# 15-744: Computer Networking

L-1 Intro to Computer Networks

## Outline

- Administrivia
- Layering



## Who's Who?

- Professor: Srinivasan Seshan
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- TA: Xi Liu
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- Course info
  - http://www.cs.cmu.edu/~srini/15-744/F10/



## 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 class different from undergraduate networking (15-441)
  - Training network programmers vs. training network researchers

## Web Page

- Check regularly!!
- Course schedule
- Reading list
- Lecture notes/**videos**
- Announcements
- Assignments
- Project ideas
- Exams

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## Discussion Site

- http://sourcery.cmcl.cs.cmu.edu:4000/
  - Please visit http://sourcery.cmcl.cs.cmu.edu:4000/ and create an account. Open the collection CMU 15-744: Computer Networks -- Fall 10. You should then add yourself to the collection using the subscription code: ”15744”

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## Discussion Site

- For each lecture, post a brief comment about each paper:
  - Since I would like to read the reviews before the lecture, you should have this done by 5pm the day before the lecture.
  - 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 have done differently?
- Each student will present a 10 minute broader critique in class once this semester and post longer “public” review once
  - Looking at related work, etc.
  - Email signup

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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

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## Grading

- Homework assignments (15%)
  - 4 Problem sets & hands-on assignments
- Class + discussion site participation (10%)
- Midterm exam + final exam (35%)
  - Closed book, in-class
- 2 or 3 person project (40%)
  - Main focus of class work
  - Make project productive for you!

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## Class Coverage

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

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## Lecture Topics

**Traditional**

- Layering
- Internet architecture
- Routing (IP)
- Transport (TCP)
- Queue management (FQ, RED)
- Naming (DNS)

**Recent Topics**

- Machine rooms
- Mobility/wireless
- QoS
- Security
- Network measurement
- Overlay networks
- P2P applications

+ 2 TBD slots

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## Homework 0

- Email xil@cs.cmu.edu & srini@cs.cmu.edu
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- 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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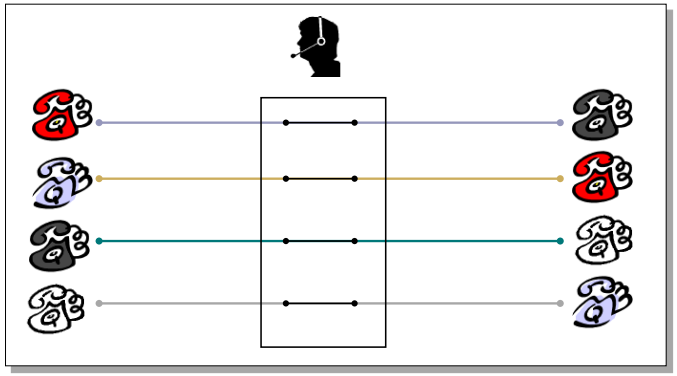
## Back in the Old Days…



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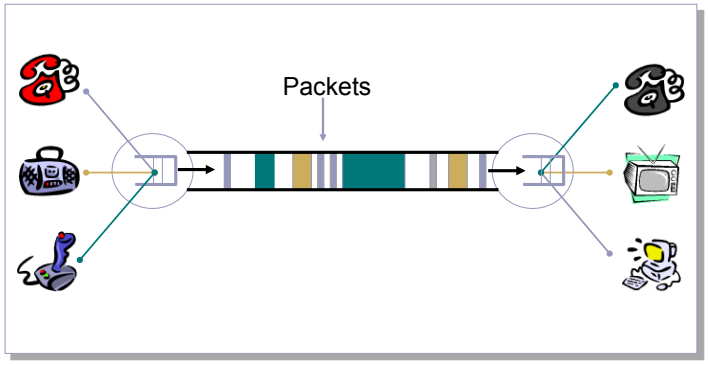
## Packet Switching (Internet)

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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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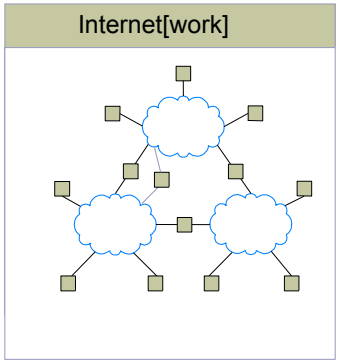
## Internet[work]

