SRI KRISHNA ARTS AND SCIENCE COLLEGE

DEPARTMENT OF COMPUTER SCIENCE

21CDC09 - COMPUTER NETWORKS

Unit- I **Lecture -1**

Introduction : Uses of Computer Network

Facilitator : Spelmen Vimalraj.S

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Topics Covered

- What is Computer Networks
- Uses of Computer Networks
  - ✔ Business Applications
  - ✔ Home Applications
  - ✔ Mobile Users
  - ✔ Social Issues

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What is Computer Network?

- **"Computer Network"** to mean a collection of autonomous computers interconnected by a single technology.
- Two computers are said to be interconnected if they are able to **exchange information**.
- The connection need not be via a copper wire; fiber optics, microwaves, infrared, and communication satellites, etc.

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Introduction

- A **computer network** is a set of computers connected together for the purpose of **sharing resources**
- The most common resource shared today is connection to the **Internet**.
- Other shared resources can include a printer or a file server.
- The **Internet** itself can be considered a **computer network**.

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- Networks come in many large sizes, shapes and forms.
- Computers on a network are called **nodes**.
- The connection between computers can be done via cabling, most commonly the Ethernet cable, or wirelessly through radio waves.
- Connected computers can share resources, like access to the Internet, printers, file servers, and others.

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- A network is a multipurpose connection, which allows a single computer to do more.

- A layer of software on top of the operating system is called middleware.

- **Example** of a distributed system is the world wide web.

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Uses of Computer Networks

1. Business Applications
2. Home Applications
3. Mobile Users
4. Social Issues

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Business Applications

1. Resource Sharing
2. Server-Client model
3. Communication Medium
4. E-Commerce

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Business Applications

1. Resource Sharing:

- The goal is to make all programs, equipments(like printers etc), and especially data, **available to anyone on the network** without regard to the physical location of the resource and the user.

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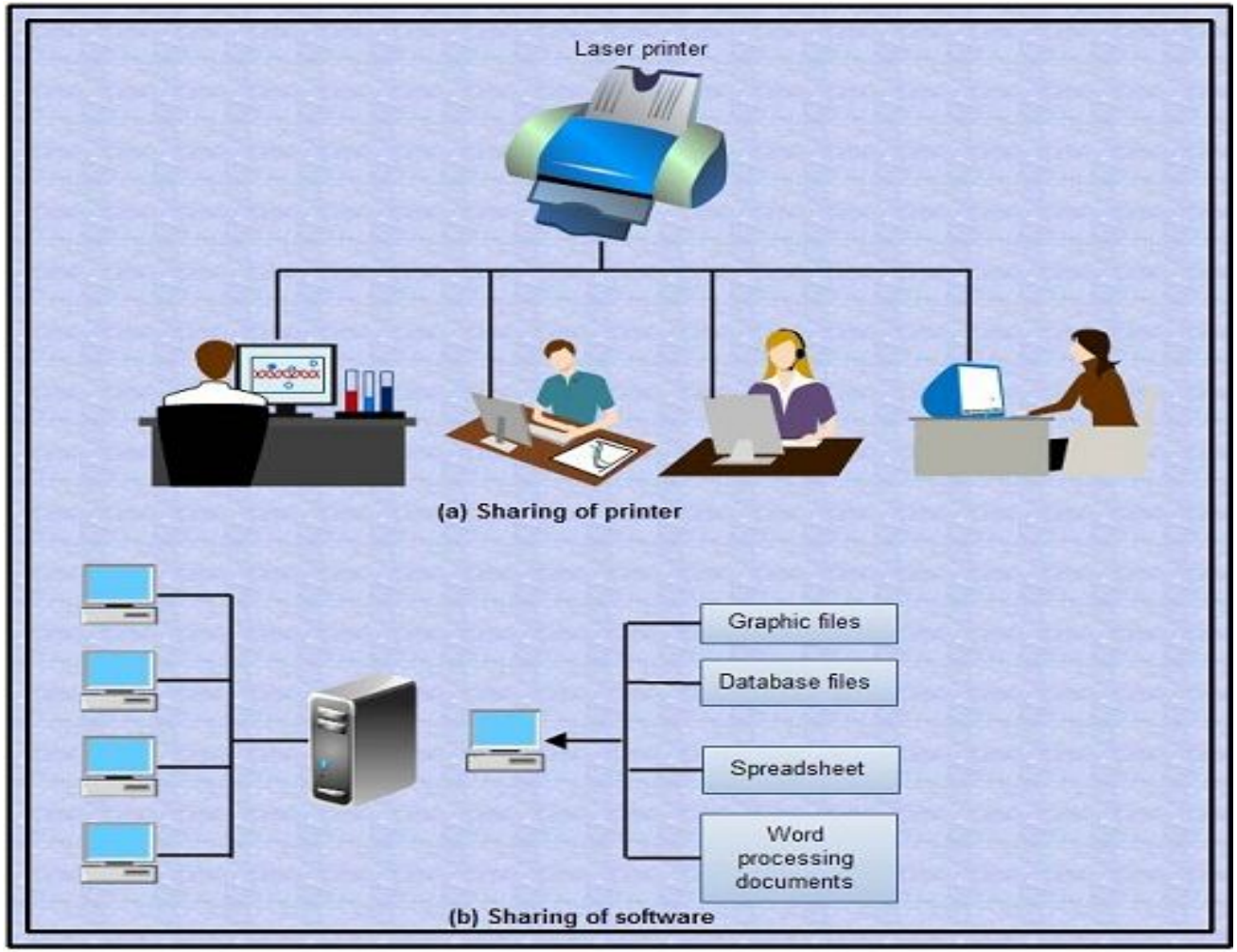
A printer being shared and different information being shared.



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2. Server-Client model

- If a company's information system consists of one or more databases and some employees who need to access it remotely.
- The data is stored on powerful computers called **Servers**.
- These are centrally housed and maintained by a system administrator.
- The employees have simple machines, called **Clients**, on their desks, using which they access remote data.

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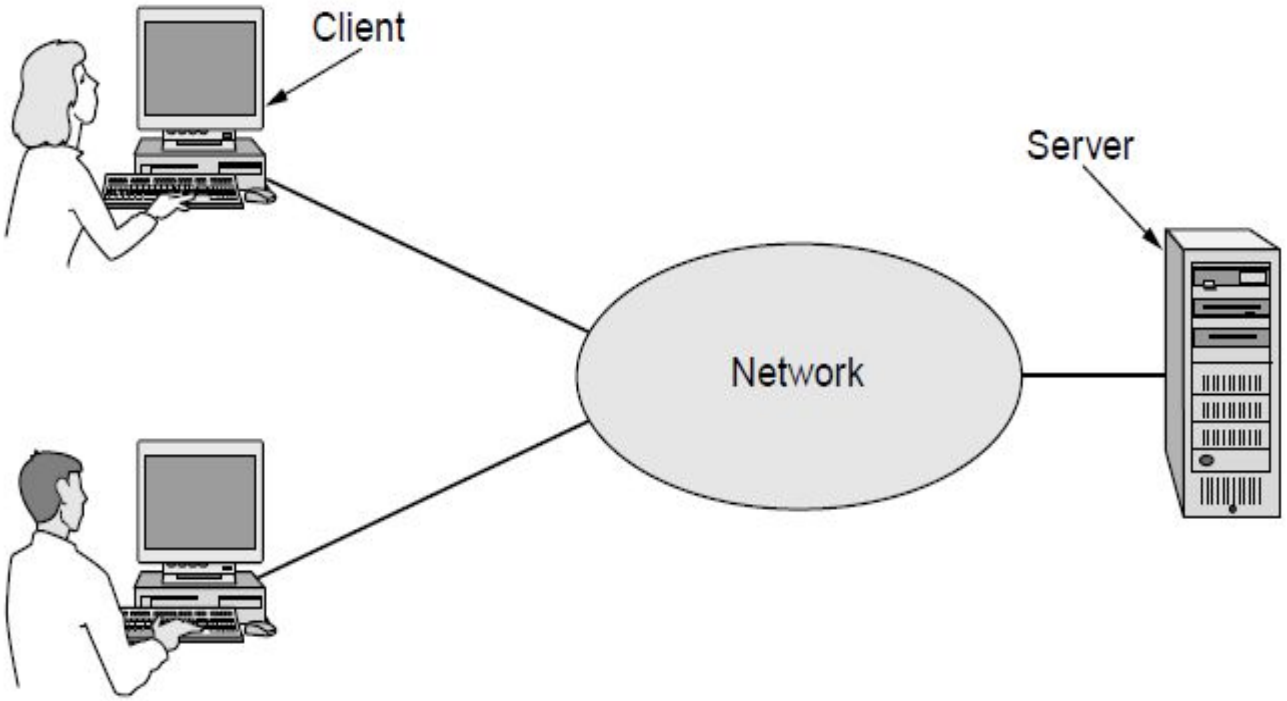
A network with two clients and one server.



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- Networks called **VPNs(Virtual Private network)** may be used to join the individual networks at different sites into one extended network
- **Client** : The individual workstations in the network are called as clients.
- **Server:** The central computer which is more powerful than the clients and which allows the clients to access its software and database is called as the server.
- Server computers typically are more powerful than client computers or are optimized to function as servers.

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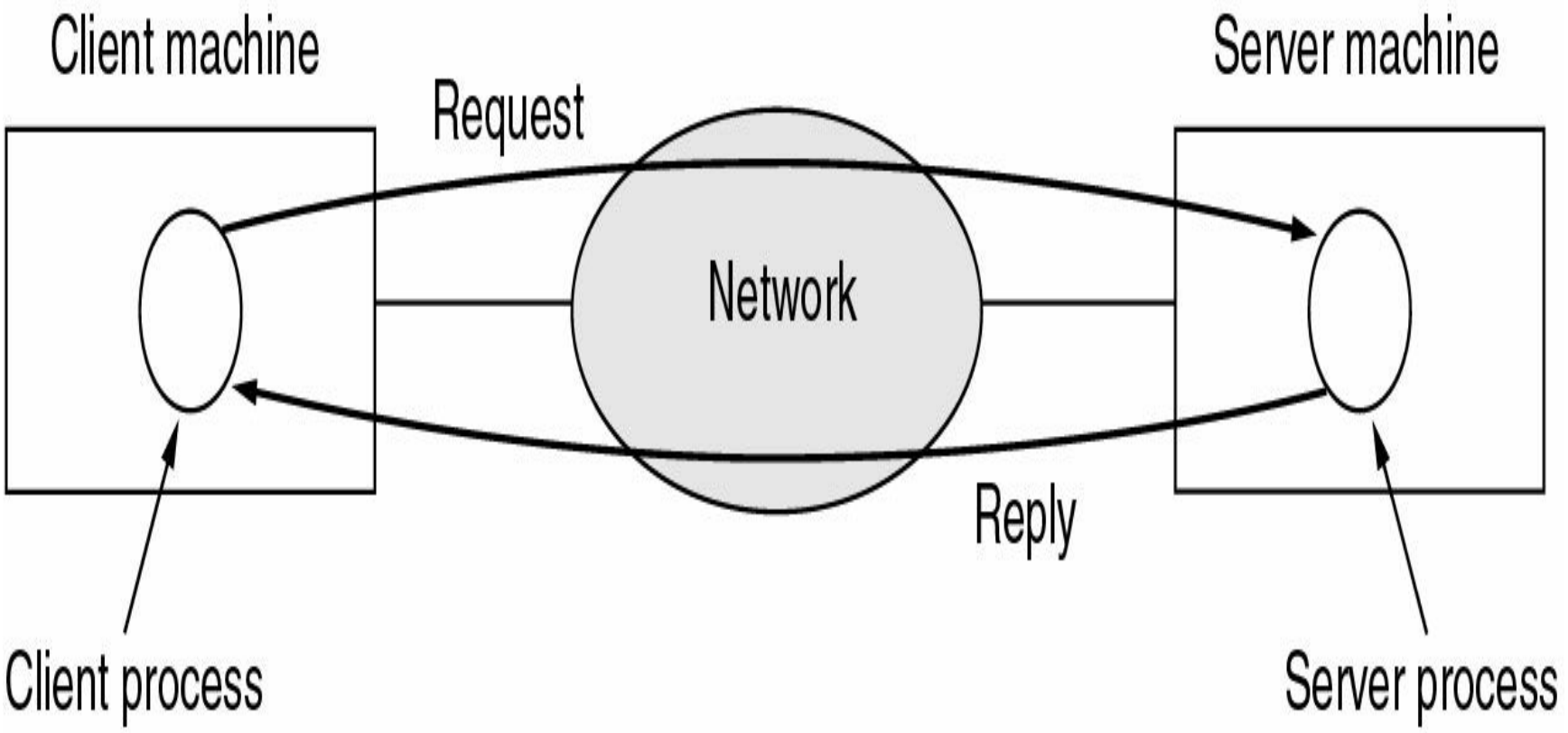
The client-server model involves requests and replies.



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3. Communication Medium

- A computer network can provide a powerful communication medium among employees.

- Virtually every company that has two or more computers now has **e-mail (electronic mail)**, which employees generally use for a great deal of daily communication

Person to person communication includes

i) Electronic-mail (e-mail)

(ii) Real time e-mail i.e. video conferencing allows remote users to communicate with no delay by seeing and hearing each other. **Video-conferencing** is being used for remote school, getting medical opinion from distant specialists etc.

(iii) Worldwide newsgroups in which one person posts a message and all other subscribers to the newsgroup can read it or give their feedbacks.

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Contd…,

iv)VoIP Telephone calls between employees may be carried by the computer network instead of by the phone company. This technology is called **IP telephony or Voice over IP.**

- **Desktop sharing** lets remote workers see and interact with a graphical computer screen.

