CS 640: Introduction to Computer Networks

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Lecture 1
Introduction

http://www.cs.wisc.edu/~akella/CS640/F07

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Goals of This Class

- Understand principles and practice of networking
- How are modern networks designed? Operated? Managed?
- Performance and design trade-offs in network protocols and applications
- How do network applications work? How to write applications that use the network?
  - Hands-on approach to understand network internals
- How will different aspects of networking evolve in the future?

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Goal of Networking

- Enable *communication* between *network applications* on different *end-points*
  - End-points? computers, cell phones….
  - Application? Web, Peer to Peer, Streaming video, IM
  - Communication? transfer bits or information across a "network"
- Network must understand application needs/demands
  - What data rate?
  - Traffic pattern? (bursty or constant bit rate)
  - Traffic target? (multipoint or single destination, mobile or fixed)
  - App sensitivity? (to delay, "jitter", loss)
  - Difficulty: Network may not know these in the first place!
- How does the application "use" the network?
  - Peer to peer: how to find nearest host
  - Web: how to modulate sending rate? Coexist with other users/apps?

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Defining a "Network"

- Network = nodes + links
  - Will build on this soon
- Intentionally vague. There are several different networks:
  - The Internet
  - Wisc CS network
  - Telephone network
  - Home wireless networks
  - Others – sensor nets, "On Star", cellular networks
- Our focus on Internet
  - Also explore important common issues and challenges

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Challenges for Networking

- Accommodate different geographic scopes
  - The Internet vs. home network
- Enable scale
  - CS network vs. the Internet
- Seamlessly integrate different application types
  - Email vs. video conferencing
- Independent administration and Trust
  - Corporate network – owned by one entity
  - Internet owned and managed by 17,000 network providers
    - Independent, conflicting interests

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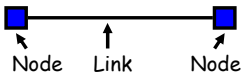
Network Building Block: Links



- "Physical"-layer questions
  - Wired or wireless
  - Voltage (Electrical) or wavelength (optical)
- "Link"-layer issues: How to send data?
  - Medium access – can either side talk at once?
  - Data format?

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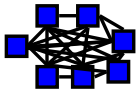
Basic Building Block: Links

- … But what if we want more hosts?



Wires for everybody?

How many wires?

- How many additional wires per host?
- Scalability?

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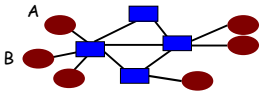
Key Idea: Multiplexing

- Multiplex: share network resources
  - Resources need "provisioning"
  - Grow at slower rate than number of nodes



- How to share? Switched network
  - Party "A" gets resources sometimes
  - Party "B" gets them sometimes
- Interior nodes act as "Switches"

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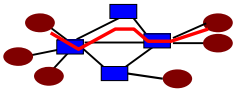
Circuit Switching

- Source first establishes a circuit to destination
  - Switches along the way stores info about connection
    - Possibly allocate resources
    - Different srs-dst's get different paths



- Source sends the data over the circuit
  - No address required since path is established beforehand
- The connection is explicitly set up and torn down
- Switches use TDM (digital) or FDM (analog) to transmit data from various circuits

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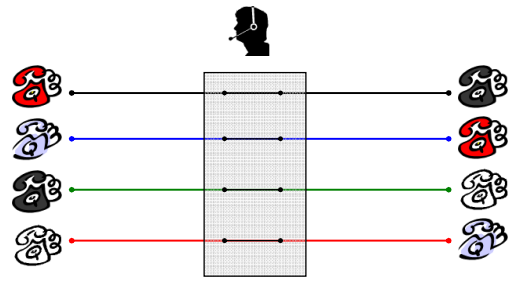
Switching in the Telephone Network



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Circuit Switching Discussion

- Positives
  - *Fast and simple* data transfer, once the circuit has been established
  - Predictable performance since the circuit provides *isolation* from other users
    - E.g. guaranteed max bandwidth
- Negatives
  - How about bursty traffic
    - Circuit will be idle for significant periods of time
    - Also, can't send more than max rate
  - Circuit set-up/tear down is expensive
  - Also, reconfiguration is slow
    - Fast becoming a non-issue

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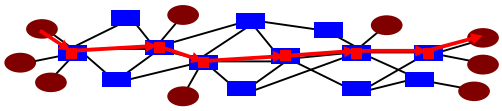
Packet Switching

- Source sends information as self-contained packets
  - Packets have an address.
  - Source may have to break up single message in multiple packets
- Packets travel independently to the destination host
  - Switches use the address in the packet to determine how to forward the packets
  - "Store and forward"
- Analogy: a letter in surface mail



