CSC 450 – COMPUTER NETWORKS

Lecture 1

Introduction to Computer Networks

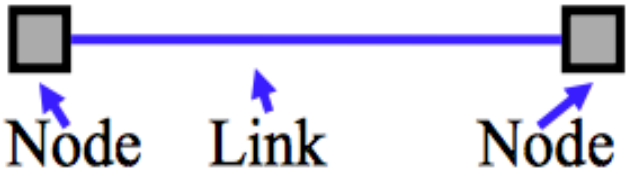
Recap: What is a Network?

- Collection of nodes and links that connect them.
- This is vague. Why? Consider different networks:
  - Internet
  - Telephone / cell phone
  - Sensor Networks

Recap: How to Draw a Network

Recap - Basic Building Block: Link

- Electrical questions
  - Voltage, frequency,…
  - Wired or wireless

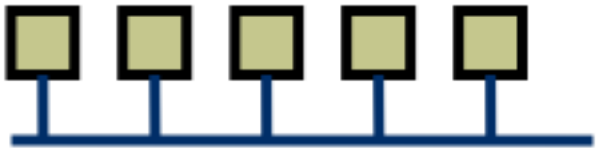


- Link-layer issues: How to send data?
  - When to talk – can either side talk at once?
  - What to say – low-level format?

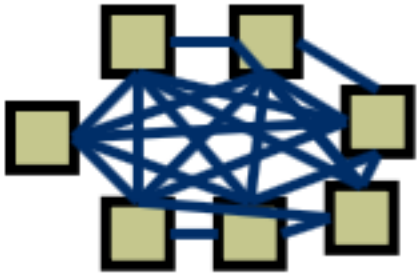
- Okay…what about more nodes?

Basic Building Blocks: Links

- … But what if we want more hosts?



One wire



Wires for everybody!

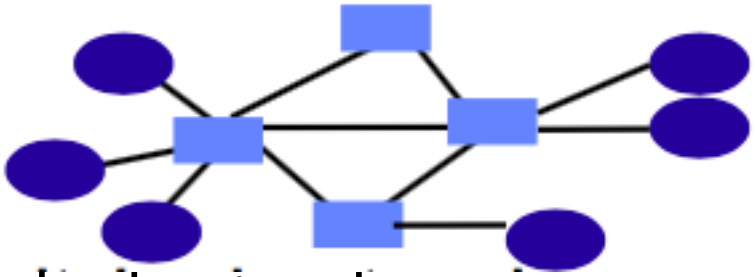
- Scalability

Local Area Networks (LANs)

- Benefits of being “local”:
  - Lower cost
  - Short distance = faster links, low latency
    - Efficiency less pressing
  - One management domain
  - More homogenous
- Examples:
  - Ethernet
  - Token ring, Fiber distributed data interface (FDDI)
  - 802.11 wireless