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4. e-Commerce

- A goal that is starting to become more important in businesses is doing business with consumers over the Internet.

- To do business electronically by interacting with customers and suppliers.

- Airlines, bookstores and music vendors have discovered that many customers like the convenience of shopping from home. This sector is expected to grow quickly in the future.

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Home Applications

1. Access to remote information
2. Peer-to-peer communication
3. Electronic commerce
4. Interactive entertainment

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Introduction

- In 1977, Ken Olsen was president of the Digital Equipment Corporation, then the number two computer vendor in the world (after IBM)
- Internet access provides home users with **connectivity** to remote computers.
- As with companies, home users can access information, communicate with other people, and buy products and services with e-commerce.

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Access to remote information

- Access to remote information comes in many forms.
- It can be surfing the World Wide Web for information or just for fun.

- Information available includes the **arts, business, cooking, government, health, history, hobbies, recreation, science, sports, travel, and many others.**

- Many newspapers have gone online and can be personalized.

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Peer-to-peer communication

- Much of this information is accessed using the client-server model, but there is different, popular model for accessing information that goes by the name of **peer-to-peer communication.**

- Every person can, in principle, communicate with one or more other people; there is no fixed division into clients and servers

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Contd…,

- Many peer-to-peer systems, such Bit Torrent (Cohen, 2003), do not have any central database of content.

- Instead, each user maintains his own database locally and provides a list of other nearby people who are members of the system.

- **Peer-to-peer communication** is often used **to share music and videos.** It really hit the big time around 2000 with a music sharing service called **Napster.**

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Contd…,

- Any teenager worth his or her salt is addicted to **instant messaging**

- There are multi-person messaging services too, such as the **Twitter** service that lets people send short text messages called ‘‘tweets’’ to their circle of friends or other willing audiences.

- Between person-to-person communications and acc essing information are **social network** applications.

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Contd..,

- One of the most popular social networking sites is **Facebook.**

- It lets people update their personal profiles and shares the updates with other people who they have declared to be their friends.

- Other social networking applications can make introductions via friends of friends, send news messages to friends such as Twitter above, and much more.

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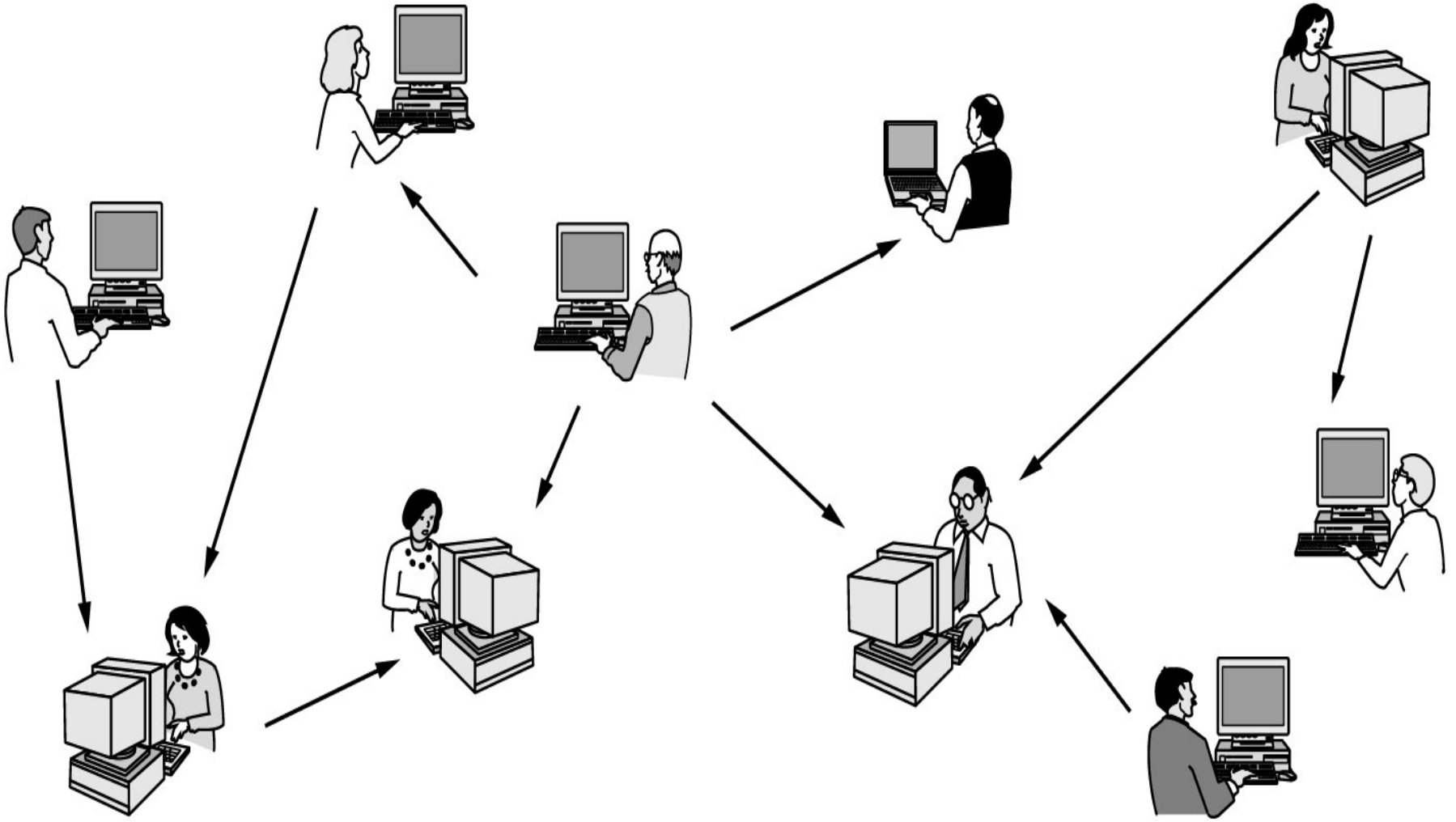
Contd…,

- A **wiki, for example, is a collaborative Web site that the members of a community** edit.
- The most famous wiki is the **Wikipedia, an encyclopedia anyone can edit,** but there are thousands of other wikis.

Peer-to-Peer system no fixed clients and servers



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Electronic commerce

- E-Commerce is widely used is access to financial institutions
- People pay their bills , manage their bank accounts and handle their investments electronically
- Trend will continue as network becomes more secure.
- Online auctions

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Some forms of e-commerce

Tag	Full name	Example
B2C	Business-to-consumer	Ordering books on-line
B2B	Business-to-business	Car manufacturer ordering tires from supplier
G2C	Government-to-consumer	Government distributing tax forms electronically
C2C	Consumer-to-consumer	Auctioning second-hand products on-line
P2P	Peer-to-peer	File sharing

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Interactive entertainment

- TV shows now reach many homes via **IPTV (IP TeleVision)** systems that are based on IP technology instead of cable TV or radio transmissions.
- Game Playing
- Virtual worlds provide a persistent setting in which thousands of users can experience a shared reality with three-dimensional graphics.

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Ubiquitous computing

- Our last category is **ubiquitous computing** in which computing is embedded into everyday life, as in the vision of Mark Weiser (1991).

- Many homes are already wired with security systems that include door and window sensors, and there are many more sensors that can be folded in to a smart home monitor, such as energy consumption.

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Contd….,

- Devices such as televisions that plug into the wall can use **power-line networks** to send information throughout the house over the wires that carry electricity.

- A technology called **RFID(Radio Frequency Identification)** will push this idea even further in the future.

- **RFID tags are passive** (i.e., have no battery) chips the size of stamps and they can already be affixed to books, passports, pets, credit cards, and other items in the home and out.

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Mobile Users

- Mobile computers, such as laptop and handheld computers, are one of the fastest-growing segments of the computer industry.

- **Connectivity** to the Internet enables many of these mobile uses. Since having a wired connection is impossible in cars, boats, and airplanes, there is a lot of interest in wireless networks.

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Contd…,

- Cellular networks operated by the telephone com-panies are one familiar kind of wireless network that blankets us with coverage for mobile phones.

- Wireless **hotspots** based on the 802.11 standard are another kind of wireless network for mobile computers.

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Contd….,

- Mobile computers, such as notebook computers and Mobile phones, is one of the fastest-growing segment of the entire computer industry.

- Wireless networking and mobile computing are often related, they are not identical, as the below figure shows.

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Mobile Network Users

Combinations of wireless networks and mobile computing

Wireless	Mobile	Applications
No	No	Desktop computers in offices
No	Yes	A notebook computer used in a hotel room
Yes	No	Networks in older, unwired buildings
Yes	Yes	Portable office; PDA for store inventory

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Contd…,

- Perhaps the key driver of mobile, wireless applications is the mobile phone. **Text messaging** or **texting** is tremendously popular.

- **Smart phones** such as the popular iPhone, combine aspects of mobile phones and mobile computers.

- The (3G and 4G) cellular networks to which they connect can provide fast data services for using the Internet as well as handling phone calls.

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Contd…,

- Since mobile phones know their locations, often because they are equipped with **GPS (Global Positioning System)** receivers, some services are intentionally location dependent.

- An area in which mobile phones are now starting to be used is **m-commerce (mobile-commerce)** (Senn, 2000).

- When equipped with **NFC (Near Field Communication)**technology the mobile can act as an RFID smartcard and interact with a nearby reader for payment.

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Contd…,

- **Sensor networks** are made up of nodes that gather and wirelessly relay information they sense about the state of the physical world.

- **Wearable computers** are another promising application. Some of these can be con-trolled over a wireless network

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SOCIAL ISSUES

- Computer networks, like the printing press 500 years a go, allow ordinary citizens to distribute and view content in ways that were not previously possible.
-
- Social networks, message boards, content sharing sites, and a host of other applications allow people to share their views with like-minded individuals.

- As long as the subjects are restricted to technical topics or hobbies like gardening, not too many problems will arise.

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Contd…,

- Opponents of this practice argue that peer-to-peer and other content should be treated in the same way because they are all just bits to the network.

- This argument for communications that are not differentiated by their content or source or who is providing the content is known as **network neutrality.**

- There are now automated systems that search peer-to-peer networks and fire off warnings to network operators and users who are suspected of infringing copyright

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Contd…,

- In the United States, these warnings are known as **DMCA takedown notices** after the **Digital Millennium Copyright Act**

- **Phishing** messages masquerade as originating from a trustworthy party, for example, your bank, to try to trick you into revealing sensitive information, for example, credit card number

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Contd…,

- It can be difficult to prevent computers from impersonating people on the Internet.
- This problem has led to the development of **CAPTCHAs** , in which a computer asks a person to solve a short recognition task

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21CDC09 - COMPUTER NETWORKS

Unit- I **Lecture -2**

Introduction : Network Hardware

Course Facilitator : Spelmen Vimalraj.S

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Topics Covered

- Network Hardware
  - Personal Area Network
  - Local Area Network
  - Metropolitan Area Network
  - Wide Area Network
  - Internetworks

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Network Hardware

1. Personal Area Networks
2. Local Area Networks
3. Metropolitan Area Networks
4. Wide Area Networks
5. Internetworks

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NETWORK HARDWARE

- **DEFINITION:**

  Networking hardware, also known as network equipment or computer networking devices, are electronic devices which are required for communication and interaction between devices on a computer network.

- There are two types of transmission technology that are in widespread use:

1. **broadcast** links and
2. **point-to-point** links

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Point-to-point links

- Point-to-point links connect individual pairs of machines.
- To go from the source to the destination on a network made up of point-to-point links, short messages, called **packets** in certain contexts.
- Often multiple routes, of different lengths, are possible, so finding good ones is important in point-to-point networks.
- Point-to-point transmission with exactly one sender and exactly one receiver is sometimes called

  unicasting

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Broadcast links

- Broadcast systems usually also allow the possibility of addressing a packet to *all* destinations by using a special code in the address field.
- When a packet with this code is transmitted, it is received and processed by every machine on the net-work. This mode of operation is called **broadcasting.**
- Some broadcast systems also support transmission to a subset of the machines, which known as **multicasting**

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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

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PERSONAL AREA NETWORK

- **PANs(Personal Area Networks)** let devices communicate over the range of a person.

- A common example is a wireless network that con nects a computer with its peripherals.

- To help these users, some companies got together to design a short-range wireless network called **Bluetooth** to connect these components without wires.

