15-744: Computer Networking

L-1 Intro to Computer Networks

Outline

- Administrivia
- Layering

Who's Who?

- Professor: Peter Steenkiste
  - http://www.cs.cmu.edu/~prs
  - prs@cs.cmu.edu
- TA:
  - Matt Mukerjee
  - David Naylor
- Course info
  - http://www.cs.cmu.edu/~prs/15-744-F12
- Office hours: TBD

Objectives

- Understand the state-of-the-art in network protocols, architectures and applications
- Understand how networking research is done
  - Teach the typical constraints and thought processes used in networking research
- How is this course different from undergraduate networking (15-441)?
  - Training network programmers vs. training network researchers

Web Page

- Check regularly!!
  - Content is updated as semester progresses
- Course schedule
- Reading list
- Lecture notes
- Announcements
- Assignments
- Project ideas
- Exams

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Course Schedule

- We will have one lecture each of the first two weeks of the semester
  - Wednesday, 3:50-5pm
- We will start the regular schedule in week 4
- The first part of the semester we will have three lectures per week
  - Fewer or no lectures in the last few weeks of the semester – better load distribution
  - I will also use slack to work around travel

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Course Materials

- Research papers
  - Links to ps or pdf on Web page
  - Combination of classic and recent work
  - ~40 papers
  - Optional readings
- Recommended textbooks
  - For students not familiar with networking
  - Peterson & Davie or Kurose & Ross
- A couple of background lectures

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Class Coverage

- Little coverage of undergraduate material
  - Students expected to know this
  - Especially true for physical and data link layer
- Focus on network to application layer
- We will deal with:
  - Protocol rules and algorithms
  - Investigate protocol trade-offs
  - Why and when this way and not another?

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Lecture Topics

Traditional

- Layering
- Internet architecture
- Routing (IP)
- Transport (TCP)
- Naming (DNS)
- Mobility/wireless

Recent Topics

- Machine rooms
- Security
- Overlay networks
- P2P applications
- Future Internet
- Topology

+ 2-3 TBD slots

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Lectures Format

- Lectures include an overview and discussion of the research papers
- To prepare for the lectures, you must read the assigned papers before the lecture
- You must also comment on the paper and review other people's comments
  - Affects part of your grade
- The goal is to learn to critique and appreciate systems papers
  - Try to be positive…
  - Why or why not keep this paper in syllabus?
  - What issues are left open for future research?
  - What are the important implications of the work?
  - What would you have done differently?

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Discussion Site

- For each lecture, post a brief comment about the assigned paper:
  - You should do this by 5pm the day before the lecture
  - Write access is removed at 5pm
  - Also read the other comments
- The discussion site is:
  http://sourcery.cmcl.cs.cmu.edu:4000/
  - Please visit this web site to create an account. Open the collection CMU 15-744: Computer Networks -- Fall 12. You should then add yourself to the collection using the subscription code: <<ask instructor>>

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Student Presentation

- Each student will present a 15 minute presentation based on one of the papers
  - Complements the course material
  - Looking at related work, put within the context of the lecture, contrast with other readings, etc.
  - Lead a discussion
  - Slides are part of the course content
- Goals are …
  - Develop a deeper understanding of one of the course topics
  - Gain experience in giving short talks

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Projects

- The goal of the project is to give you a taste of systems research in a networking context
  - Emphasis on the word “research”
- Teams of 2-3 students
- Proposal is due on September 26
- You should be very proactive – start today!
  - Example topics on course web page – will be updated
  - Use our office hours for brainstorming

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Homework 0

- Respond to my e-mails asking for:
  - 4 lecture choices for presentation
  - 2-3 topic choice for TBD lectures
  - 1 sentence version of project interest & list of project partner
    - E.g., I want to apply game theory to network routing.
- Register on discussion site
  - Post comments for 1st two papers

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Grading

- Homework assignments (15%)
  - 4 Problem sets
- Class + discussion site participation (15%)
- Midterm exam + final exam (35%)
  - Closed book, in-class
- 2 or 3 person project (35%)
  - Main focus of class work
  - Make project productive for you!

