CS 425: Computer Networks **Jan-Apr 2020**

Lecture 2: Computer Networks – January 7, 2020

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2.1 Uses of Computer Networks

2.1.1 User - User Applications

As the name suggests they are applications where a user can directly interact with other user over a network e.g. Email, Instant messaging, Video calls, etc.

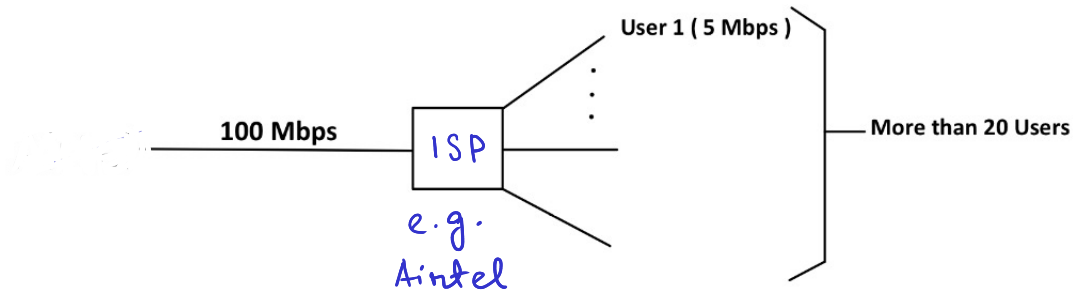
2.1.2 Business Applications

- **Virtual Private Networks (VPNs):** they extend a private network across a public network and enable users to send and receive data across public networks as if their computing devices were directly connected to the private network.
- **Voice over IP (VoIP):** Internet technology is where internet is used for telephonic communication
- **Sensor Networks:** made up of nodes that gather and relay information they sense about the state of the physical world

2.1.3 Resource Allocation

- **Network Bandwidth** is the capacity of a network to transmit max amount of data from one point of network to other in a unit time.
- **Cloud computing** is the on-demand availability of computer system resources, especially data storage and computing power, without direct active management by the user.

Lets understand it through an example. Consider the following network model



Problem: In the above network, how many users can be supported so that the overflow (beyond 100Mbps) in the network happens with probability ≤ 0.025 ? Suppose that each user is active only with a probability of 0.5.

Solution: Let n users be active each with probability p. In our case $p = 0.5$

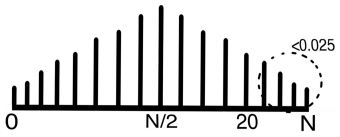
$$P\,(\,exactly\ k\ users\ are\ active\,) = \binom{n}{k} p^k (1-p)^{n-k}$$

$$P\,(\,exactly\ k\ users\ are\ active\,) = \binom{n}{k} \frac{1}{2^n}$$

In our problem, we want the probability of $k > 20$ i.e. when it overflows the capacity and want that to be ≤ 0.025. Hence the problem turns out to be

$$\max\ n, \text{s.t.}\ \sum_{k=21}^{n} \binom{n}{k} \frac{1}{2^n} \leq 0.025 \implies n = 30$$

Here the Probability distribution takes the following form

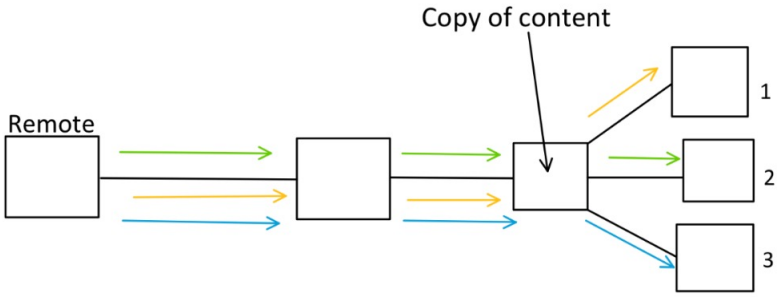


This is called **Statistical Multiplexing**.

Imp: demands are independent – correlation may fail this calculation
downside: some unlucky moment when quality may be poor.

2.1.4 Content Delivery

The use of a link in a network is costly as it requires electric signals to be passed and also other things (like maintenance). Hence, we need to design a proper **CDN - Content Distribution Network** for efficient use. Let us understand it via an example, Consider the following network model -



Here the remote machine wants to send some data to each of the n machines on the network. If it sends each data one after other then the 2 links from remote to the host that directly connects with the users is unnecessarily used multiple times. So, in order to avoid over-use we can store a copy of data on the host as marked in the diagram to avoid using the above 2 links multiple times.