Multicasting

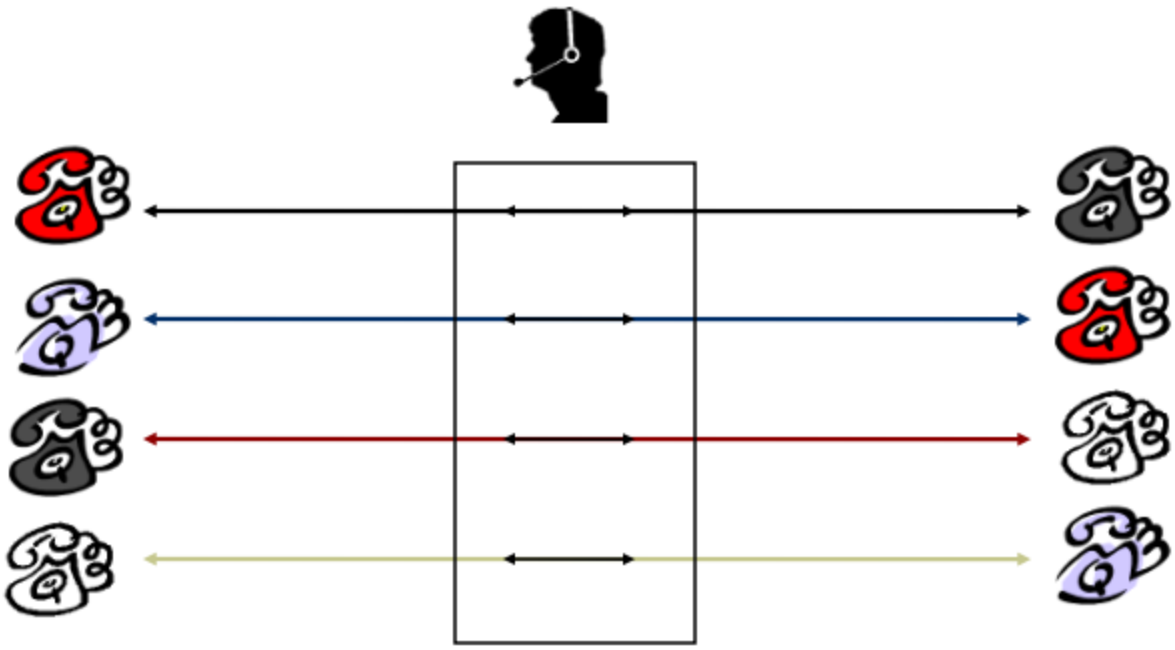
- Need to share network resources



- How? --- Switched network
  - Party “A” gets resources sometimes
  - Party “B” gets them sometimes
- Interior nodes act as “switches”

- What mechanisms to share resources?

Back in the old days….



Circuit Switching

- Source first establishes a connection (circuit) to the destination
  - Each switch along the way stores information about the connection (and possibly allocates resources)
- Source sends the data over the circuit
  - No need to include the destination address with the data since the switches know the path
- The connection is explicitly torn down
- Example: telephone network (analog)

Circuit Switching Discussion

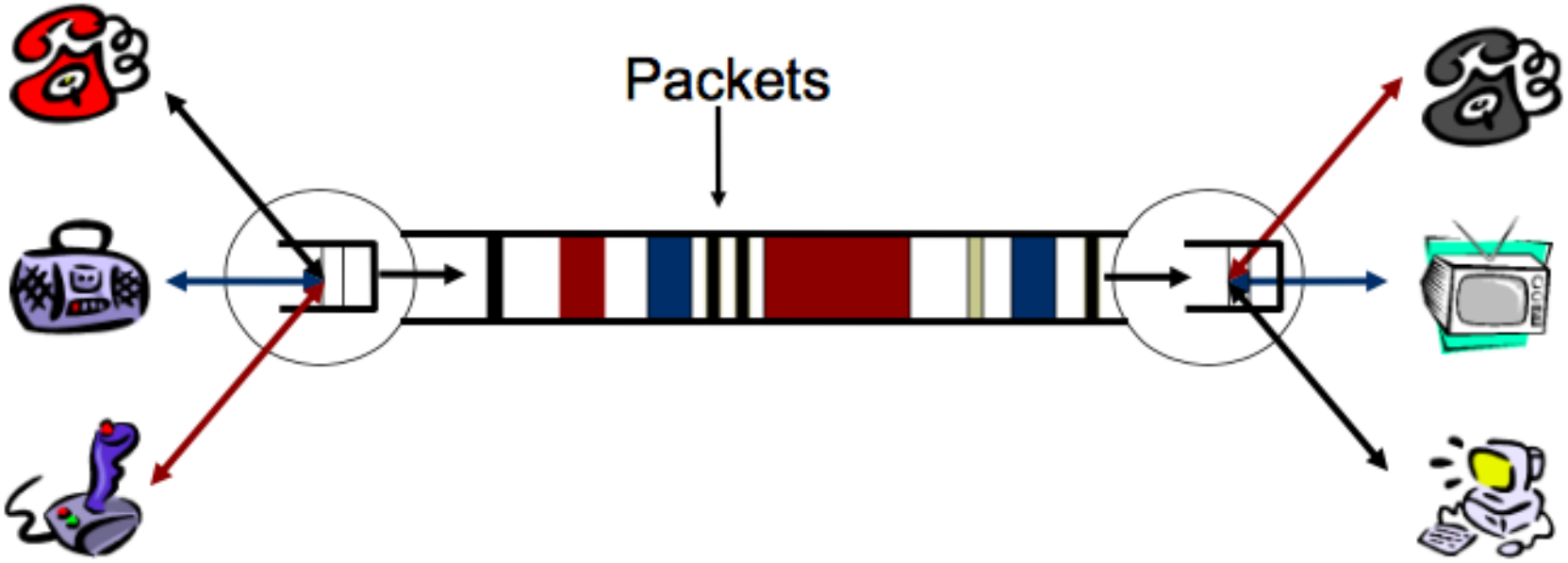
- Circuits have some very attractive properties.
  - Fast and simple data transfer, once the circuit has been established
  - Predictable performance since the circuit provides isolation from other users
  - Eg. Guaranteed bandwidth.
- But it also has some shortcomings
  - How about bursty traffic
    - Circuit will be idle for significant periods of time
  - How about users with different bandwidth needs
    - Do they have to use multiple circuits
- Alternative: packet switching

