CSE3213 Computer Network I

Introduction

Course page:

http://www.cse.yorku.ca/course/3213

Course Contents

3 general areas: data communications, networking, and protocols

1. Data communications: basic concept of digital communications including signal transmission, signal encoding, multiplexing, error detection and error correction schemes.
2. Networking: technology and architecture of communication networks →WANs, LANs
3. Protocols: a set of rules that governs how two communicating parties are to interact (i.e. IP, TCP, DNS, HTTP, FTP, etc.)

A communication network

- *"is a set of equipment and facilities that provides a service: the transfer of information between users located at various geographical points"*

What is the most familiar example of a communication network ?

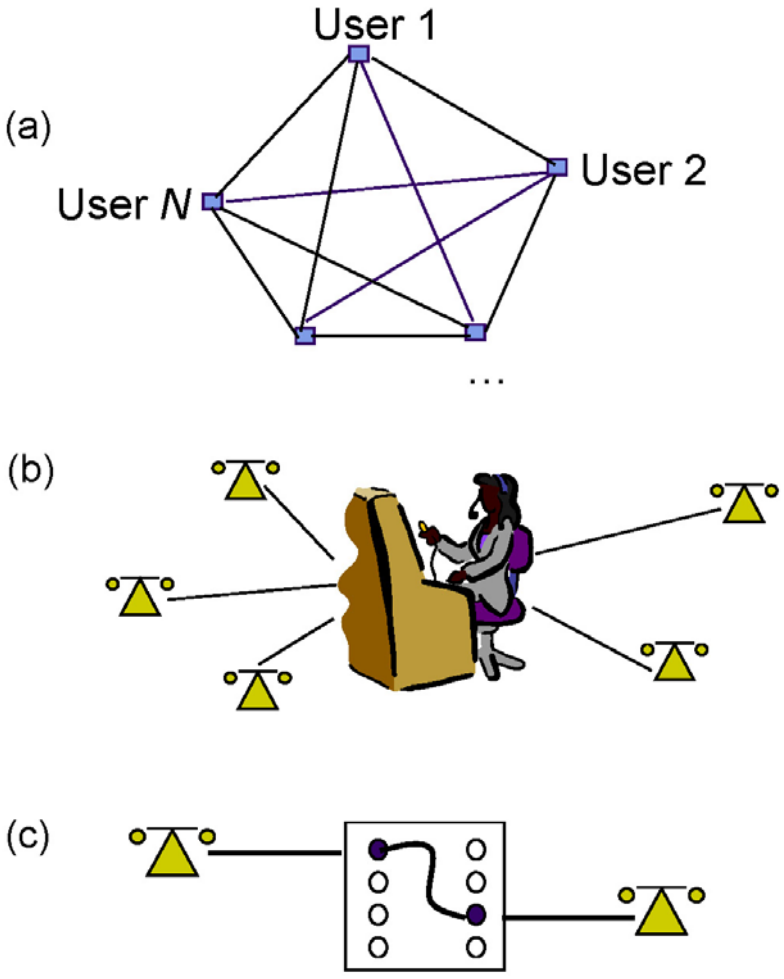
Evolution of Network Architecture and Services

- Telegraph Networks
  - Message Switching
- Telephone Networks
  - Circuit Switching
- The Internet and Computer Networks
  - Packet Switching

