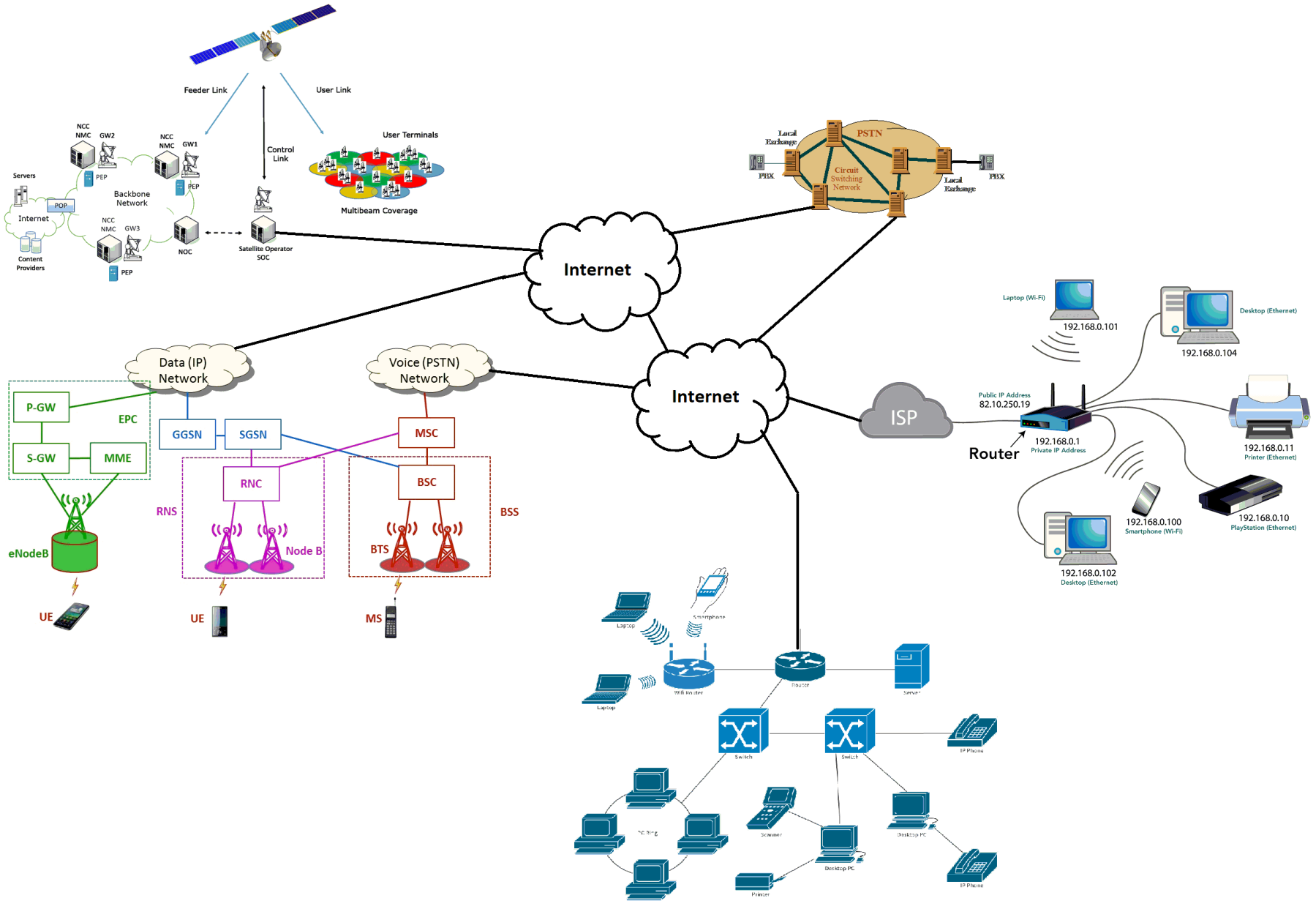
Introduction to Telecommunications
EN1052