Packet Switching (our emphasis)

- Source sends information as self-contained packets that have an address
  - Source may have to break up single message in multiple
- Each packet travels 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

Packet Switching – Statistical Multiplexing

- Switches arbitrate between inputs
- Can send from any input that's ready
  - Links never idle when traffic to send.
  - (Efficiency!)



Packet Switching Discussion

- Efficient
  - Can send from any input that is ready
- General
  - Multiple types of applications
- Accommodates bursty traffic
  - Addition of queues
- Store and forward
  - Packets are self contained units
  - Can use alternate paths – reordering
- Contention (i.e. no isolation)
  - Congestion
  - Delay

Networks Juggle Many Goals

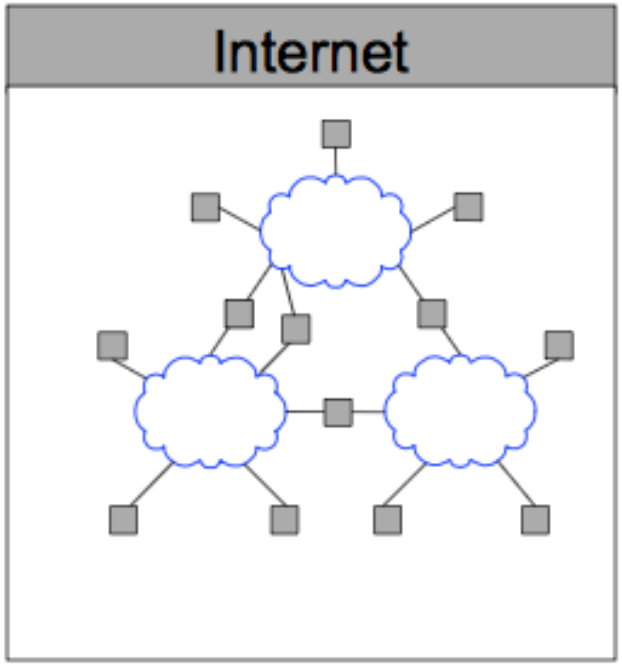
- Efficiency – resource use; cost
- The “ilities”:
  - Reliability
  - Manageability
  - Security (securability, if you must)
  - Ease of:
    - Creation
    - Deployment
    - Creating useful applications
  - Scalability

Challenges for Networks

- Geographic scope
  - The Internet vs LAN
- Scale
  - The Internet vs. your home network
- Application types
  - Email vs. video conferencing
- Trust and Administration
  - Corporate network – one network “provider”
  - Internet – 17,000 network providers

