainframes unable to communicate
- ARPA (Advanced Research Projects Agency in Dod (Department of Defense)
- 1969 four nodes at UCLA, UCSB, Stanford, Utah were connected
- 1972 Internetting Project by Vint Cerf and Bob Kahn – TCP
- TCP/IP

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Internet Today

- **Local ISP**
- **National ISP backbone net created by companies**
- **Regional ISP**

National ISP **National ISP**

/ \ |

Regional ISP **Regional ISP** --- __ **NAP** __ -----

/ |

Local ISP …….. **National ISP**

ISP: Internet Service Provider

NAP: Network Access Point

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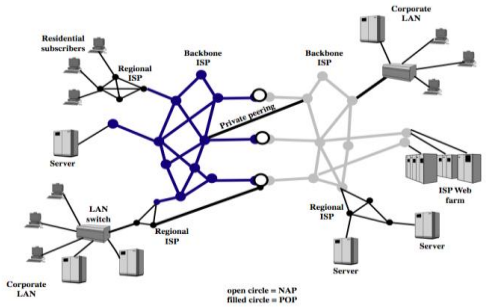
Internet Architecture



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Internet Architecture

•computer produces to analog signals that can pass unhindered over the telephone system. These signals are transferred to the ISP's POP (Point of Presence), where they are removed from the telephone system and injected into the ISP's regional network.

•The ISP's regional network consists of interconnected routers in the various cities the ISP serves.

•major backbone operators, companies like AT&T and Sprint. They operate large international backbone networks, with thousands of routers connected by high-bandwidth fiber optics.

•To allow packets to hop between backbones, all the major backbones connect at the NAPs discussed earlier.

•Larger backbones have numerous direct connections between their routers, a technique known as private peering.

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Uses of Computer Networks

- Business Applications
- Home Applications
- Mobile Users
- Social Issues

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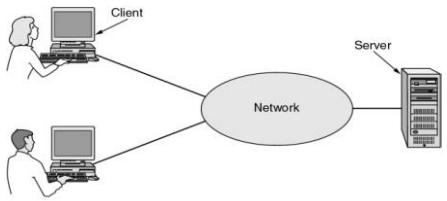
Business Applications of Networks

- A network with two clients and one server.



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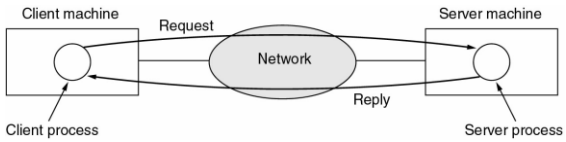
Business Applications of Networks (2)

- The client-server model involves requests and replies.



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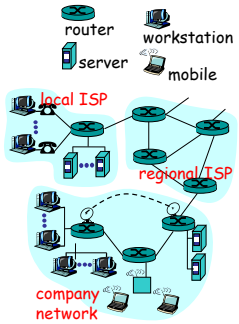
Business Application

- Resource sharing
- Communication
- Reduction in inventory
- E-commerce with consumers

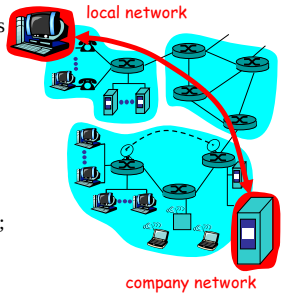
Detailed Business application 1

- millions of connected computing devices like PCs workstations, servers, Mobile phones, iPod, CCTV running network apps
- communication links with different bandwidth like fiber, copper, radio, satellite
- routers: forward packets
- Packet: a piece of message.