Chathuranga Weeraddana

February 2021

Lecture 6: Networking Principles I

Networks


Feeder Link
User Link
Control Link
User Terminals
Multibeam Coverage
NCC NMC
GW1
GW2
GW3
PEP
POP
Servers
Backbone Network
Internet
Content Providers
NOC
Satellite Operator SOC
Local Exchange
PSTN
Circuit Switching Network
PBX
Internet
Data (IP) Network
Voice (PSTN) Network
P-GW
S-GW
MME
EPC
GGSN
SGSN
MSC
RNC
BSC
RNS
BSS
Node B
BTS
eNodeB
UE
MS
ISP
Router
Public IP Address
82.10.250.19
192.168.0.1
Private IP Address
Laptop (Wi-Fi)
192.168.0.101
Desktop (Ethernet)
192.168.0.104
192.168.0.11
Printer (Ethernet)
192.168.0.100
Smartphone (Wi-Fi)
192.168.0.10
PlayStation (Ethernet)
192.168.0.102
Desktop (Ethernet)

Networks

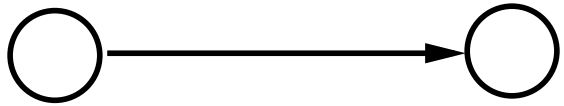
- a system with many senders and receivers
- includes computer networks
- includes satellite networks
- includes phone system
- includes cellular networks
- and many others

Building Blocks of a Network

- there are no explicit demarcations
- yet, depending on the attributes, one can see there are different types of communications available in any network:
- e.g.,
  - point-to-point communication
  - multipoint-to-point communication
  - point-to-multipoint communication
  - communication via relay nodes

Point-to-Point Communication

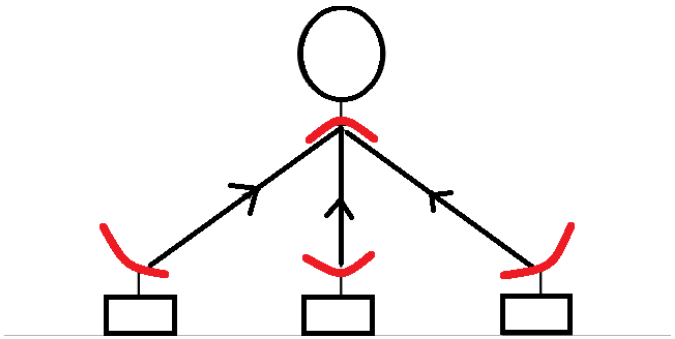
- communication from one node to another node, usually via a dedicated channel



- e.g.,
  - leased lines
  - microwave radio links
  - bluetooth connection between two phones
  - computer to projector communication

Multipoint-to-Point Communication

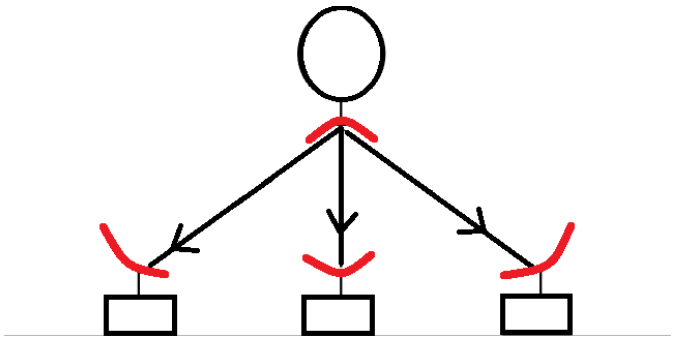
- communication from a number of nodes to one node



- e.g.,
  - many ground stations communicate with a satellite over a common channel
  - many mobile users communicate with a base station over a common channel
  - many computers communicate with an access point over a common channel

Point-to-Multipoint Communication

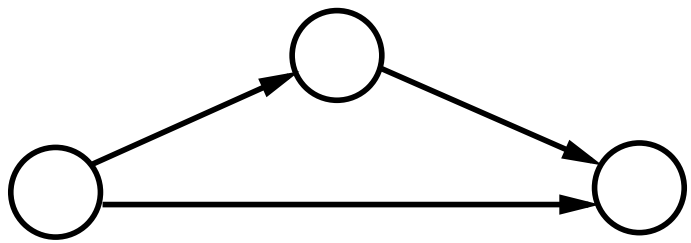
- communication from one node to a number of nodes



- e.g.,
  - TV broadcast station communicate with many household televisions over a common channel
  - a base station communicate to many mobile users over a common channel