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Outline

- Administrivia
- Layering

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This/Next Lecture: Design Considerations

- How to determine split of functionality
  - Across protocol layers
  - Across network nodes
- Assigned Reading
  - [SRC84] End-to-end Arguments in System Design
  - [Cla88] Design Philosophy of the DARPA Internet Protocols
- Optional Reading
  - [CT90] Architectural Considerations for a New Generation of Protocols

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What is the Objective of Networking?

- Communication between applications on different computers
- Must understand application needs/demands
  - Traffic data rate
  - Traffic pattern (bursty or constant bit rate)
  - Traffic target (multipoint or single destination, mobile or fixed)
  - Delay sensitivity
  - Loss sensitivity

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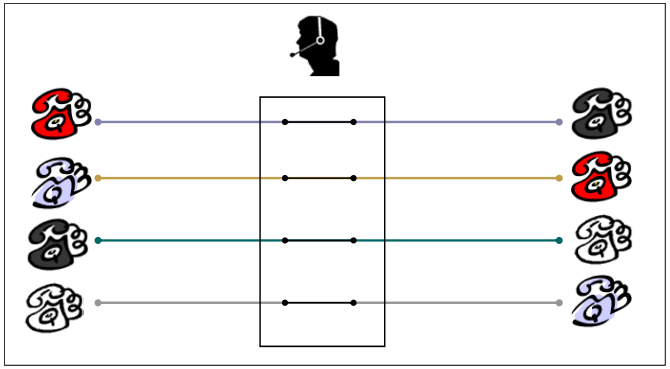
Back in the Old Days…



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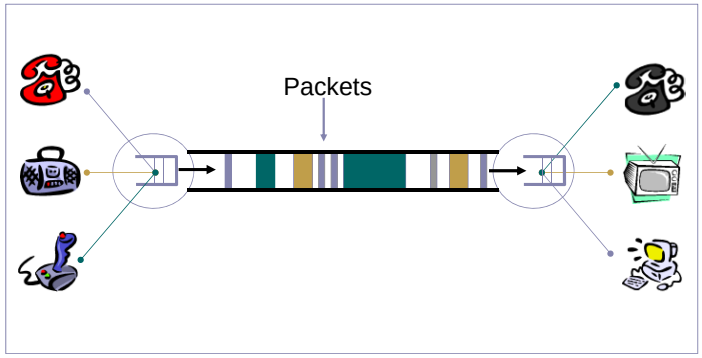
Packet Switching (Internet)



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Packet Switching

Positives

- Interleave packets from different sources
- Efficient: resources used on demand
  - Statistical multiplexing
- General
  - Multiple types of applications
- Allows for bursty traffic
  - Addition of queues

Challenges

- Store and forward
  - Packets are self contained units
  - Can use alternate paths – reordering
- Contention
  - Congestion
  - Delay

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Challenge

- Many differences between networks
  - Address formats
  - Performance – bandwidth/latency
  - Packet size
  - Loss rate/pattern/handling
  - Routing
- How to translate between various network technologies?

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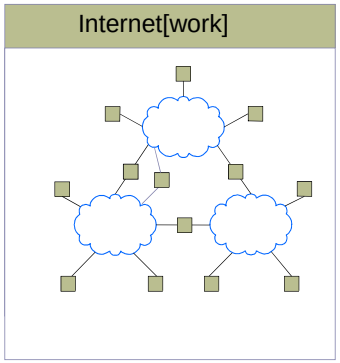
Internet[work]

- A collection of interconnected networks
- Host: network endpoints (computer, PDA, light switch, …)
- Router: node that connects networks
  - How do we translate?



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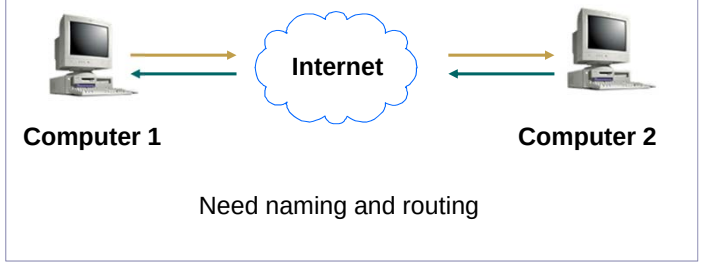
How To Find Nodes?