2.1.5 Sensing physical world : CCTV cameras , mobile phone location etc.

Metcalfe's Law

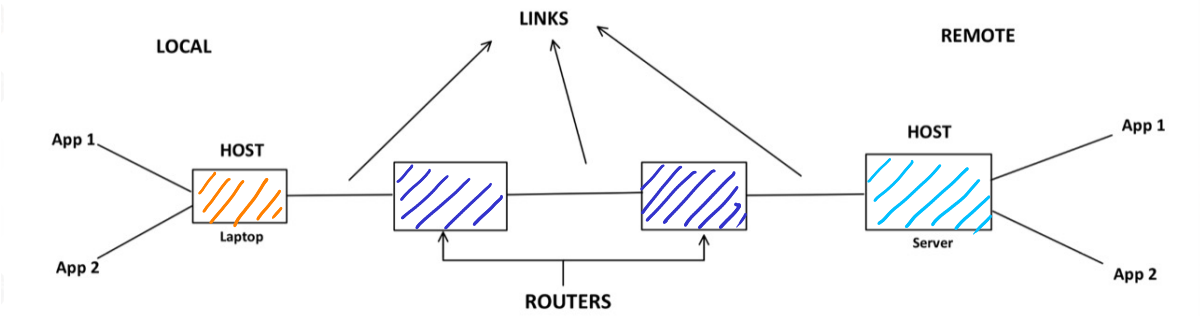
$$value\ of\ connectivity\ \propto (\,size\ of\ Network\,)^2$$

Value of connectivity is basically the measure of monetary profit that the service provider can make. So a network of size N has more value of connectivity (value = N^2) than 2 networks of size N/2 each (value = $N^2/2$). Hence it is more profitable to use the later network.

2.2 Basic computer network components

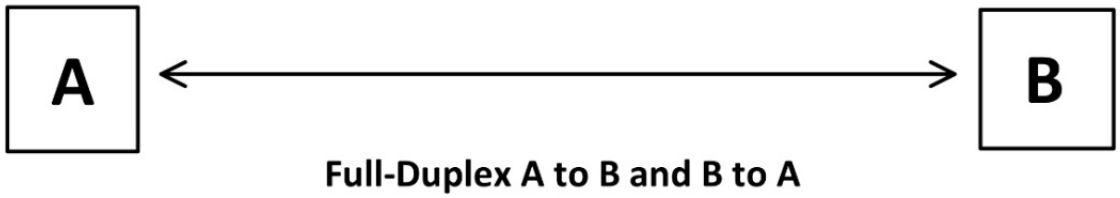
Network comprises of devices with various functions and features which along with the transmission media are known components of network. Various resources along with their uses and their examples are listed in the following table [WIKI].

Components	**Uses**	**Examples**
Applications	Are software applications that utilize the network to send and receive information.	Web browser, e-mail, instant messaging, online stores
Server	Servers are the computing devices that hold the shared files, programs that support the functioning of applications.	Database servers, File servers, Web servers
Host,end device (client's laptop)	Support the applications and are used to connect, to the network and access network's resources.	Laptops, Personal computers, Mobile, Tablets
Hub,Repeater, Router,Switch	Primary use of these devices is to relay information **Hub** transmits a request to the entire network **Switch** uses physical devices' address in each incoming messages to deliver the message to the right port **Router** routes data packets based on their IP addresses. It normally connects two distinct networks. **Repeater** regenerate the signal over the same network before the signal becomes too weak or corrupted	access points, modems
Links(Channel)	Physical and logical network components used to interconnect hosts or nodes in the network.	**Wired:** twisted-copper wire pair, coaxial cable, optical fibers **Wireless:** terrestrial radio channels and satellite radio channels

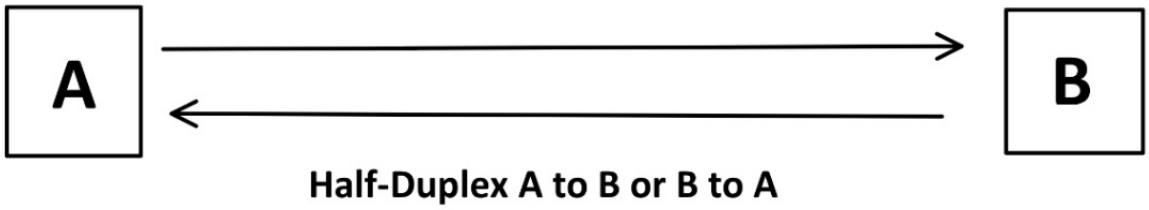


2.2.1 Types of Links[HFD]

Full-duplex link: Describes the link that allows to simultaneously data transmission and reception over one channel. A full-duplex device is capable of bi-directional network data transmissions at the same time. Example twisted-copper wire, coaxial wire