Detailed Business application 2

- end systems (hosts):
  - run application programs
  - e.g. Web, email
  - at "edge of network"
- client/server model
  - client host requests, receives service from always-on server
  - e.g. Web browser/server; email client/server



Home Network Applications

- Access to remote information
- Person-to-person communication
- Interactive entertainment
- Electronic commerce

Some Home Applications

- WWW
- Instant Messaging (Internet chat, text messaging on cellular phones)
- Peer-to-Peer
- Internet Phone
- Video-on-demand
- Distributed Games
- Remote Login (SSH client, Telnet)
- File Transfer
- Remote monitoring/ Spying

Mobile Network Users

- Wireless != Mobile

Wireless Network	Mobile Network
uses 802.11 standards	uses cellular phone technology
gives you the ability to move around a campus	Gives you the ability to move around city to city

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Social Issues

- Exploitation of expression
- Virtual world – can be misleading
- Identity theft

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Roadmap

- What is a computer network?
- Evolution of computer networks
- Applications of computer networks
- Reference models

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Network Hardware

- Transmission Technology
- Types of networks:
  - Local Area Networks
  - Metropolitan Area Networks
  - Wide Area Networks
  - Wireless Networks
  - Home Networks
  - Internetworks

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Transmission Technology

- Broadcast links
  - Broadcasting and Multicasting
- Point-to-point links

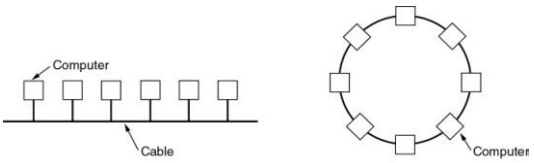
Broadcast Networks (2)

- Classification of interconnected processors by scale.

Interprocessor distance	Processors located in same	Example
1 m	Square meter	Personal area network
10 m	Room	Local area network
100 m	Building	
1 km	Campus	
10 km	City	Metropolitan area network
100 km	Country	Wide area network
1000 km	Continent	
10,000 km	Planet	The Internet

Local Area Networks

Network in small geographical Area (Room, Building or a Campus) is called LAN (Local Area Network)



- Two broadcast networks
- (a) Bus
- (b) Ring

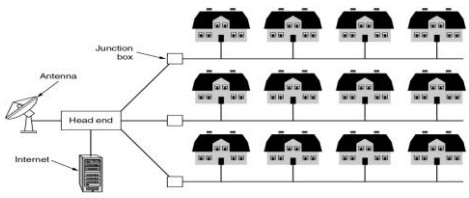
Local Area Networks (2)

- Span few km
- Ethernet IEEE 802.3 standard
  - Bus topology
  - 10 Mbps to 10 Gbps
- Token ring:
  - Ring topology IEEE 802.5
  - 4 to 16 Mbps

IEEE - Institute of Electrical and Electronics Engineers

Metropolitan Area Networks

- Network in a City is call MAN (Metropolitan Area Network)
- metropolitan area network based on cable TV.



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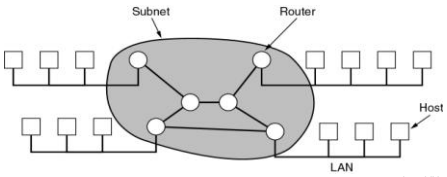
Wide Area Networks

- Network spread geographically (Country or across Globe) is called WAN (Wide Area Network)
- Relation between hosts on LANs and the subnet.



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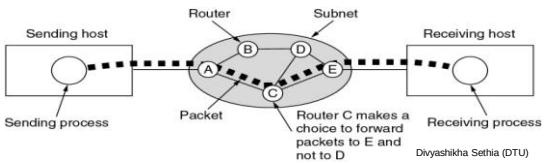
Wide Area Networks (2)

- Subnet – collection of routers and communication lines
- A stream of packets from sender to receiver.
- Store-and-forward or packet-switched subnet
- Routers – Routing algorithm



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Wireless Networks

➢Categories of wireless networks:

- System interconnection
- Wireless LANs
- Wireless WANs

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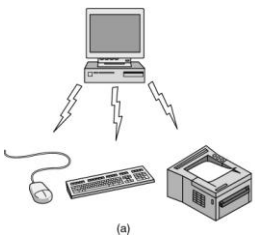
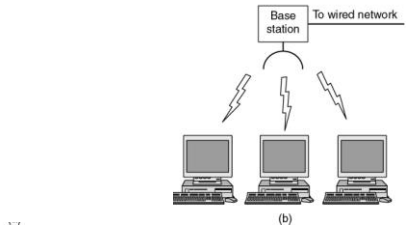
Wireless Networks (2)