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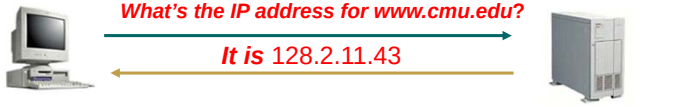
Naming



Translates human readable names to logical endpoints

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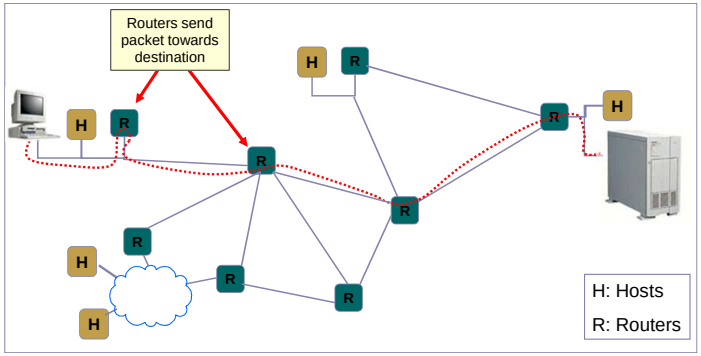
Routing



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Meeting Application Demands

- Reliability
  - Corruption
  - Lost packets
- Flow and congestion control
- Fragmentation
- In-order delivery
- Etc…

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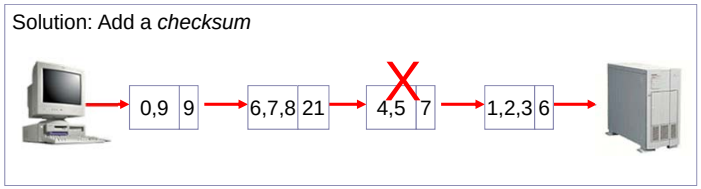
What if the Data gets Corrupted?



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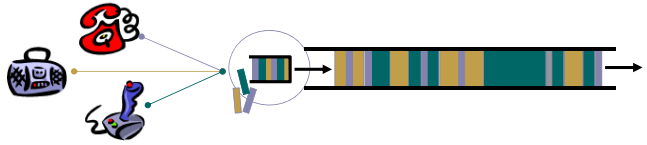
What if Network is Overloaded?

Problem: Network Overload



Solution: Buffering and Congestion Control

- Short bursts: buffer
- What if buffer overflows?
  - Packets dropped
  - Sender adjusts rate until load = resources → "congestion control"

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What if the Data gets Lost?

Problem: Lost Data

Solution: Timeout and Retransmit

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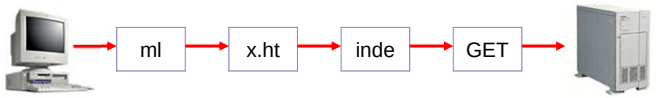
What if the Data Doesn't Fit?

Problem: Packet size

- On Ethernet, max IP packet is 1.5kbytes
- Typical web page is 10kbytes

Solution: Fragment data across packets



GET index.html

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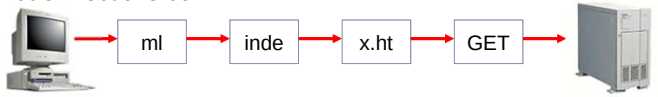
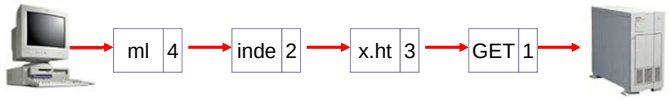
What if the Data is Out of Order?

Problem: Out of Order



GET x.htindeml

Solution: Add Sequence Numbers



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Lots of Functions Needed

- Link
- Multiplexing
- Routing
- Addressing/naming (locating peers)
- Reliability
- Flow control
- Fragmentation
- Etc….

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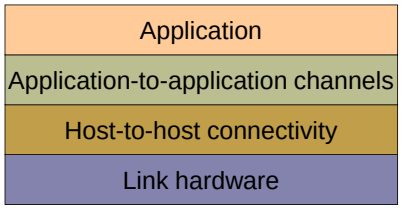
What is Layering?