Communication via a Relay

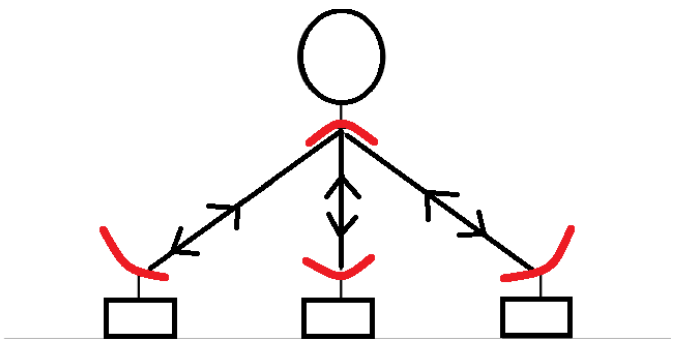
- communication from one node to another, where a relay node also plays role



- e.g.,
  - internet itself

Two Way Communication

- usually in any communication between two parties (e.g., nodes), both are involved in transmitting information
- thus, duplex communication is required in general, e.g.,



Two Way Communication

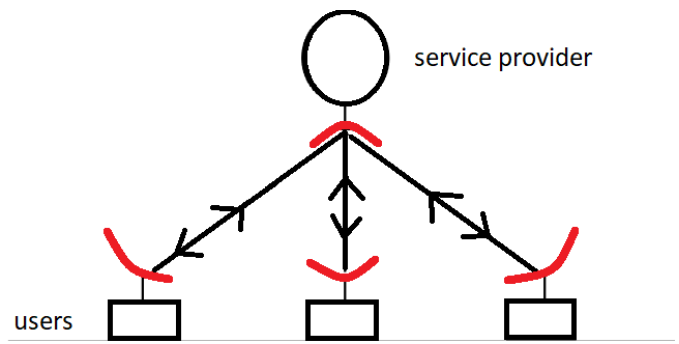
- duplex communication systems: nodes can communicate in both directions
  - half-duplex communication systems: one node take the control at a time and thus there is no simultaneous communications, e.g., walkie-talkie two way radio
  - full-duplex communication systems: simultaneous communication is allowed, e.g., telephone to telephone

FDD and TDD

- in a common resource, (e.g., time, frequency), achieving full-duplex communication is challenging
- why? e.g.,
  - interference
  - received signal power is overwhelmed by the transmitted signal power
- a commonly used mechanism to accomplish full-duplex communication is by
  - FDD: frequency division duplexing: transmitter and receiver operate at different frequencies
  - TDD: time division duplexing: to separate transmitted and received signals in time