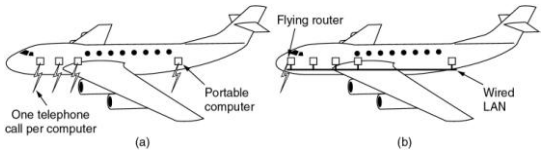
- System interconnection – interconnecting components using short range radio
- Bluetooth configuration

Wireless Networks (2)



- (b) Wireless LAN
- IEEE 802.11

Wireless Networks (3)

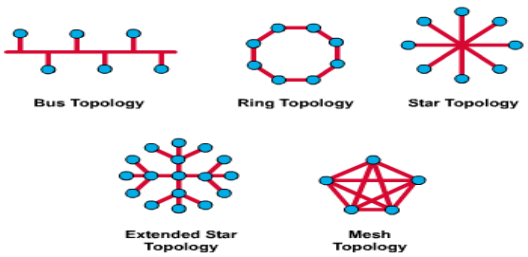


- (a) Individual mobile computers
- (b) A flying LAN mobile router maintains radio link with router on ground

"internetworking"?

- internetwork – interconnection of networks – also called an "internet"
- Subnetwork – a constituent of an internet
- Intermediate system – a device used to connect two networks allowing hosts of the networks to correspond with each other
  - Bridge
  - Routers
- Internet is an example of an internetwork.

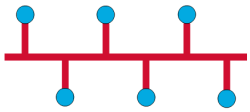
Network Topology



- The network topology defines the way in which computers, printers, and other devices are connected.

Bus Topology

- Commonly referred to as a linear bus, all the devices on a bus topology are connected by one single cable
- As signal travels along bus energy transformed into heat and hence become weaker – hence limitation to the length of the bus



Bus Topology

Advantages
•Easy to implement and extend.
•Easy to install.
•Well-suited for temporary or small networks not requiring high speeds (quick setup), resulting in faster networks.
•less expensive than other topologies
• Cost effective; only a single cable is used.
•Easy identification of cable faults.

Disadvantages
•Limited cable length and number of stations.
•If there is a problem with the cable, the entire network breaks down.
•Maintenance costs may be higher in the long run.
•Performance degrades as additional computers are added or on heavy traffic (shared bandwidth).
•Commonly has a slower data transfer rate than other topologies.
•Only one packet can remain on the bus during one clock pulse

Reference: http://en.wikipedia.org/wiki/Bus_network

Star Topology

- The star topology is the most commonly used architecture in Ethernet LANs.
- When installed, the star topology resembles spokes in a bicycle wheel.

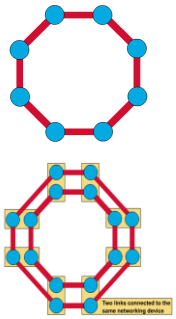
Star Topology

Advantages
•**Better performance:**
- prevents passing of data packets through an excessive number of nodes.
•**Isolation of devices:** Each device is inherently isolated by the link that connects it to the hub which prevents any non-centralized failure from affecting the network.
• **Benefits from centralization:** allows the inspection of traffic through the network. This facilitates analysis of the traffic and detection of suspicious behaviour.
• Easy to detect faults and to remove parts.
• No disruptions to the network when connecting or removing devices.

Disadvantages
•High dependence of the system on the functioning of the central hub
•Failure of the central hub renders the network inoperable

Ring Topology

- A frame travels around the ring, stopping at each node. If a node wants to transmit data, it adds the data as well as the destination address to the frame.
- The frame then continues around the ring until it finds the destination node, which takes the data out of the frame.
  - Single ring – All the devices on the network share a single cable
  - Dual ring – The dual ring topology allows data to be sent in both directions.