Internet

- An inter-net: a network of networks
  - Networks are connected using routers that support communication in a hierarchical fashion
  - Often need other special devices at the boundaries for security, accounting,…
- The Internet: the interconnected set of networks of the Internet Service Providers (ISPs)
  - About 17,000 different networks make up the Internet



Challenges of the Internet

- Heterogeneity
  - Address formats
  - Performance – bandwidth/latency
  - Packet size
  - Loss rate / pattern / handling
  - Routing
  - Diverse network technologies → satellite links, cellular links, carrier pigeons

Challenges of the Internet

- Scale
  - 100,000,000s of hosts
  - 17,000 + administrative domains,
  - Thousands of applications
- Adversarial environment
- On, and let’s make it easy to use…

- How to translate between various network technologies?

Internet Design

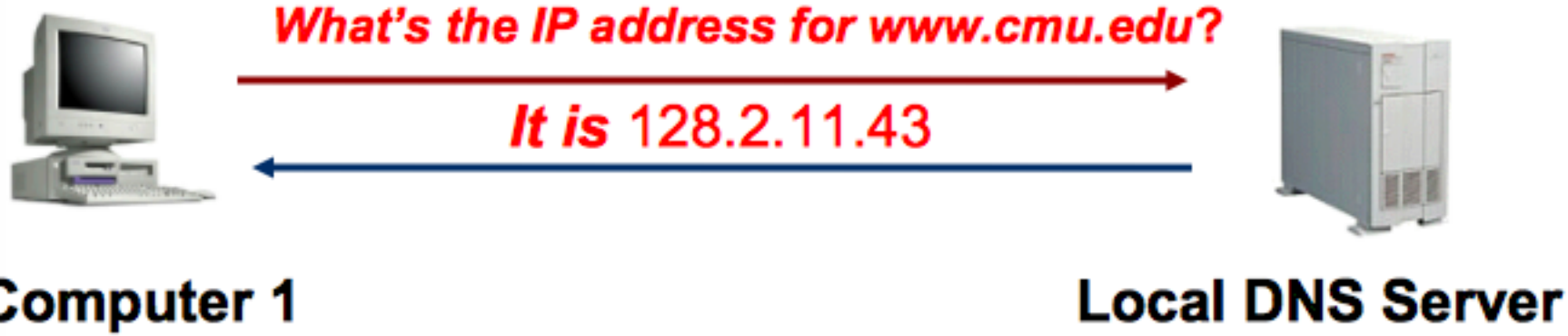
- In order to inter-operate, all participating networks have to follow a common set of rules

- E.g., requirements for packets:
  - Header information: Addresses, etc.
  - Data: What is packet size limit?

How to Find Nodes?

