Lec 01-02
Introduction to Computer Networks

Computer Networks (CSE232) Section A

Instructor: Rinku Shah

These slides are inspired and adapted from:

1. *Computer Networking: A Top-Down Approach*
   6th edition, Jim Kurose, Keith Ross, Pearson, 2017

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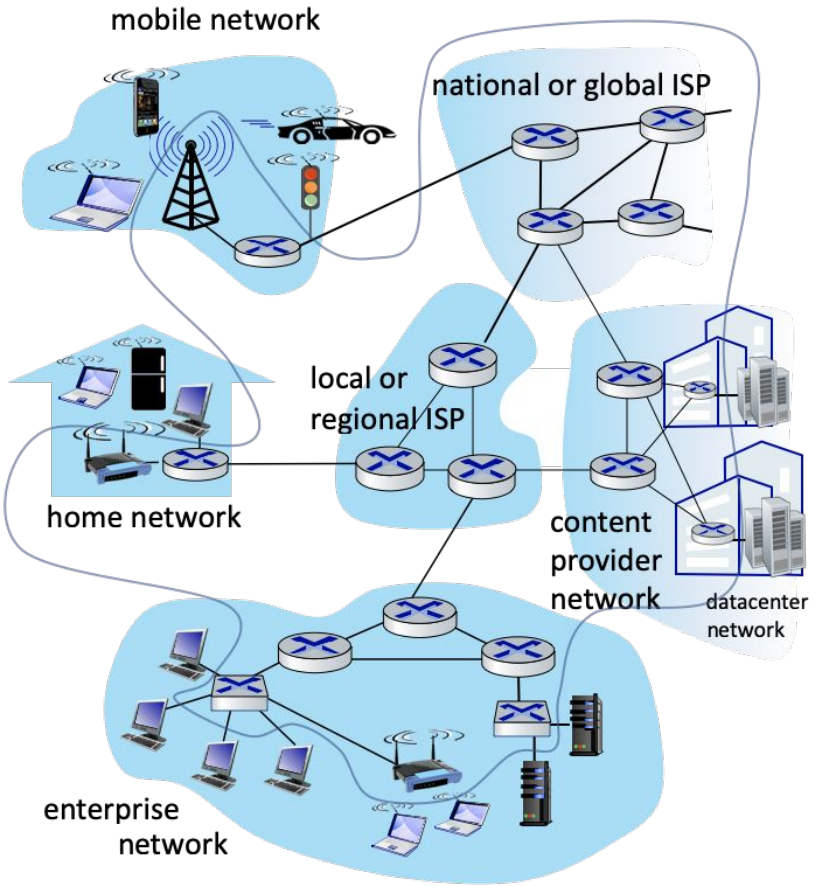
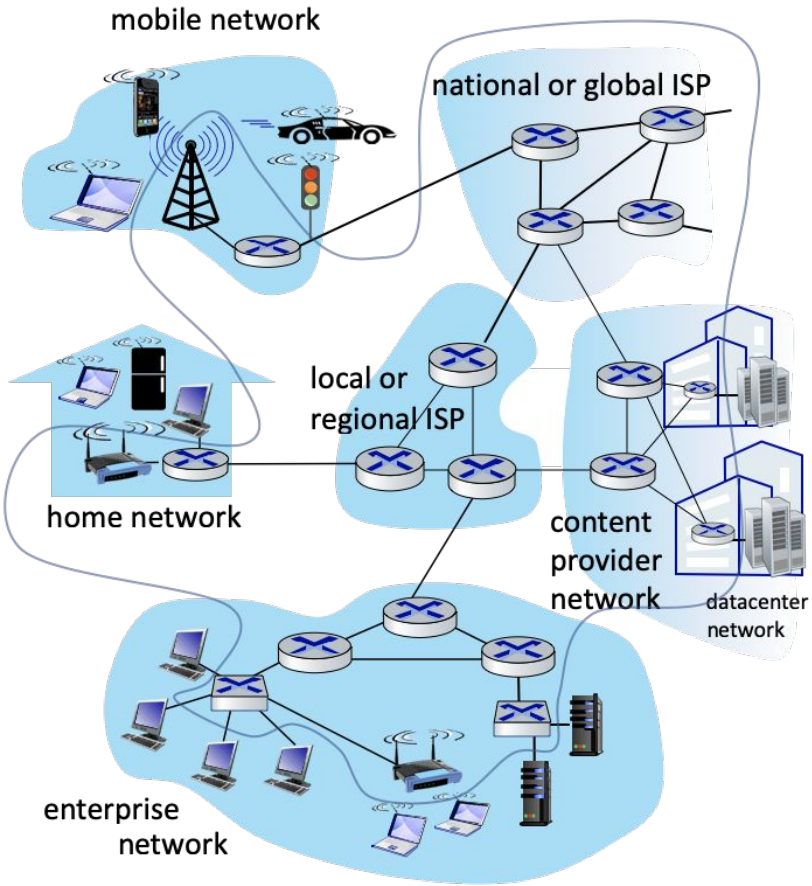
DELHI