Telegraph Networks

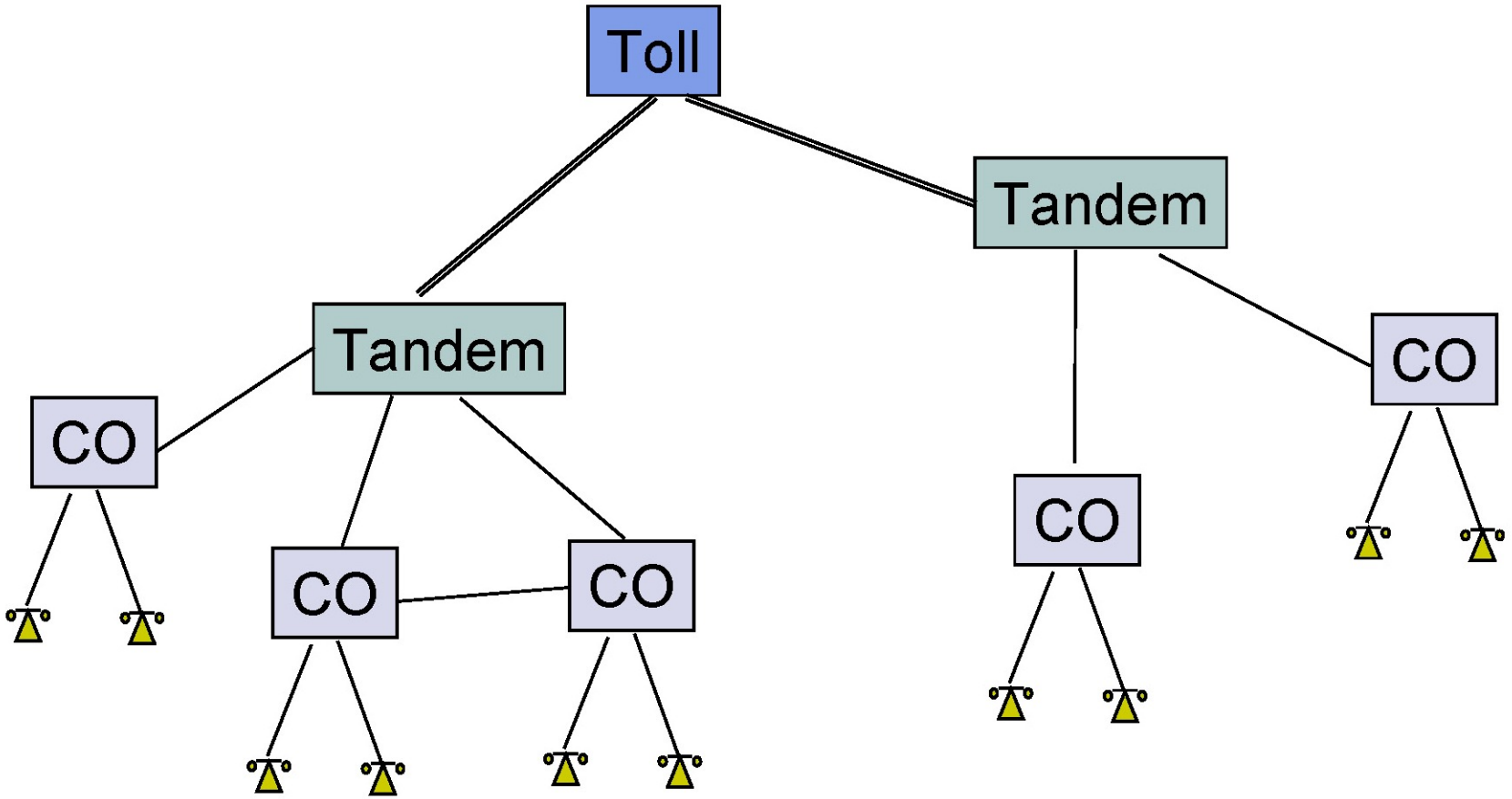
- Morse code: sequences of dots and dashes
- Store-and-forward
- No dedicated circuit/connection
- Data units are relayed one hop at a time, stored, processed and then forwarded to the next switch
- Requires routing capability
- Message Switching: messages were routed in their entirety

Telephone Networks (2)



a) Dedicated resources require numerous lines
b) A switch in the form of an operator with a patch cord panel
c) Cords interconnecting user sockets providing end-to-end connection

Telephone Networks (3)



CO = central office

Telephone Networks (4)