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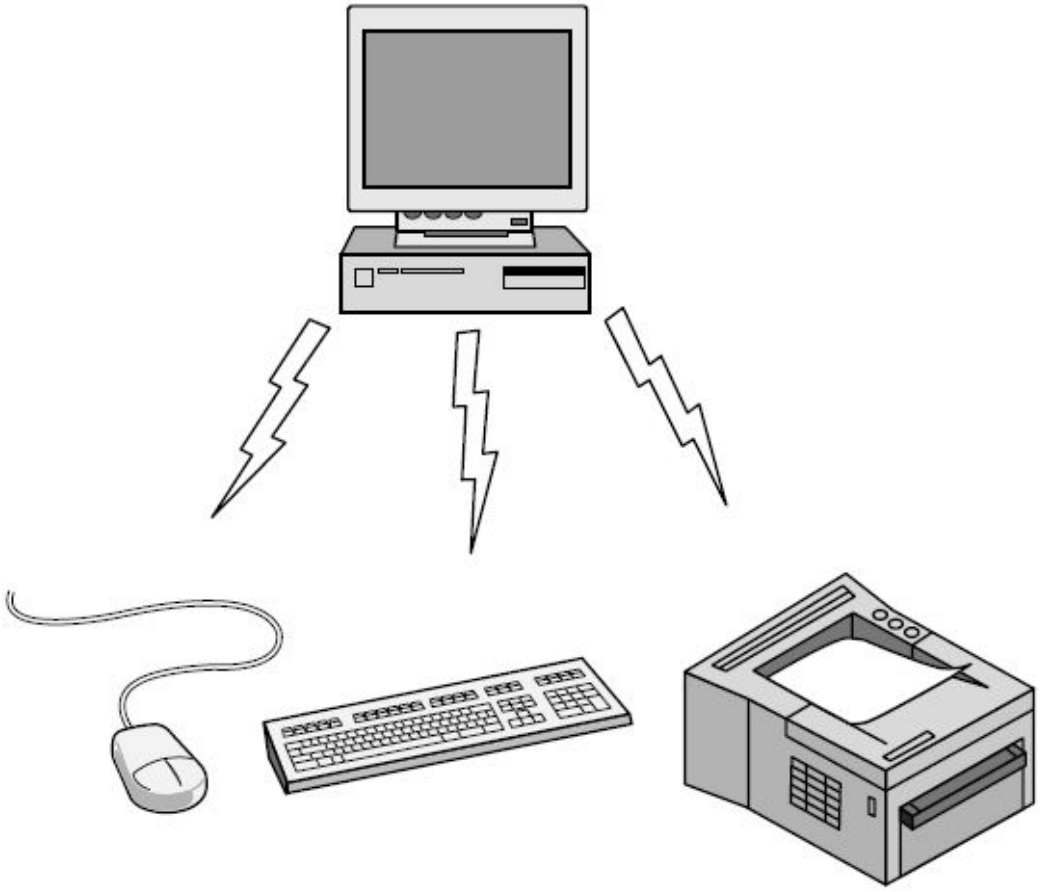
Bluetooth PAN configuration



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Contd…,

- Bluetooth networks use the **master-slave paradigm**
- The system unit (the PC) is normally the master, talking to the mouse, keyboard, etc., as slaves.
- The master tells the slaves what addresses to use, when they can broadcast, how long they can transmit, what frequencies they can use, and so on.
- It is often used to connect a headset to a mobile phone without cords and it can allow your digital music player

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Contd…,

- A completely different kind of PAN is formed when an embedded medical device such as a pacemaker, insulin pump, or hearing aid talks to a user-operated remote control.

- PANs can also be built with other technologies that communicate over short ranges, such as RFID on smartcards and library books

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Local Area Network

- A LAN is a privately owned network that operates within and nearby a single building like a home, office or factory.
- LANs are widely used to connect personal computers and consumer electronics to let them share resources (e.g., printers) and exchange information.
- When LANs are used by companies, they are called **enterprise networks**

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Contd…,

- In most cases, each computer talks to a device in the ceiling

- This device, called an **AP(Access Point)**, **wireless router**,or **base station,** relays packets between th e wireless computers and also between them and the Internet.

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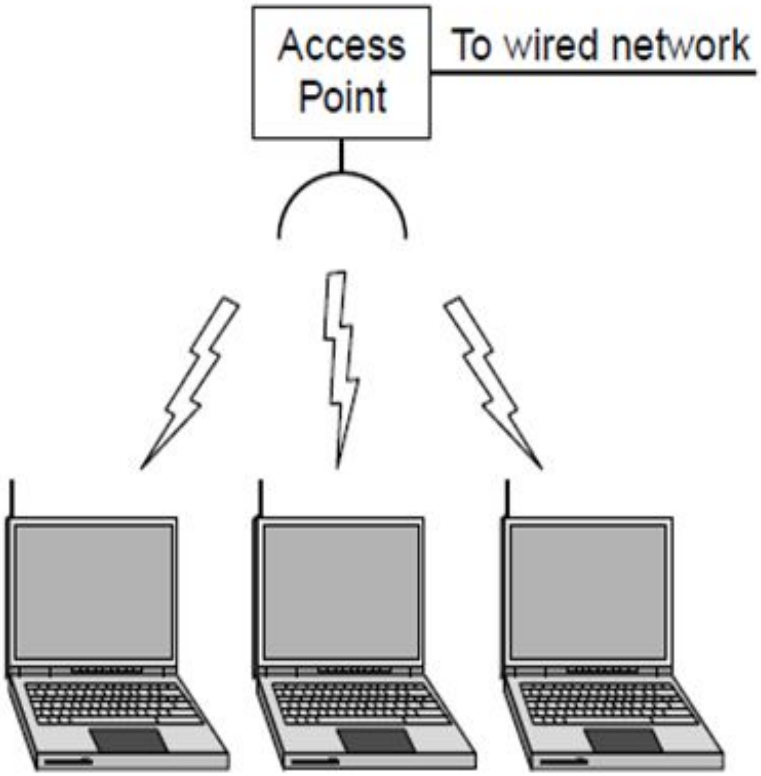
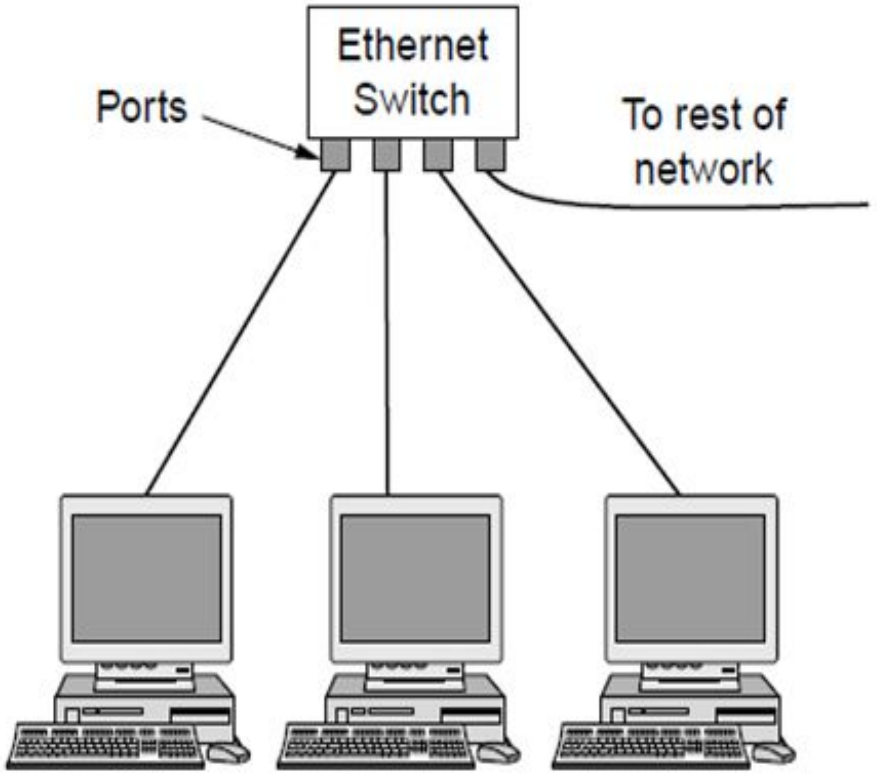
Wireless and Wired LANs
a)802.11
b)Switched Ethernet





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Contd…,

- There is a standard for wireless LANs called **IEEE 802.11** , popularly known as **WiFi** , which has become very widespread.

- Wired LANs use a range of different transmission tech nolo-gies. Most of them use copper wires, but some use optical fiber.

- LANs are restricted in size, which means that the worst-case transmission time is bounded and known in advance

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Contd…,

- Newer LANs can operate at up to 10 Gbps.
- Compared to wireless networks, wired LANs exceed the min all dimensions of performance.
- It is just easier to send signals over a wire or through a fiber than through the air

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Contd…,

- The topology of many wired LANs is built from point-to-point links.
- IEEE802.3, popularly called **Ethernet** , is, by far, the most common type of wired LAN.
- Each computer speaks the Ethernet protocol and connects to a box called a **switch** with a point-to-point link.
- A switch has multiple **ports** , each of which can connect to one computer.

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Contd….,

- The job of the switch is to relay packets between computers that are attached to it, using the address in each packet to determine which computer to send it to.

- **Power-line networks** let devices that plug into outlet s broadcast information throughout the house.

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Metropolitan Area Network

- A **MAN(Metropolitan Area Network)** covers a city.
- The best-known examples of MANs are the cable television networks available in many cities.
- These systems grew from earlier community antenna systems used in areas with poor over-the-air television reception.
- In those early systems, a large antenna was placed on top of a nearby hill and a signal was then piped to the subscribers houses.

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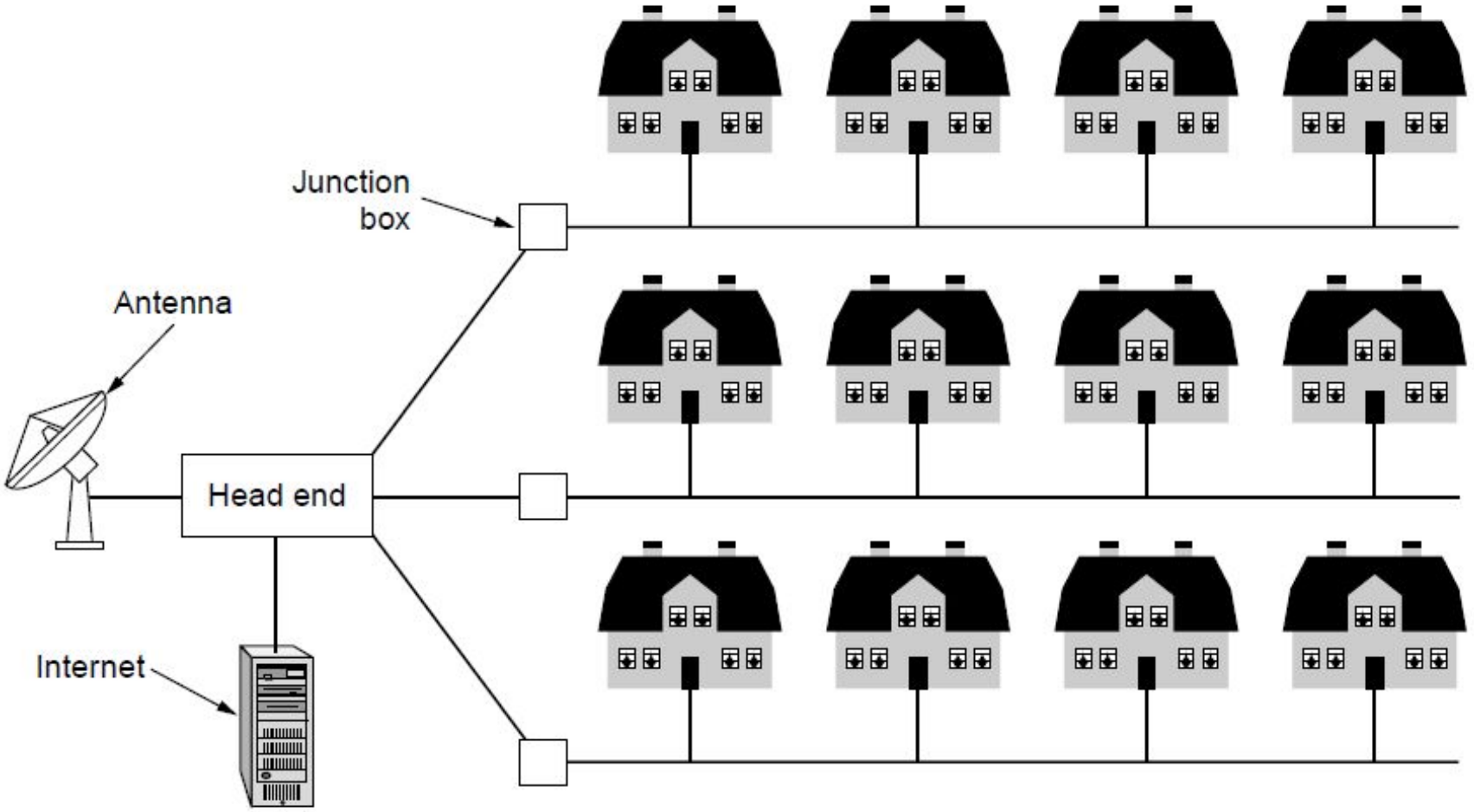
Contd…,

- At first, these were locally designed, ad hoc systems.
- Then companies began jumping into the business, getting contracts from local governments to wire up entire cities.
- The next step was television programming and even entire channels designed for cable only.

A Metropolitan area network Based on cable TV



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Contd…,

- In the above diagram both television signals and Internet being fed into the centralized **cable headend** for subsequent distribution to people's homes.

- Cable television is not the only MAN, though. Recent developments in high speed wireless Internet access have resulted in another MAN, which has been

  standardized as IEEE 802.16 and is popularly known as **WiMAX.**

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Wide Area Network

- A **WAN(Wide Area Network)** spans a large geograp hical area, often a country or continent.
- The rest of the network that connects these hosts is called the **communication subnet**, or just **subnet** for short.
- A **subnet** is a logical partition of an IP **network** into multiple, smaller **network** segments.
- It is typically used to subdivide large **networks** into smaller, more efficient subnetworks.

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Contd….,

- **Transmission lines** move bits between machines.
- They can be made of copper wire, optical fiber, or even radio links.
- Most companies do not have transmission lines lying about, so instead they lease the lines from a telecommunications company.
- **Switching elements** , or just **switches** , are specialized computers that connect two or more transmission lines.

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Contd…,

- The networks inside the offices may be switched Ether-net, for example, while the long-distance transmission lines may be SONET links.

- This means that many WANs will in fact be **internetworks**, or composite networks that are made up of more than one network.

- This arrangement, is called a **VPN (Virtual Private Network)**.