Network structure



- Network edge
  - End hosts
    - Clients, servers
- Access networks
  - Physical media
    - Wired, wireless
  - Edge routers
- Network core
  - Interconnected routers
  - Builds a network of networks

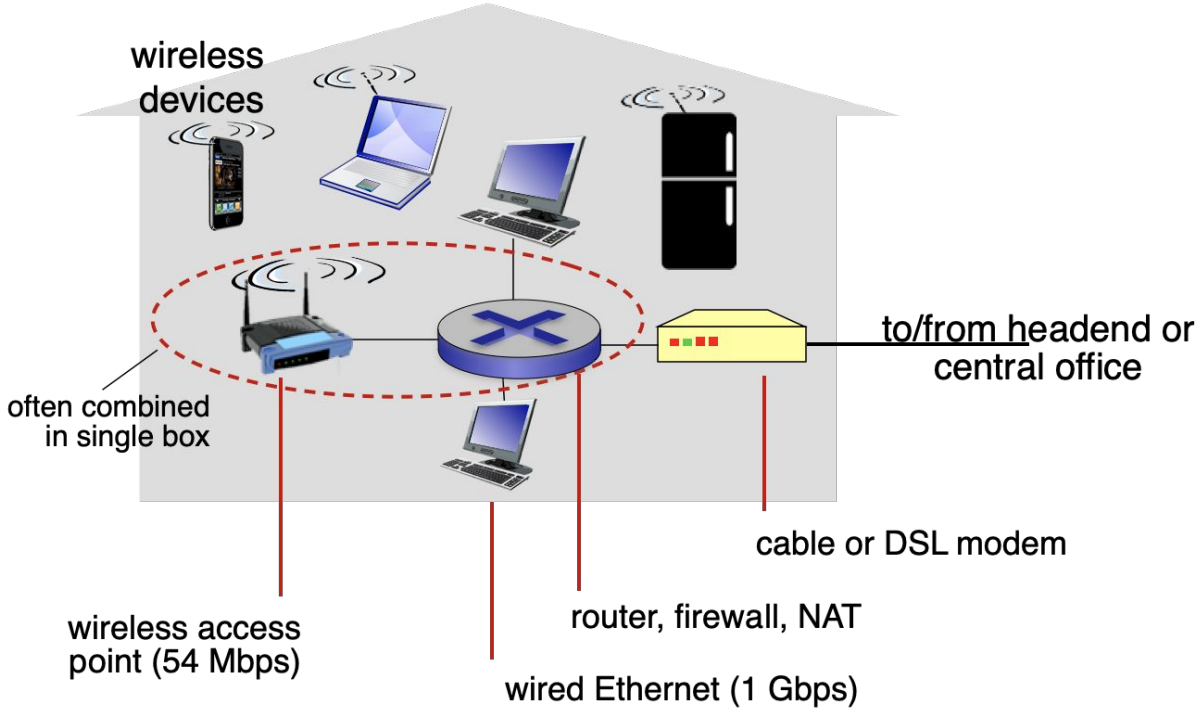
Access networks



How do end hosts connect to edge routers?