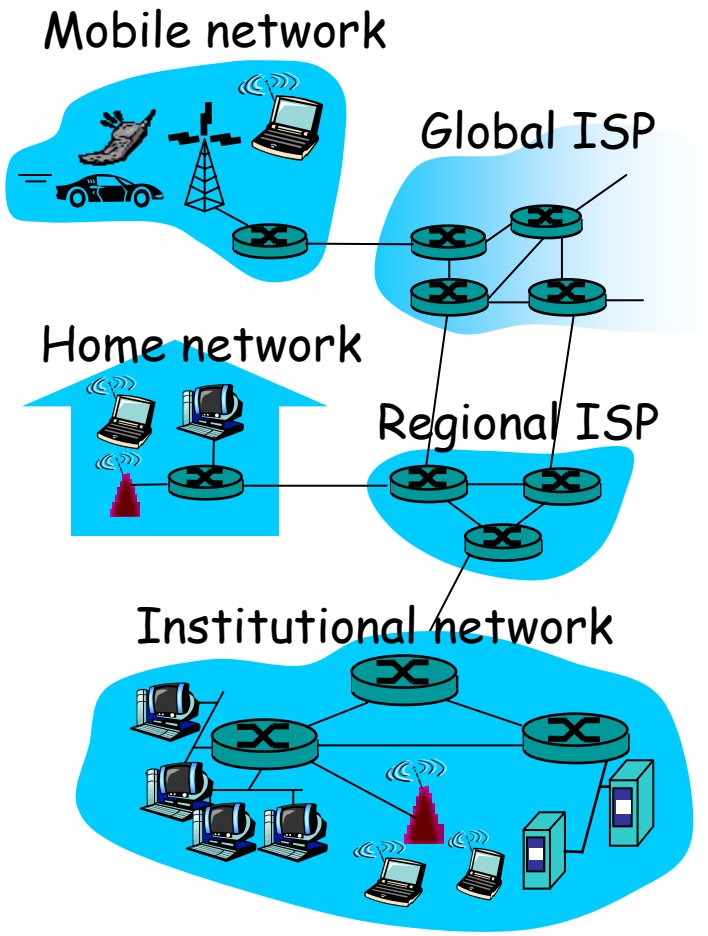
- Connection-oriented
  - Requires session or call set up before any data can be transmitted
  - Uses the same route for all data units
  - Guarantees data will arrive in order
- Circuit switching
  - Dedicated communication path established for the duration of the conversation
- Multiplexing i.e. T1 → 24 digitized voice signals

The Internet

- Internet Protocol (IP) provides datagram service, namely, the transfer of "packets" of information across multiple, possibly dissimilar networks.
- IP is used to create a single global internetwork out of many diverse networks.

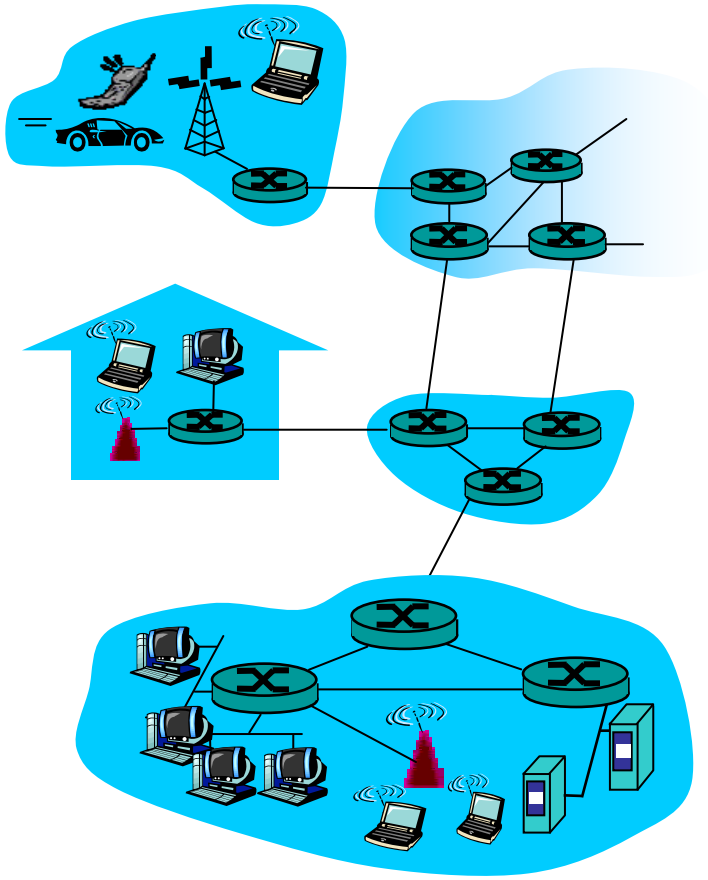
What's the Internet: "nuts and bolts" view