Access Network

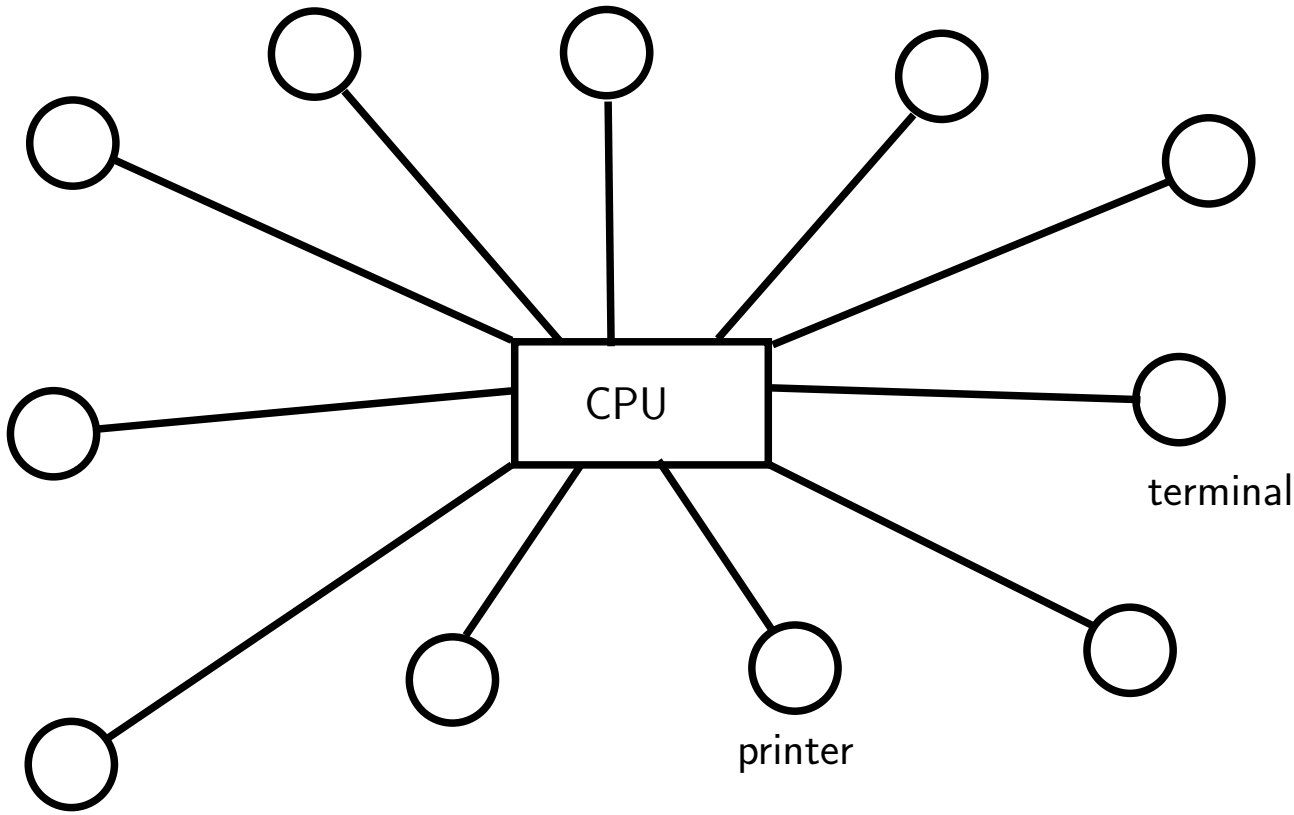
- form the point of view of the subscribers or the users of a communication system, access network plays a key role
- access network simply provides access to subscribers so that they can connect to the communication service provider (e.g., mobile network operator, internet service provider, PSTN: public switched telephone network)



Access Network

- commonly used access technologies:
  - local loop (analog, wired): copper wire pairs optimized to carry voice in analog form
  - digital subscriber loop (DSL): modified to carry data and voice within certain constraints on copper local loop
  - wireless local loop (WLL): local loop with wireless connection, which can be fixed or mobile
  - fiber to the home (FTTH): optical fiber local loop