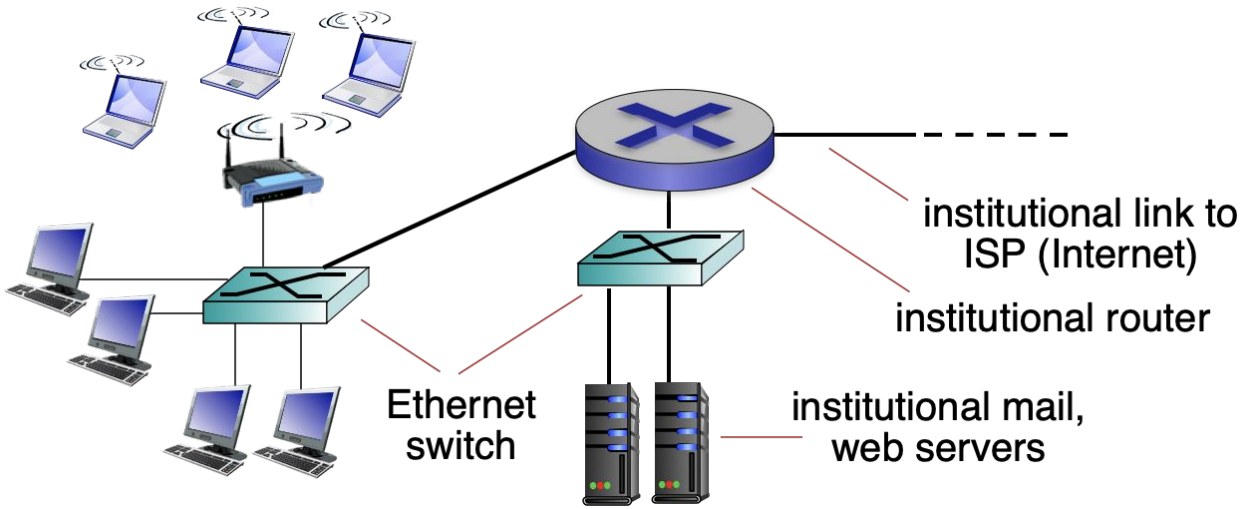
- Physical media
  - Guided
    - Coaxial cable
    - Twisted pair
    - Fiber optics
  - Unguided
    - Radio
- Digital subscriber link (DSL), Cable network, Fiber Internet, …

Access networks: Home network



Take home task: Learn more about Digital Subscriber Link (DSL)

Access networks: Enterprise access networks



- Typically used in companies, universities, ...
- 10 Mbps to 10 Gbps transmission rates
- End systems typically connect to Ethernet switches

Access networks: Wireless access networks

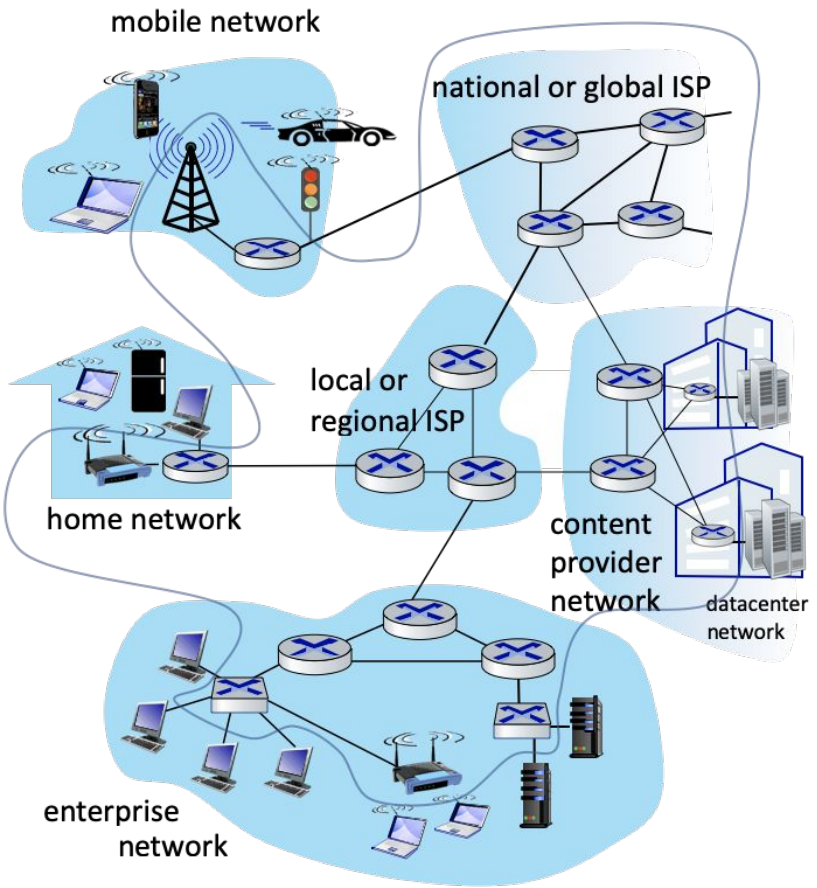
Wireless LANs

- Range
  - within a building/organisation
- Standards
  - IEEE 802.11 a/b/g/n
- Data rates
  - 11, 54, 450 Mbps

Wide area wireless access

- Range
  - 10’s of kms
- Provided by telco operator
- Standards
  - 3G, 4G LTE, 5G
- Data rates
  - Between 1 to 10 Mbps
  - Upto 1 Gbps (expected) with 5G