- *protocols* control sending, receiving of msgs
  - e.g., TCP, IP, HTTP, Skype, Ethernet
- *Internet:* "network of networks"
  - loosely hierarchical
  - public Internet versus private intranet
- Internet standards
  - RFC: Request for comments
  - IETF: Internet Engineering Task Force



What's the Internet: a service view

- communication *infrastructure* enables distributed applications:
  - Web, VoIP, email, games, e-commerce, file sharing
- communication services provided to apps:
  - reliable data delivery from source to destination
  - "best effort" (unreliable) data delivery



What's a protocol?

human protocols:

- "what's the time?"
- "I have a question"
- introductions

… specific msgs sent

… specific actions taken when msgs received, or other events

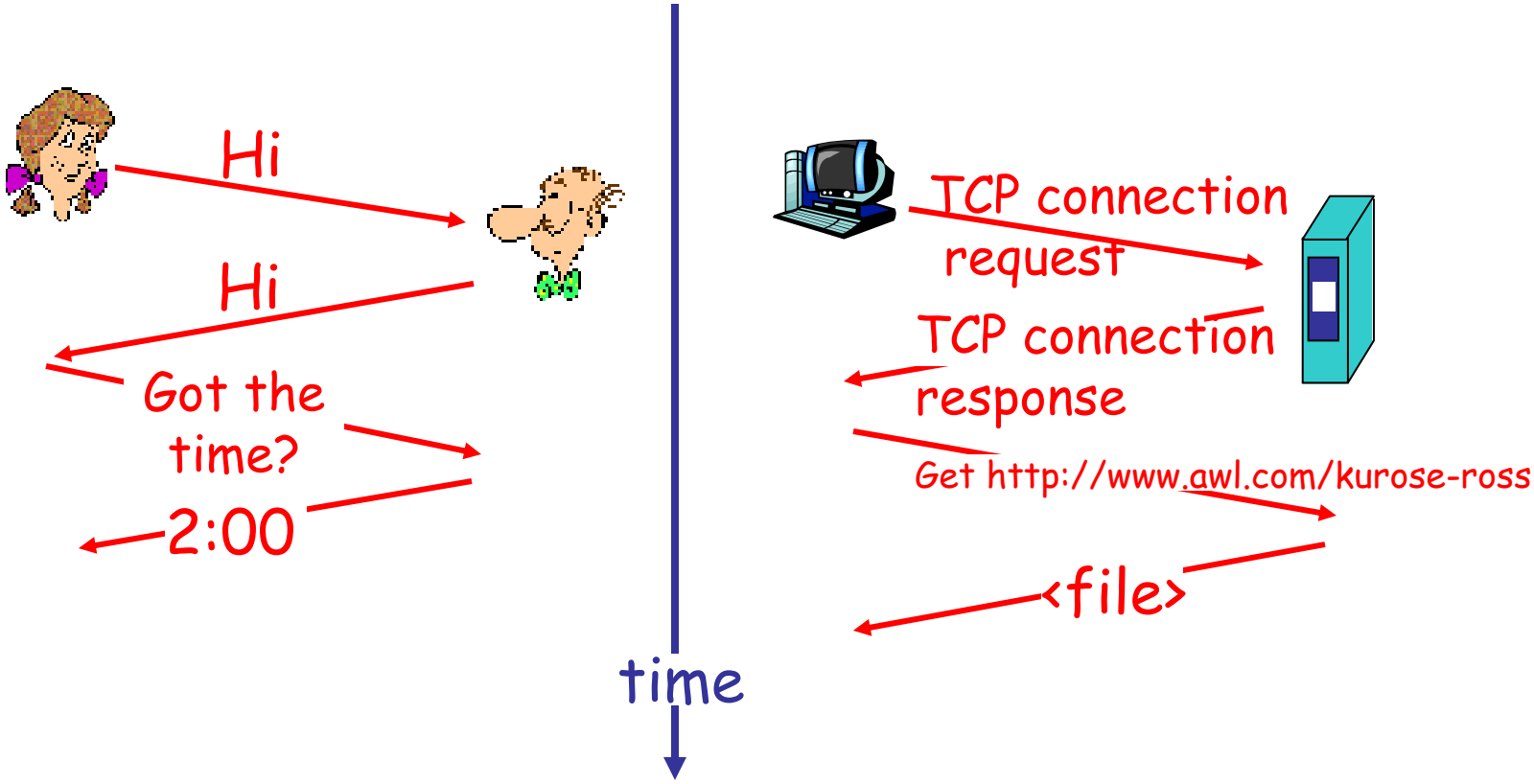
network protocols:

- machines rather than humans
- all communication activity in Internet governed by protocols

protocols define format, order of msgs sent and received among network entities, and actions taken on msg transmission, receipt

What's a protocol?

a human protocol and a computer network protocol:



Q: Other human protocols?

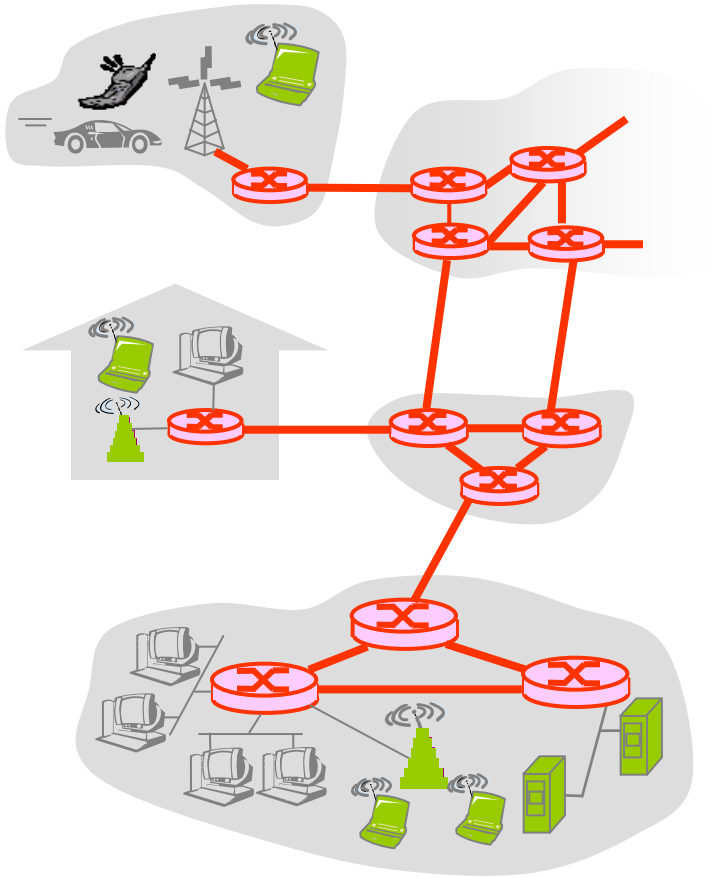
Computer-to-Computer Networks

- Packet Switching
  - Provides packet transfer service where a packet is a variable-length block of information
  - Message switching imposes high delay on interactive messages