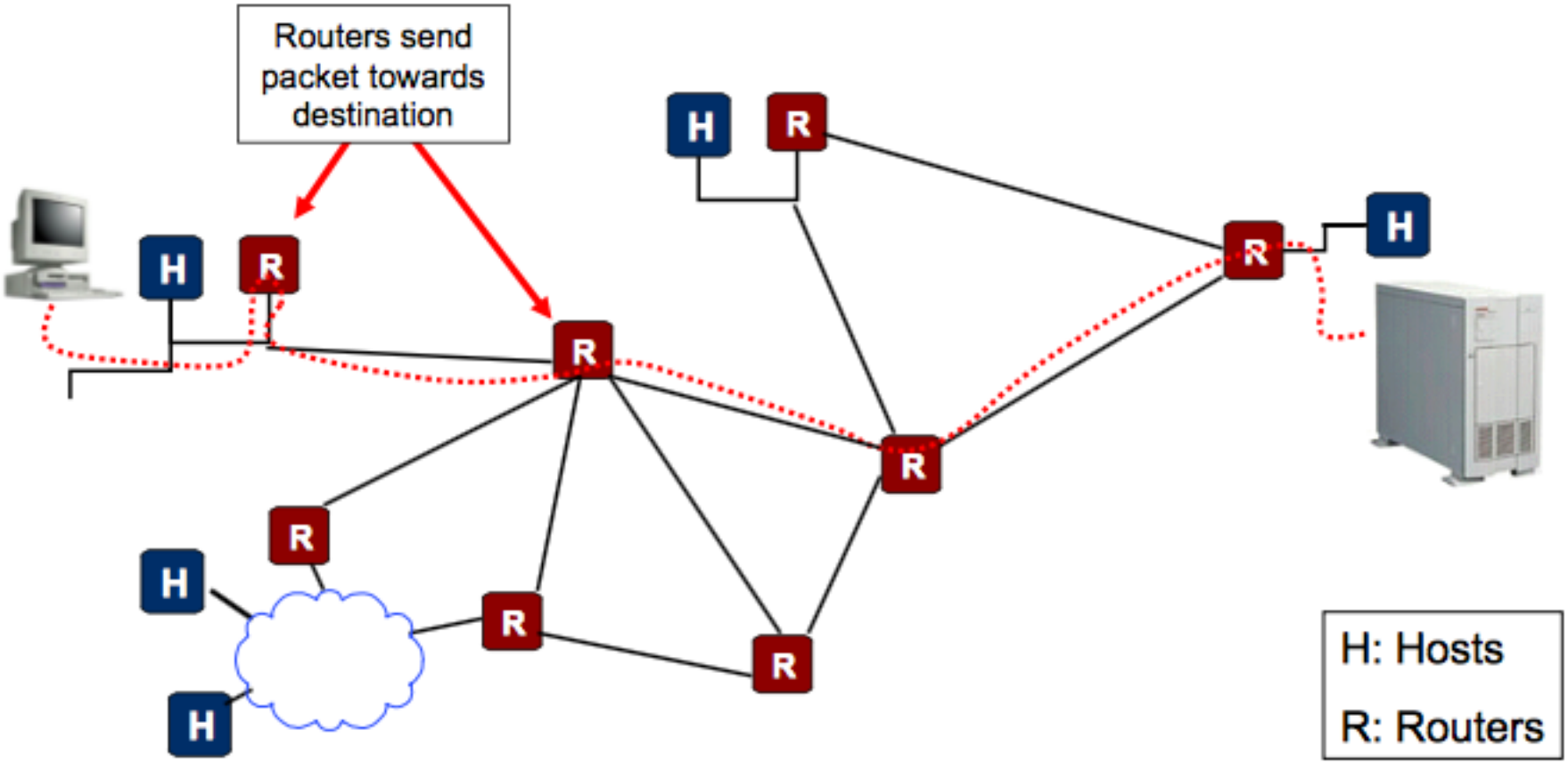
Need naming and routing

Naming



Translates human readable names to logical endpoints

Routing


Routers send packet towards destination
H
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H: Hosts
R: Routers

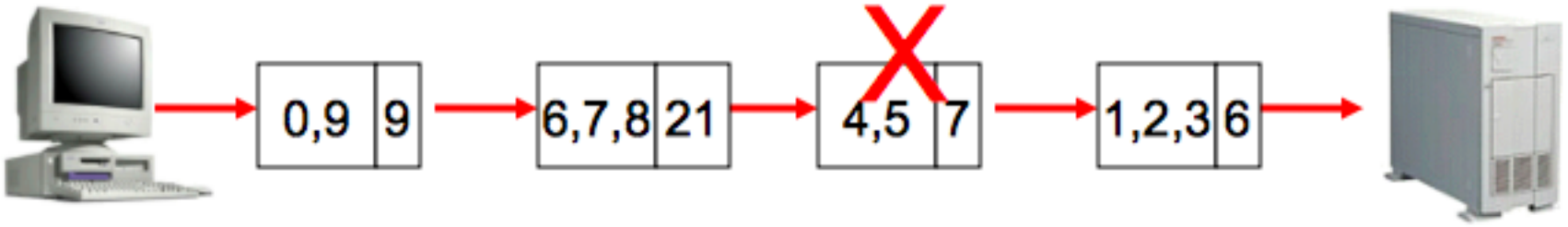
Network Service Model

- What is the service model?
  - Ethernet / Internet: best-effort – packets can get lost, etc.
- What if you want more?
  - Performance guarantees (QoS)
  - Reliability
    - Corruption
    - Lost packets
  - Flow and congestion control
  - Fragmentation
  - In-order delivery
  - Etc…

