Chancellor's Inspirational Message

The most accessible Chancellor!

- *"Along with a connection to the Internet, we also need to rediscover our 'Inner-net' connection.* Real Education teaches us how to manage both our internal and external worlds" Amma, Sri Mata Amritanandamayi, Chancellor
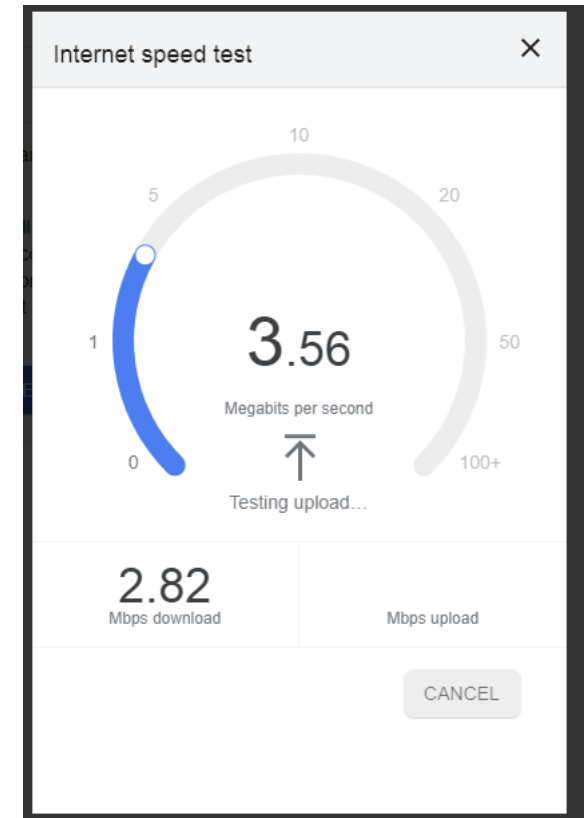
Key points to discuss in Internet Access

- Internet Access

  - Residential home access

    - DSL

    - Cable

 - Institutional access

  - Mobile access

Internet access

- Access networks helps to connect end systems to the internet.

- Shared/dedicated access depends on the network classification

- Internet speed?
  - Also depends on the type of networks and link capacity
  - Measured in bits per second the (bps)
    - Download speed: Time taken for client end systems to access files from servers.
    - Upload speed: Time taken to upload files from clients to servers.

Internet speed test ✕

10
5   20

1   3.56   50
    Megabits per second
0   100+
    Testing upload...

2.82
Mbps download   Mbps upload

CANCEL

Home Access Methods?

- Home access methods: DSL, Cable, Dial-up & Satellite
  - Two Prevalent types of broadband residential access: DSL, Cable
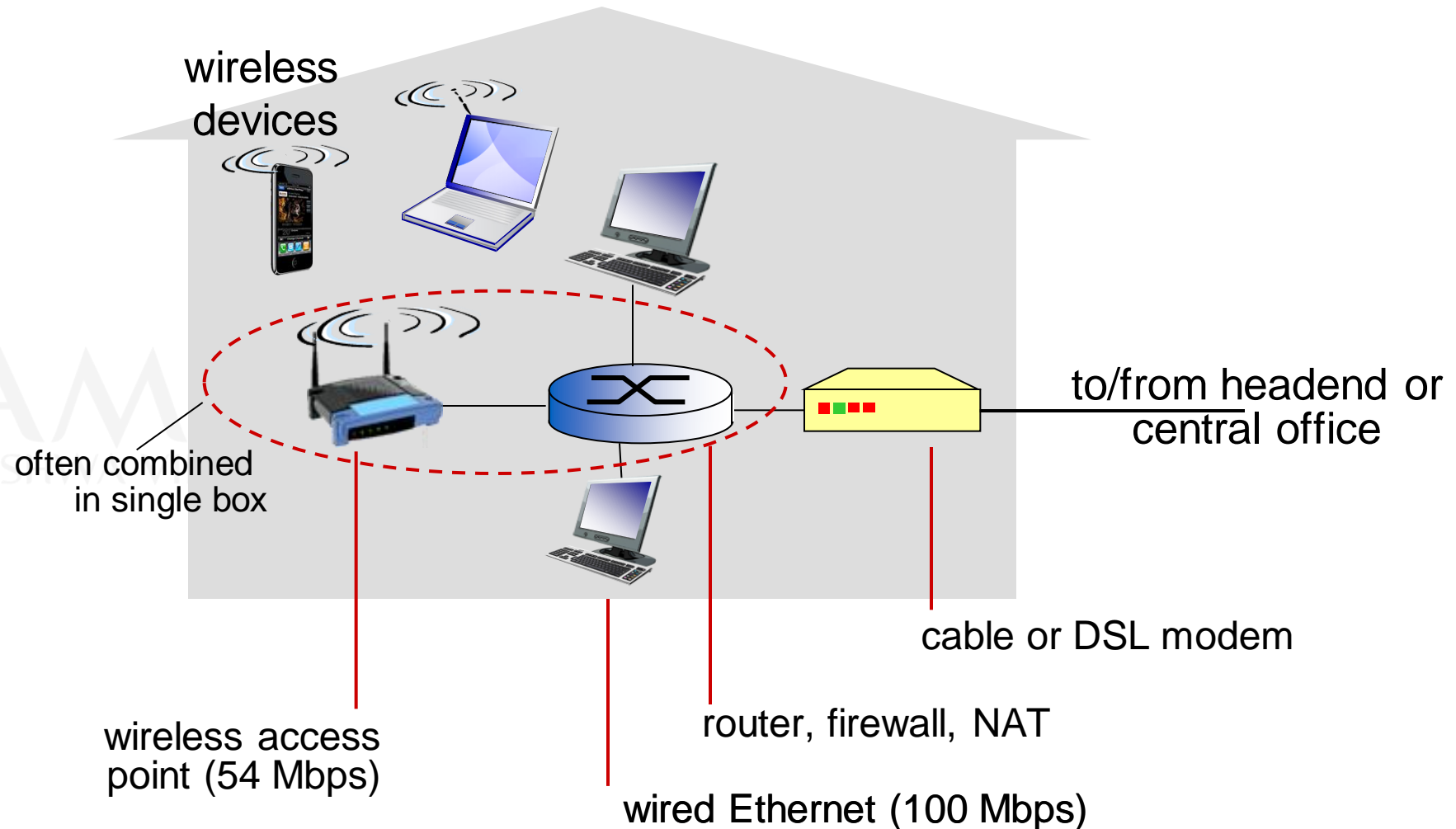 - DSL – Digital Subscriber Line
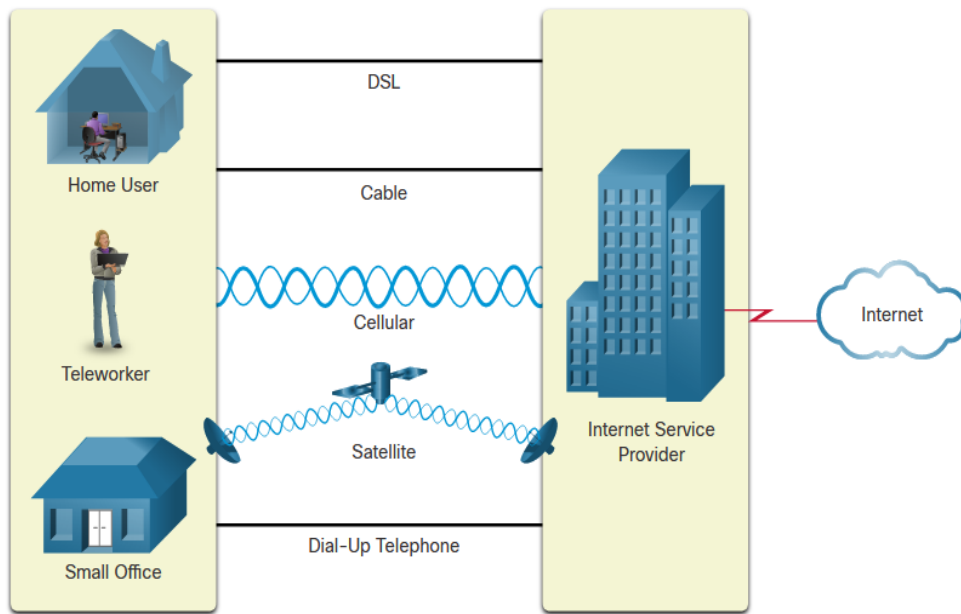
Ref: CCNA Introduction to Networks from Cisco Netacad