- Modular approach to network functionality
- Example:



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Protocols

- Module in layered structure
- Set of rules governing communication between network elements (applications, hosts, routers)
- Protocols define:
  - Interface to higher layers (API)
  - Interface to peer
    - Format and order of messages
    - Actions taken on receipt of a message

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Layering Characteristics

- Each layer relies on services from layer below and exports services to layer above
- Interface defines interaction
- Hides implementation - layers can change without disturbing other layers (black box)

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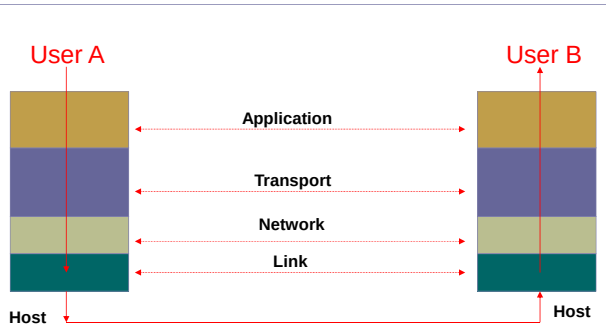
Layering



Layering: technique to simplify complex systems

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E.g.: OSI Model: 7 Protocol Layers

- Physical: how to transmit bits
- Data link: how to transmit frames
- Network: how to route packets
- Transport: how to send packets end2end
- Session: how to tie flows together
- Presentation: byte ordering, security
- Application: everything else

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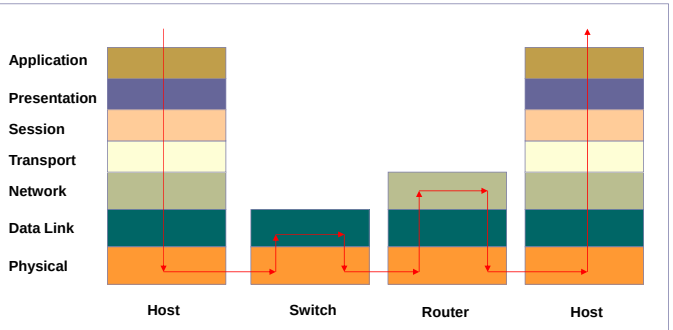
OSI Layers and Locations



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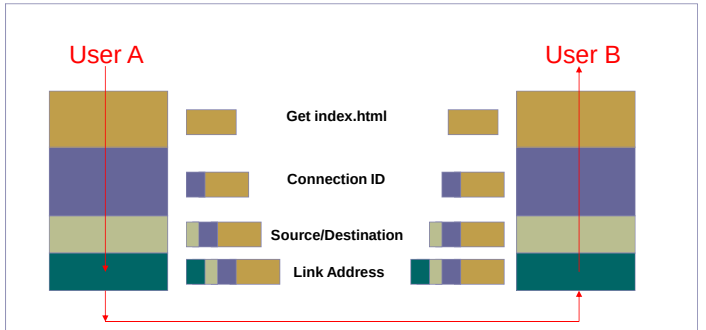
Layer Encapsulation



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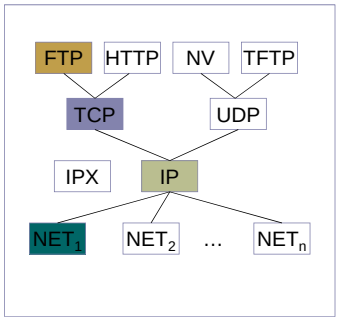
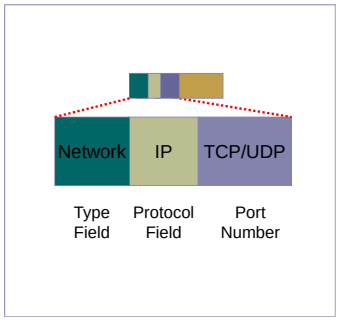
Protocol Demultiplexing

- Multiple choices at each layer





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Is Layering Harmful?

- Sometimes..
  - Layer N may duplicate lower level functionality (e.g., error recovery)
  - Layers may need same info (timestamp, MTU)
  - Strict adherence to layering may hurt performance

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Next Lecture: Design Considerations

- How to determine split of functionality
  - Across protocol layers
  - Across network nodes
- Assigned Reading
  - [SRC84] End-to-end Arguments in System Design
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- Optional Reading
  - [CT90] Architectural Considerations for a New Generation of Protocols

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