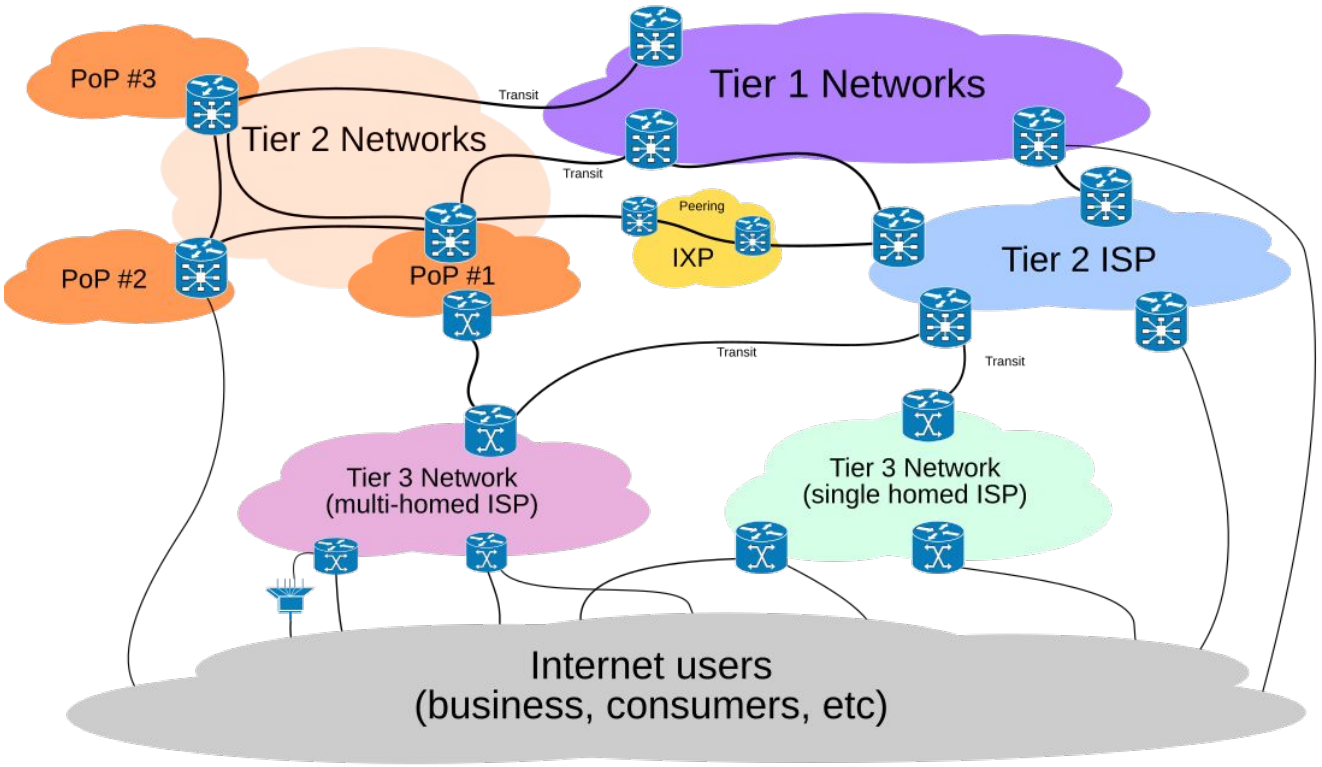
What is the Internet? What are its components?



- **End devices** connected by communication links (wired/wireless)
  - Some end hosts provide special services such as mail server, ...
- **Links** terminate at switches and routers
- Multiple switches/routers in an organization connect to form an **enterprise network**
- **Tier-2 ISPs** have several routers that connect **multiple enterprise networks**
- **Tier-1 ISPs** form the **backbone of Internet**