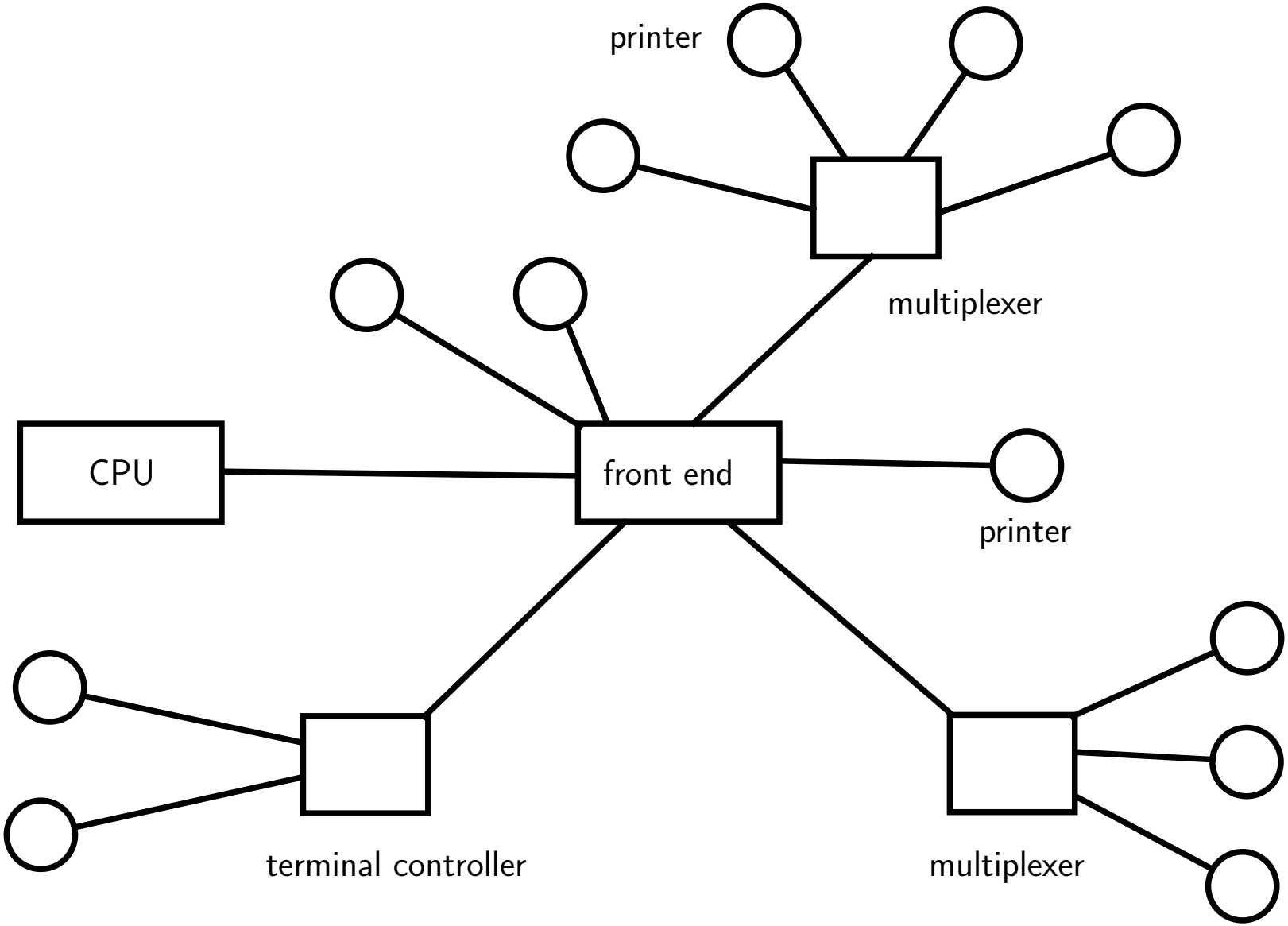
Proliferation of Peripherals



Proliferation of Peripherals

- early 1950s: the use of communication links to connect central computers to remote terminals and other peripheral devices, e.g., printers
- peripheral devices expanded rapidly in the 1960s with time-shared computer systems
- uneconomical to provide a separate communication link to each peripheral

