Delays

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Delays in Packet Switched Networks

- Packets travel from source to destination via intermediate routers/switches.
  - Processing delay
  - Queueing delay
  - Transmission delay
  - Propagation delay
- Nodal delay = Processing delay + Queuing delay + Transmission delay + Propagation delay

Processing Delay

- Time required to examine the packets header
  - Determines where to direct the packet
  - Check for errors
- Order of microseconds

Queuing Delay

- If a router is busy in processing and transmitting a packet, a freshly arrived packet has to wait in queue (buffer) for its turn.
- No queuing delay if the router is idle.
- Queuing delay varies with time and location. In general, it is a random variable.
- Order of microseconds to milliseconds.

Transmission Delay

- Time required to push the packet into the link
- If the length of the packet is L bits and transmission rate of the link is R bps, then

$$\text{Transmission delay} = \frac{L}{R}$$

- Order of microseconds to milliseconds

Propagation Delay

- Time required to propagate from one end of the link to the other end
- The propagation speed depends on the physical link between the routers
- In general, propagation speed s, is in the order of $2 \times 10^8 - 3 \times 10^8 m/s$.
- Propagation speed depends on the distance bewteen the routers, d
- Propagation delay $= \frac{d}{s}$

Traffic Intensity

- Queuing delays are random in nature
- Arrivals to a queue are also random in nature
- Traffic intensity is an indication of queuing delay
- Let a be the average number of packets arriving at a queue
- Each packet is of length L bits adn transmission rate is R bps
- Traffic intensity $= \frac{La}{R}$

Traffic Intensity

- If traffic intensity > 1, the *queuelength* increases to ∞
- It is desirable to have traffic intensity < 1.
- If traffic intensity close to 1, there will be a significant queuing delay

Throughput

- Suppose Host A is sending data to Host B across a computer network
- Instantaneous throughput is the rate at which Host B is receiving data
- Suppose it takes T seconds to transfer F bits from Host A to Host B, then average throughput $= \frac{F}{T}$ bps.

Problems

- Suppose Host A wants to send a large file to Host B. The path from Host A to Host B has three links of rates $R_1 = 500\text{kbps}$, $R_2 = 2\text{Mbps}$, $R_3 = 1\text{Mbps}$.
  - Assuming no other traffic, what is the throughput for the file transfer
  - Suppose the file size is 4 million bytes, how long will it take to transfer the file from A to B?
- How long does it take for a packet of length 1000 bytes to propagate over a link of propagation speed 2.5×10^8 m/s. Length of the link is 2,500 Km and transmission rate is 2Mbps.

Problem 3

Suppose N packets arrive simultaneously to a link at which no packets are currently being transmitted or queued. Each packet is of length L bits and the link has a transmission rate of R bits/sec. What is the average queueing delay for the N packets ?

Problem 4

Suppose that x bits of user data has to be transmitted over a k-hop path in a packet switched network as a series of packets. Each packet contains p data bits and h header bits, with $x >> p + h$. The bits rate of the links is b bps. Ignoring propagation delay and processing delay find the value of p that minimizes total delay.