LAN/MAN/WAN, Intranet

Internet architecture



POP: Point of presence

IXP: Internet exchange point

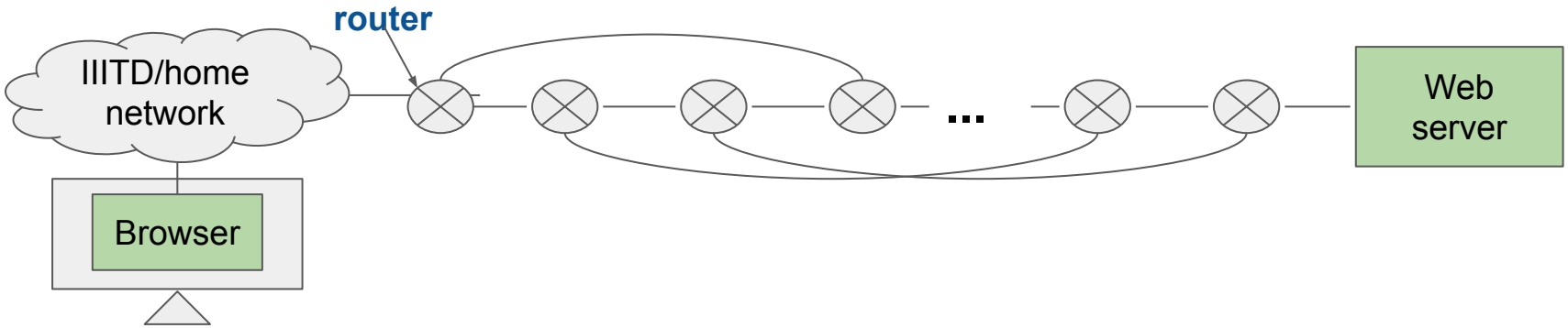
Tier-1 ISPs in India

- **Bharti**
- **Reliance**
- **Tata**
- **VSNL**

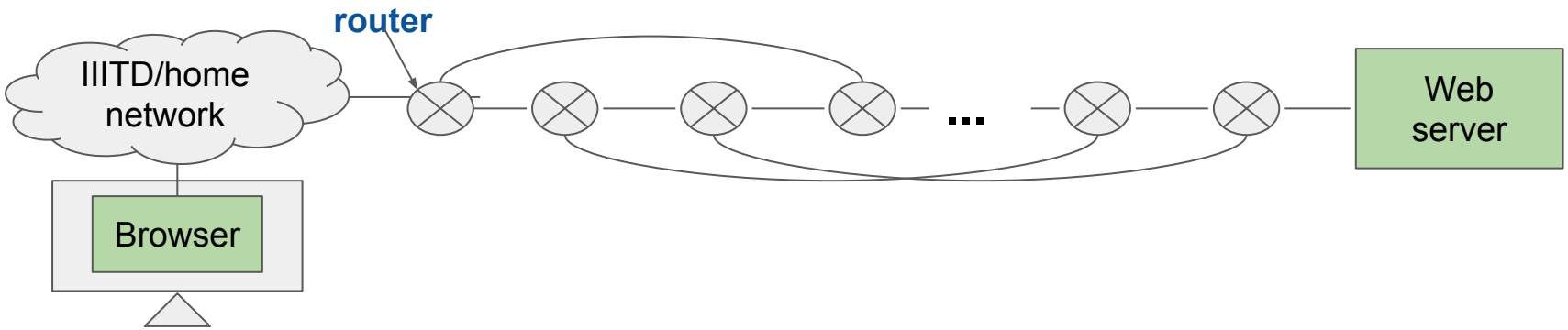
Tier-2 ISPs in India

- **Hathway**
- **Spectranet**
- **Tikona Digital**
- **Sify Technologies**

Communication from “browser” to “web server” & back?



Communication from “browser” to “web server” & back? **Addressing**



Addressing:

- **Physical/MAC address**
- **IP address**
- **Port address**
- **Socket address**
  - **Connection end points**

Addressing in Internet

- Physical or MAC address
  - Uniquely identifies a machine on the local network
  - 48 bits, hexadecimal notation
  - Example- 1a:23:76:af:86:fe
- Logical or IP address
  - Uniquely identifies a machine on the global network
  - IPv4
    - 32 bits, dotted decimal notation
    - Example
      - 192.168.100.1, 6.2.1.4
  - IPv6
    - 128 bits
    - Example
      - fa13:0:0:0:0:0:0:c3 can also be written as fa13::c3
    - Many alternative notations …
  - More on IP addresses
    - Public vs. Private
    - Static vs. Dynamic

Addressing in Internet, contd…

- Port address
  - Uniquely identifies a process on a machine
  - 16 bits; range: 0 to 65535 (2^16-1)
  - **0 to 1023**: Reserved port address; for server applications (public)
  - **1024 to 49151** (2^15+2^14-1): Semi reserved port address; assigned by IANA
  - **49152 to 65535**: ephemeral port address; client-side process
- Socket address
  - Uniquely identifies a process on the global network, i.e., the Internet
  - IP address, port address
- Connection end points (srcIP, srcPort, dstIP, dstPort)

Watch the videos for broader understanding: Where did all this start from? And where is it going?