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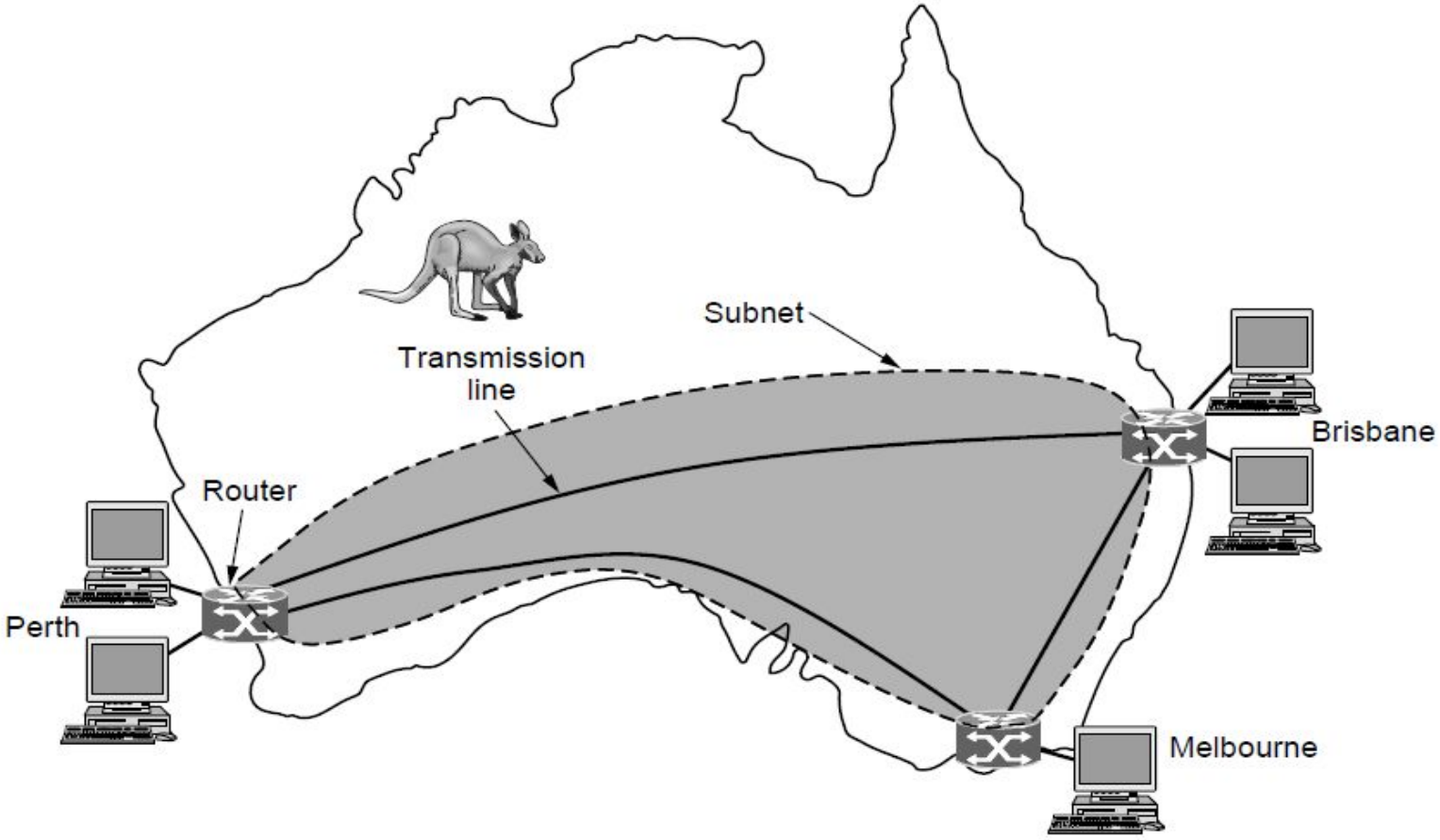
Contd…,

- Compared to the dedicated arrangement, a VPN has the usual advantage of virtualization, which is that it provides flexible reuse of a resource (Internet connectivity).

- A VPN also has the usual disadvantage of virtualization, which is a lack of control over the underlying resources.

WAN that connects three branch offices in Australia



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Contd….,

- The second variation is that the subnet may be run by a different company.

- The subnet operator is known as a **network service provider** and the offices are its customers.

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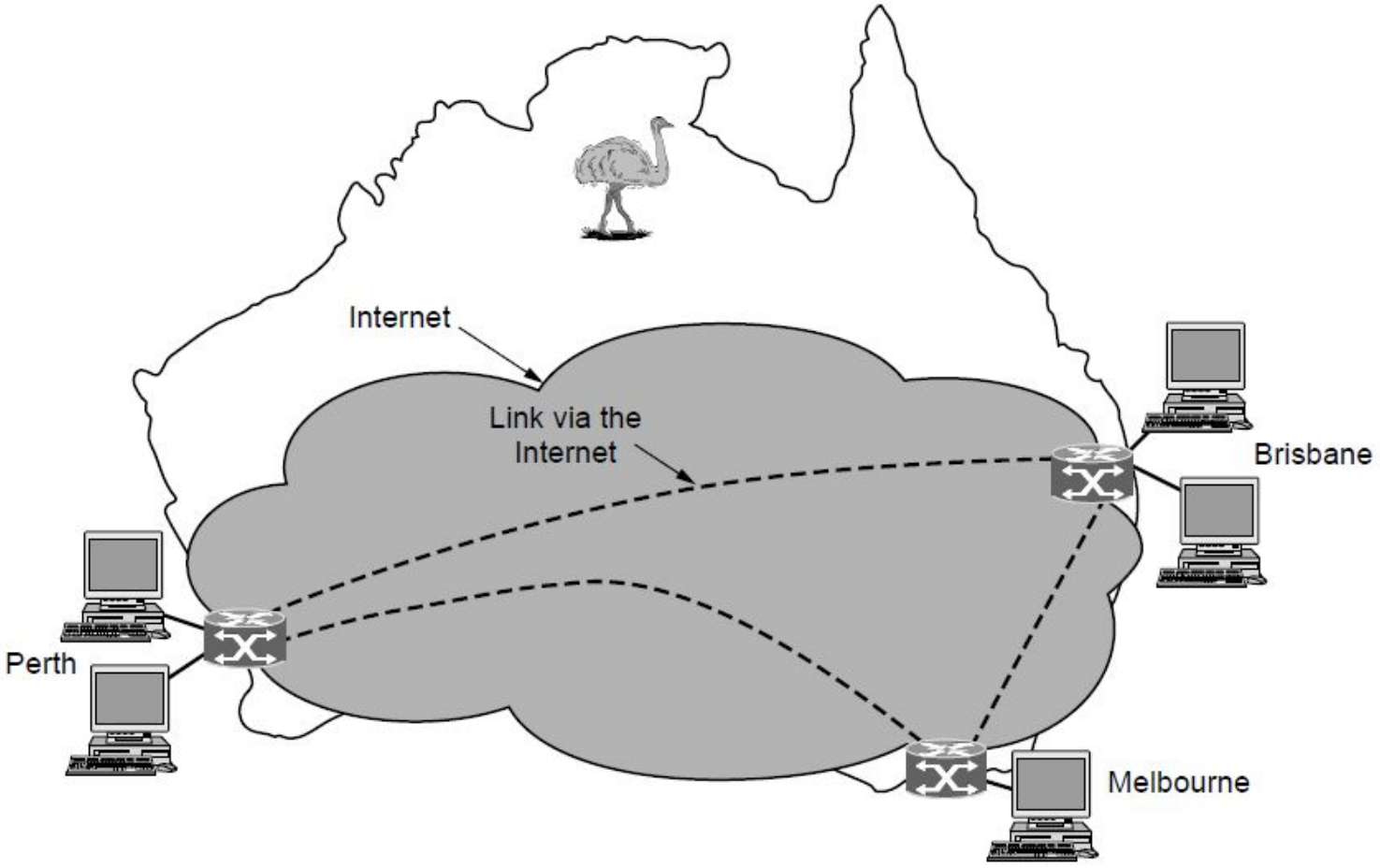
WAN using a virtual private network.



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Contd…,

- The subnet operator will con-nect to other customers too, as long as they can pay and it can provide service.
- Such a subnet operator is called an **ISP (Internet Service Provider)** and the subnet is an **ISP network.**
- Its customers who connect to the ISP receive Internet service.

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Contd…,

- There may be many paths in the network that connect these two routers. How the net-work makes the decision as to which path to use is called the **routing algorithm**

- Many such algorithms exist. How each router makes the decision as to where to send a packet next is called the **forwarding algorithm**

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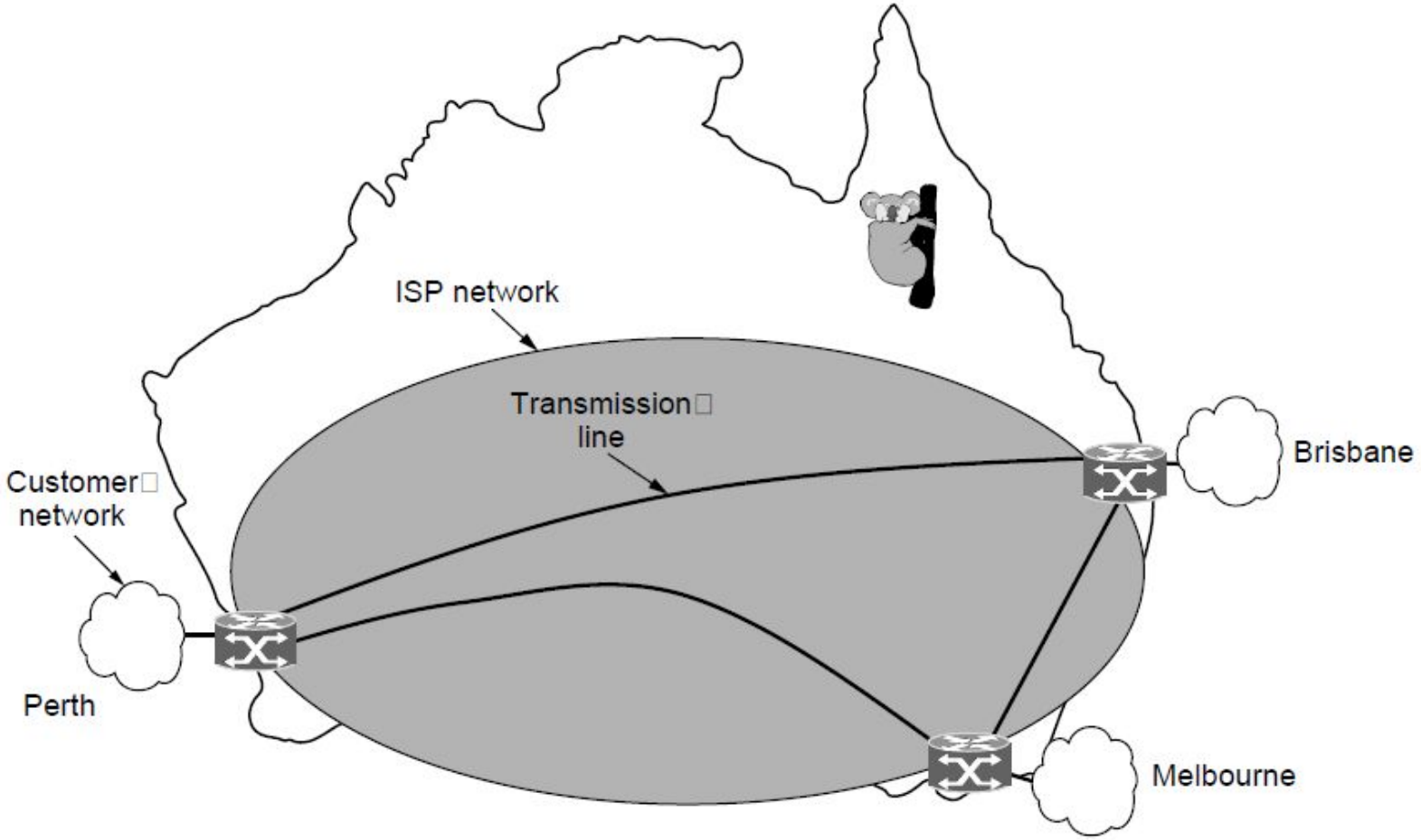
WAN using an ISP network



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Internetworks

- Many networks exist in the world, often with different hardware and software.
- People connected to one network often want to communicate with people attached to a different one.
- The fulfillment of this desire requires that different, and frequently incompatible, networks be connected.

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Contd…,

- A collection of interconnected net-works is called an **internetwork** or **internet.**

- The Internet uses ISP networks to connect enterprise networks, home networks, and many other networks.

- The term "subnet" makes the most sense in the context of a wide area network, where it refers to the collection of routers and communication lines owned by the network operator.

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Contd…,

- These lines and equipment, owned and managed by the telephone company, form the subnet of the telephone system.
- The telephones themselves (the hosts in this analogy) are not part of the subnet.
- A network is formed by the combination of a subnet and its hosts. However, the word ‘‘network’’ is often used in a loose sense as well.

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Contd…,

- The general name for a machine that makes a connection between two or more networks and provides the necessary translation, both in terms of hardware and software, is a **gateway.**

- Gateways are distinguished by the layer at which they operate in the protocol hierarchy.

- The level in the middle that is ‘‘just right’’ is often called the network layer, and a router is a gateway that switches packets at the network layer.

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21CDC09- COMPUTER NETWORKS

Unit- I Lecture -3

Introduction : Network Software

Course Facilitator :
Spelmen Vimalraj.S

Topics Covered

- **Network Software**

1. Protocol hierarchies
2. Design issues for the layers
3. Connection-oriented versus connectionless service
4. Service primitives
5. Relationship of services to protocols

Network Software

1. Protocol hierarchies
2. Design issues for the layers
3. Connection-oriented versus connectionless service
4. Service primitives
5. Relationship of services to protocols

Protocol Hierarchies

- To reduce their design complexity, most networks are organized as a stack of **layers** or **levels**, each one built upon the one below it.