- 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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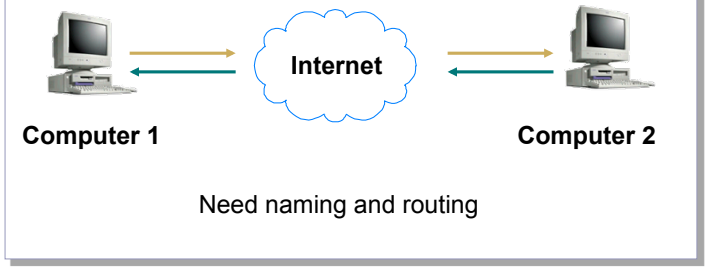
## How To Find Nodes?




Need naming and routing

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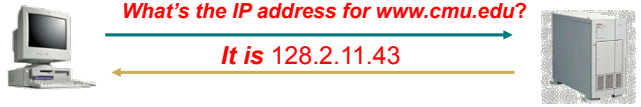
## Naming




Translates human readable names to logical endpoints

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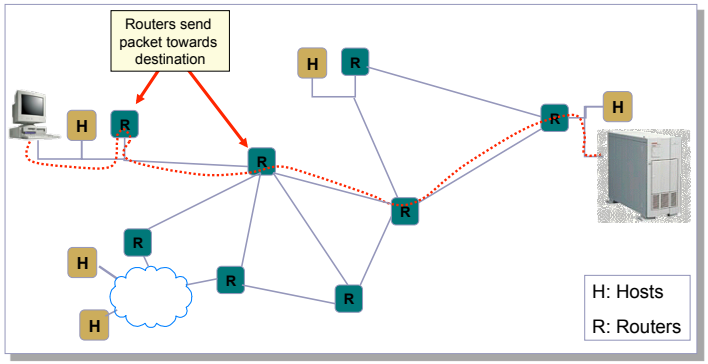
## Routing

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## Meeting Application Demands

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

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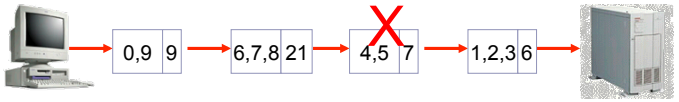
## What if the Data gets Corrupted?

Problem: Data Corruption


Solution: Add a *checksum*

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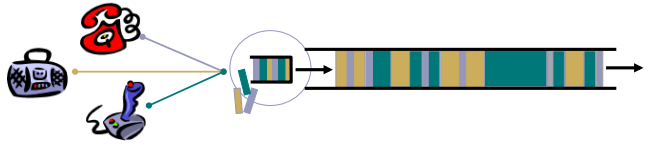
## What if Network is Overloaded?

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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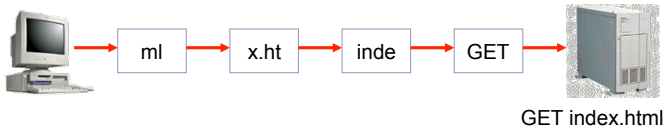
## What if the Data Doesn't Fit?

Problem: Packet size

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

Solution: Fragment data across packets

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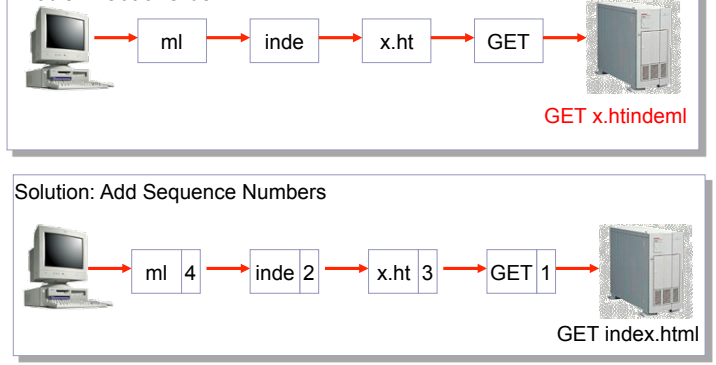
## What if the Data is Out of Order?