- **History of the Internet**

  https://www.youtube.com/watch?v=9hIQjrMHTv4

- **What are the core principles behind Google data centers?**

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- **How does networking work across Google's data centers?**

  This video is a bit advanced; you may not understand everything

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Lec 02
Network design

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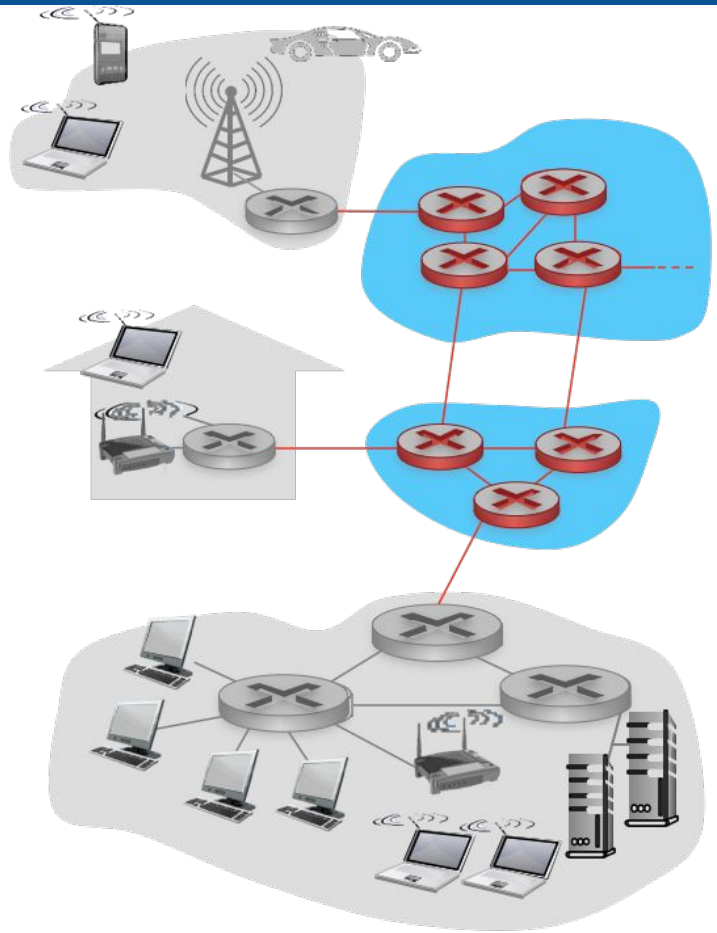
Network design requirements

1. Scalability
   - How can we increase the number of connected end hosts?
2. Efficient resource utilization
   - Resources such as network link/router capacities are fixed. How do we optimally utilize them?
     - Increase number of simultaneous flows?
     - Are application service requirements satisfied?
3. Provisioning flow-specific services
   - Request/Reply messages
   - Streaming messages
4. Manageability
   - monitor, debug (crash/failure), configure, modify the network

Scalability (Network design requirement 1)

- Point to point networks
- Multiple access networks (Broadcast networks)
- Switched networks
- Interconnection of switched networks