- The **number of layers, the name of each layer, the contents of each layer, and the function of each layer differ from network to network.**

- The purpose of each layer is to offer certain services to the higher layers while shielding those layers from the details of how the offered services are actually implemented.

Contd….,

- In a sense, **each layer is a kind of virtual machine,** offering certain services to the layer above it.
- This concept is actually a familiar one and is used throughout computer science, where it is variously known as information hiding, abstract data types, data encapsulation, and object-oriented programming
- The fundamental idea is that a particular piece of software (or hardware) provides a service to its users but keeps the details of its internal state and algorithms hidden from them

Contd….,

- When layer *n* on one machine carries on a conversation with layer *n* on another machine, the rules and conventions used in this conversation are collectively known as the layer *n* protocol.

- A **protocol** is an agreement between the communicating parties on how communication is to proceed.

- The entities comprising the corresponding layers on different machines are called **peers.**

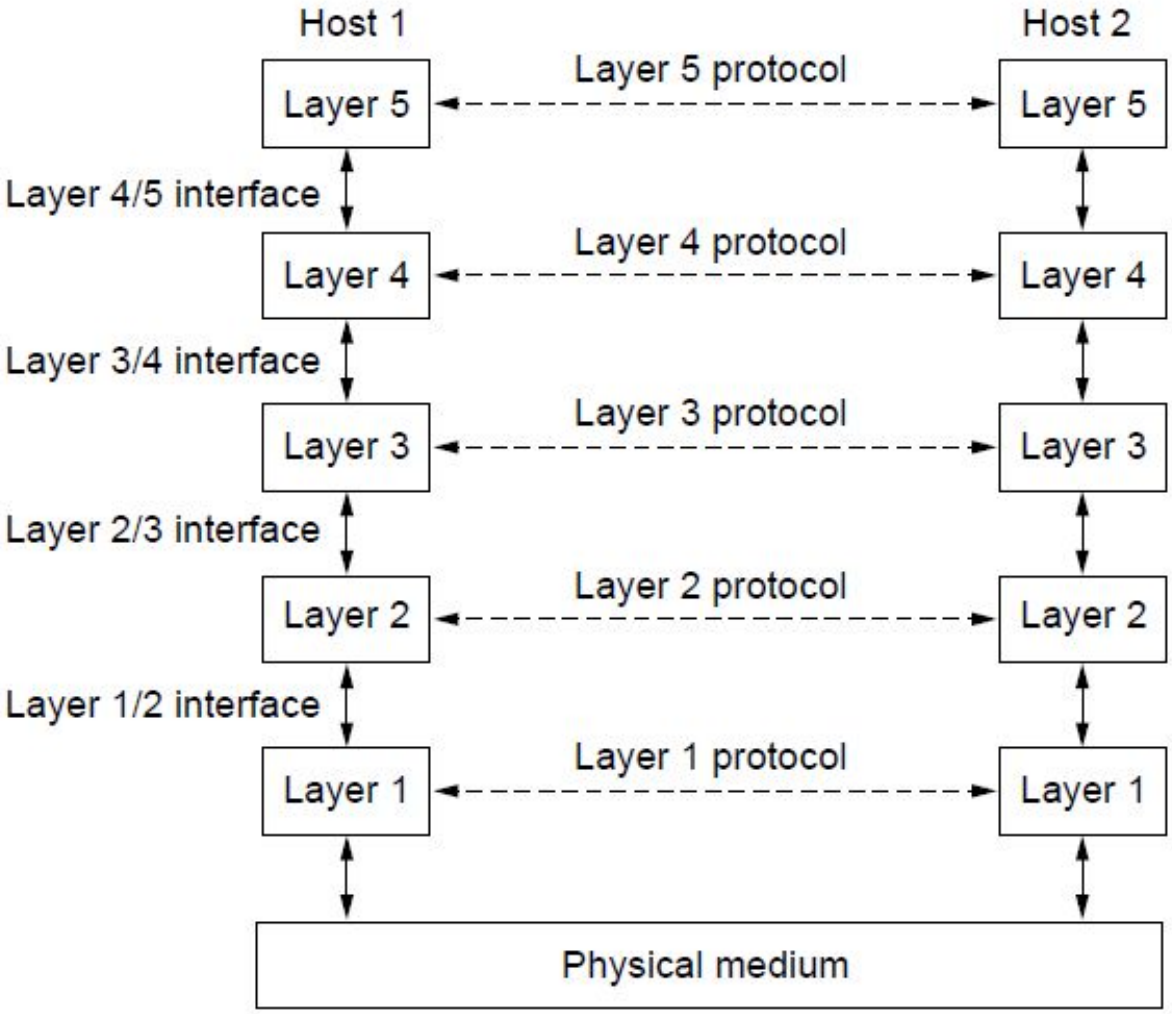
Contd….,

- The peers may be software processes, hardware devices, or even human beings.
- In other words, it is the peers that communicate by using the protocol to talk to each other.
- In reality, no data are directly transferred from layer *n* on one machine to layer *n* on another machine.

Contd….,

- Each layer passes data and control information to the layer immediately below it, until the lowest layer is reached.
- Below layer 1 is the **physical medium** through which actual communication occurs.
- **Virtual communication is shown by dotted lines and physical communication by solid lines**

Layers, protocols, and interfaces



Contd….,

- Between each pair of adjacent layers is an **interface** .
- The interface defines which primitive operations and services the lower layer makes available to the upper one.
- When network designers decide how many layers to include in a network and what each one should do, one of the most important considerations is defining clean interfaces between the layers.

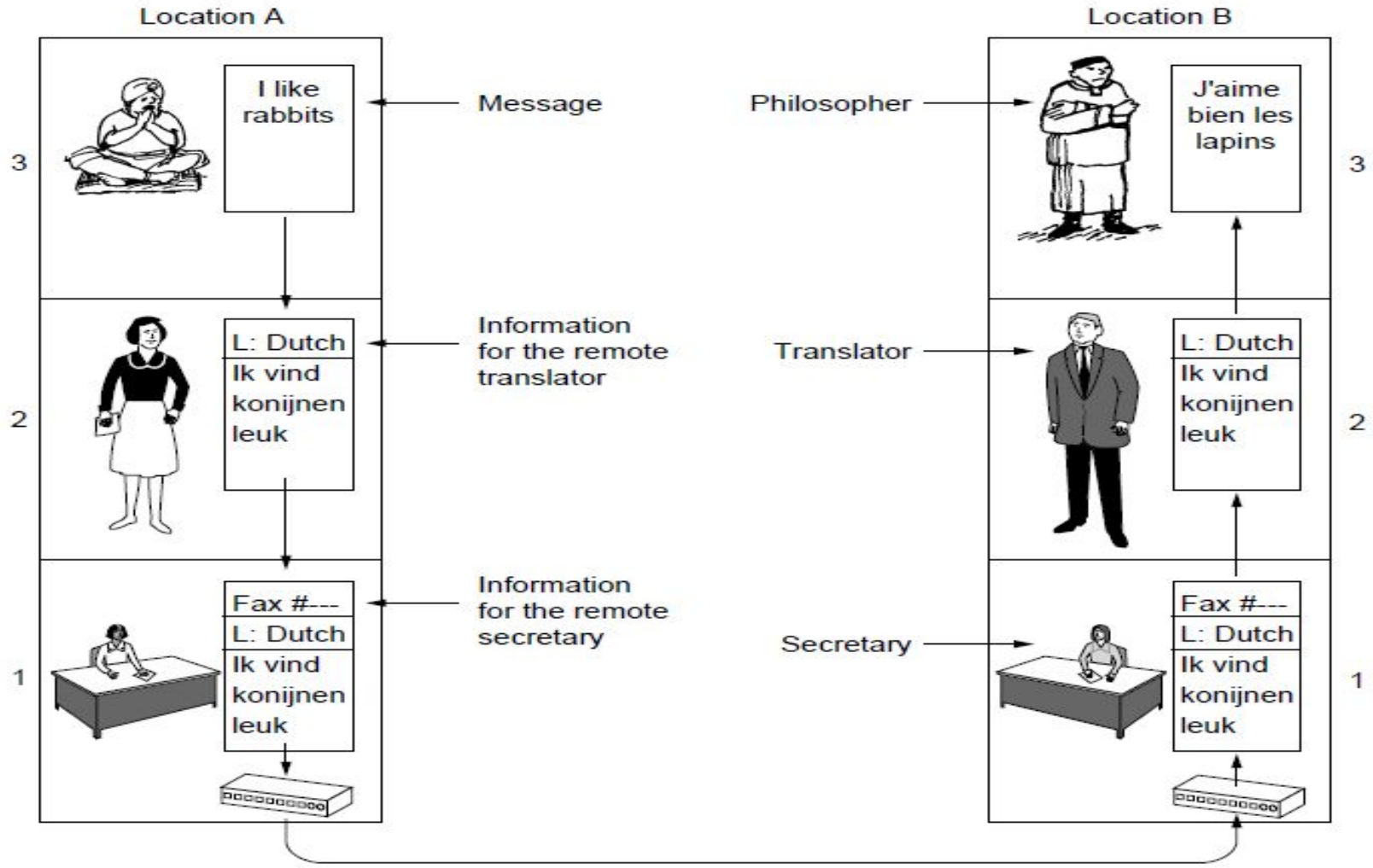
Contd….,

- A set of layers and protocols is called a **network architecture**

- The specification of an architecture must contain enough information to allow an implementer to write the program or build the hardware for each layer so that it will correctly obey the appropriate protocol.

- A list of the protocols used by a certain system, one protocol per layer, is called a **protocol stack**

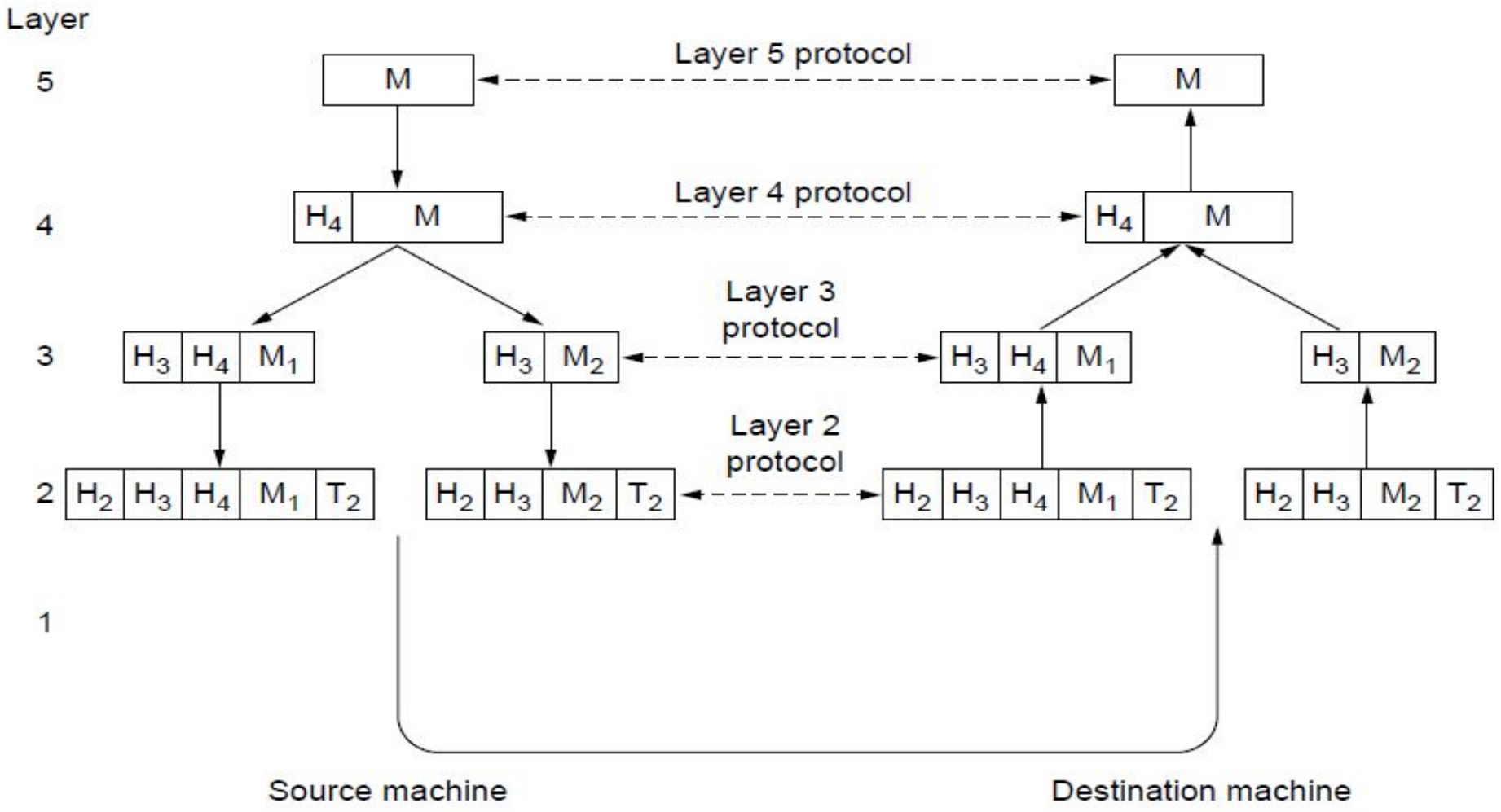
The philosopher-translator-secretary architecture



Contd….,

- Philosopher 1 wishes to convey his affection for *oryctolagus cuniculus* to his peer.
- To do so, he passes a message (in English) across the 2/3 interface to his translator, saying ‘‘I like rabbits,’’ as illustrated in Fig. 1-14.
- The translators have agreed on a neutral language known to both of them, Dutch, so the message is converted to ‘‘Ik vindkonijnen leuk.’’
- The choice of the language is the layer 2 protocol and is up to the layer 2 peer processes.
- The translator then gives the message to a secretary for transmission, for example, by email (the layer 1 protocol).
- When the message arrives at the other secretary, it is passed to the local translator, who translates it into French and passes it across the 2/3 interface to the second philosopher.