Ring topology

Advantages:

•Very orderly network where every device has access to the token and the opportunity to transmit
•Performs better than a bus topology under heavy network load
•Does not require network server to manage the connectivity between the computers

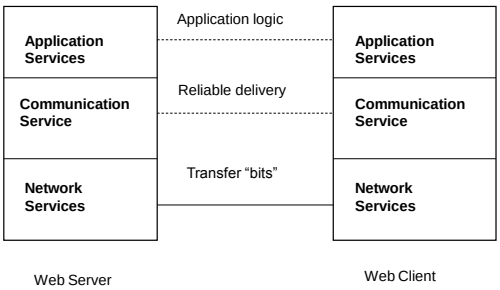
Disadvantages:

•One malfunctioning workstation or bad port in the MAU can create problems for the entire network
•Moves, adds and changes of devices can affect the network
•Network adapter cards and MAU's are much more expensive than Ethernet cards and hubs
•Much slower than an Ethernet network under normal load

Reference Model Based on Layered Architecture

- Networks are complex with many pieces
  - Hosts, routers, links, applications, protocols, hardware, software
- Can we organize it, somehow?
- Let's consider a Web page request:
  - Browser requests Web page from server
  - Server should determine if access is privileged
  - Reliable transfer page from server to client
  - Physical transfer of "bits" from server to client

Motivation Continued …

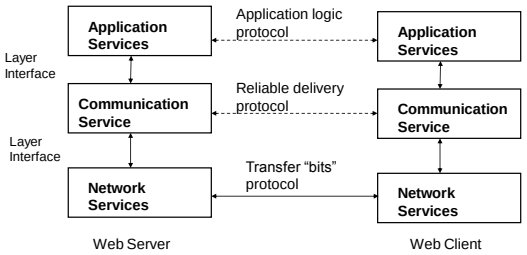


Motivation Continued …

Dealing with complex systems:

- explicit structure allows identification, relationship of complex system's pieces
  - layered reference model
- modularization eases maintenance, updating of system
  - change of implementation of layer's service transparent to rest of system
  - e.g., change in gate procedure doesn't affect rest of system
- layering considered harmful?

Layers, Protocols, Interfaces



Layered Architecture (Review 1/2)

- Networks organized as a stack of layers?
  - The purpose of a layer is to offer services to the layer above it using an interface (programming language analogy: libraries hide details while providing a service)
  - Reduces design complexity
- Protocols: peer-to-peer layer-n conversations
- Data Transfer: each layer passes data & control information to the layer below; eventually physical medium is reached.

Review (2/2)

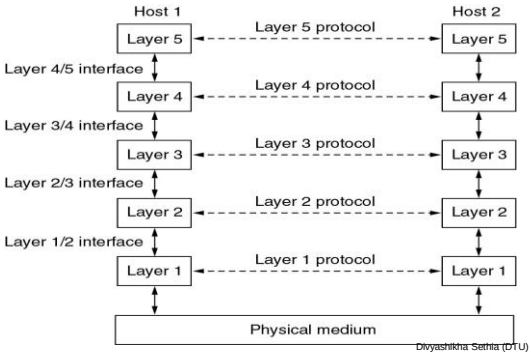
- A set of layers & protocols is called a Network Architecture. These specifications enable hardware/software developers to build systems compliant with a particular architecture.
  - E.g., TCP/IP, OSI
- Protocol stack : list of protocols used by a system with one protocol per layer.

Layering: Design Issues

- Identify senders/receivers?
  - Addressing
- Unreliable physical communication medium?
  - Error detection
  - Error control
  - Message reordering
- Sender can swamp the receiver?
  - Flow control
- Multiplexing/Demultiplexing

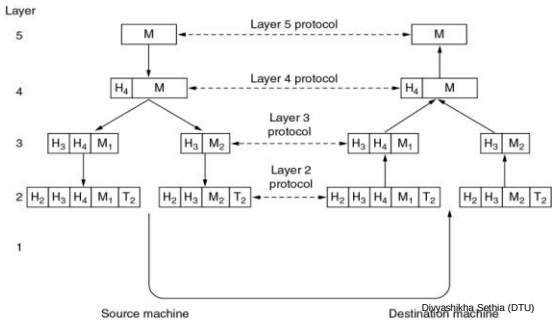
Network Software

Protocol Hierarchies



Protocol Hierarchies

- Information flow supporting virtual communication in layer 5.