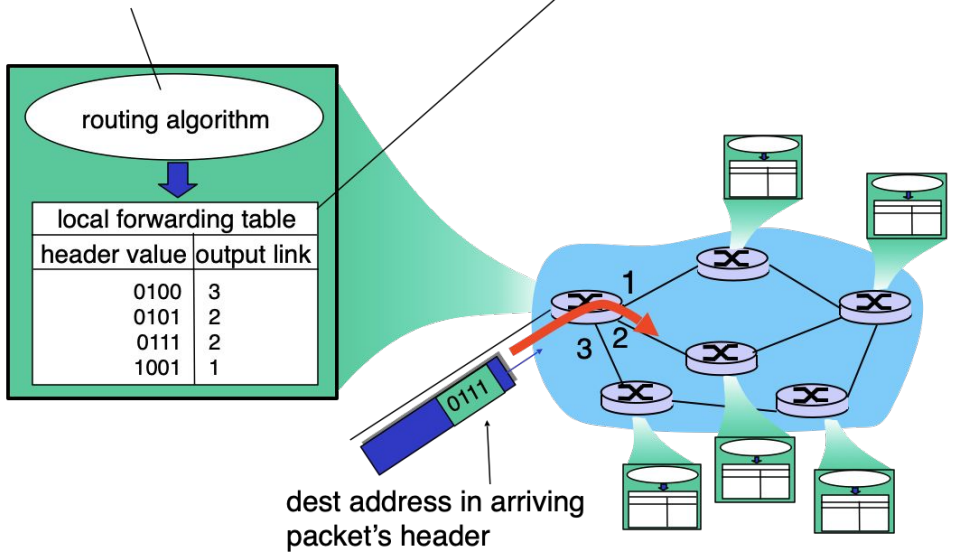
The network core



Functions of the network core: Packet switching

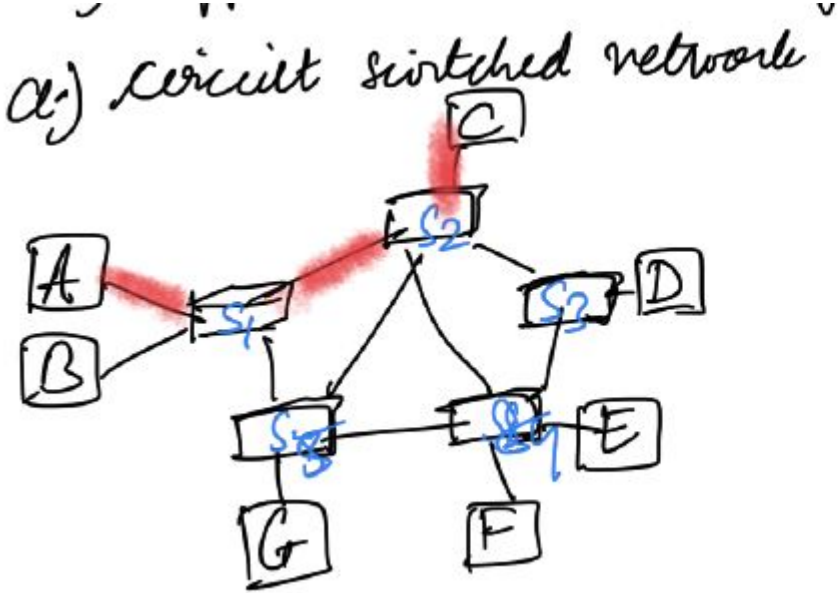
routing: determines source-destination route taken by packets
- *routing algorithms*

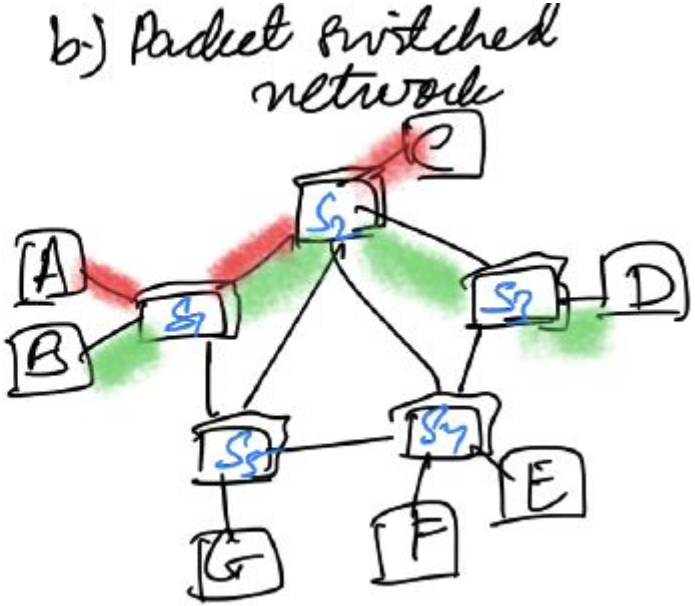
forwarding: move packets from router's input to appropriate router output