Connection	Description
DSL	high bandwidth, always on, internet connection that runs over a telephone line.
Cable	high bandwidth, always on, internet offered by cable television service providers.
Cellular	uses a cell phone network to connect to the internet.
Satellite	major benefit to rural areas without Internet Service Providers.
Dial-up telephone	an inexpensive, low bandwidth option using a modem.

Home Access Network

- Modem = modulator/ demodulator

- Hardware device

- Modulator = Converts digital data to analog

- Demodulator = Converts analog signals to digital form

wireless devices

often combined in single box

to/from headend or central office

cable or DSL modem

wireless access point (54 Mbps)

router, firewall, NAT

wired Ethernet (100 Mbps)

J. Kurose and K. Ross 2012, Computer Network,6th ed.

DSL

- Digital Subscriber Line (DSL) uses existing telephone Infrastructure.
- DSL provider provide different transmission rates at different price
  - Speed affected by distance
- DSL Standards
  - 12 Mbps downstream & 1.8 Mbps upstream [ITU 1999]
  - 24 Mbps downstream & 2.5 Mbps upstream [ITU 2003]
- Internet access is asymmetric
  - Because the downstream and upstream speed are different

DSL

- @Customer Side
  - DSL Modem uses the existing telephone line(twisted pair)
  - Splitter separates the data and telephone signals arriving at home and forwards the data signal to the DSL modem

- @Telecommunication Side
  - DSL Access Multiplexer (DSLAM) separates the data and phone signals and sends the data into the internet
- Same DSL link shared for
  - Phone line
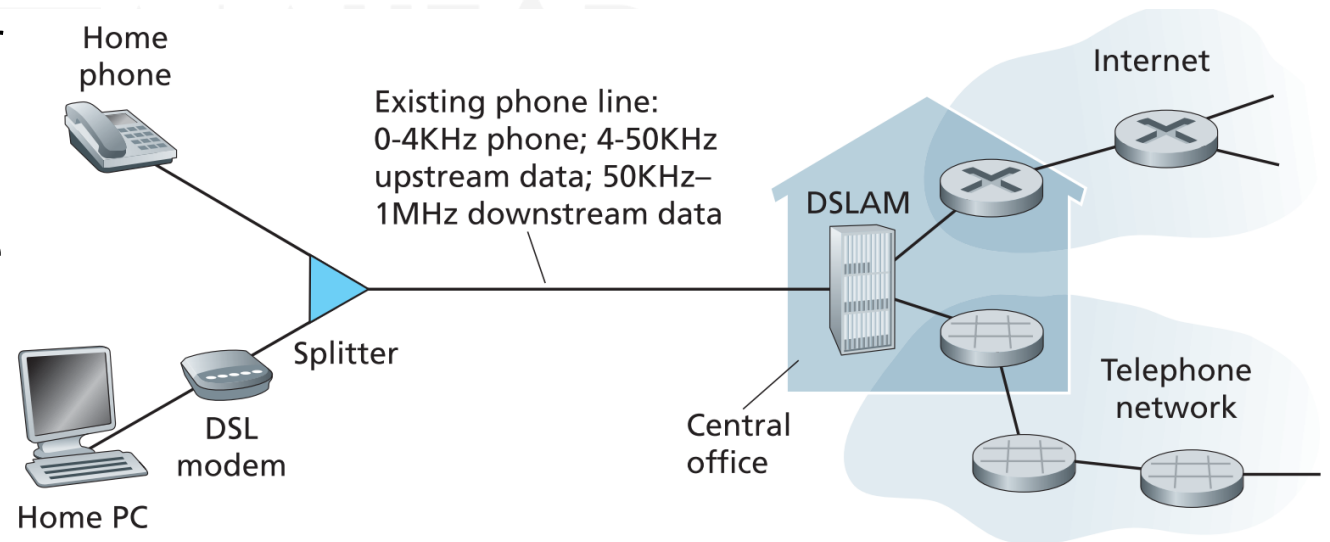 - Upstream data
  - Downstream data

Home phone

Existing phone line:
0-4KHz phone; 4-50KHz
upstream data; 50KHz–
1MHz downstream data

DSLAM

Internet

Splitter

Central office

Telephone network

DSL modem

Home PC

Figure 1.5 ♦ DSL Internet access

Cable Internet Access

- Cable Internet Access uses existing Cable TV infrastructure.