Example information flow supporting virtual communication in layer 5



Contd….,

- The translators can switch from Dutch to, say, Finnish, at will, provided that they both agree and neither changes his interface with either layer 1 or layer3.

- The secretaries can switch from email to telephone without disturbing (or even informing) the other layers.

- A message, *M* , is produced by an application process running in layer 5 and given to layer 4 for transmission.

Contd….,

- Layer 4 puts a **header** in front of the message to identify the message and passes the result to layer 3.

- The header includes control information, such as addresses, to allow layer 4 on the destination machine to deliver the message.

- Other examples of control information used in some layers are sequence numbers (in case the lower layer does not preserve message order), sizes, and times

Contd….,

- In many networks, no limit is placed on the size of messages transmitted in the layer 4 protocol but there is nearly always a limit imposed by the layer 3 protocol.

- Consequently, layer 3 must break up the incoming messages into smaller units, packets, prepending a layer 3 header to each packet. In this example, M is split into two parts, $M1$ and $M2$, that will be transmitted separately.

Contd….,

- Layer 3 decides which of the outgoing lines to use and passes the packets to layer 2. Layer 2 adds to each piece not only a header but also a trailer, and gives the resulting unit to layer 1 for physical transmission.

- At the receiving machine the message moves upward, from layer to layer, with headers being stripped off as it progresses. None of the headers for layers below *n* are passed up to layer *n.*
- The important thing to understand about is the relation between the virtual and actual communication and the difference between protocols and inter-faces.

Contd….,

- The peer processes in layer 4, for example, concep tually think of their communication as being “horizontal,” using the layer 4 protocol.

- The peer process abstraction is crucial to all network design.

- Using it, the unmanageable task of designing the complete network can be broken into several smaller, manageable design problems, namely, the design of the individual layers.

Design Issues for the Layers

- **Reliability** is the design issue of making a network that operates correctly even though it is made up of a collection of components that are themselves unreliable.

- Think about the **bits of a packet** traveling through the network.

- There is a chance that some of these bits will be received damaged (inverted) due to fluke electrical noise, random wireless signals, hardware flaws, software bugs and so on.

Contd….,

- One mechanism for finding errors in received information uses codes for **error detection.**
- Information that is incorrectly received can then be retransmitted until it is received correctly.
- More powerful codes allow for **error correction**, where the correct message is recovered from the possibly incorrect bits that were originally received.
- Both of these mechanisms work by adding redundant information.

Contd….,

- They are used at low layers, to protect packets sent over individual links, and high layers, to check that the right contents were received
- A second design issue concerns **the evolution of the network**.
- Over time, networks grow larger and new designs emerge that need to be connected to the existing network.
- The key structuring mechanism used to support change by dividing the overall problem and hiding implementation details: **protocol layering**

Contd….,

- Since there are many computers on the network, every layer needs a mechanism for identifying the senders and receivers that are involved in a particular message.

- This mechanism is called **addressing** or **naming** in the low and high layers, respectively.

- A third design issue is **resource allocation**.

- Networks provide a service to hosts from their underlying resources, such as the capacity of transmission lines.

Contd….,

- Many designs **share network bandwidth dynamically**, according to the short-term needs of hosts, rather than by giving each host a fixed fraction of the band-width that it may or may not use.

- This design is called **statistical multiplexing** meaning **sharing based on the statistics of demand**.

- It can be applied at low layers for a single link, or at high layers for a network or even applications that use the network.

Contd….,

- An allocation problem that occurs at every level is how to keep a fast sender from swamping a slow receiver with data. Feedback from the receiver to the sender is often used. This subject is called **flow control.**

- Sometimes the problem is that the network is oversubscribed because too many computers want to send too much traffic, and the network cannot deliver it all. This overloading of the network is called **congestion**

Contd….,

- Most networks must provide service to applications that want this **real-time** delivery at the same time that they provide service to applications that want high throughput.

- **Quality of service** is the name given to mechanisms that reconcile these competing demands

- The last major design issue is to **secure the network** by defending it against different kinds of threats.

Contd….,

- One of the threats we have mentioned previously is that of eavesdropping on communications.
- Mechanisms that provide **confidentiality** defend against this threat, and they are used in multiple layers.
- Mechanisms for **authentication** prevent someone from impersonating someone else.
- Other mechanisms for **integrity** prevent surreptitious changes to messages.

Connection-Oriented versus Connectionless service

Layers can offer two different types of service to the layers above them:

1. **Connection-oriented and**
2. **Connectionless.**

Connection-Oriented

- Connection-oriented service is **modeled after the telephone system.**

- To use a connection-oriented network service, the service user first establishes a connection, uses the connection, and then releases the connection.

- The essential aspect of a connection is that it acts like a tube: **the sender pushes objects(bits) in at one end, and the receiver takes them out at the other end.**

Contd….,

- In some cases when a connection is established, the sender, receiver, and subnet conduct a **negotiation** about the parameters to be used, such as maximum message size, quality of service required, and other issues.

- **A circuit is another name for a connection with associated resources, such as a fixed bandwidth.**

- In telephone network in which a circuit was a path over copper wire that carried a phone conversation

Connectionless Service

- **Connectionless service is modeled after the postal system.**
- Each message (letter) carries the **full destination address,** and each one is routed through the intermediate nodes inside the system independent of all the subsequent messages.
- There are different names for messages indifferent contexts; a **packet** is a message at the network layer.

Contd….,

- When the inter-mediate nodes receive a message in full before sending it on to the next node, this is called **store-and-forward switching**

- The alternative, in which the onward transmission of a message at a node starts before it is completely received by the node, is called **cut-through switching.**

- Normally, when two messages are sent to the same destination, the first one sent will be the first one to arrive.

-

Contd….,

- It is possible that the first one sent can be delayed so that the second one arrives first.

- Each kind of service can further be **characterized by its reliability.**

- Some services are reliable in the sense that they **never lose data.**

- A reliable service is implemented by having the receiver acknowledge the receipt of each messages of the sender is sure that it arrived.

Contd….,

- The acknowledgement process introduces overhead and delays, which are often worth it but are sometimes undesirable.

- Reliable connection-oriented service has two minor variations:
  - **message sequences and**
  - **byte streams.**

Contd….,

- In the former variant, **the message boundaries are pre-served**. When two 1024-byte messages are sent, they arrive as two distinct 1024-byte messages, **never as one 2048-byte message.**

- In the latter, the connection is simply a stream of bytes, with **no message boundaries**
- For some applications, the transit delays introduced by acknowledgements are unacceptable.
- One such application is digitized voice traffic for **voice over IP**

Contd….,

- Unreliable (meaning not acknowledged)connectionless service is often called **datagram** service, in analogy with telegram service, which also does not return an acknowledgement to the sender.

- The **acknowledged datagram** service can be provided for these applications.

- It is like sending a registered letter and requesting a return receipt.

Contd….,

- Still another service is the **request-reply** service.
- In this service the sender transmits a single datagram containing a request; the reply contains the answer.
- **Request-reply is commonly used** to implement communication in the **client-server model**: the client issues a request and the server responds to it.

Connection-Oriented Versus Connectionless Service

Six different types of service.

	Service	Example
Connection-oriented	Reliable message stream	Sequence of pages
	Reliable byte stream	Movie download
	Unreliable connection	Voice over IP
Connection-less	Unreliable datagram	Electronic junk mail
	Acknowledged datagram	Text messaging
	Request-reply	Database query

Contd….,

- **Packets** can occasionally be damaged in transit.
- It is up to higher protocol levels to recover from this problem.
- Many reliable services are built on top of an unreliable datagram service.
- Second, the delays inherent in providing a reliable service may be unacceptable, especially in real-time applications such as multimedia.

Service Primitives

- A service is formally specified by a set of **primitives (operations)** available to user processes to access the service.
- These primitives tell the service to perform **some action or report on an action taken by a peer entity.**
- If the protocol stack is located in the operating system, as it often is, the **primitives are normally system calls.**
- These calls cause a trap to kernel mode, which then turns control of the machine over to the operating system to send the necessary packets.

Contd….,

- The set of primitives available **depends on the nature** of the service being provided.

- The primitives for connection-oriented service are different from those of connectionless service.

Six service primitives that provide a simple connection-oriented service

Primitive	Meaning
LISTEN	Block waiting for an incoming connection
CONNECT	Establish a connection with a waiting peer
ACCEPT	Accept an incoming connection from a peer
RECEIVE	Block waiting for an incoming message
SEND	Send a message to the peer
DISCONNECT	Terminate a connection

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Contd….,

- These primitives might be used for **a request-reply interaction in a client-server environment.**
- First, **the server executes LISTEN** to indicate that it is prepared to accept in-coming connections.
- A common way to implement LISTEN is to make it a blocking system call.
- After executing the primitive, the server process is blocked until a request for connection appears

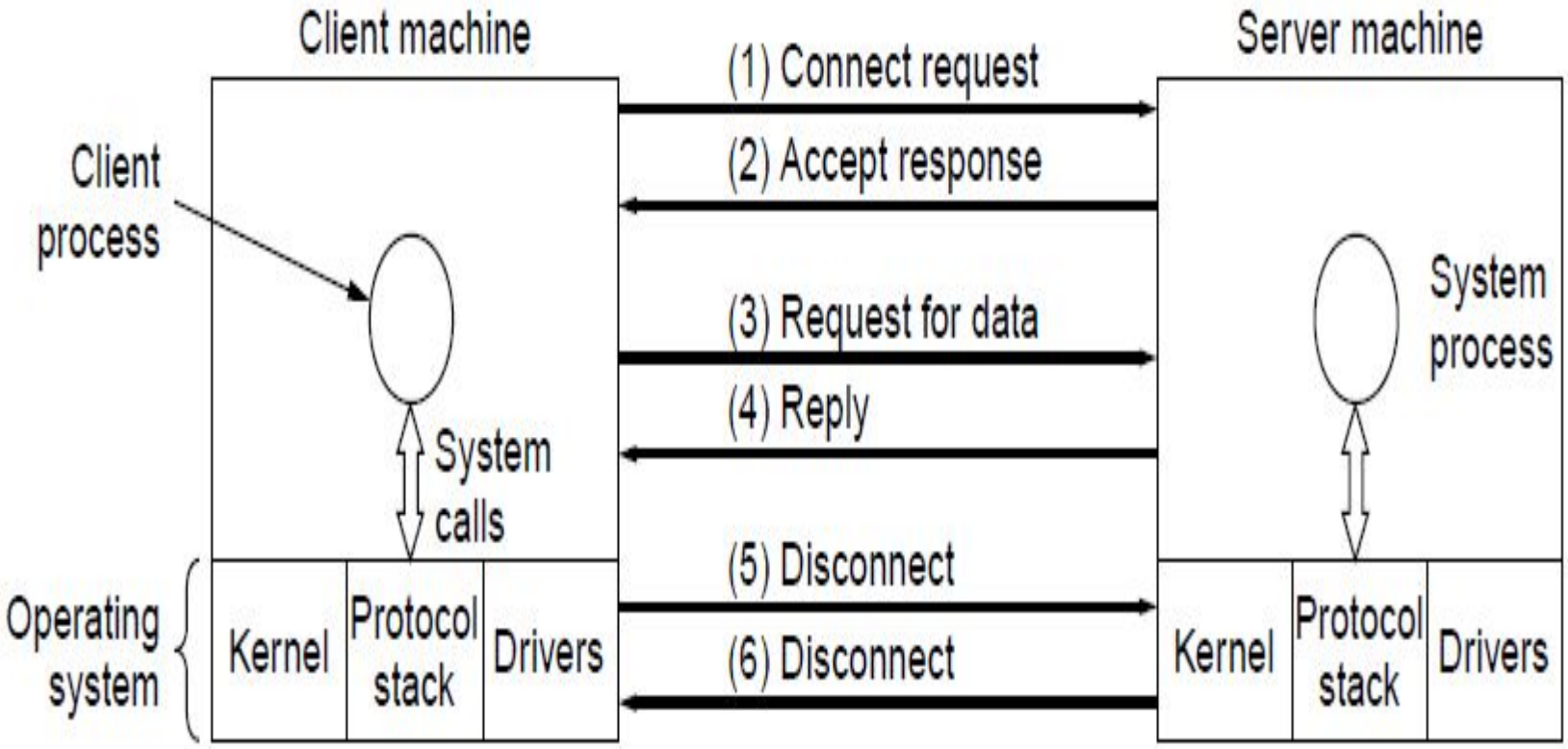
Contd….,

- Next, **the client process executes CONNECT** to establish a connection with the server.

- The CONNECT call needs to specify who to connect to, so it might have a parameter giving the server's address.

- The operating system then typically sends a packet to the peer asking it to connect (1)

A simple client-server interaction using acknowledged datagrams



Contd….,

- The client process is suspended until there is a response.
- When the packet arrives at the server, the operating system sees that the packet is requesting a connection.
- It checks to see if there is a listener, and if so it unblocks the listener. The server process can then establish the connection with the ACCEPT call.
- This sends a response (2) back to the client process to accept the connection

Contd….,

- The arrival of this response then releases the client.
- At this point the client and server are both running and they have a connection established.
- The next step is for the server to execute RECEIVE to prepare to accept the first request.
- Then the client executes SEND to transmit its request (3) followed by the execution of RECEIVE to get the reply.

Contd….,

- After it has done the work, the server uses SEND to return the answer to the client (4).

