CPE348: Introduction to Computer Networks

Lecture #3: Chapter 1.2

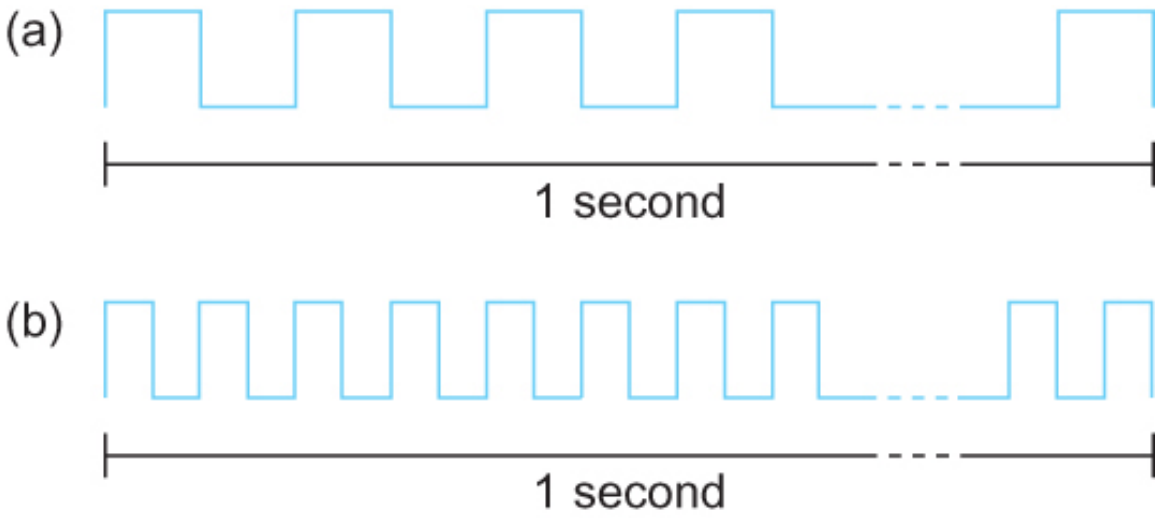
Jianqing Liu
Assistant Professor of Electrical and Computer Engineering, University of Alabama in Huntsville

jianqing.liu@uah.edu
http://jianqingliu.net

Metrics and Performance

- Bandwidth
  - Width of the frequency band
  - Number of bits per second that can be transmitted over a communication link
- 1 Mbps: 1 x 10^6 bits/second
- 1 x 10^{-6} seconds to transmit each bit or imagine that a timeline, now each bit occupies 1 micro second space.
- On a 2 Mbps link the width is 0.5 micro second.
- Smaller the width more will be transmitted per unit time.

Bandwidth



Bits transmitted at a particular bandwidth can be regarded as having some width:

(a) bits transmitted at 1Mbps (each bit 1 μs wide);

(b) bits transmitted at 2Mbps (each bit 0.5 μs wide).

Bandwidth

Bandwidth, throughput, (perceived) data rate

What are the differences?

Delay

- Latency = Propagation + transmit + queue
- Propagation = distance/speed of light*
- Transmit = size/bandwidth

- One bit transmission => propagation is important
- Large bytes transmission => bandwidth is important

- *Unless the speed of transmission is otherwise specified, the speed of light is $3x10^8$ meter/second.

Round-Trip-Time (RTT)

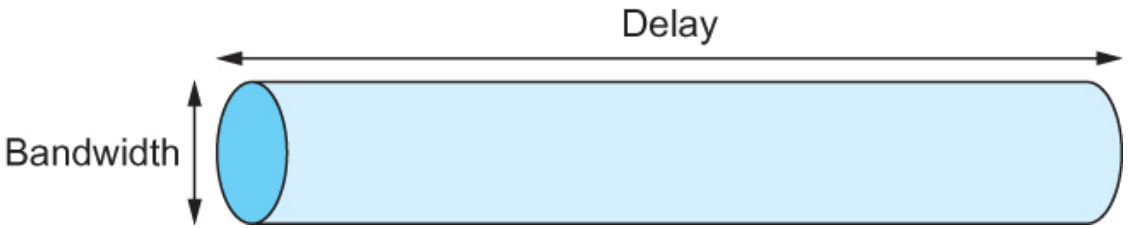
- **RTT**
  - the length of time it takes for a signal to be sent plus the length of time it takes for an acknowledgement of that signal to be received.
- **1 cross country RTT is approximately 100 milli-seconds**