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## Lots of Functions Needed

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

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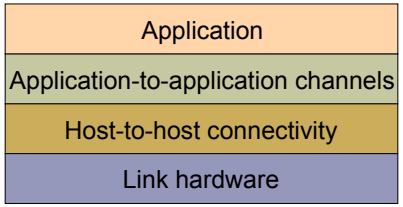
## What is Layering?

- 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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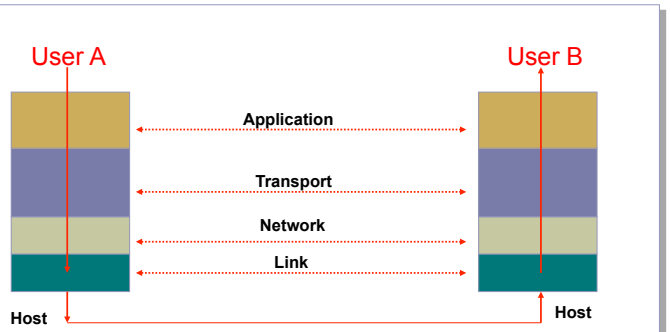
## Layering




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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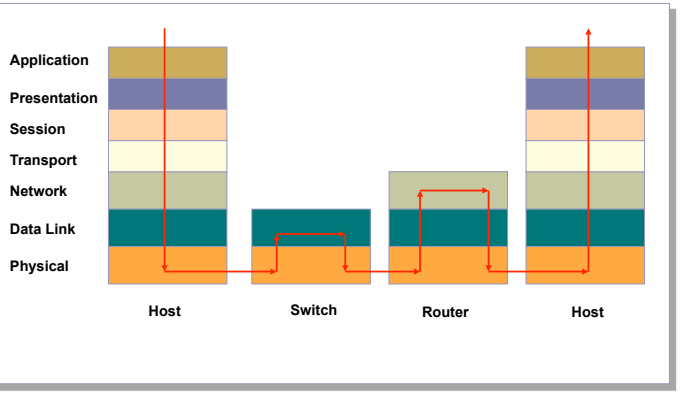
## OSI Layers and Locations

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## 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

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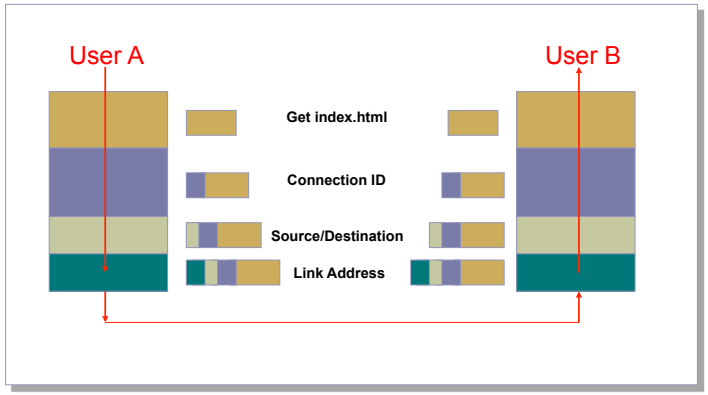
## Layer Encapsulation

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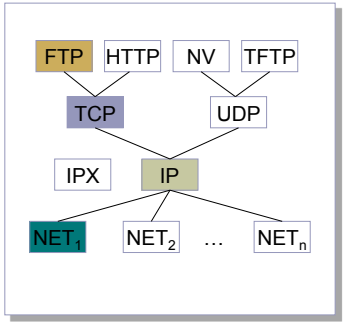
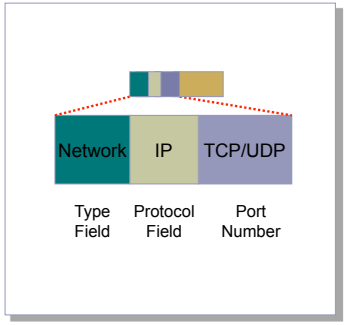
## Protocol Demultiplexing

- Multiple choices at each layer

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