- When the client is done, it executes DISCONNECT to terminate the connection(5).

- When the server gets the packet, it also issues a DISCONNECT of its own, acknowledging the client and releasing the connection(6)

RELATIONSHIP OF SERVICES TO PROTOCOLS

- **Services and protocols are distinct concepts.**

- **A *service* is a set of primitives (operations) that a layer provides to the layer above it.**

- The service defines **what operations the layer is prepared to perform on behalf of its users**, but it says nothing at all about how these operations are implemented.

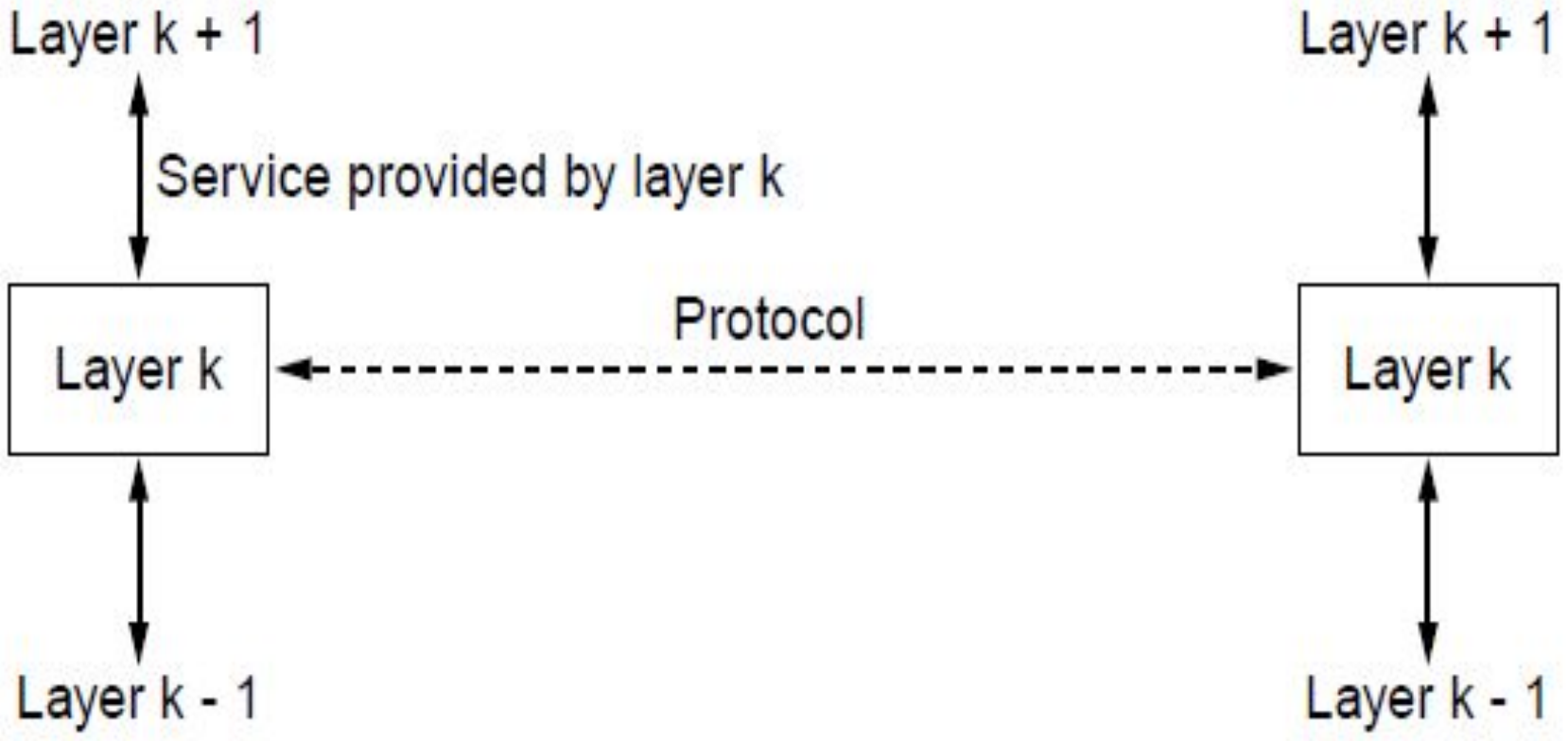
Contd….,

- **A service relates to an interface between two layers,** with the lower layer being the **service provider** and the upper layer being the **service user**

- A ***protocol***, in contrast, is a **set of rules governing the format and meaning of the packets, or messages that are exchanged by the peer entities within a layer.**

- Entities use protocols to implement their service definitions.
- They are free to change their protocols at will, provided they do not change the service visible to their users.

The relationship between a service and a protocol.



Contd….,

- A **service** is like an abstract data type or an object in an object-oriented language.

- It defines operations that can be performed on an object but does not specify how these operations are implemented.

- In contrast, a protocol relates to the *implementation* of the service and as such is not visible to the user of the service.

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DEPARTMENT OF COMPUTER SCIENCE

21CDC09 - COMPUTER NETWORKS

Unit- I Lecture -4

Introduction : Reference Models

Course Facilitator : Spelmen Vimalraj.S

Topics Covered

- Reference Models
  - The OSI Reference Model

Reference Models

- The OSI Reference Model
- The TCP/IP Reference Model
- A Comparison of OSI and TCP/IP

REFERNCE MODELS

Two important network architectures:

1. **The OSI reference model and**
2. **The TCP/IP reference model**

- **OSI (Open Systems Interconnection)** is a reference model for how applications communicate over a network.

- **The TCP/IP model** has the opposite properties: the model itself is not of much use but the protocols are widely used.

The OSI Reference Model

- OSI (Open Systems Interconnection) is a reference model for **how applications communicate over a network.**

- This model is based on a proposal developed by the **International Standards Organization (ISO)** as a first step toward international standardization of the protocols used in the various layers (Day and Zimmermann, 1983).

Contd….,

- It was revised in 1995 (Day,1995).
- The model is called the ISO **OSI (Open Systems Interconnection)**Reference Model because **it deals withconnecting open systems that is, systems that are open for communication with other systems.**
- **The OSI model has seven layers**.
- The principles that were applied to arrive at the seven layers can be briefly summarized as follows

Contd….,

1. A layer should be created where a **different abstraction is needed.**

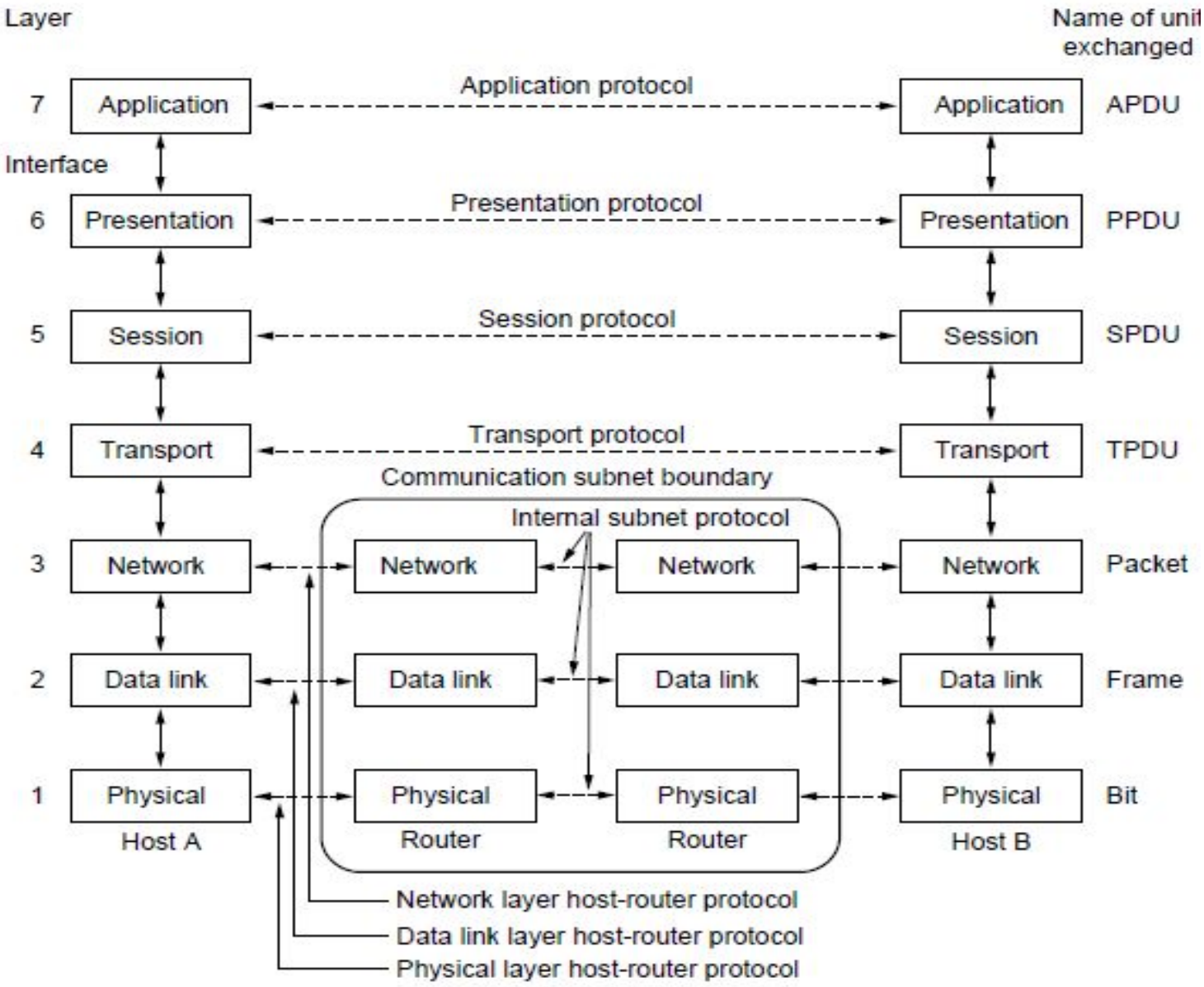
2. Each layer should perform a **well-defined function**.

3. The function of each layer should be chosen with an eye toward defining **internationally standardized protocols.**

4. The layer boundaries should be chosen to **minimize the information flow across the interfaces.**

Contd….,

5. The number of **layers should be large enough** that distinct functions need not be thrown together in the same layer out of necessity and small enough that the architecture does not become unwieldy


Layer
Name of unit exchanged
7
Application
Application protocol
Application
APDU
Interface
6
Presentation
Presentation protocol
Presentation
PPDU
5
Session
Session protocol
Session
SPDU
4
Transport
Transport protocol
Transport
TPDU
Communication subnet boundary
Internal subnet protocol
3
Network
Network
Network
Network
Packet
2
Data link
Data link
Data link
Data link
Frame
1
Physical
Physical
Physical
Physical
Bit
Host A
Router
Router
Host B
Network layer host-router protocol
Data link layer host-router protocol
Physical layer host-router protocol

OSI Reference Model Layers

1. Physical layer
2. Data link layer
3. Network layer
4. Transport layer
5. Session layer
6. Presentation layer
7. Application layer

The Physical Layer

- The **physical layer** is concerned with **transmitting raw bits over a communication channel.**
- The design issues have to do with making sure that when one side sends a 1 bit it is received by the other side as a 1 bit, not as a 0 bit.
- These design issues largely deal with mechanical, electrical, and timing interfaces, as well as the physical transmission medium, which lies below the physical layer

Contd….,

- Typical questions here are
  - what electrical signals should be used to represent a 1 and a 0,
  - how many nanoseconds a bit lasts,
  - whether transmission may proceed simultaneously in both directions,
  - how the initial connection is established,
  - how it is torn down when both sides are finished,
  - how many pins the network connector has, and
  - what teach pin is used for

The Data Link Layer

- The main task of the **data link layer** is to transform a raw transmission facility into a line that appears free of undetected transmission errors.

- It accomplishes this task by having the sender break up the input data into **data frames** (typically a few hundred or a few thousand bytes) and transmit the frames sequentially.

Contd….,

- If the service is reliable, the receiver confirms correct receipt of each frame by sending back an **acknowledgement frame.**

- Another issue that arises in the data link layer (and most of the higher layers as well) is how to keep a fast transmitter from drowning a slow receiver in data.

- Some traffic regulation mechanism may be needed to let the transmitter know when the receiver can accept more data.

Contd….,

- Broadcast networks have an additional issue in the data link layer: how to control access to the shared channel.

- A special sublayer of the data link layer, the **medium access control** sublayer, deals with this problem

The Network Layer

- **The network layer** controls the operation of the subnet.
- A key design issue is determining how packets are routed from source to destination.
- Routes can be based on static tables that are "wired into" the network and rarely changed, or more often they can be updated automatically to avoid failed components.

Contd….,

- If too many packets are present in the subnet at the same time, they will get in one another's way, forming bottlenecks.
- When a packet has to travel from one network to another to get to its destination, many problems can arise.
- The addressing used by the second network maybe different from that used by the first one.
- The second one may not accept the packet at all because it is too large.

Contd….,

- The protocols may differ, and so on.
- It is upto the network layer to overcome all these problems to allow heterogeneous networks to be interconnected.
- In broadcast networks, the routing problem is simple, so the network layer is often thin or even nonexistent

The Transport Layer

- The basic function of the **transport layer** is to accept data from above it, split it up into smaller units if need be, pass these to the network layer, and ensure that the pieces all arrive correctly at the other end.

- The transport layer also determines what type of service to provide to the session layer, and, ultimately, to the users of the network.

Contd….,

- The most popular type of transport connection is an error-free point-to-point channel that delivers messages or bytes in the order in which they were sent.

- The transport layer is a true end-to-end layer; it carries data all the way from the source to the destination.