- Shared broadcast communication medium

- @Customer side
  - Cable modem divides the hybrid fiber coaxial (HFC) network into 2 channels (up and downstream)
  - HFC standards 42.8 Mbps downstream & 30.7 Mbps upstream
- @Telecommunications side
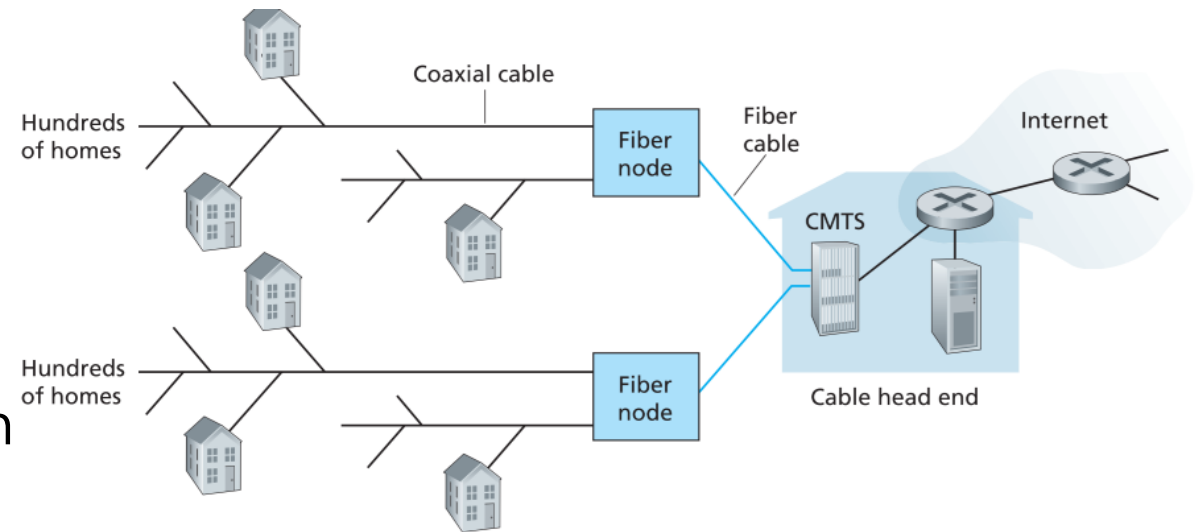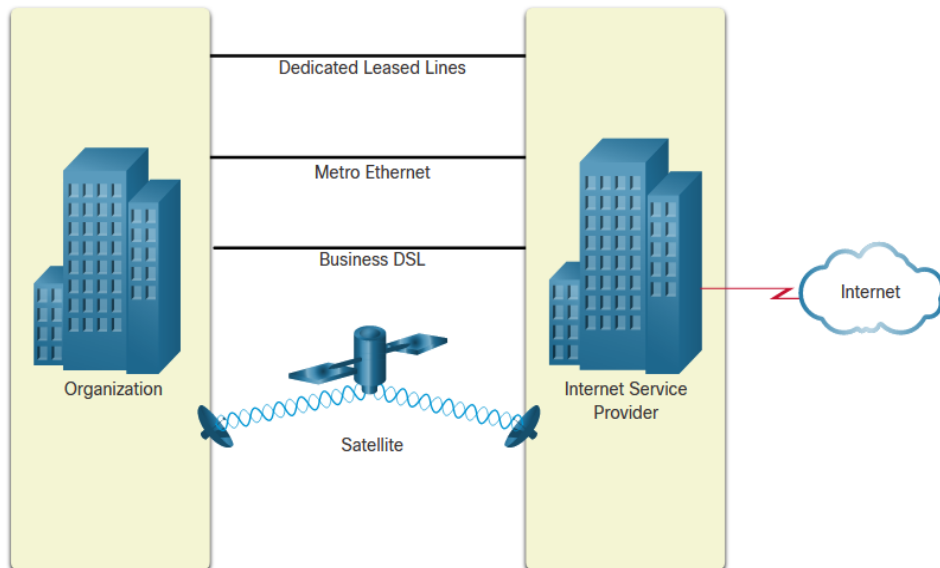 - Cable Modem Termination System (CMTS) similar to DSLAM

Figure 1.6 ♦ A hybrid fiber-coaxial access network

This Photo by J. Kurose and K. Ross 2012, Computer Network,6th ed. is licensed under CC BY

Institutional Access Network

- Institutional/Corporate business connections require:
  - Higher bandwidth, dedicated connections, managed services
  - Accessing options type

Ref: CCNA Introduction to Networks from Cisco Netacad

Type of Connection	Description
Dedicated Leased Line	These are reserved circuits within the service provider's network that connect distant offices with private voice and/or data networking.
Ethernet WAN	This extends LAN access technology into the WAN.
DSL	Business DSL is available in various formats including Symmetric Digital Subscriber Lines (SDSL).
Satellite	This can provide a connection when a wired solution is not available.

