Leco2_basic

Glossary:

1. *ISP*: Internet Service Provider
2. *src*: Source
3. *dst*: Destination
4. *TDM*: Time division multiplexing
5. *FDM*: Frequency division multiplexing

Switched networks

1. Definition: End-systems and networks connected by swtiches instead of directly connecting them.
2. Pros: allows us to scale. For example, directly connecting N nodes to each other would require N^2 links.

Two ways to share switched networks:

1. Circuit switching:

- Resource reserved per connection;
- Admission control per connection

2. Packet switching via statistical multiplexing

- Packets treated independently, on-demand;
- Admission control per connection

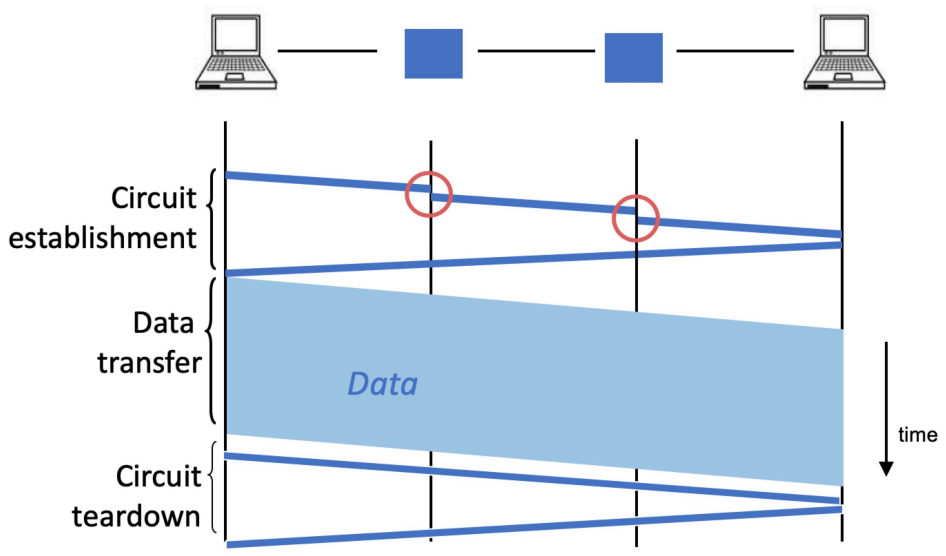
The hybrid of these two methods is called virtual circuits which emulates circuit switching with packets.

Circuit switching

1. Source sends reservation request to destination.
2. Switches create circuit after admission control.
3. Source send data.
4. Source sends teardown request.

Circuit switching using Time Division Multiplexing (TDM) or Frequency Division Multiplexing (FDM) during transmitting and receiving.

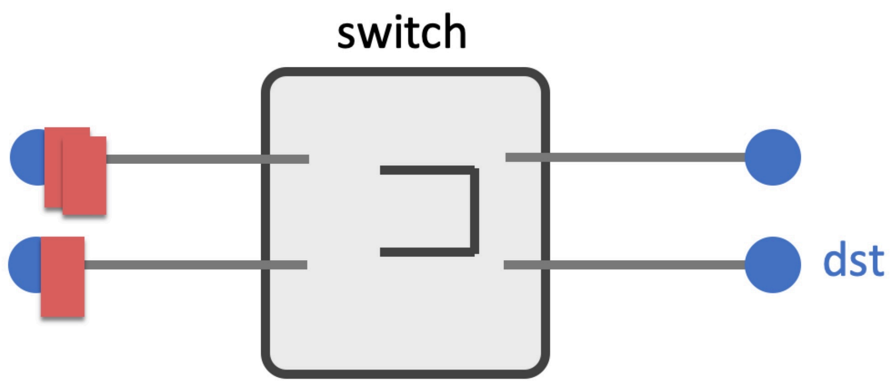
Timing of the Circuit switching:



- Pros:
  a. Predictable performance
  b. Simple/fast switching (once circuit established)
- Cons:
  a. Complexity of circuit setup/teardown
  b. Inefficient when traffic is busty
  c. Circuit setup adds delay
  d. Switch fails → its circuit(s) fails

Packet switching

1. Each packet contains destination
2. Each packet treated independently
3. With buffers to absolve transient overloads



- Pros:
  a. Efficient use of network resources (doesn't need specific line between src and dst)
  b. Simpler to implement
  c. Robust: can "route around trouble"
- Cons:
  a. Unpreidctable performance
  b. Requires buffer management and congestion control

Packet switching using realized as sequences of packets and allocate resource using Statistical Multiplexing method. In statistical multiplexing, a communication channel is divided into an arbitrary number of variable bitrate digital channels or data streams. The link sharing is adapted to the instantaneous traffic demands of the data streams that are transferred over each channel.