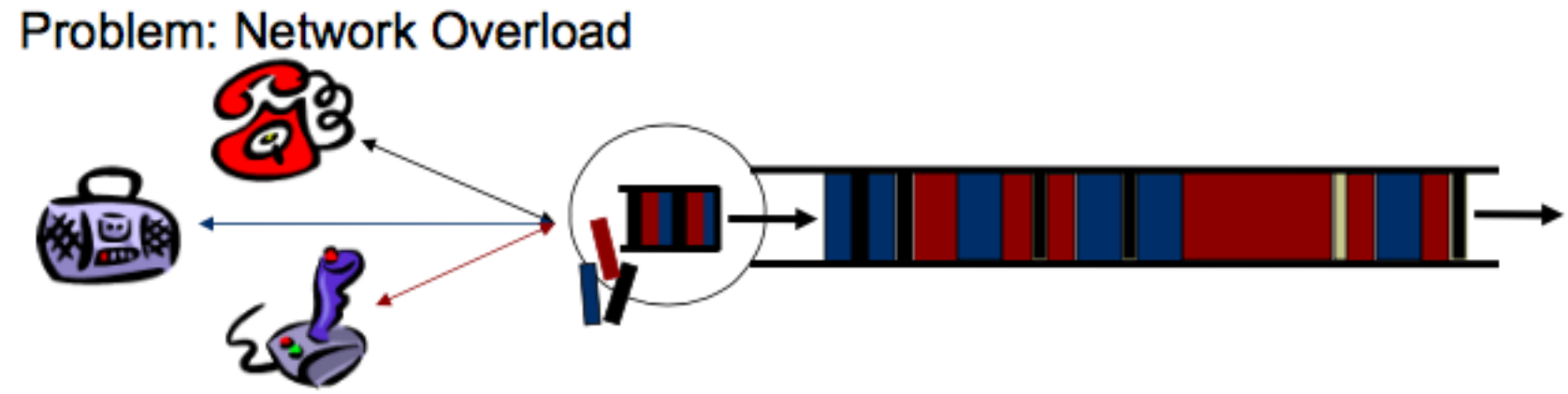
What if the Data gets Corrupted?

Problem: Data Corruption

Solution: Add a *checksum*



What if Network is Overloaded?



- Solution: Buffering and Congestion Control
  - Short bursts: buffer
  - What if buffer overflows?
    - Packets dropped
    - Sender adjusts rate until load= resources → “congestion control”

What if the Data gets lost?

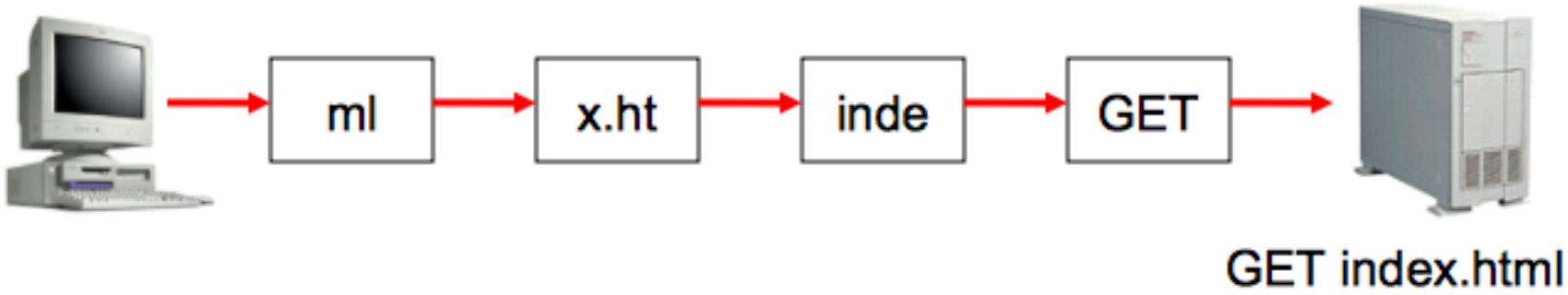
Problem: Lost Data

Solution: Timeout and Retransmit

What if the Data Doesn't Fit?