- In other words, a program on the source machine carries on a conversation with a similar program on the destination machine, using the message headers and control messages.

Contd….,

- In the lower layers, each protocols is between a machine and its immediate neighbors, and not between the ultimate source and destination machines, which may be separated by many routers

The Session Layer

- The session layer allows users on different machines to establish **sessions** between them.

- Sessions offer various services, including **dialog control, token management** and **synchronization.**

The Presentation Layer

- The **presentation layer** is concerned with the syntax and semantics of the information transmitted.

- In order to make it possible for computers with different internal data representations to communicate, the data structures to be exchanged can be defined in an abstract way, along with a standard encoding to be used ‘‘on the wire.’’

- The presentation layer manages these abstract data structures and allows higher-level data structures to be defined and exchanged

The Application Layer

- The **application layer** contains a variety of protocol s that are commonly needed by users.

- One widely used application protocol is **HTTP (Hypertext Transfer Protocol)**, which is the basis for the World Wide Web.

- When a browser wants a Web page, it sends the name of the page it wants to the server hosting the page using HTTP.

Contd….,

- The server then sends the page back.

- Other application protocols are used for file transfer, electronic mail, and network news

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DEPARTMENT OF COMPUTER SCIENCE

21CDC09- COMPUTER NETWORKS

Unit- I Lecture - 5

Introduction : Reference Models

Class : II B.Sc. 'A'
MAP Code : C

Course Facilitator : Spelmen Vimalraj.S

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The TCP/IP Reference Model

- The OSI reference model to the reference model used in the **grandparent of all wide area computer networks, the ARPANET, and its successor, the worldwide Internet.**

- Although we will give a brief history of the ARPANET later, it is useful to mention a few key asp ects of it now.

- The ARPANET was a research network sponsored by the DoD (U.S. Department of Defense)

Contd….,

- It eventually connected hundreds of universities and government installations, using leased telephone lines.
- When satellite and radio networks were added later, the existing protocols had trouble interworking with them, so a new reference architecture was needed.
- The ability to connect multiple networks in a seamless way was one of the major design goals.
- This architecture later became known as the **TCP/IP Reference Model**, after its two primary protocols

Contd….,

- It was first described by Cerf and Kahn (1974), and later refined and defined as a standard in the Internet community (Braden, 1989).

- The design philosophy behind the model is discussed by Clark (1988).

- Ranging from transferring files to real-time speech transmission, a flexible architecture was needed

The TCP/IP Reference Model Layers

1. Link layer
2. Internet layer
3. Transport layer
4. Application layer

The Link Layer

- All these requirements led to the choice of a packet-switching network based on a connectionless layer that runs across different networks.

- The lowest layer in the model, the **link layer** describes what links such as serial lines and Classic Ethernet must do to meet the needs of this connectionles s internet layer.

- It is not really a layer at all, in the normal sense of the term, but rather an interface between hosts and transmission links.

The Internet Layer

- The **internet layer** is the linchpin that holds the whole architecture together.

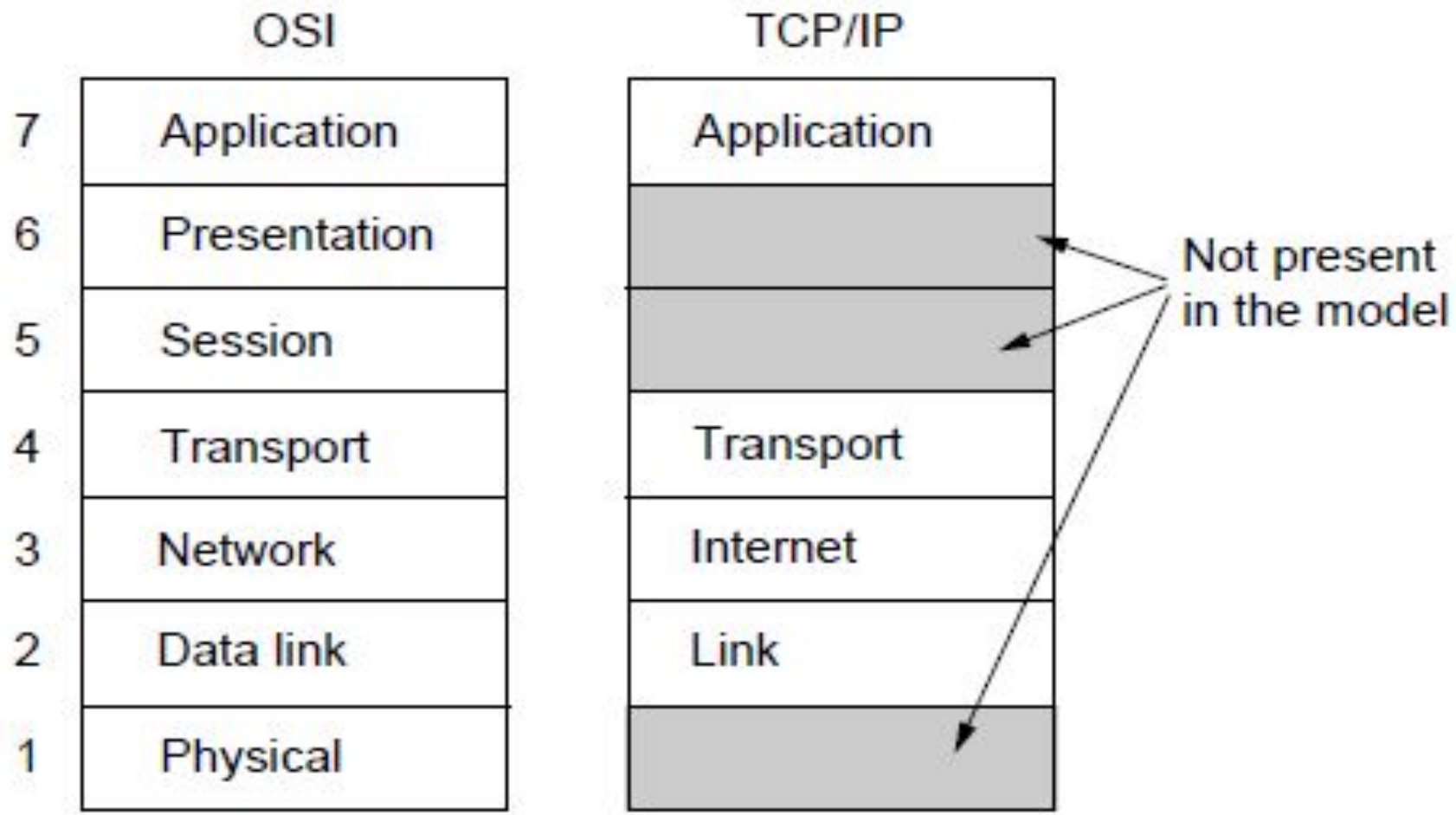
- Its job is to permit hosts to inject packets into any n etwork and have them travel in-dependently to the destination (potentially on a different network).

- They may even arrive in a completely different order than they were sent, in which case it is the job of higher layers to rearrange them, if in-order delivery is desired.

Contd….,

- The internet layer defines an official packet format and protocol called **IP(Internet Protocol),** plus a companion protocol called **ICMP (Internet Control Message Protocol)** that helps it function.

The TCP/IP reference model



The Transport Layer

- The layer above the internet layer in the TCP/IP model is now usually called the **transport layer.**

- It is designed to allow peer entities on the source and destination hosts to carry on a conversation, just as in the OSI transport layer.

- The first one **TCP(Transmission Control Protocol)**, is a reliable connection-oriented protocol that allows a byte stream originating on one machine to be delivered without error on any other machine in the internet

Contd….,

- It segments the incoming byte stream into discrete messages and passes each one on to the internet layer.

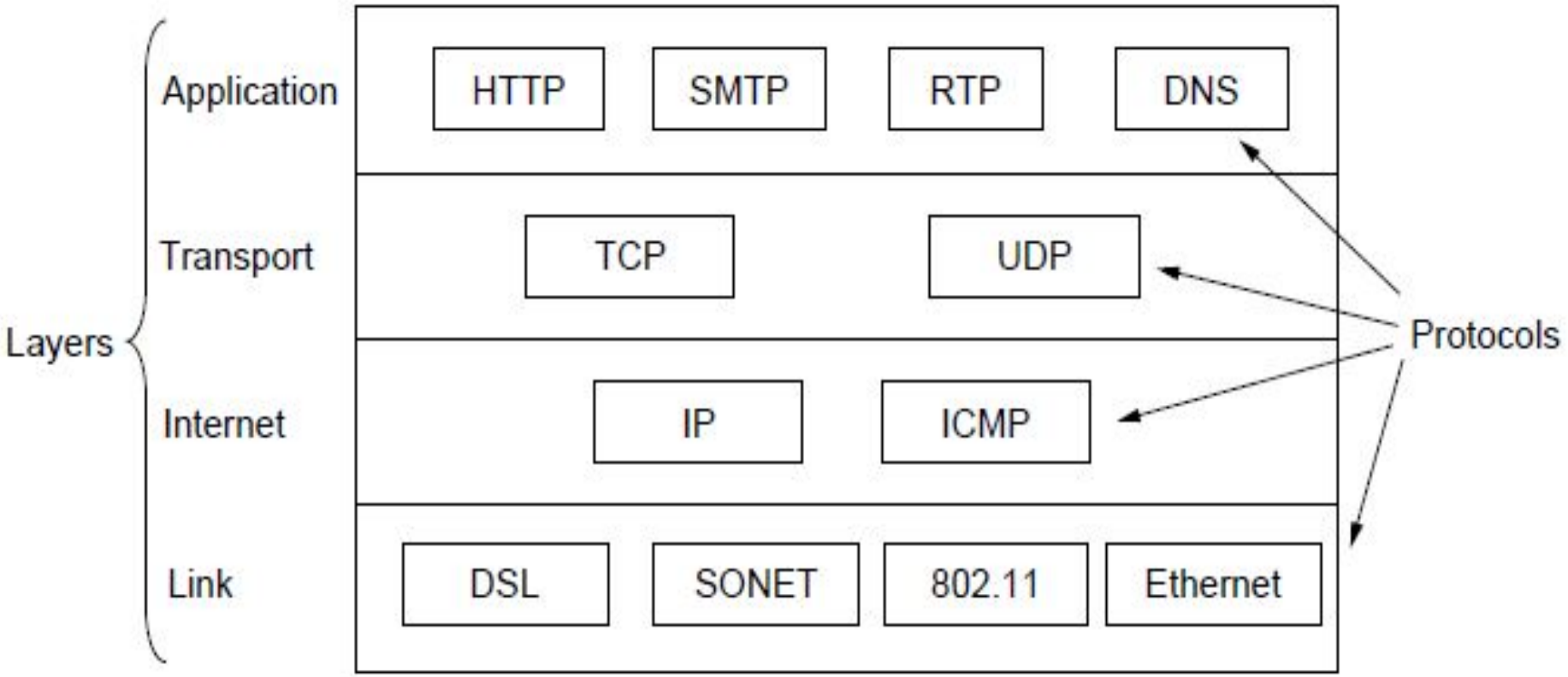
- The receiving TCP process reassembles the received messages into the output stream.

- TCP also handles flow control to make sure a fast sender cannot swamp as low receiver with more messages than it can handle.

Contd….,

- The second protocol in this layer, **UDP (User Datagram Protocol)**, is an unreliable, connectionless protocol for applications t hat do not want TCP's sequencing or flow control and wish to provide their own

The TCP/IP reference model with some protocols



The Application Layer

- The TCP/IP model does not have session or presentation layers.
- On top of the transport layer is the **application layer**
- It contains all the higher level protocols.
- The early ones included virtual terminal (TELNET), file transfer (FTP), and electronic mail (SMTP).

Contd….,

- Many other protocols have been added to these over the years.

- HTTP, the protocol for fetching pages on the World Wide Web,and RTP, the protocol for delivering real-time media such as voice or movies

Comparison of the OSI and TCP/IP Reference models

- The OSI and TCP/IP reference models have much in common.
- Both are based on the concept of a stack of independent protocols.
- Three concepts are central to the OSI model:

1. Services.

2. Interfaces.

3. Protocols

Contd….,

- Each layer performs some *services* for the layer above it.
- The service definition tells what the layer does, not how entities above it access it or how the layer works.

  It defines the layer's semantics.
- A layer's *interface* tells the processes above it how to access it.
- It specifies what the parameters are and what results to expect.

Contd….,

- It, too, says nothing about how the layer works inside
- Finally, the peer *protocols* used in a layer are the layer's own business.
- It can use any protocols it wants to, as long as it gets the job done (i.e., provides the offered services).
- It can also change them at will without affecting software in higher layers.

Contd….,

- An object, like a layer, has a set of methods (operations) that processes outside the object can invoke.
- The semantics of these methods define the set of services that the object offers.
- The methods' parameters and results form the object's interface.
- The code internal to the object is its protocol and is not visible or of any concern outside the object

Contd….,

- For example, the only real services offered by the internet layer are SEND IP PACKET and RECEIVE IP PACKET

- As a consequence, the proto-cols in the OSI model are better hidden than in the TCP/IP model and can be replaced relatively easily as the technology changes

Contd….,

- Turning from philosophical matters to more specific o nes, an obvious difference between the two models is the number of layers:
  1. **The OSI model has seven layers and the**
  2. **TCP/IP model has four.**

- Both have (inter)network, transport, and application layers, but the other layers are different

Contd…,

- Another difference is in the area of connectionless versus connection-oriented communication.

- The OSI model supports both connectionless and c onnection-oriented communication in the network layer, but only connection-oriented communication in the transport layer, where it counts.

- The TCP/IP model supports only one mode in the network layer (connectionless) but both in the transport layer, giving the users a choice.