Textbook

Computer Networks: A Top-Down Approach
Kurose and Ross
Fifth Edition

• Library has two copies on reserve
• 4th edition also ok
Teaching Staff

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Topics Covered

• How does the Internet work?
• Learn to design and analyze network infrastructure, applications and services
• Build several networked programs
  – Lots of programming!

• NOT
  – System administration
  – Network configuration
How does a message travel from me to my friend?
Homeworks

- Most of them programming assignments, approximately one per week
- C in Linux/Unix environment
- Discuss in groups, submit your own work
- Submit on Blackboard
- Late submission
  - Two days late: max(80%, your score)
  - More than two days late: 0
Exams

• Two in-class exams
• No final exam!
## Grades

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homeworks and Projects</td>
<td>55</td>
</tr>
<tr>
<td>Exams</td>
<td>40</td>
</tr>
<tr>
<td>Participation</td>
<td>5</td>
</tr>
</tbody>
</table>

Final grade curved, but modified to take into account your mastery of material
Getting Help

• General questions on Piazza
• Come to office hours
• Wikipedia / Google / YouTube

• Put COSC 4377 in subject in emails
  – Email not preferred for technical discussion
Why Study Networks?

• Critical Infrastructure for everyday life
  – How does it work?
  – What are its shortcomings?
• Most applications are networked
  – Designing and building
  – Debugging and understanding
• Internet as human right?
Disclosure

• Material will be liberally taken from the textbook, Wikipedia, and other online sources

• Some material taken from slides that come with the textbook, Rodrigo Fonseca, and many others
Course Website

http://www2.cs.uh.edu/~gnawali/courses/cosc4377-s12/
When should we have a C-programming tutorial?

Wednesday evening
Thursday evening
Today’s topics

• Networking the nodes
• Network metrics
• Protocols
The Internet

• Collection of nodes, wire and wireless technology connecting those nodes, applications and services

• Types of nodes
  – Desktops and Laptops
  – Servers
  – TV / Refrigerator
  – Cellphones
• **Goal:** Connect all the nodes to each other

• **Solutions**
  – $N^2$ cables
  – Sharing the links
    • Circuit Switching
    • Packet Switching
• Packet
  – Collection of bits to transfer across a network
  – Think: envelope and its content

• Circuit
  – Pre-allocated path/resource
Packet vs Circuit Switching

Wireless AP
Switch
Router
Circuit Switching

- Setup the connection or resource
  - Schedule (e.g., TDMA)
  - State in the network

<table>
<thead>
<tr>
<th>Time</th>
<th>Circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>T, 3T, 5T, ...</td>
<td>A-D</td>
</tr>
<tr>
<td>2T, 4T, 6T, ...</td>
<td>B-C</td>
</tr>
</tbody>
</table>
Circuit Switching

• Natural for predictable data rates
• Can guarantee certain level of service
• Can be inefficient for many applications

http://en.wikipedia.org/wiki/Circuit_switching
Some Circuit Switching Techniques

• Time
  – Reserve to use the link at a given schedule

• Frequency
  – Reserve to use certain frequencies (channel)
  – Read: http://en.wikipedia.org/wiki/Frequency-division_multiplexing
Packet Switching

- Wire is selected for each packet
- No network \textbf{state}
- Supports unpredictable / bursty traffic pattern
- Higher link utilization
- No guarantees but good enough for most applications

http://en.wikipedia.org/wiki/Packet_switching
Packet vs Circuit Switching

• Packet Switching
  – Plus: More sharing (more efficient)
  – Minus: No service guarantee

• Circuit Switching
  – Plus: Service Guarantee
  – Minus: Less sharing (less efficient)

• Every day examples
  – Road network
We will study these topics in greater detail when we study switching and routing later in the semester.
Describing a Network

• How to describe how well a network is working?
  – metrics

• Performance metrics
  – Throughput
  – Latency
  – Reliability
Throughput

- How many bytes can we send through in a given time?
  - Bytes per second
  - How many bits/s in kbps?
  - Read: http://en.wikipedia.org/wiki/Data_rate_units

- Useful bytes transferred vs overhead
  - Goodput
  - Everyday example: car vs passenger

- How do you measure throughput?
  http://en.wikipedia.org/wiki/Throughput
Latency

• How long does it take for one bit to travel from one end to the other end
  – ms, s, minutes..

• Typical latencies
  – Speed of light
  – Why is web browsing latency in seconds?
Relation between Latency and Throughput
Characterize the latency and throughput of Oil tanker, Aircraft, Car, Tractor Trailer.
• Which metrics matter most for these applications?
  – Netflix
  – Skype
  – Amazon
  – Facebook
Reliability

• How often does a network fail?
• How often do packets drop?
  – Damage (corruption)
  – Drops in the queues
• How persistent are failures?
• Typical metrics
  – uptime percentage
  – packet or bit loss rates
Protocols

• Agreed-upon rules, format, and meaning for message exchange

• Let's examine this sequence:
  – Hello
  – How are you?
  – Fine.

http://en.wikipedia.org/wiki/Communications_protocol
Network Protocols

GET FACEBOOK/profile-for-coolguy

Your Phone

OK name: cool,
year in school: 4, ...
OR
(*^*$^*&#$^%
%*$#^%*$#&

Facebook Server

What are the rules, format, and meaning in this message exchange?
Protocols and Standards

• How can your phone (HTC running Android?) access Facebook (runs on UNIX-like OS on big servers)?
• Using standard protocol enables inter-operation
• Who standardizes the protocols?
Protocol Layers

• Lower level to higher level message exchange
  – Organize the functionalities
  – Abstractions in services used and provided
• 5-7 layers depending on who you talk to
  – Physical, Link, Network, Transport, Application
• Should a smartphone app developer worry about
  – Voltages being applied on the wire
  – If the underlying media uses packet or circuit switching

Encapsulation

• Think of how paperwork is processed in a university
  – Each person processes and adds some information to it and passes it along

• On the transmitter: the lower layers include the message from upper layers, add their own information and send it along

• On the receiver: reverse