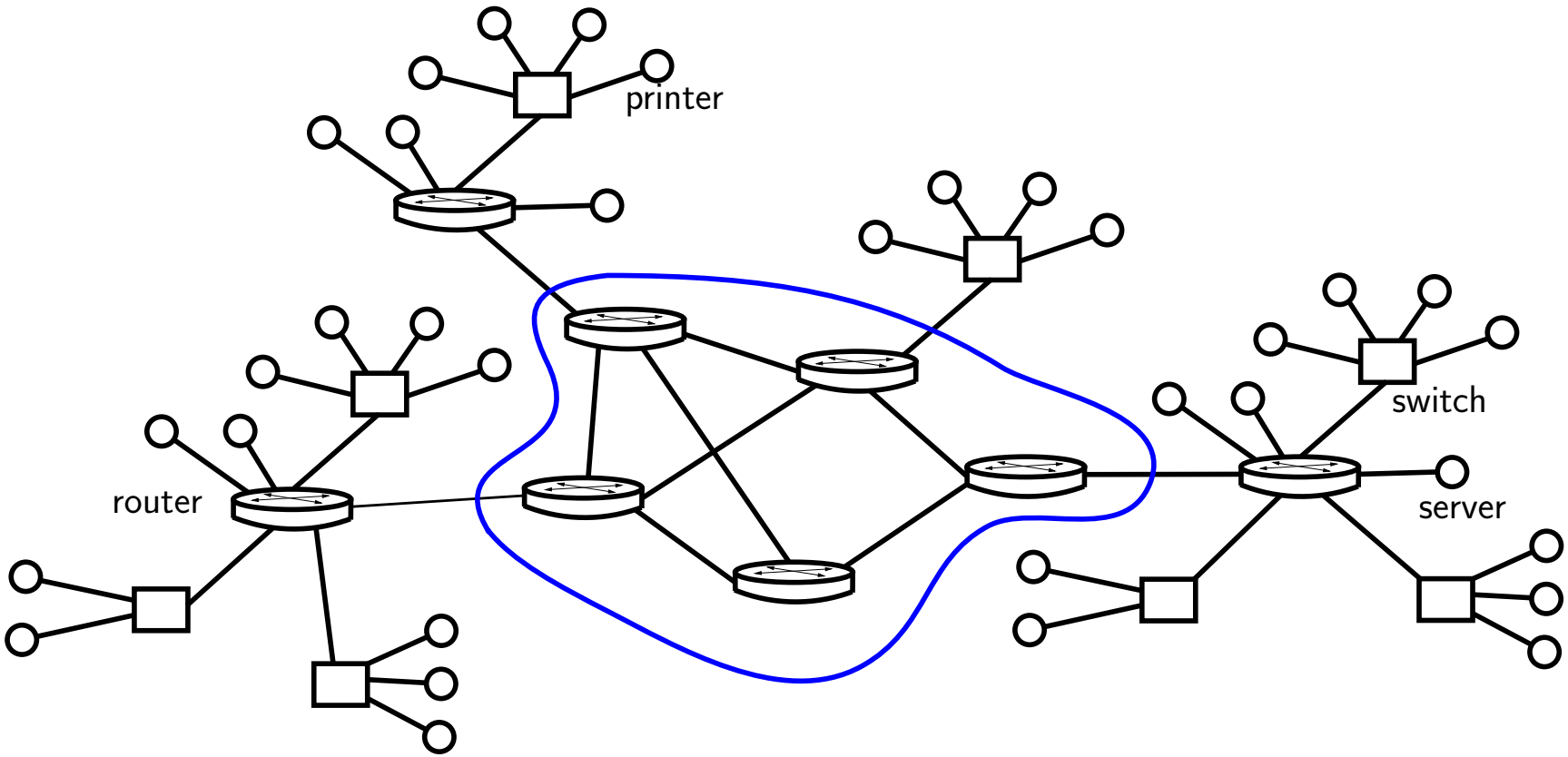
More Complex Structures



More Complex Structures

- multiplexers were developed to collect all the traffic locally
- send the traffic on a single link to the central processor
- the overall operation is centrally exercised at the central processor
- yet problems such as distributed control, the relaying of messages over multiple communication links do not arise in these centralized systems

Geographically Distributed Systems



Geographically Distributed Systems

- around 1970: the first large-scale, general-purpose data networks
- those connect geographically distributed computer systems, users, and peripherals
- nodes of the subnets are also computers
- the subnet nodes however are logically distinct from the external computers

