# Agenda and Due Dates

- Programming Assignment I (due March 29,11:59PM)
- Term Paper Email(due February 5, 11:59PM)
- Term Paper Proposal (due February 19, 11:59PM)
- **Midterm Examination (March 12)**
- Full term Paper (due May 6, 11:59PM)
- Today’s Class
  - Performance
    - Bandwidth, Latency, Delay x Bandwidth
    - In-class examples

# Programming Assignment 1

- Read the handout
- March 29,11:59PM
- Will be posted on Blackboard
- No partnering or sharing code
- Chat program based on simple client-server architecture
- No restrictions on programming language
- Be ready to demonstrate/explain code
- Max point:100
- Document your code!!!!!

# Term paper topic (Due Feb. 5)

- Example proposals posted on Blackboard
- Email your topic(s) to me for approval
  - Examples: a critique on state-of-the-art in email security, web security methods, new virus detectors, privacy issues in routing, voice over IP (from a network perspective), vulnerability analysis, new arguments, comparisons, insights, etc.
  - SPECIFICITY over GENERALITY (Introduction to cloud security, attacks on browsers and networks, introduction to social networks, introduction to routing protocols)
  - Do not choose topics that we will discuss in detail in class (for example, a term paper on routing protocols)

# Term paper proposal

- Due February 19, 11:59PM.
- Proposal only on an approved topic
- Examples posted on Blackboard
- Proposal should be at least 2 pages (and NOT more than 3 pages) in length, single-column, single-spaced, and 12 point Times New Roman font.
- Maximum points: 100 (Participation Credit)
- I have posted writing material on Blackboard
  - Please read

# Term paper proposal (cont.)

You proposal will be evaluated as follows:

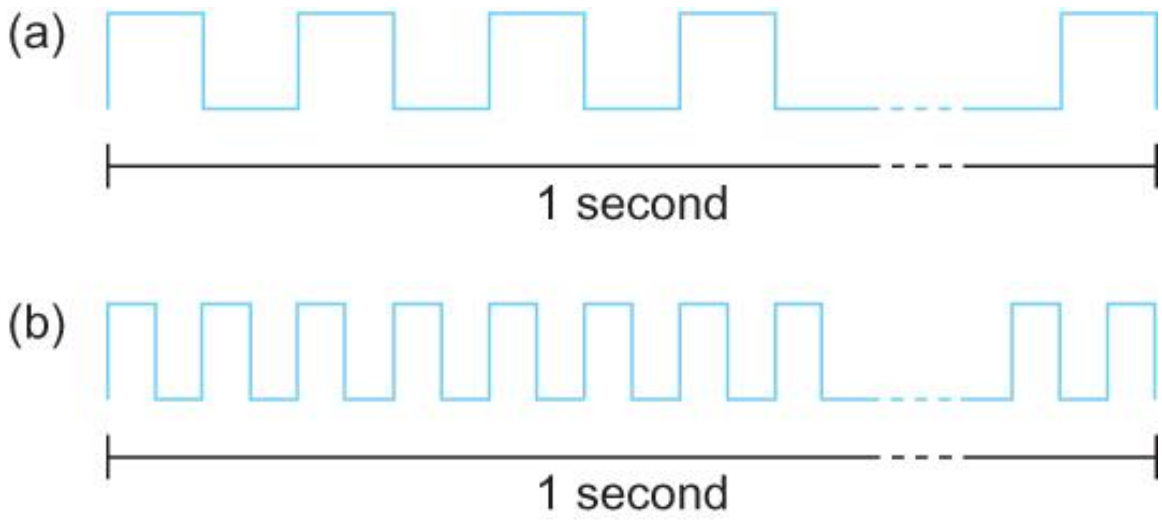
- 1) What "original or new" thoughts/arguments does the proposal investigate. How relevant is the proposed topic to the course. (25 points)
- 2) Did the author ensure that the reader clearly understands what the proposal is about? (20 points)
- 3) What is the significance of the proposed topic. Did the author justify significance? (25 points)
- 4) How well did the author organize the proposal. (20 points)
- 5) Overall writing, grammar, and spelling quality. (10 points)
- Read the material on writing, posted on Blackboard.

# Class Lecture

# 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 = $1x2^{20}$ bits/sec
- 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 transmission 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).