Institutional Access Network

institutional link to ISP (Internet)

institutional router

Ethernet switch

institutional mail, web servers
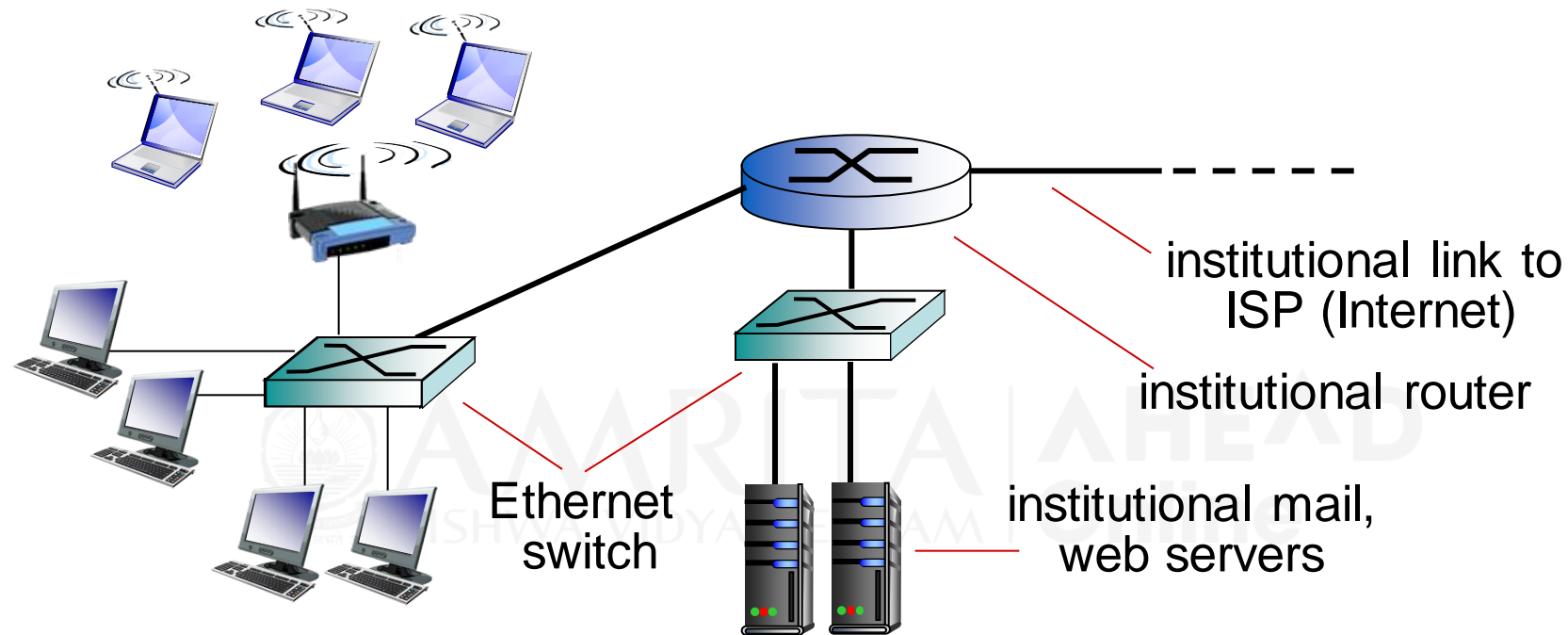
- Larger LAN typically used in companies, universities, etc.
  - ❖ 10 Mbps, 100Mbps, 1Gbps, 10Gbps transmission rates
  - ❖ today, end systems typically connect into Ethernet switch

J. Kurose and K. Ross 2012, Computer Network,6th ed.

Mobile Access Cellular Network

- How Mobile/ Cell phone connected to the Internet?
  - Coverage area of one Base Station is termed as cell
  - Mobiles in one cell sends messages to the Base Station in that cell.
  - Base Station is connected to the Edge Router for Internet Access
- Mobility concept – Smooth transfer of data messages from one Base Station in a cell to the other known as handoff


Cell 1

Cell 2

Handover
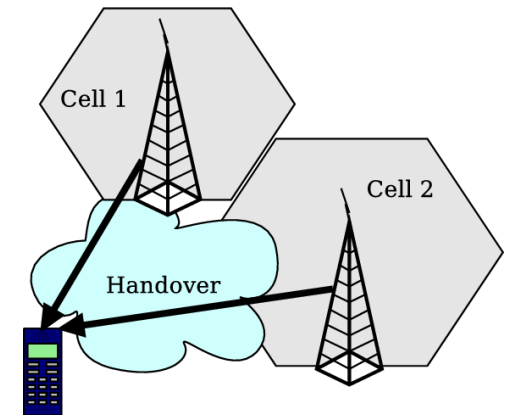
J. Kurose and K. Ross 2012, Computer Network,6th ed.

Krauthoff, Tobias. (2014). Measurement of Position-based Network-Characteristics in Cellular Networks while Moving. 10.13140/RG.2.2.31844.99206.

Converged Network

- Before Separate networks
  - using different technologies to carry signals based on specific rules

- Converged network deliver data, voice and video on one link having same set of rules
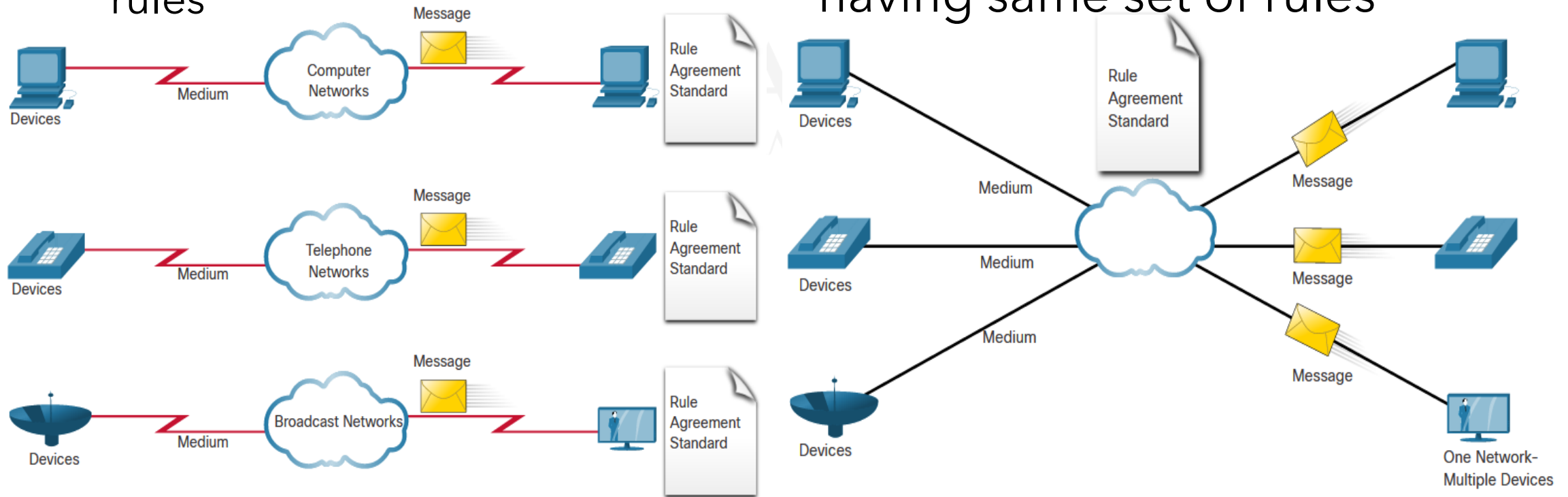
Summary