Network core: circuit switching, packet switching, network structure

The Network Core

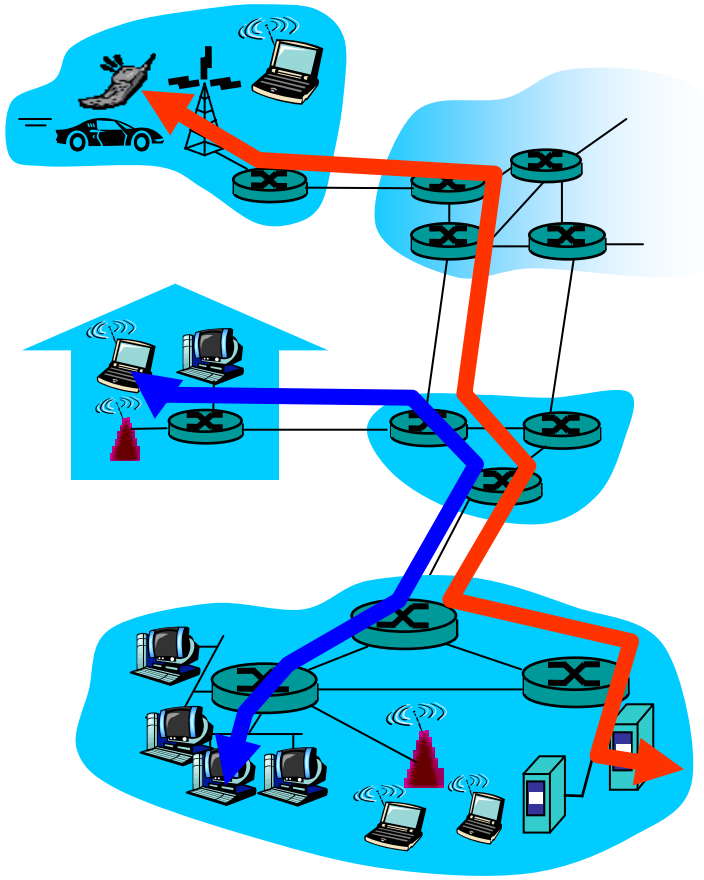
- mesh of interconnected routers
- *the* fundamental question: how is data transferred through net?
  - circuit switching: dedicated circuit per call: telephone net
  - packet-switching: data sent thru net in discrete "chunks"



Network Core: Circuit Switching

End-end resources reserved for "call"

- link bandwidth, switch capacity
- dedicated resources: no sharing
- circuit-like (guaranteed) performance
- call setup required



Network Core: Circuit Switching

network resources (e.g., bandwidth) divided into "pieces"

- pieces allocated to calls
- resource piece *idle* if not used by owning call *(no sharing)*

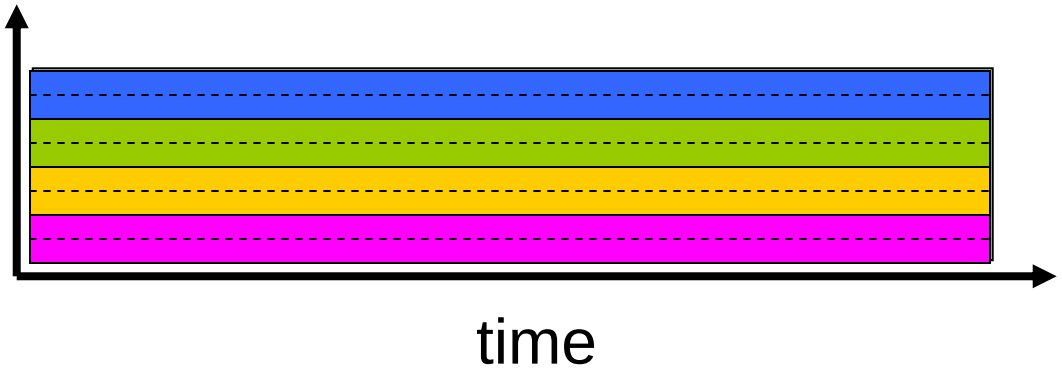
- dividing link bandwidth into "pieces"
  - frequency division
  - time division

Circuit Switching: FDM and TDM

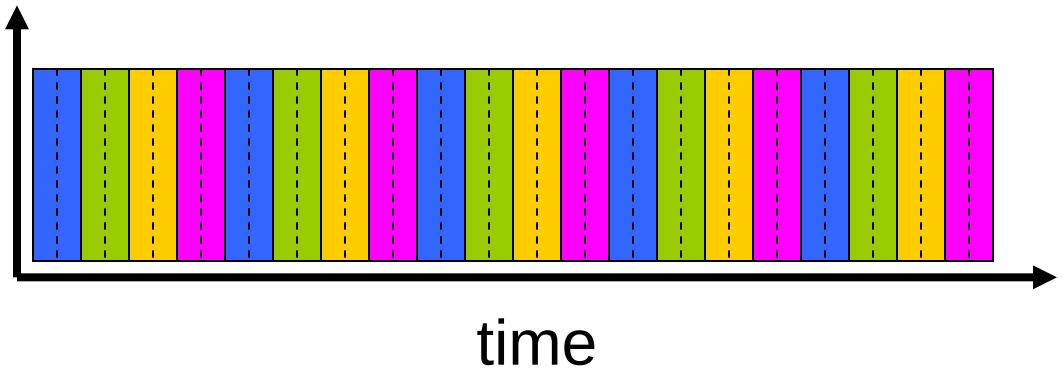
Example:

4 users

FDM



TDM



Numerical example

- How long does it take to send a file of 640,000 bits from host A to host B over a circuit-switched network?
  - All links are 1.536 Mbps
  - Each link uses TDM with 24 slots/sec
  - 500 msec to establish end-to-end circuit

Let's work it out!

Network Core: Packet Switching

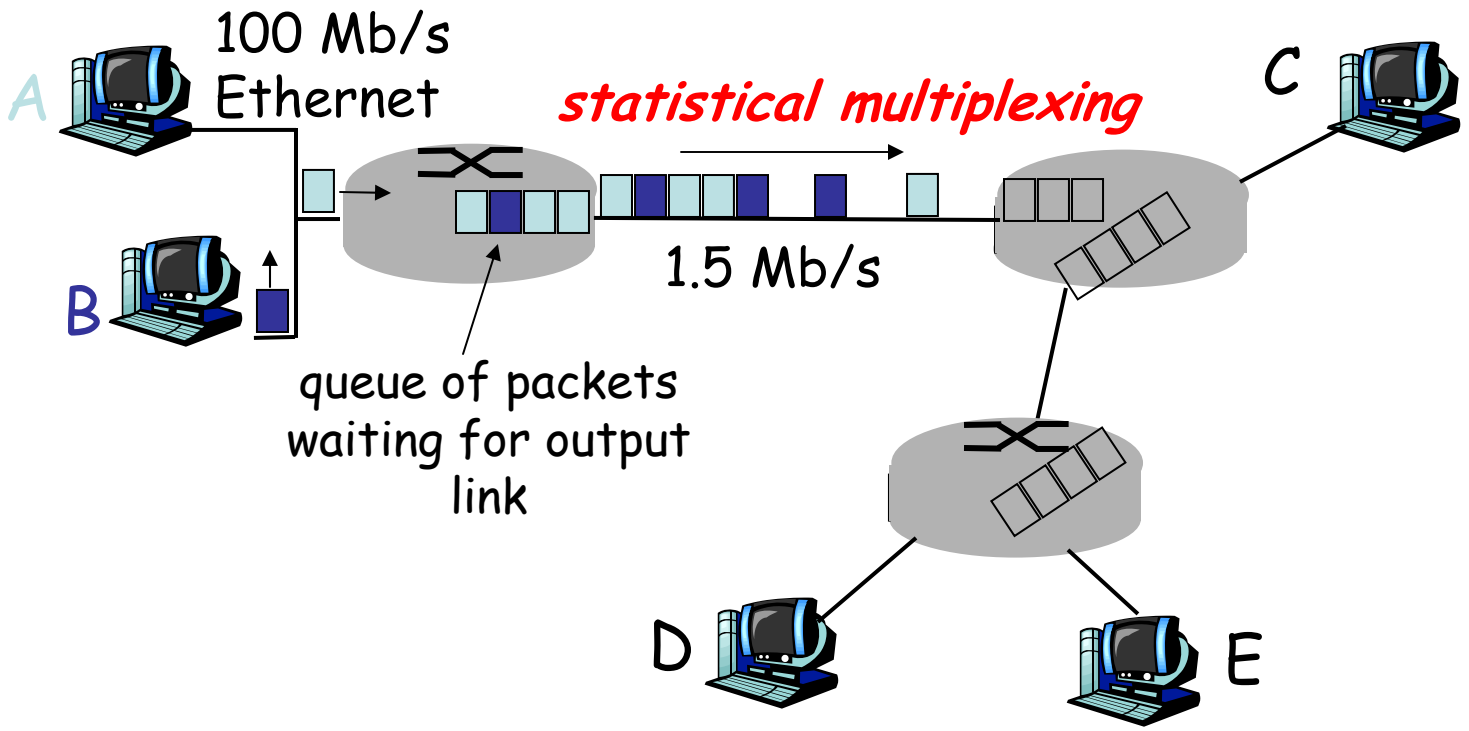
each end-end data stream divided into *packets*