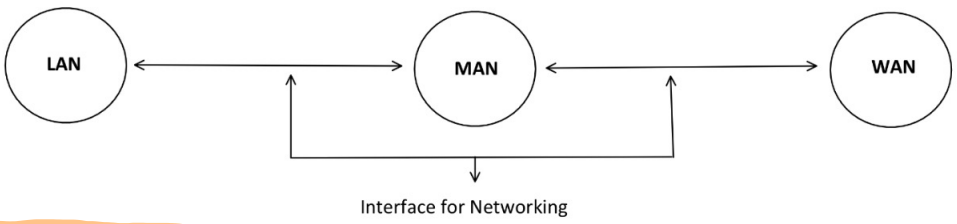


Halft-duplex link: Describes the link that can only transmit data in one direction at a time.In half-duplex link, data can move in both directions but not at the same time. Example wireless links in broadcast networks.



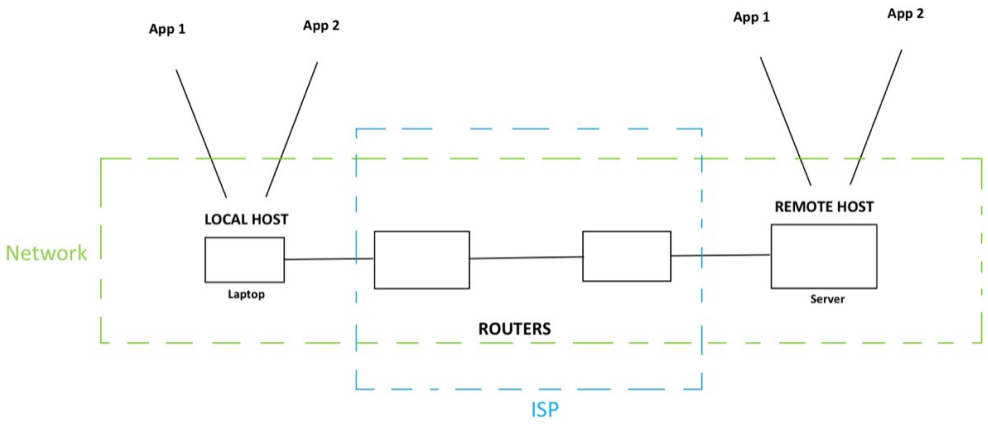
2.3 Classification of Networks on the basis of size

1. **Personal Area Network**: A PAN is a network for interconnecting devices on an individual person's work space. Examples of PAN are Bluetooth, USB connected network of mouse, keyboard etc.
2. **Local Area Network**: These are privately owned networks that operate within and nearby a single building or in an organization. Example WiFi network in houses, Enterprise network in large organizations.
3. **Metropolitan Area Network**: A MAN is a network that spans area equivalent to an entire city. Example various ISP's network like Jio, Airtel etc.
4. **Wide Area Network**: A wide area network (WAN) is a network that exists over a large-scale geographical area, often comparable to a country's or a continent's area. Example: Telephone network



Internetworking: Interconnecting different types of networks to build a large network such that any pair of connecting hosts can exchange packets. *Internet* is the largest internetwork.

2.4 Network Boundaries



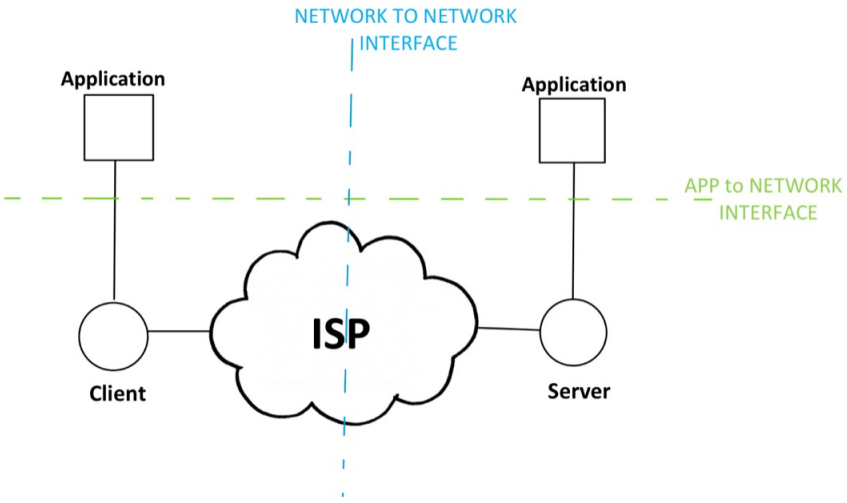
Teacher: Which part in this diagram is called a network ?

Student: The remaining part after removing the applications constitutes the network. Applications are not included as they run on hosts and are not responsible for transmission of data.

A host is a computer that is accessible over a network. It can be a client, server, or any other type of computer. The rest of the network that connects these hosts is called the communication subnet or just subnet. Different parts of network are maintained by different people For eg. users maintain client's device, hosting companies maintain servers and ISPs maintain links and routers in between client and host's server.