Design Issues for the Layers

- Addressing
- Error Control
- Flow Control
- Multiplexing
- Routing

Connection-Oriented and Connectionless Services

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- Layers can offer two different types of service to the layers above them: connection-oriented and connectionless
- Connection-oriented service is modeled after the telephone system
  - connection acts like a tube: sender pushes bits at one end, and receiver takes them out at other end.
  - sender, receiver, and subnet conduct a negotiation about parameters (maximum message size, Quality of service)
- Connectionless service modeled after postal system: Each message (letter) carries the full destination address, and each one is routed through the system independent of all the others (can be out of order)

Reliable and unreliable service

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• Reliable service: never loose data , receiver could acknowledge receipt of message

Connection-Oriented and Connectionless Services

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- Six different types of service.

	Service	Example
Connection-oriented	Reliable message stream	Sequence of pages
	Reliable byte stream	Remote login
	Unreliable connection	Digitized voice
Connection-less	Unreliable datagram	Electronic junk mail
	Acknowledged datagram	Registered mail
	Request-reply	Database query

Open Systems Interconnection (OSI)

- International standard organization (ISO) established a committee in 1977 to develop an architecture for computer communication.
- Open Systems Interconnection (OSI) reference model is the result of this effort.
- In 1984, the Open Systems Interconnection (OSI) reference model was approved as an international standard for communications architecture.
- Term "open" denotes the ability to connect any two systems which conform to the reference model and associated standards.

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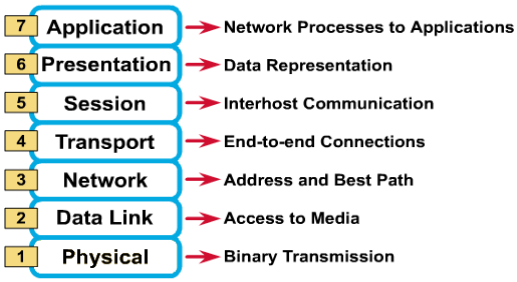
OSI Reference Model: 7 Layers



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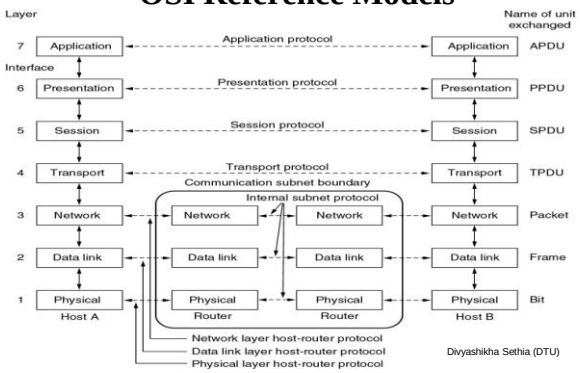
OSI Reference Models



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Physical Layer

- Provides physical interface for transmission of information.
- Defines rules by which bits are passed from one system to another on a physical communication medium.
- Covers all - mechanical, electrical, functional and procedural - aspects for physical communication.

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Data Link Layer

- Data link layer attempts to provide reliable communication over the physical layer interface.
- Breaks the outgoing data into frames and reassemble the received frames – frame boundaries
- Handle errors by implementing an acknowledgement and retransmission scheme.
- Implement flow control.
- Supports points-to-point as well as broadcast communication.

Network Layer

- Implements routing of frames (packets) through the network.
- Defines the most optimum path the packet should take from the source to the destination
- Defines logical addressing so that any endpoint can be identified.
- Handles congestion in the network.
- Facilitates interconnection between heterogeneous networks (Internetworking).
- The network layer also defines how to fragment a packet into smaller packets to accommodate different media.

Transport Layer

- Provides reliable mechanism for the exchange of data between two processes in different computers.
- Ensures that the data units are delivered error free.
- Ensures that data units are delivered in sequence.
- Ensures that there is no loss or duplication of data units.
- Provides connectionless or connection oriented service.
- Provides for the connection management.
- Multiplex multiple connection over a single channel.