- Revised Network Structure
- Discussed various ways to Network Access
    - Residential home access
    - Institutional access
    - Mobile access
    - Converged networks
- Next lecture discussion
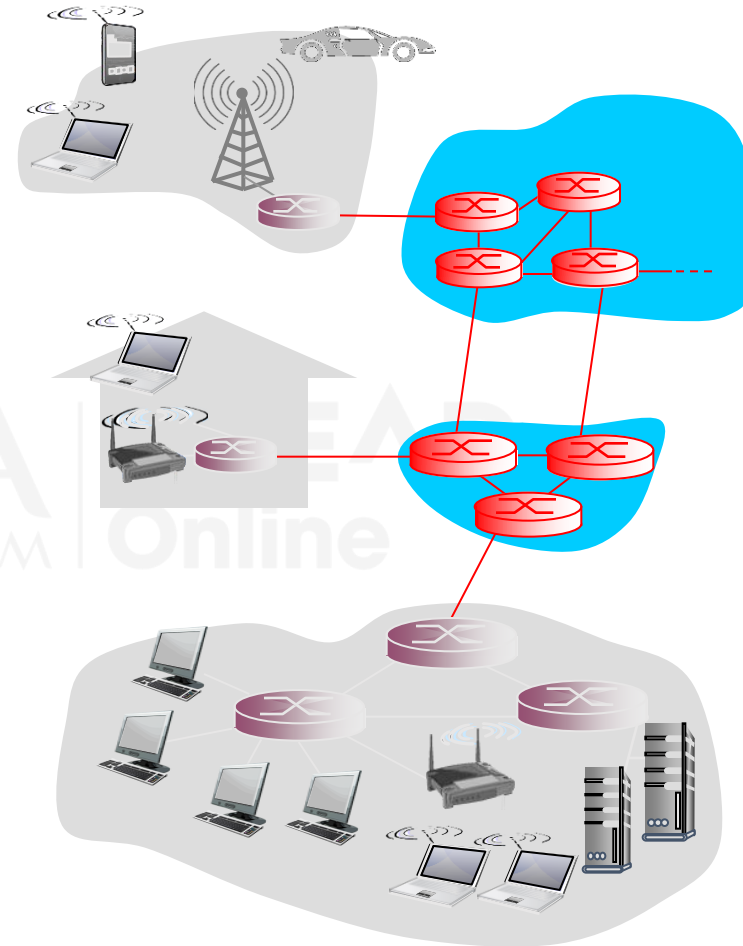   - Network Core

Network Core

Learning Objectives in Network Core

- Understand Network core

- Analyze the difference between circuit switching and packet switching

- Analyze how different users share the link

- Understand the network core functions

Network Core

- Network Structure = End devices, Access Network & Core Network

- Network Edge = End Devices with Network Access devices like Edge router

- Network Core
  - Provides services to the Edge
  - Mesh of interconnected routers

Ref: J. Kurose and K. Ross 2012, Computer Network,6th ed.

Network Core Implementation

- Network Core answers – "How is data transfer through network?"

