Introduction to Data Communications

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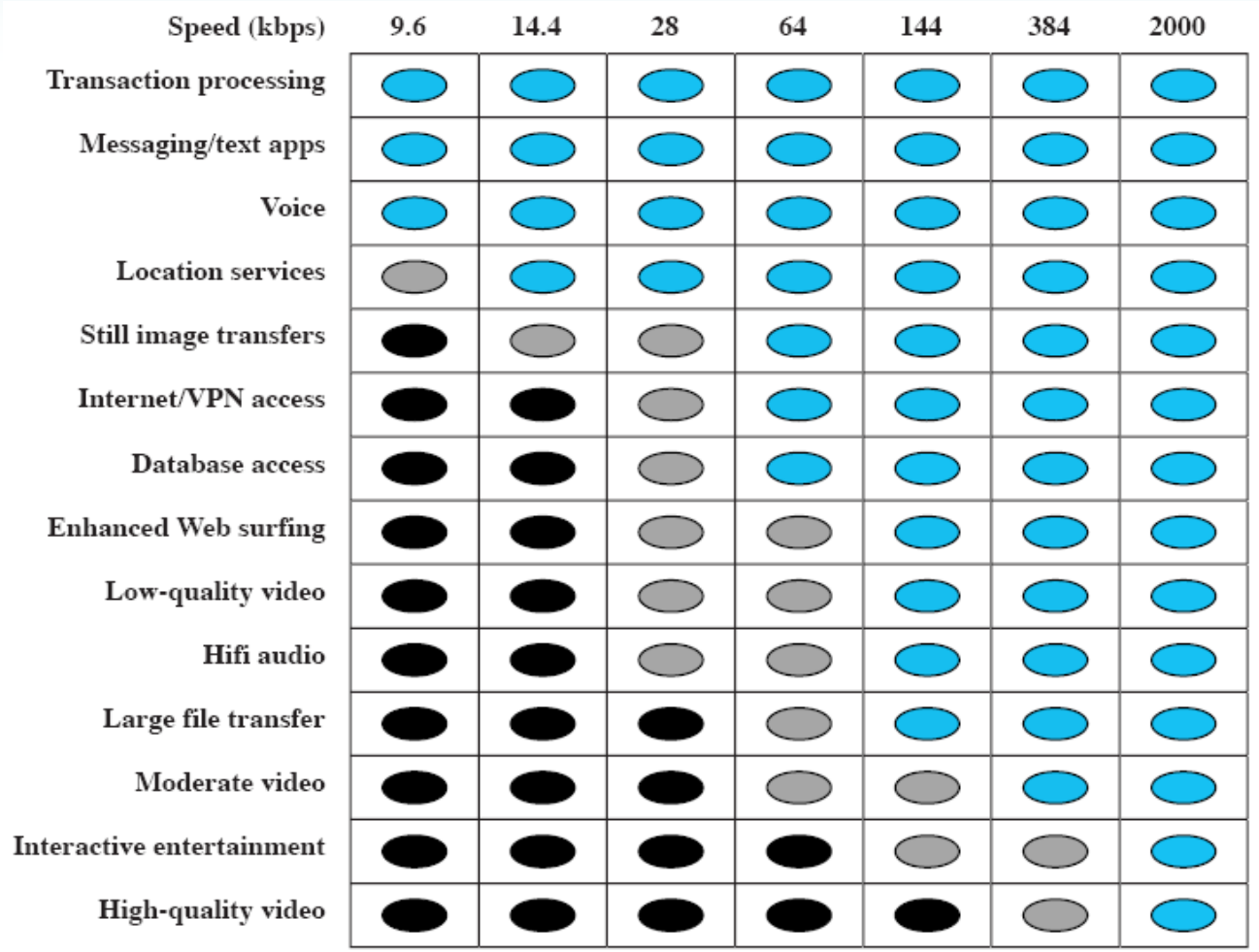
Today's Data Communications

- Trends:
  - Traffic growth at a high and steady rate
    - Office automation, remote access, online transactions, …
  - Development of new services
    - New services require higher capacity; higher capacity enables new services
  - Advances in technology
    - Cheaper and faster computer and communication technologies
    - Intelligent voice and data services, e.g. giving different levels of service to different traffic
    - The Internet and Web provide businesses with new ways of reaching customers, suppliers partners, …
    - Mobility - people do not want to be restricted to desks/homes to access network services

Networks Services and Speeds



VPN: virtual private network

Performance:

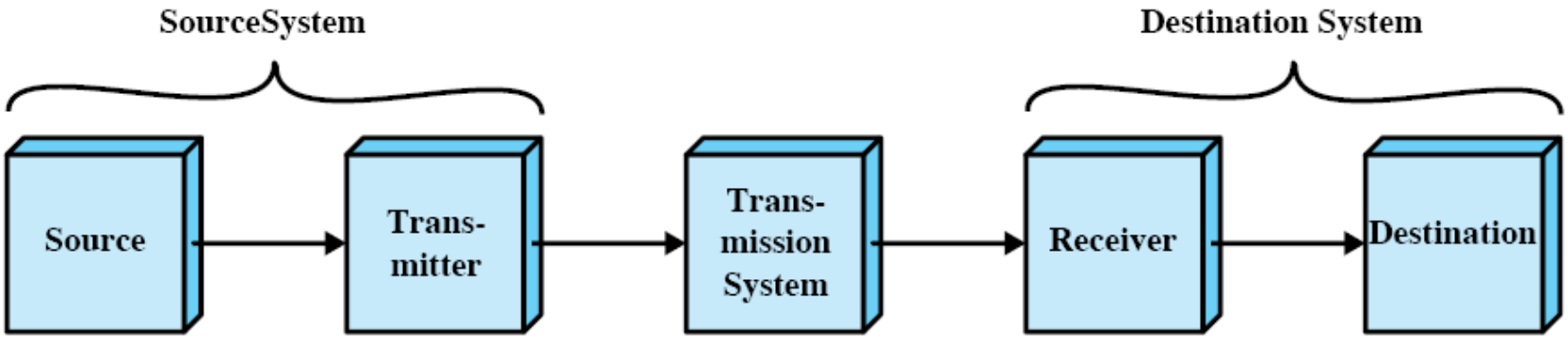
Poor **Adequate** **Good**

Today's Data Communications

- Developments of network technology has changed way organisations work
  - Also: ways in which organisations work drives changes in network technologies
- Significant change in requirements
  - Emergence of high-speed LANs
    - LANs are now essential part of any organisation
    - High speed LANs are needed for use of data intensive applications (media, publishing, CAD, engineering, …)
  - Corporate Wide Area Networking
    - Organisations want to link their LANs together and allow employees and others remote access to their LAN
    - Increase amount of traffic sent on WANs
      - Used to be 80% internal (LAN), 20% external (WAN)
      - Now the external component is much more significant
  - Digital electronics
    - Consumer electronics moved to digital technologies
      - Digital cameras, CDs, DVDs, …
    - Desire to transfer this content over LANs, WANs and Internet
    - Networks must be faster to support this traffic

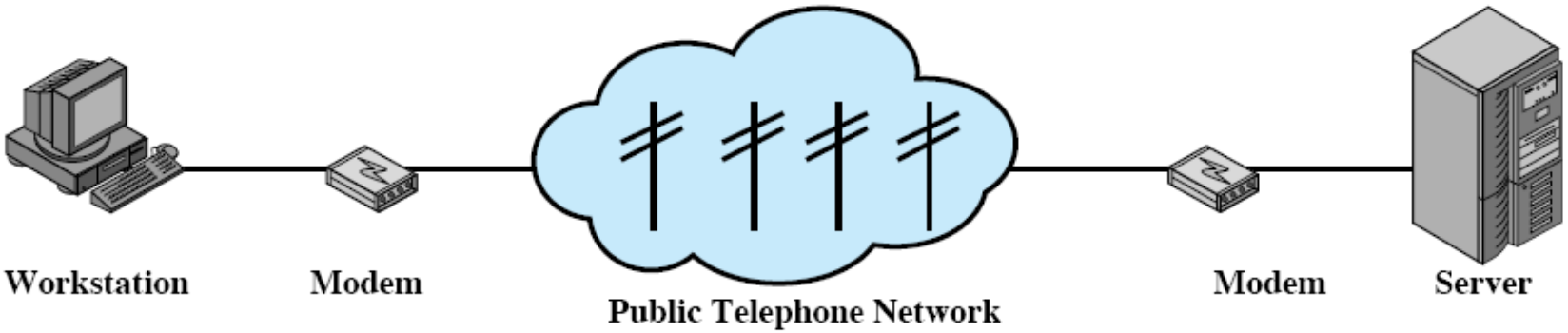
Simplified Communications Model

Fundamental purpose of communications system is the exchange of data between two parties



- Source - Device that generates data to be transmitted, e.g. telephone, PC
- Transmitter - Converts data from source into transmittable signals
  - E.g. Modem takes bits (0's and 1's) and converts into analog signal)
- Transmission System - Carries data from source to destination
  - Maybe a single physical line or complex set of networks
- Receiver - Converts received signal into data; dual of transmitter
- Destination - Takes incoming data (dual of source)