# Performance

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

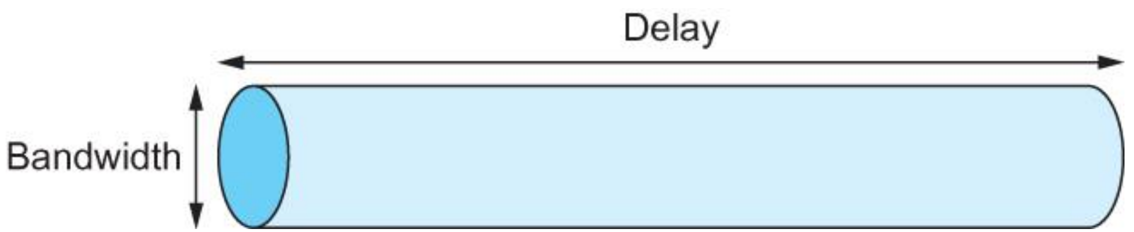
- One bit transmission => propagation is important
- Large bytes transmission => bandwidth is important

# Delay X Bandwidth

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

⇒ $50 \times 10^{-3}$ seconds x $45 \times 10^{6}$ bits/second

⇒ $2.25 \times 10^{6}$ bits = 280 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, NFS, etc.), latency is critical
  - Variance in latency (jitter) can also affect some applications (*e.g.*, audio/video conferencing)

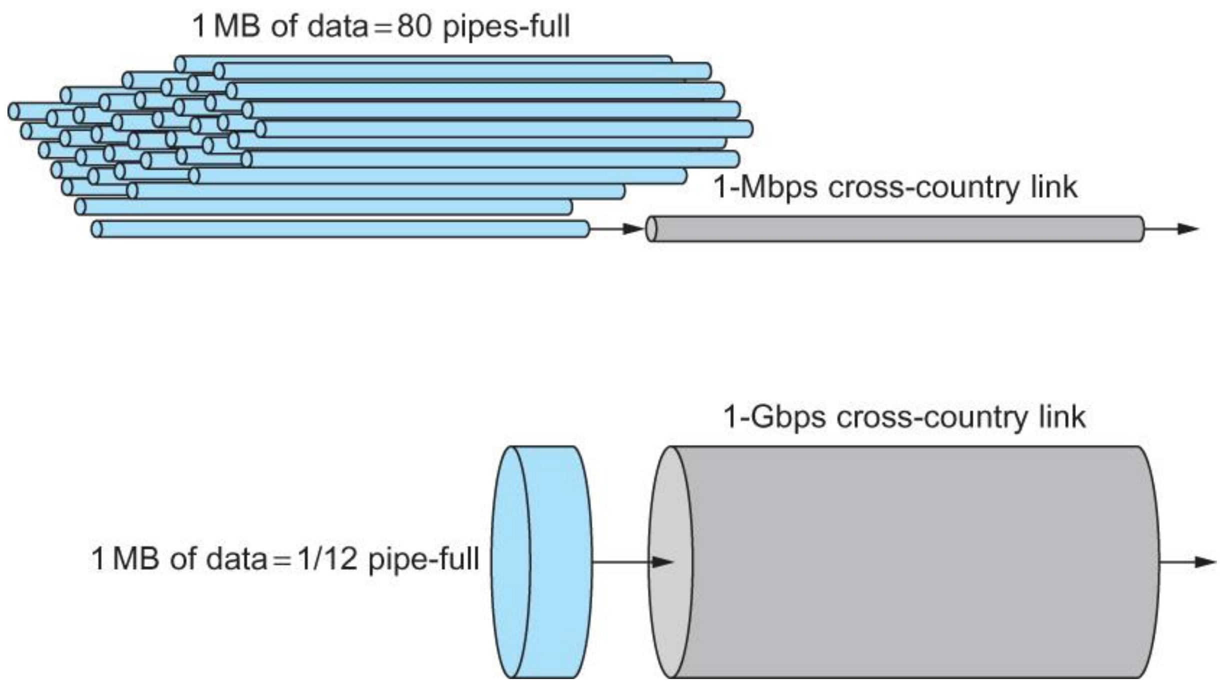
# Delay X Bandwidth

- How many bits the sender must transmit before the first bit arrives at the receiver if the sender keeps the pipe full
- Takes another one-way latency to receive a response from the receiver
- If the sender does not fill the pipe—send a whole delay × bandwidth product's worth of data before it stops to wait for a signal—the sender will not fully utilize the network

# Delay X Bandwidth

- Infinite bandwidth
  - RTT dominates
  - Throughput = TransferSize / TransferTime
  - TransferTime = RTT + 1/Bandwidth x TransferSize
- Its all relative
  - 1-MB file to 1-Gbps link looks like a 1-KB packet to 1-Mbps link

# Relationship between bandwidth and latency




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