- Implemented by switching techniques
  - Circuit Switching
    - Dedicated circuit per call
    - Connection oriented service
    - Ex: telephone network
  - Packet Switching
    - Data or messages are divided into small chunks known as packets and they are sent through network
    - Connection less service
    - Ex: Ethernet network
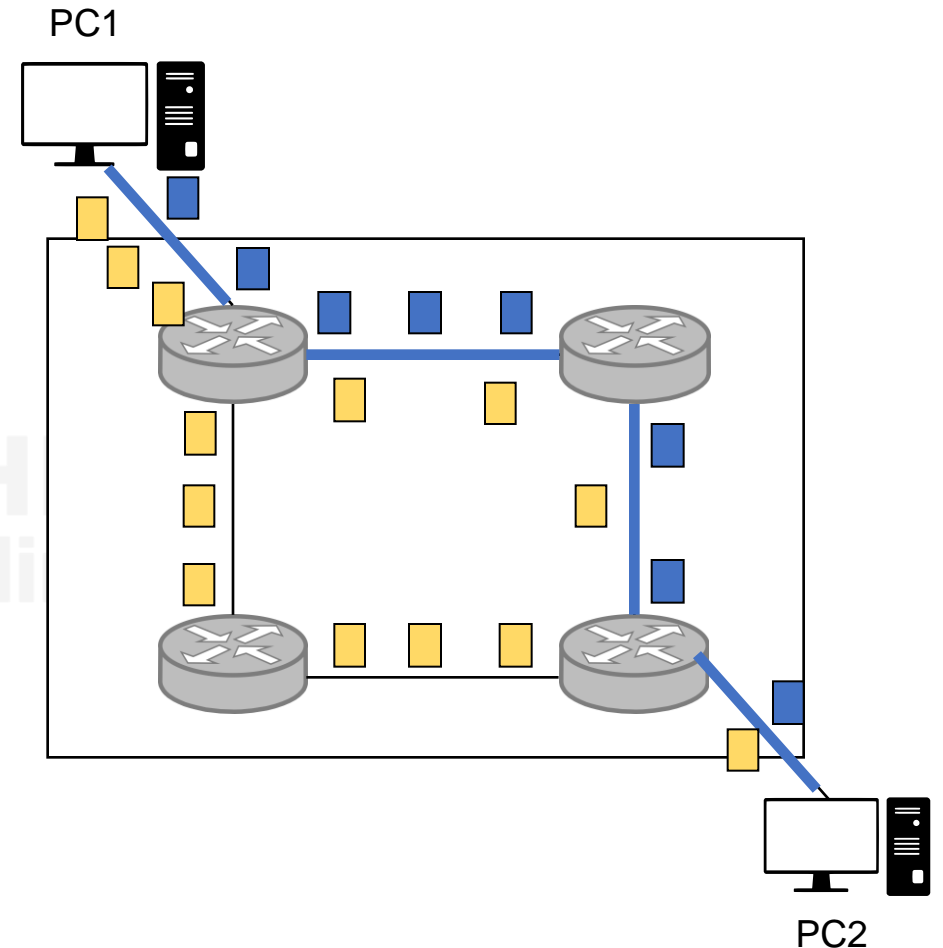
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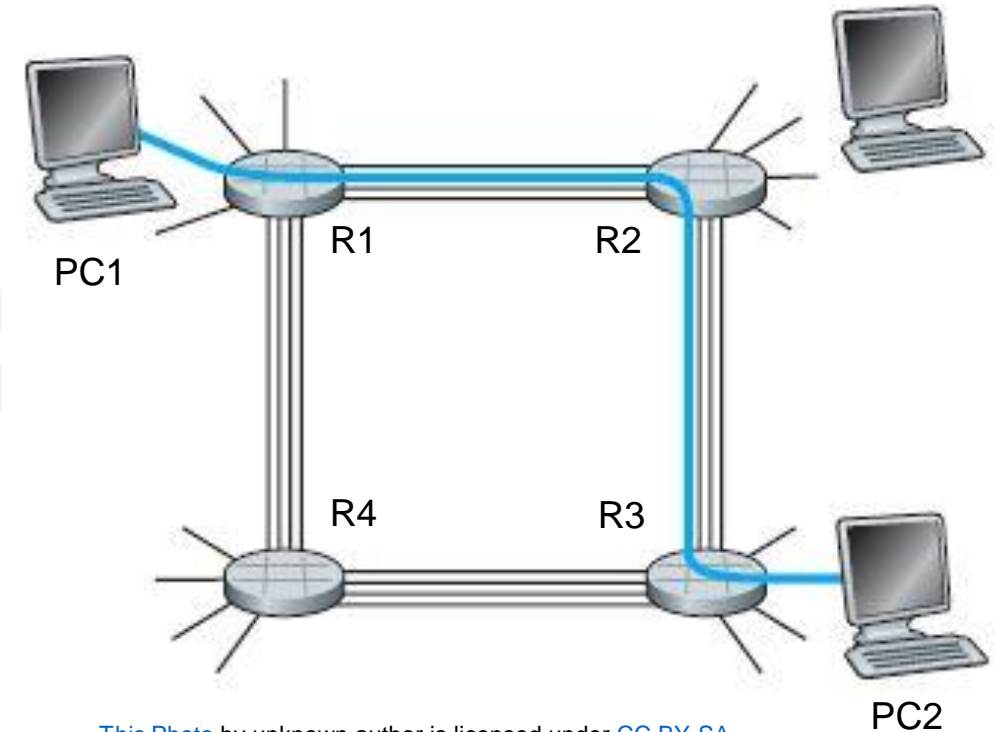
Circuit Switched Network

- Circuit = dedicated path between sender and receiver

- Mostly used for voice communication real time services to avoid delay

- Three phases involved in circuit switching
  - Circuit establishment
  - Data Transfer
  - Circuit disconnect

Circuit Establishment - Connect

Voice Data Transfer without delay

Circuit disconnect
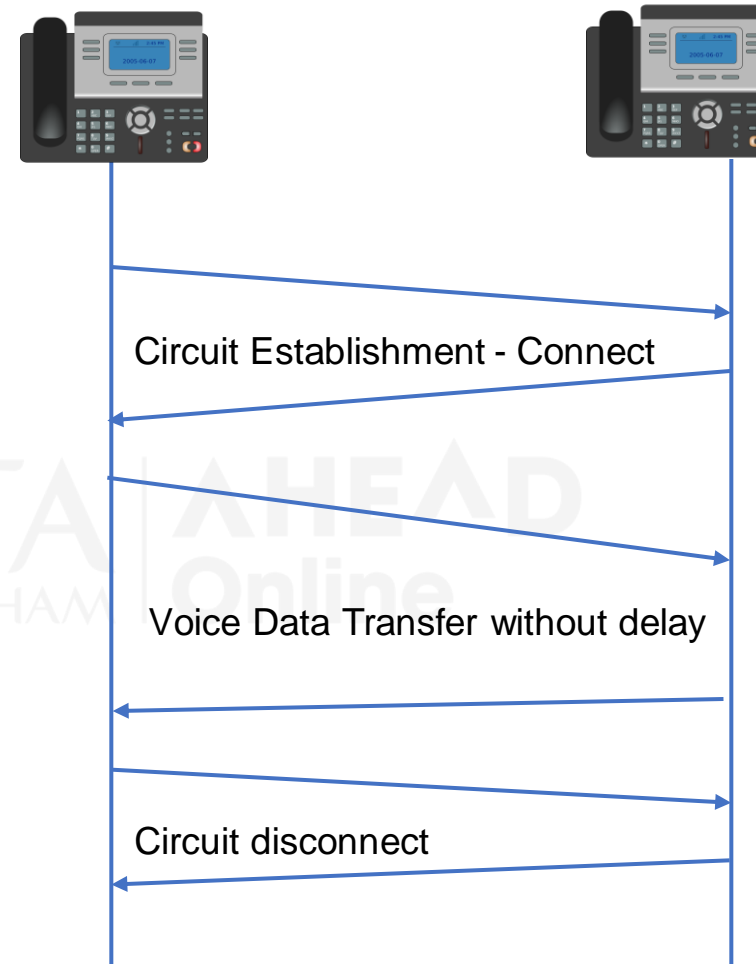
Ref: J. Kurose and K. Ross 2012, Computer Network,6th ed.