Using Statistical Multiplexing allowing more demands than the network can handle (utilization improvement, called the statistical multiplexing gain.) while hoping that not all demands are required at the same time. Though statistical multiplexing results in unpredictability, it works well except for the extreme cases.

Evaluation of a network

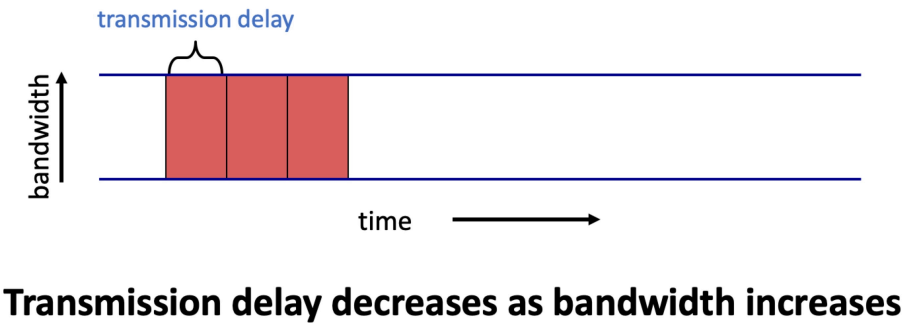
Performance metrics:

1. Delay
2. Loss
3. Throughput

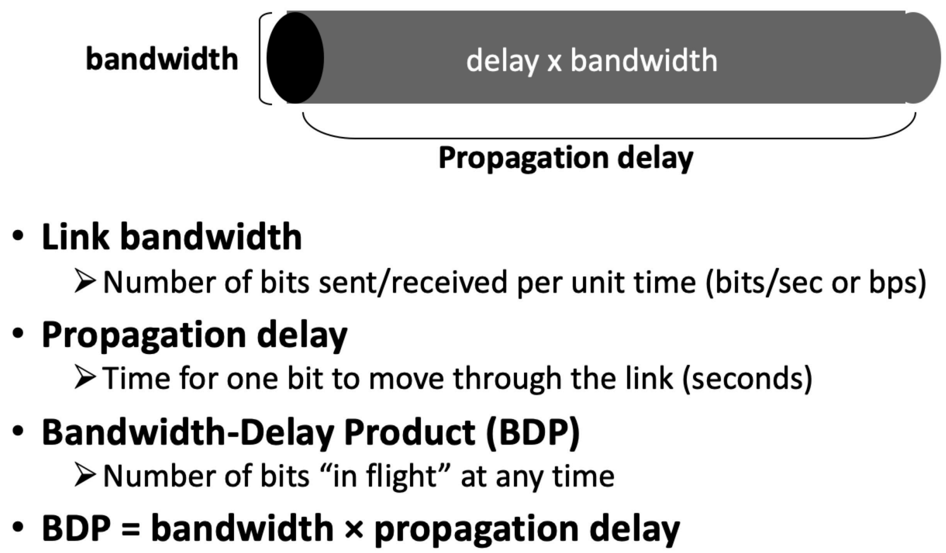
Delay

How long does it take to send a packet from src to dst.
Consists of four components:

1. Transmission delay: how long does it take to push all the bits of a packet into a link
   $transition\ delay = \frac{packet\ size}{transmission\ rate\ of\ the\ link\ (bandwidth)}$

2. propagation delay: how long does it take to move one bit from one end of a link to the other.
   $propagation\ delay = \frac{link\ length}{propagation\ speed\ of\ link\ (3*10^8 m/s)}$

3. queueing delay: how long does a packet have to sit in a buffer before it is processed.

When the transient pip is not overload, then there is no need for sitting in buffer queue. Once transient overload happened, a buffer queue is necessary to keep the overload packet till the pip has empty space/time for its transient. Persistent overload leads to packet loss.