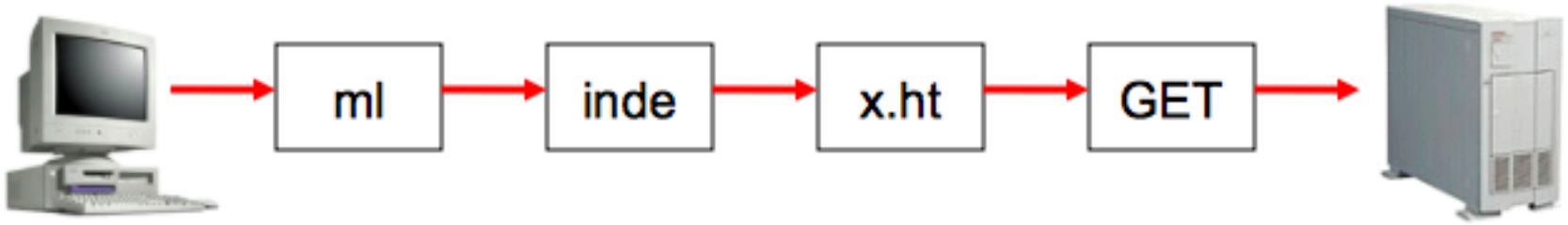
- Problem: Packet size
  - On Ethernet, max IP packet is 1.5 kbytes
  - Typical web page is 10 kbytes

Solution: Fragment data across packets



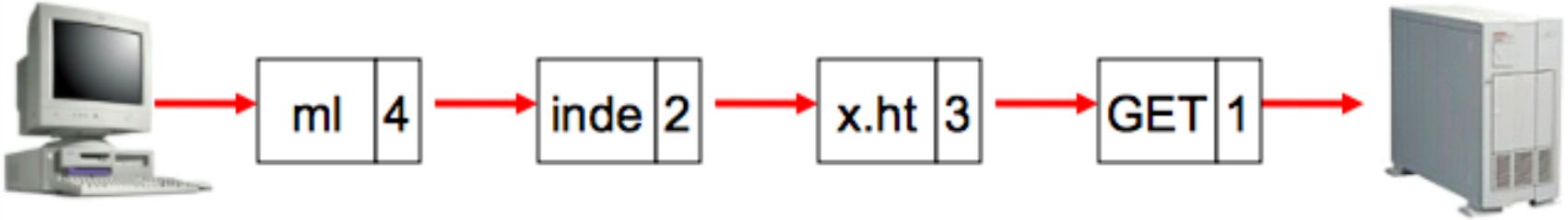
What if the Data is Out of Order?

Problem: Out of Order



GET x.htindeml

Solution: Add Sequence Numbers



GET index.html

Networks [including end points] Implement Many Functions

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

Meeting Application Demands

- Sometimes interior if the network can do it
  - Eg., Quality of Service
    - Benefits of circuit switching in packet-switched net
    - Hard in the Internet, easy in restricted contexts
- OR hosts can do it
  - Eg., end-to-end Transport protocols
    - TCP performs end-to-end retransmission of lost packets to give the illusion of a reliable underlying network.

Interesting Papers

- Read two papers on the motivations for the internet architecture:
  - “The design philosophy of the DARPA Internet Protocols”, Dave Clark, SIGCOMM 88
  - “End-to-end arguments in system design”, Saltzer Reed, and Clark, ACM Transactions on Computer Systems, November 1984