Geographically Distributed Systems

- the subnet had been central
- LANs and WANs

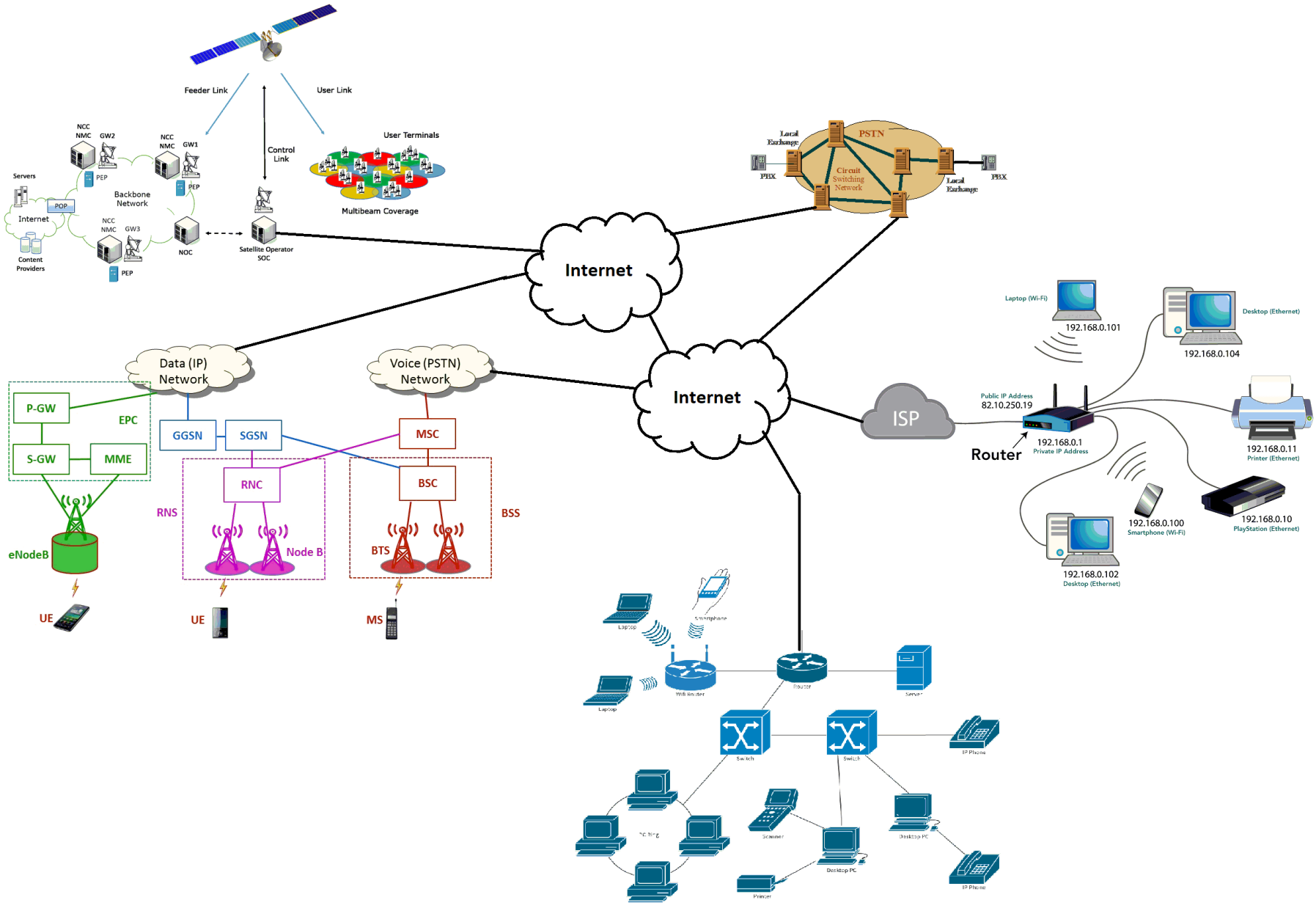
Further Growth

- 1980s more and more networks have been connected
- gateways, bridges allow users of one network to send data to users of other networks
- thus, networks of networks

More Complications

- network of networks: much more complex than a single network
- each constituent subnet has its own conventions and control algorithms (i.e., protocols)
- thus, gateways and bridges must deal with this inhomogeneity

Recent Communication Networks



Recent Communication Networks

- communication networks are usually a blend of systems with point-to-point communications, multipoint-to-point communications, and point-to-multipoint communications, which in turn yields, mutipoint-to-multipoint communications

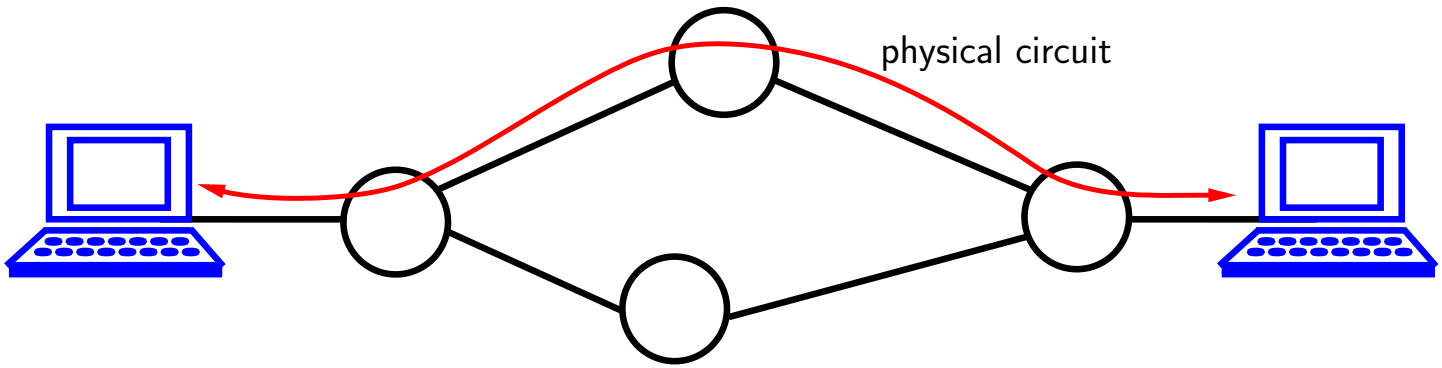
- almost always, these networks are equipped with a well defined physical infrastructures, e.g., base stations, routers, switches, access points, servers, computers, hubs, telephone exchanges or central offices, satellites, wire-line or wireless media between the nodes, fiber optic networks, and many others