Therefore, queueing delay depends on traffic pattern: arrival rate at the queue, nature of arriving traffic (bursty or not) and transmission rate of outgoing link.

Characterized with statistical measures: average queueing delay, variance of queueing delay and probability delay exceeds a threshold value.

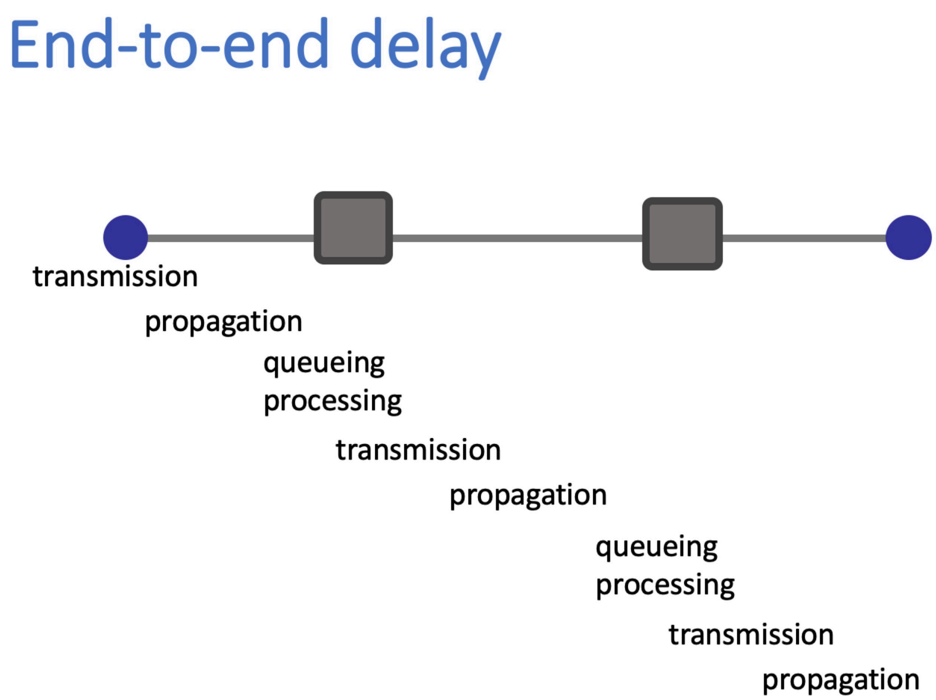
If we want to calculate the average time packets wait in the queue, we can use Little's law:

$$L = A \times w$$

where A is average rate of arrival process, W is average time packets wait in the queue and L is average number of packets waiting in the queue. We can compute L by counting packets in queue every second.

4. processing delay: how long does the switch take to process a packet.(negligible)

The first tow delays are due to link properties and the last two delays are due to traffic mix and switch internals.



Loss

What fraction of the packets sent to dst are dropped.

Throughput

At what rate is the dst receiving data from the src.

Throughput

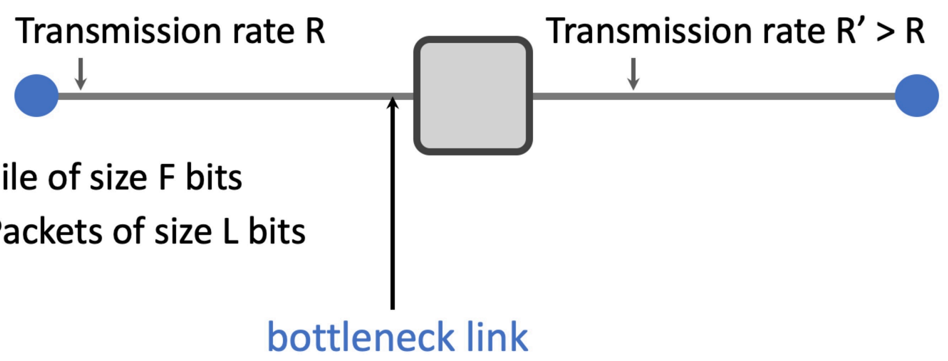
File of size F bits

Packets of size L bits

Transfer time (T) = F/R + propagation delay

Average throughput = F/T ≈ R

End-to-end throughput



File of size F bits

Packets of size L bits

Average throughput = **min{R, R'} = R**