Circuit Switching

- One Communication link can have many circuits.
  - Here each link has 4 circuits
- Three phases involved in PC1 calling PC2
  - Dedicated path or circuit:
    - PC1-R1(2nd circuit)
    - R2-R2(1st circuit)
    - R3- PC2 – resources allocated
  - Data transfer between PC1 and PC2 in the circuit
 - Circuit disconnected after the call ends

PC1

R1   R2

R4   R3

PC2

Ref: J. Kurose and K. Ross 2012, Computer Network,6th ed.

Sharing the link in Circuit Switching

- How Communication link can be shared by different users?

- Multiplexing allows simultaneous transmission of multiple signals along the same link
  - Divides a link into multiple channels
  - Frequency Division Multiplexing (FDM) shares a portion of bandwidth among 4 users
    - Ex: AM and FM radio broadcasting
  - Time Division Multiplexing (TDM) shares time slots among 4 users
    - Ex: Radio programs at different time periods
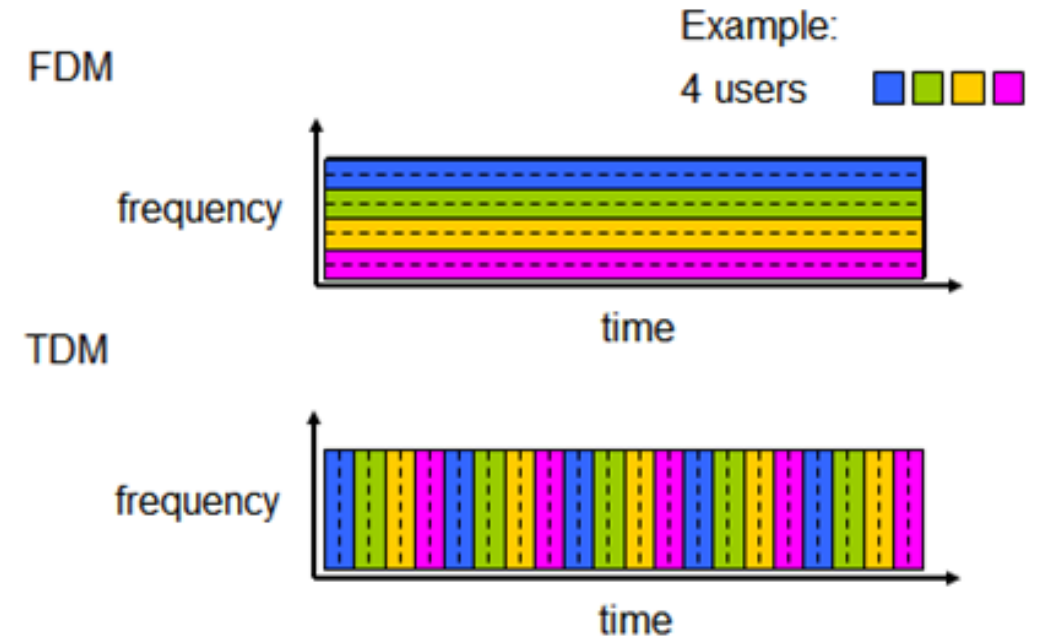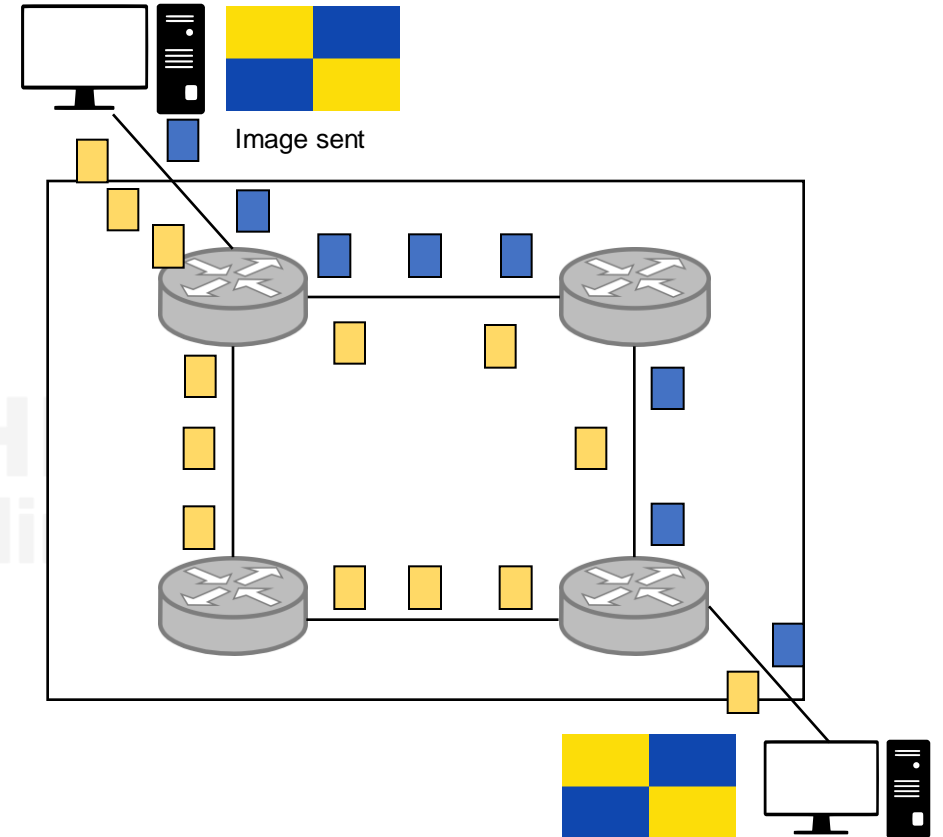

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Ref: J. Kurose and K. Ross 2012, Computer Network,6th ed.