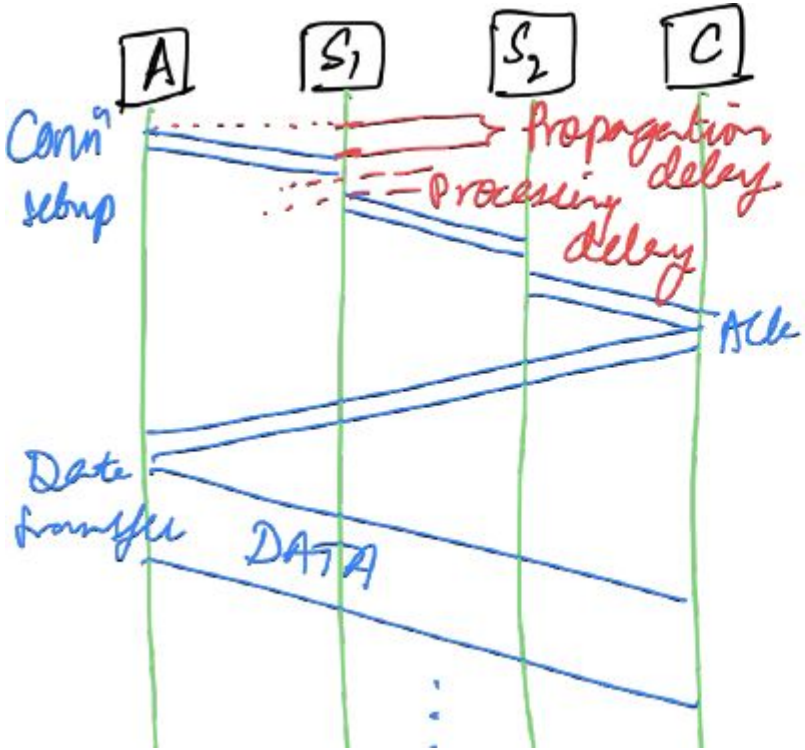
Store & forward switching

Circuit switching vs. Packet switching

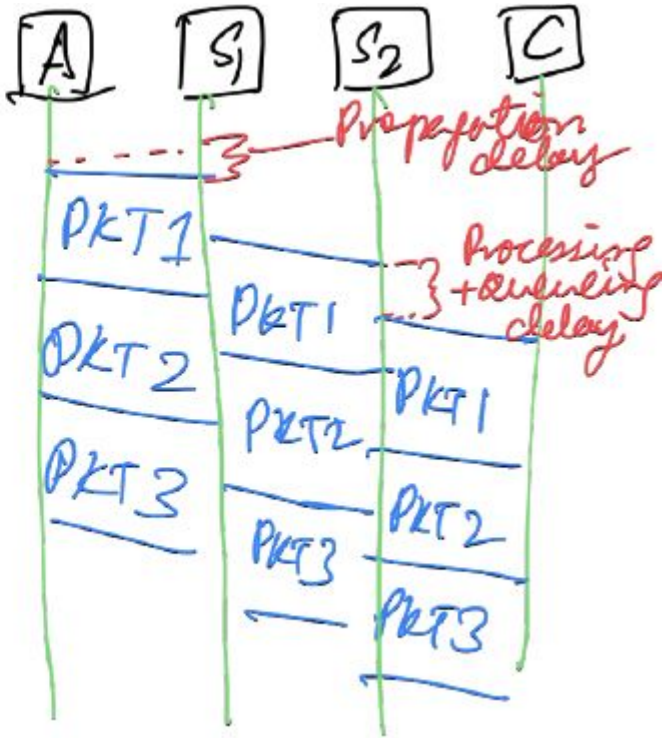




Circuit switching vs. Packet switching

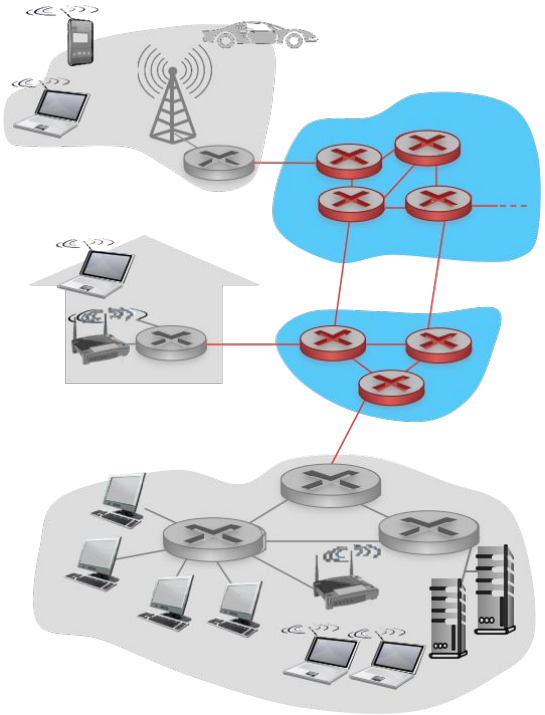


Circuit switching



Packet switching

Efficient resource utilization (Network design requirement 2)



Circuit switching	Packet switching
Data path is setup & fixed during the life of the connection	Application message broken into packets; router decides next hop
Reserve resources along all links of the path	No resource reservation; store-and-forward approach
Path fixed during setup; multiple access using TDM or FDM	Medium shared using Statistical TDM
Connection oriented; low delay/jitter	Packet buffered/dropped if previous packets are not transmitted
Idle connection => resources wasted	Efficient resource utilization; great for bursty data
Could provide performance guarantees (QoS)	Cannot provide performance guarantees; “Best effort” traffic
Implemented by traditional telephone networks	Implemented by the Internet, cellular networks (4G/5G/...)

Provision of traffic-specific services (Network design requirement 3)

- Different traffic types
  - Data, voice, video, streaming, live
- Different requirements
  - Reliability
  - Security
  - Sensitivity to packet losses
  - Sensitivity to delays
  - Bandwidth/throughput
  - Packet ordering

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