2.4.1 Interfacing

Interfacing provides the *function abstraction* to communicate over the network. They are two types of network interfaces:



- **Application-Network Interface:** Provides functions which can be called by the applications to communicate over the network. E.g. Socket API.
- **Network-Network Interface:** Specifies signaling and management functions between two networks. It can be the interface between the network that is from user to his ISP and the network that is from remote host to its ISP.

2.4.2 Application-Network Interface

It provides the abstraction so that the applications can communicate over the network without worrying about the details of the network. E.g. Socket API.
The goal of the application-network interface is to:

- Let the applications talk to each other.
- Hide the details of the network.

Teacher: How to write a client-server program ?

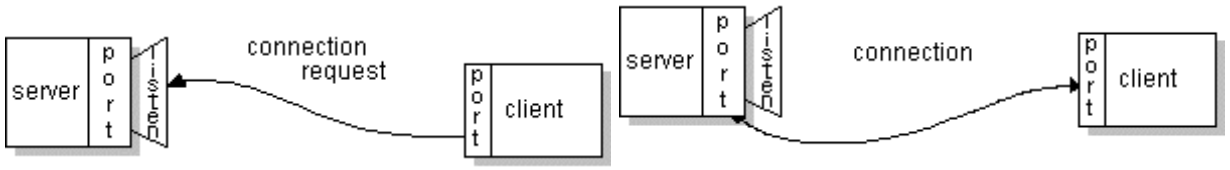
Student: We can write a client-server program by using the socket API.

Socket: A socket is one endpoint of a two-way communication link between two applications running on the network. It is a way to talk to other computers using standard Unix file descriptors. Each application running on the network has a socket that is bound to a specific port number. There are various Socket API calls that are simply functions to facilitate socket programming. Some of them are:

- BIND: Binds the socket to the specified port number and the IP address
- LISTEN: Waits for an incoming connection

- CONNECT: Establishes a connection with a waiting peer
- ACCEPT: Accepts an incoming connection from a peer
- RECEIVE: Waits for an incoming message
- SEND: Sends a message to the peer

(more details when we discuss TCP)



Representing LISTEN, CONNECT and ACCEPT API calls [ORA]

References

[WIKI] https://en.wikiversity.org/wiki/Basic_computer_network_components

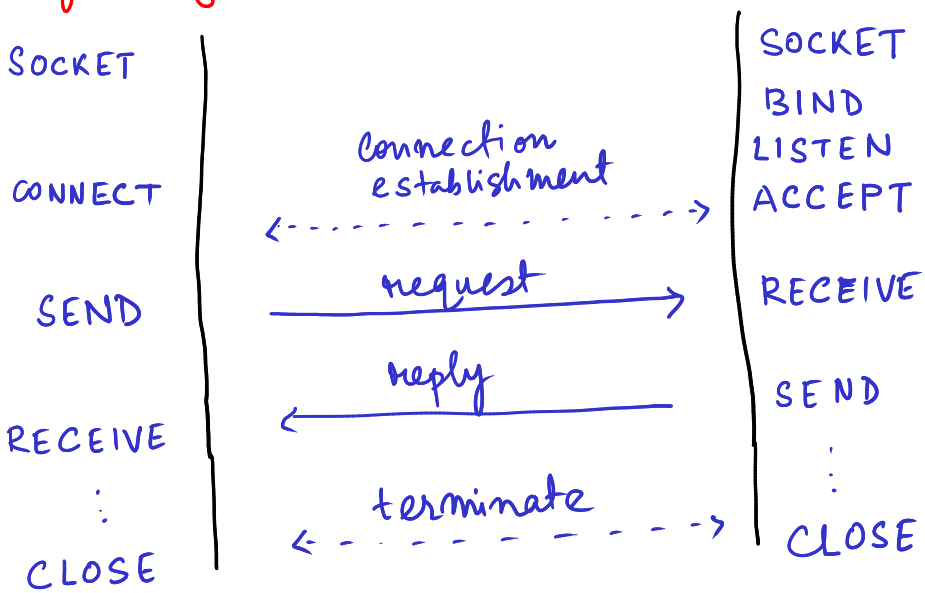
[HFD] https://www.comms-express.com/infozone/article/half-full-duplex/

[CN5] "AS Tanenbaum, DJ Wetherall, Computer Networks, 5th Ed., Prentice-Hall, 2010."

[GKS] https://www.geeksforgeeks.org

[ORA] https://docs.oracle.com/javase/tutorial/networking/sockets/definition.html

Time diagram of a socket establishment and usage



Client Server

Each call has equivalent functions, some of which are already part of standard operating systems.