- user A, B packets *share* network resources
- each packet uses full link bandwidth
- resources used *as needed*

resource contention:

- aggregate resource demand can exceed amount available
- congestion: packets queue, wait for link use
- store and forward: packets move one hop at a time
  - Node receives complete packet before forwarding

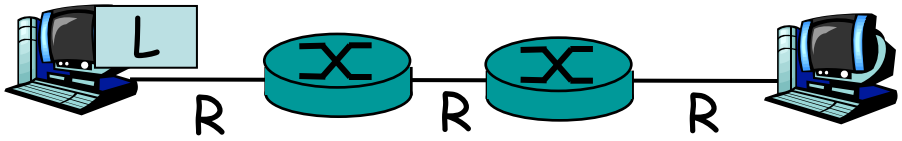
Packet Switching: Statistical Multiplexing



Sequence of A & B packets does not have fixed pattern, bandwidth shared on demand ➔ ***statistical multiplexing***.

TDM: each host gets same slot in revolving TDM frame.

Packet-switching: store-and-forward



- takes L/R seconds to transmit (push out) packet of L bits on to link at R bps
- *store and forward:* entire packet must arrive at router before it can be transmitted on next link
- delay = 3L/R (assuming zero propagation delay)

Example:

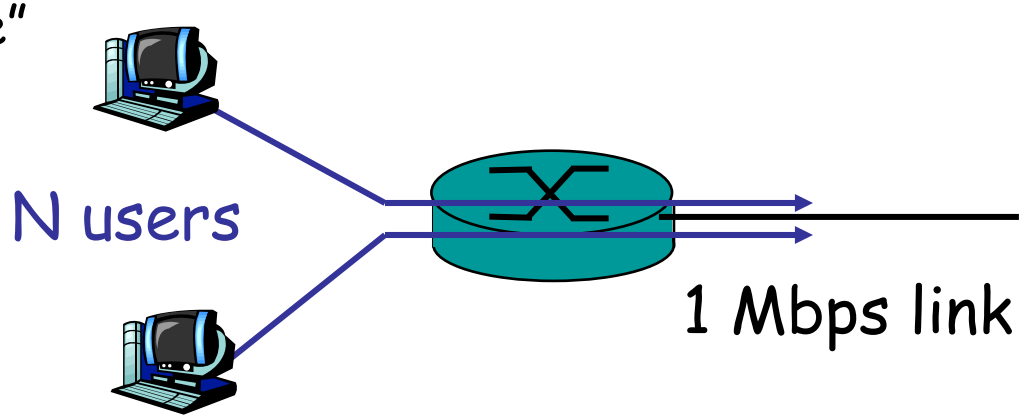
- L = 7.5 Mbits
- R = 1.5 Mbps
- transmission delay = 15 sec

more on delay shortly …

Packet switching versus circuit switching

Packet switching allows more users to use network!

- 1 Mb/s link
- each user:
  - 100 kb/s when "active"
  - active 10% of time



- *circuit-switching:*
  - 10 users
- *packet switching:*
  - 10 users or less → no problem
  - >10 users → queuing delay but still possible to support 11+ users

Packet switching versus circuit switching

Is packet switching a "slam dunk winner?"

- great for bursty data
  - resource sharing
  - simpler, no call setup
- excessive congestion: packet delay and loss
  - protocols needed for reliable data transfer, congestion control
- Q: How to provide circuit-like behavior?
  - bandwidth guarantees needed for audio/video apps
  - still an unsolved problem (chapter 7)

Q: human analogies of reserved resources (circuit switching) versus on-demand allocation (packet-switching)?

How do packets make their way through packet-switched networks?

- ???