Packet Switched Network
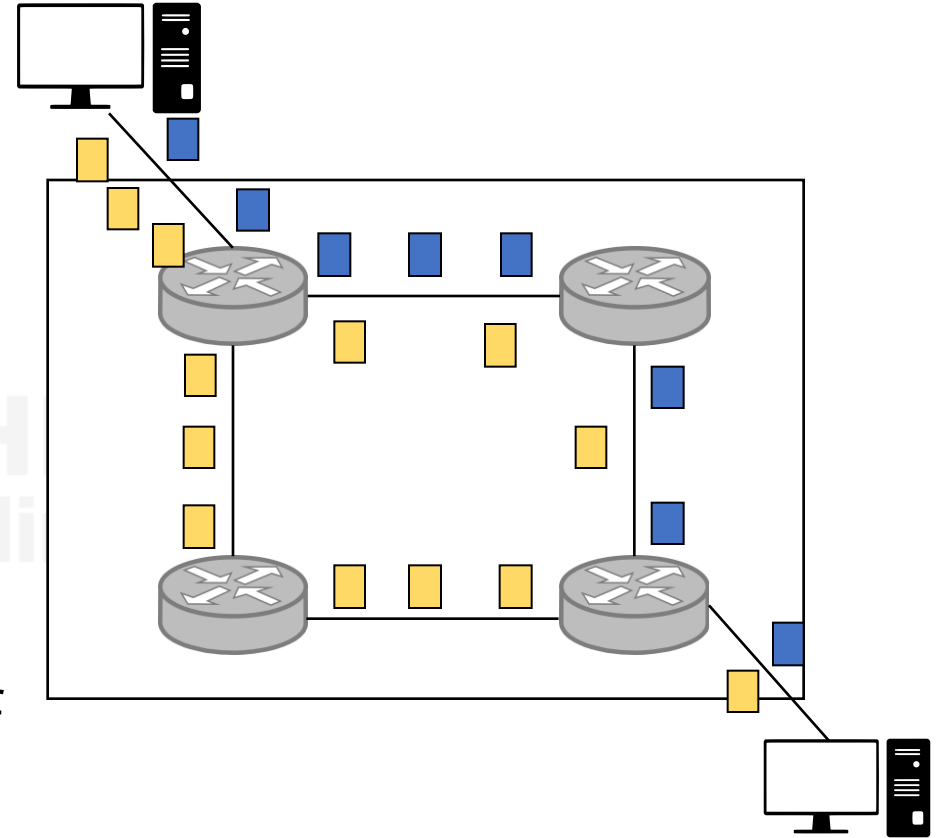
- Used in the Internet and most LANs
- Host breaks the large messages into packets known as segmentation
    - Ex: Message such as Image or Video or audio file are segmented into small packets
    - Packets travel independently and need not take same path
- No bandwidth shared or time reserved in sending packets
    - No dedicated path or circuit
    - Resources used as needed
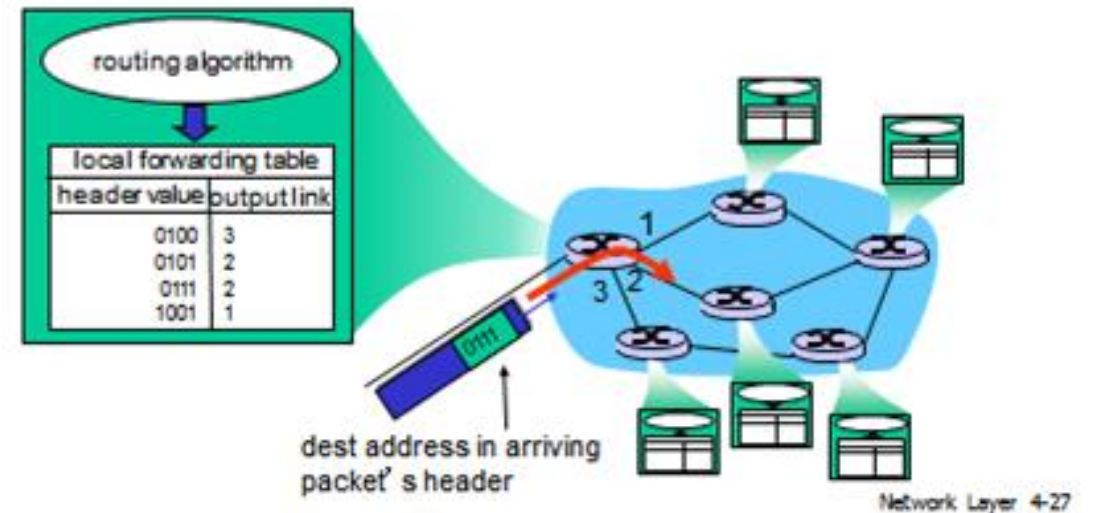   - Reason for connection less service

Image sent

Packet Switching

- ## Statistical multiplexing
  - Packets from different incoming links are sent by router to different outgoing links based on demand

- ## Routers store and forward the packets
  - Entire packet must arrive at the router, stored in buffer and then forwarded

- Sending Packets from source to destination undergo random delay and loss in each of the intermediary devices or hops in between
  - Each packet transmitted at the full link capacity

Network Core Functions

- **Routing** determines the route or path based on the destination host address
  - Here path or route to reach 0111 destination address is referred
  - **Routing algorithm** maintains table specific for each router
- **Forwarding** moves packet from the incoming link to the right outgoing link
  - Here packet is forwarded to the output link 2 for dest addr 0111

Ref: J. Kurose and K. Ross 2012, Computer Network,6th ed.

Summary

- Network Core Switching
  - Circuit Switching
    - FDM & TDM multiplexing
    - Connection oriented service
    - Guaranteed service

  - Packet Switching
    - Statistical Multiplexing
    - Connection less service
    - Best effort service
  - Routing Vs Forwarding
- Next lecture discussion
  - Delays, Loss, Throughput in networks