Chapter 1

From slide#20 of the first lecture:
How long does it take to send a file of 640,000 bits from host A to host B over a circuit-switched network?

- All links are 1.536 Mbps
- Each link uses TDM with 24 slots/sec
- 500 msec to establish end-to-end circuit

Solution:

For a TDM link, time is divided into frames of fixed duration and each frame is divided into a fixed number of time slots. When the network establish a connection across a link, the network dedicates one time slot in every frame to the connection. These slots are edicated for the sole use of that connection, with a time slot available for use (in every frame) to transmit the connection's data.

Each circuit has a transmission rate of (1.536 Mbps)/24 = 64 Kbps, so it takes (640bits)/(64 Kbps) = 10 seconds to transmit the file. To this 10 seconds we add the the circuit establishment time, giving 10.5 seconds to send the file. Note that the transmission time is independent of the number links: the transmission time would be 10 seconds if the end-to-end circuit passes through one link or one-hundred links.

Q.10 Discuss the similarities between the following national transportation networks and a communications network. Is the transportation system more similar to a telephone network or to a packet network?

Solution:

Transportation networks are designed to transfer people and goods; communications networks are designed to transfer information. Like communication networks, all transportation systems involve links, in the form of roads, rails, or air corridors, and switching points, in the form of stations, airports, and highway interchanges. Addressing and geographical names are used in transportation networks to identify destinations, and routing of various forms is required to direct goods to their destinations. Transportation resources, in the forms of cars or airplanes, are shared or "multiplexed" among various goods that traverse common parts of the network.

a. Railroad network.

Railroad network: Goods or people arrive at train stations and are loaded for transport to specific places. Tickets are purchased for a given destination, usually guaranteeing that there will be a place in a car from the starting station all the way to the destination station. This is similar to establishing a connection across a telephone network.

Alternatively, a passenger may choose to purchase a ticket at each station along the way. This corresponds more closely to a connectionless packet network model.

b. Airline network.

Airline network: In this case passengers purchase tickets that guarantee a seat all the way to the destination, even if transfers are made at intermediate airports. This is similar to the establishment of connections across a telephone network.

c. Highway system.

Highway systems: Trucks or cars enter the highway without making reservations ahead of time and without informing any central authority of their destination or route. This mode of operation corresponds closely to the operation of a connectionless packet network.

d. Combination of (a), (b), and (c).

Combination of transportation systems: The combination of air, rail, and highway transportation systems can and are used jointly for the transfer of people and goods. Each transportation system is different in how it is organized and how transfers are accomplished. Nevertheless, it is possible to use these systems in combination to provide a higher degree of connectivity between sources and destinations of people and goods. We will see that the Internet plays a role similar to the combined transportation systems in that the Internet enables the transfer of information across multiple dissimilar networks that may differ in how they are organized and how they operate.

Q.14 The propagation delay is the time that is required for the energy of a signal to propagate from one point to another.
a. Find the propagation delay for a signal traversing the following networks at the speed of light in cable (2.3×10^8 meters/second):

- a circuit board 10 cm
- a room 10 m
- a building 100 m
- a metropolitan area 100 km
- a continent 5000 km
- up and down to a geostationary satellite 2 x 36000 km

Solution:

To find the propagation delay, divide distance by the speed of light in cable. Thus we have:

- a circuit board $t_{prop} = 4.347 \times 10^{-10}$ seconds
- a room $t_{prop} = 4.3478 \times 10^{-8}$ seconds
- a building $t_{prop} = 4.3478 \times 10^{-7}$ seconds
- a metropolitan area $t_{prop} = 4.3478 \times 10^{-4}$ seconds
- a continent $t_{prop} = 0.02174$ seconds
- up and down to a geostationary satellite $t_{prop} = 0.31304$ seconds

14b. How many bits are in transit during the propagation delay in the above cases, if bits are entering the above networks at the following transmission speeds: 10,000 bits/second; 1 megabit/second; 100 megabits/second; 10 gigabits/second.

Solution:

The number of bits in transit is obtained by multiplying the transmission rate R by the propagation delay:

Distance (m)	10 Kbps	1 Mbps	100 Mbps	10 Gbps
0.1	4.347×10^{-6}	4.347×10^{-4}	0.04347	4.3478
10	4.3478×10^{-4}	0.043478	4.3478	434.780
100	4.3478×10^{-3}	0.43478	43.478	4347.800
100 000	4.3478	434.78	43478	4.3478×10^{6}
5 000 000	217.4	21740	2174000	2.174×10^{8}
72 000 000	3130.4	313040	31304000	3.1304×10^{9}

Q. 18 The introduction of new communications services usually impacts other services through substitution. Describe how substitution takes place in the following cases.

Solutions follow questions:

a. E-mail, facsimile, and postal mail.

E-mail is used for most of the correspondence previously handled by postal mail. Documents sent by facsimile are also transferred using E-mail as attachments. Hardcopies can be scanned for electronic transmission.

b. E-mail, local, and long-distance phone service.

E-mail is an inexpensive and convenient alternative for most of the communication in which real-time interaction is not essential. Instant-messaging is faster than email and more closely approaches the real-time experience of the telephone.

c. Cell phone, local, and long-distance phone service.

Cell phone is used for local or long distance calls mostly because users can be reached even if they are not in a specific location such as home or office. The steep drop in the cost of long-distance relative to the cost of cellular airtime has enable “call anywhere” cellular service offerings.

d. Peer-to-peer file exchange and commercial CD recording.

Peer-to-peer file exchange provides an easy means to access and share commercial recordings. Individual songs rather than entire albums can be acquired. Users can readily arrange their personalized song mixes.