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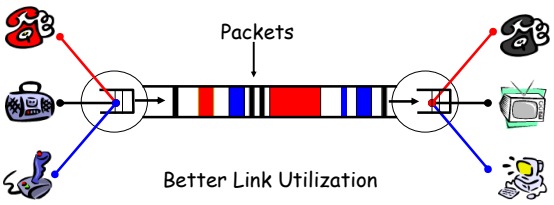
Benefits of Statistical Multiplexing

TDM: Flow gets chance in fixed time-slots

SM: Flow gets chance on demand; no need to wait for slot



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Packets vs. Circuits

- Efficient
  - Can send from any input that is ready
  - No notion of wastage of resources that could be used otherwise
- Contention (i.e. no isolation)
  - Congestion
  - Delay
- Accommodates bursty traffic
  - But need packet buffers
- Address look-up and forwarding
  - Need optimization
- Packet switching pre-dominant
  - Circuit switching used on large time-scales, low granularities

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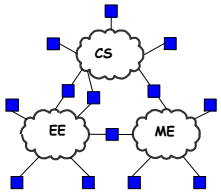
Internetwork

- A collection of interconnected networks
- **Networks**: Different depts, labs, etc.
- **Router**: node that connects distinct networks
- **Host**: network endpoints (computer, PDA, light switch, …)
- Together, an independently administered entity
  - Enterprise, ISP, etc.

Internet[work]



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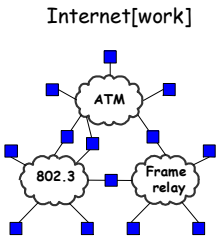
Internetwork Challenges

- Many differences between networks
  - Address formats
  - Performance – bandwidth/latency
  - Packet size
  - Loss rate/pattern/handling
  - Routing
- How to translate and inter-operate?
  - Routers are key to many of these issues



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"The Internet"

- Internet vs. internet
- The Internet: the interconnected set of networks of the Internet Service Providers (ISPs) and end-networks, providing data communications services.
  - Network of internetworks, and more
  - About 17,000 different ISP networks make up the Internet
  - Many other "end" networks
  - 100,000,000s of hosts

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Internet Design Issues

- Extra Slides…
  - We will cover these topics in greater detail in future lectures

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Some Key "Internet" Design Issues

Computer 1 Computer 2

Need:
(1) naming,
(2) addressing and
(3) routing
(4) ...

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Key Issues: Naming/Addressing

Computer 1 Local DNS Server

Translates human readable names to logical endpoints

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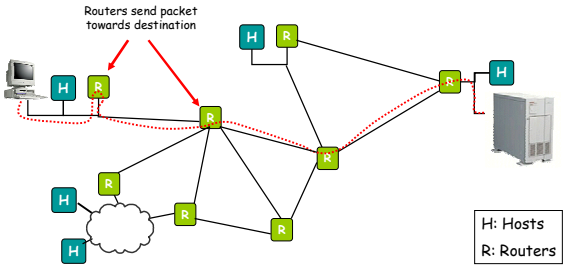
Key Issues: Routing



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Key Issues: Network Service Model

- What is the *service model?*
  - Defines what to expect from the network
  - ***Best-effort:*** packets can get lost, no guaranteed delivery
- What if you want more?
  - Performance guarantees (QoS)
  - Reliability
    - Corruption
    - Lost packets
  - In-order delivery for file chunks
  - Etc…

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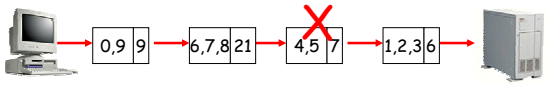
What if the Data gets Corrupted?

Problem: Data Corruption

Solution: Add a *checksum*



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What if the Data gets Lost?

Problem: Lost Data

Solution: Timeout and Retransmit

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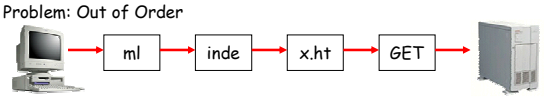
What if Data is Out of Order?

Problem: Out of Order



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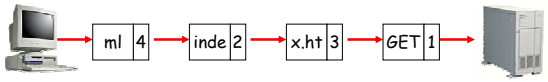
Solution: Add Sequence Numbers



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Meeting Application Demands

- Sometimes network can do it
  - E.g., Quality of Service
    - Benefits of circuit switching in packet-switched net
    - Hard in the Internet, easy in restricted contexts
    - Lecture 20
- OR hosts can do it
  - E.g., end-to-end *Transport protocols*
    - TCP performs end-to-end retransmission of lost packets to give the illusion of a reliable underlying network.
    - Lectures 16-19

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To Summarize…

Networks implement many functions

- Links
- Sharing/Multiplexing
- Routing
- Addressing/naming
- Reliability
- Flow control
- Fragmentation
- Etc….

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