Delay X Bandwidth

- We think of the channel between a pair of processes as a hollow pipe
  - Latency (delay) - length of the pipe and
  - Bandwidth (transmission rate) - the width of the pipe
- Delay of 50 ms and bandwidth of 45 Mbps

⇒ 50×10^{-3} seconds x 45×10^{6} bits/second

⇒ 2.25×10^{6} bits = 281.25×10^{3} Bytes = 274.66 KB data.



Network as a pipe

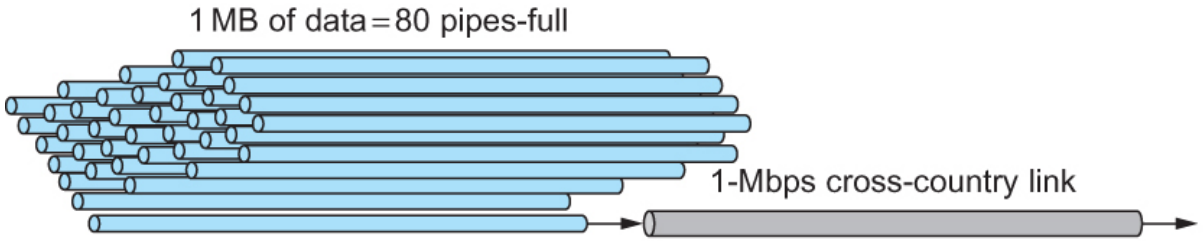
Delay X Bandwidth

- Relative importance of bandwidth and latency depends on application
  - For large file transfer, bandwidth is critical
  - For small messages (HTTP, SMS, etc.), latency is critical

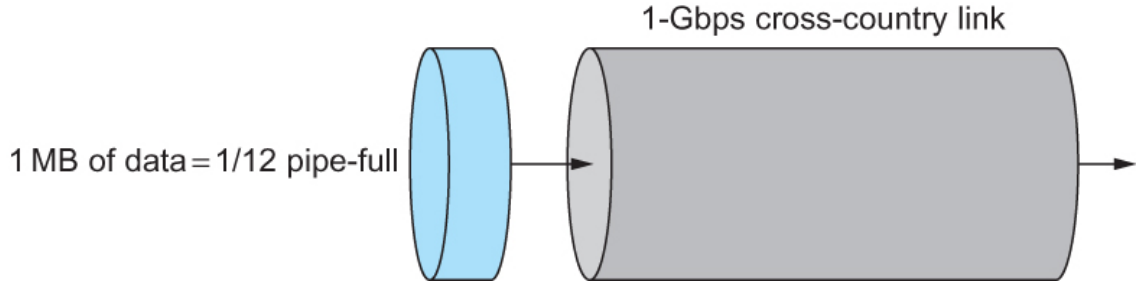
Delay X Bandwidth

How many bits the sender must transmit before the first bit arrives at the receiver if the sender keeps the pipe full.

Relationship between bandwidth and latency



1 pipe-full = Delay X BW = $1x10^6$ (0.1) = 100,000 bits
1 MB = 1024(1024)*8 bits = $8.3886x10^6$ bits = 83.9 pipe-fulls



1 pipe-full = Delay X BW = $1x10^9$ (0.1) = $1x10^8$ bits
1 MB = 1024(1024)/8 bits = $8.3886x10^6$ bits = 0.0839 pipe-fulls

A 1-MB file would fill the 1-Mbps link 80 times,
but only fill the 1-Gbps link 1/12 of one time

Other Metrics

- Reliability
  - How a connection, a device or a service is resilient to disruptions.
- Packet loss
  - Due to errors in link, buffer overflow in network devices (e.g., routers)
  - Will be covered in Chapter 6
- Number of hops

Summary

- A layered architecture for computer network;
- A network application case study from top-bottom;
- Metrics and performance for computer networks;