Circuit Switching and Packet Switching

- two general approaches used within a subnet to transmit the traffic for the various sessions [1]
  - circuit switching
  - packet switching (store and forward switching)

[1] A message sequence between two users is called a session.

Circuit Switching



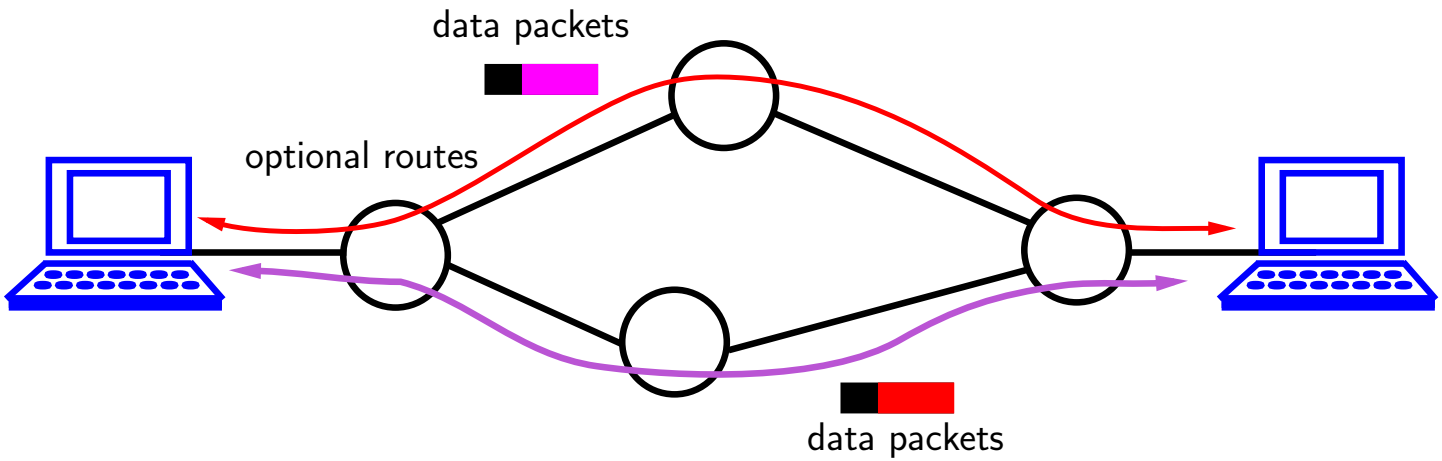
Circuit Switching

- when a session s is initiated, it is allocated a given transmission rate r_s
- a path is then created from the transmitting site through the subnet and to the destination site
- each communication link on this path then allocates a portion r_s of its total capacity
- resource allocation for different sessions is by multiplexing, e.g., TDM of FDM

Circuit Switching

- communication rate of admitted sessions are guaranteed
- a communication link is fully allocated $\rightarrow$, no new sessions are admitted
- i.e., the request is rejected
- e.g., telephone network, cellular telephone network

Packet Switching



Packet Switching

- circuit switching is rarely used in data networks
- main reason: very inefficient use of links
- analogy: what if dedicated roads for us to travel?

Packet Switching

- links are fully utilized whenever it has any traffic to send
- using communication links on a demand basis
- often decreases the delay in the network relative to the circuit switching
- queueing delay: when a message from session arrives while another message is in transmission

Packet Switching

- queueing delay cannot be controlled
- some sort of flow control mechanisms are necessary
- e.g., LAN, internet, packet-switched cellular networks

Leased or Dedicated Links

- a dedicated pipe from a service provider

Concept of Layering

- the required network operations for communication between nodes are indeed intricate
- a modular approach is adopted
- in fact a hierarchical modularity is central to network design
- this leads to the idea of layered architecture of networks