Session Layer

- Provides mechanism for controlling the dialogue between the two end systems. It defines how to start, control and end conversations (called sessions) between applications.
- This layer requests for a logical connection to be established on an end-user's request.
- Any necessary log-on or password validation is also handled by this layer.
- This layer provides services like dialogue discipline which can be full duplex or half duplex.
- Session layer can also provide check-pointing mechanism such that if a failure of some sort occurs between checkpoints, all data can be retransmitted from the last checkpoint.

Presentation Layer

- Presentation layer defines the format in which the data is to be exchanged between the two communicating entities.
- Also handles data compression and data encryption (cryptography).

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Application Layer

- Application layer interacts with application programs and is the highest level of OSI model.
- Application layer contains management functions to support distributed applications.
- Examples of application layer are applications such as file transfer, electronic mail, remote login etc.

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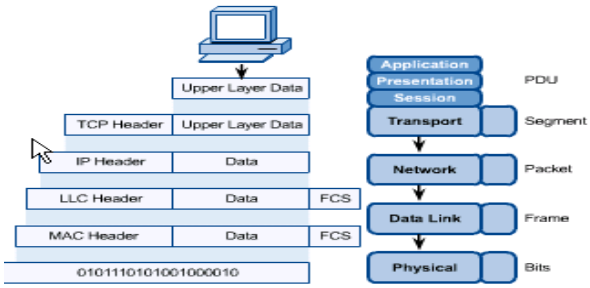
OSI in Action Transmission



Good Animation :
http://www.youtube.com/watch?v=fiMswfo45DQ

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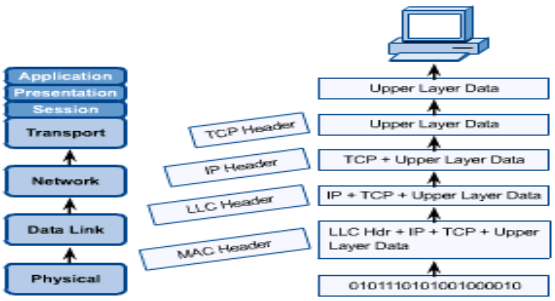
OSI in Action Reception



Good Animation : http://www.youtube.com/watch?v=fiMswfo45DQ

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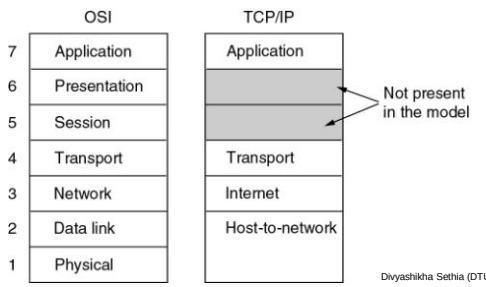
Reference Models (2)

- The TCP/IP reference model.



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TCP/IP Model

Application Layer
Application programs using the network

Transport Layer (TCP/UDP)
Management of end-to-end message transmission, error detection and error correction

Network Layer (IP)
Handling of datagrams : routing and congestion

Data Link Layer
Management of cost effective and reliable data delivery, access to physical networks

Physical Layer
Physical Media

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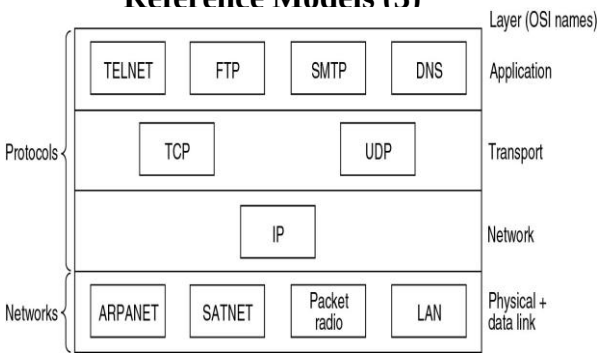
Reference Models (3)



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Example Networks

- The Internet
- Ethernet
- Wireless LANs: 802:11

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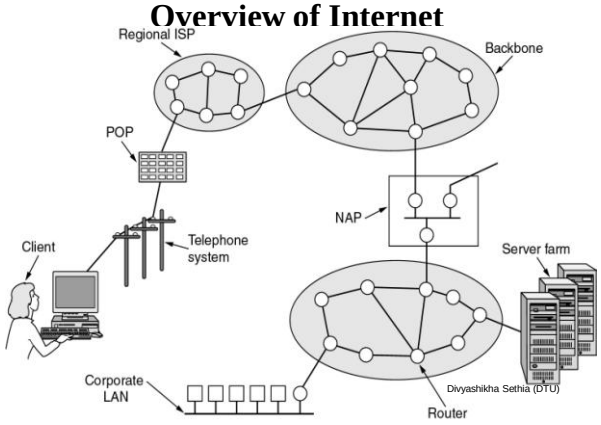
Overview of Internet



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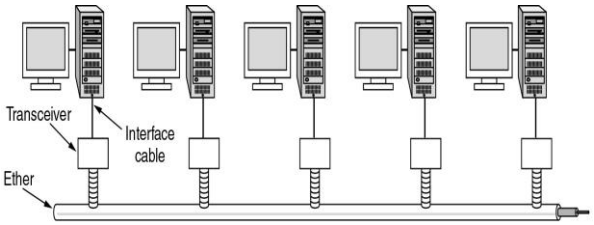
Ethernet

- Architecture of the original Ethernet.



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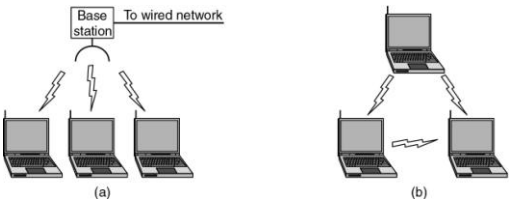
Wireless LANs



- (a) Wireless networking with a base station.
- (b) Ad hoc networking.

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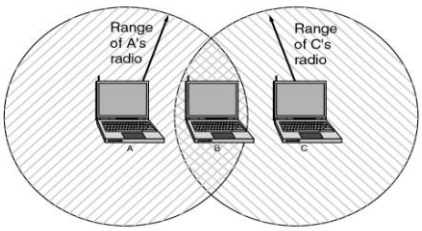
Wireless LANs (2)

- The range of a single radio may not cover the entire system.



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802.11 comparison with Ethernet

- Signal collision for out of range devices
- Multipath fading – reflection off from solid objects causes signal to be received multiple times resulting into interference.
- Mobility and handing off to new base station

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Standards

Standards are essential in creating and maintaining an open and competitive market for equipment manufacturers and in guaranteeing national and international interoperability of data and telecommunications technology and processes. Standards provide guidelines to manufacturers, vendors, government agencies, and other service providers to ensure the kind of interconnectivity necessary in today's marketplace and in international communications. Data communication standards fall into two categories: *de facto* (meaning "by fact" or "by convention") and *de jure* (meaning "by law" or "by regulation").

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Difference Protocols and Standards

- A protocol : series of prescribed steps to be taken, to allow for the coordinated action of multiple parties. Computer Network protocols are used to allow different computers and/or software applications to work and communicate with one another.
- Standards are simply agreed-upon models for comparison, such as the meter and the gram. In the world of computers, standards are often used to define syntactic or other rule sets, and occasionally protocols, that are used as a basis for comparison. Some good examples include ANSI SQL, used to compare derivations of the SQL database query language, and ANSI C, used to compare derivations of the C programming language

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Standard Creation Committees

- International Organization for Standardization (ISO) (multinational body)
- International Telecommunication Union – Telecommunication Standards Sector (ITU-T)
  - United Nations formed a committee as part of ITU Consultative Committee for International Telegraphy and Telephony (CCITT) for establishment of standards for telecommunication (later name changed to ITU –T
- ANSI (American National Standards Institute)
- IEEE (Institute of Electrical and Electronics Engineers)

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Internet Standards

- Internet standard is a tested specification that is useful to and meant for those who work with the Internet
- Specification begins as an Internet draft (work in progress) with no official status and a 6 month lifetime
- On recommendation from Internet authorities draft may be published as a Request for Comment (RFC)
- Each RFC is edited, assigned a number and made available for access with a specific requirement level

References

Chapter 1: Introduction, Tanenbaum

THANKS