Example Communications Model



Communications Tasks

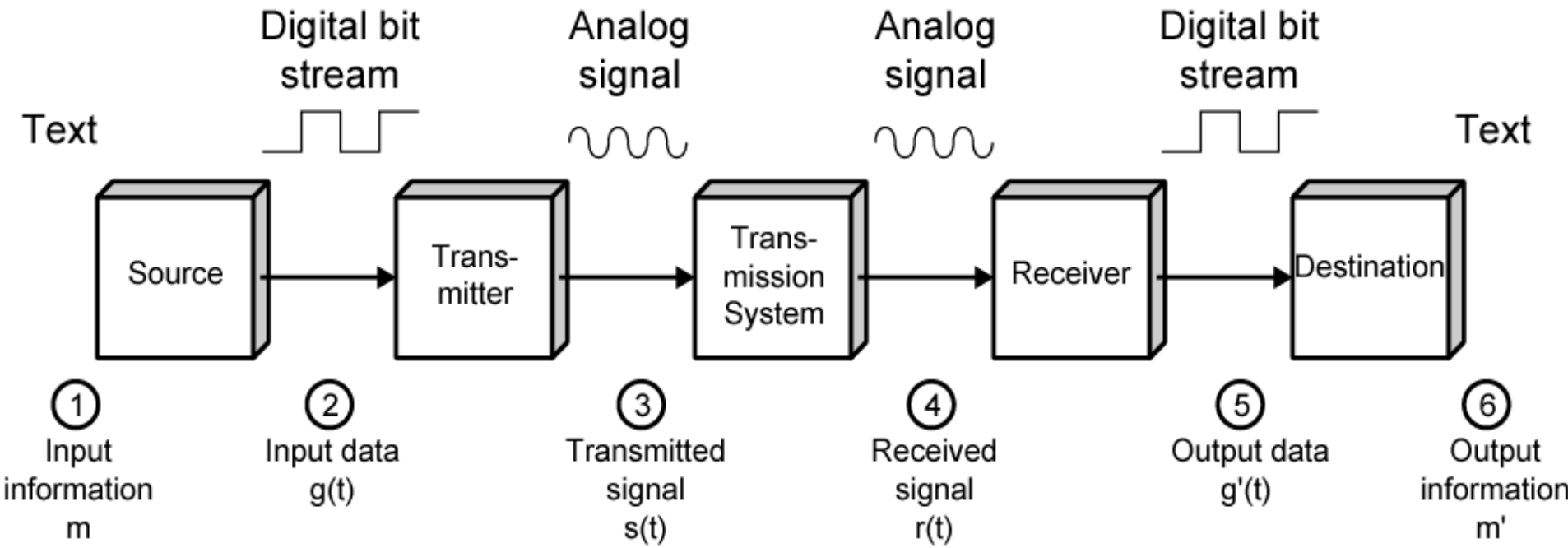
Communications model makes it look easy!
But many tasks must be performed …

Transmission system utilization	Addressing
Interfacing	Routing
Signal generation	Recovery
Synchronization	Message formatting
Exchange management	Security
Error detection and correction	Network management
Flow control	

Communications Tasks

- **Transmission system utilization** - need to make efficient use of transmission facilities typically shared among a number of communicating devices
- a device must **interface** with the transmission system
- once an interface is established, **signal generation** is required for communication
- there must be **synchronization** between transmitter and receiver, to determine when a signal begins to arrive and when it ends
- there is a variety of requirements for communication between two parties that might be collected under the term **exchange management**
- **Error detection and correction** are required in circumstances where errors cannot be tolerated
- **Flow control** is required to assure that the source does not overwhelm the destination by sending data faster than they can be processed and absorbed
- **addressing** and **routing**, so a source system can indicate the identity of the intended destination, and can choose a specific route through this network
- **Recovery** allows an interrupted transaction to resume activity at the point of interruption or to condition prior to the beginning of the exchange
- **Message formatting** has to do with an agreement between two parties as to the form of the data to be exchanged or transmitted
- Frequently need to provide some measure of **security** in a data communications system
- **Network management** capabilities are needed to configure the system, monitor its status, react to failures and overloads, and plan intelligently for future growth

Data Communications Model



Example 1 - Email

- Sending an email message:
  1. User keys in message *m*; *m* is a sequence of bits *g*
  2. Input data is transferred to I/O device (transmitter) as sequence of bits *g(t)* using voltage shifts
  3. Transmitter converts g into a signal *s(t)* suitable for the transmission media being used
  4. Whilst transmitting media, the signal may be impaired so received signal *r(t)* may differ from *s(t)*
  5. Receiver decodes signal recovering *g'(t)* as estimate of original *g(t)*
  6. *g'(t)* is buffered in destination PC memory as bits *g'* being the received message *m'*

Example 2 – Voice Call

- Telephone conversation:
  1. The input into the telephone (message *m*) is now in form of sounds waves
  2. Telephone converts sound waves to electrical signals *g(t)* at same frequency
  3. *g(t)* is transmitted without modification over medium (that is, *g(t)* is identical to *s(t)*)
  4. Again, due to distortion, *r(t)* will not be identical to *s(t)*
  5. *r(t)* converted to sound wave to produce *m'* (which is different from m, but normally a listener can understand)

Transmission Medium

- Transmission line is building block of a communications facility
- When choosing what medium to use:
  - Internal use entirely up to business (e.g. end-user, company)
  - Long-distance links made by carrier (e.g. TOT, ISP)
- Many different technologies to choose from. Two prominent technologies today:
  - Fiber optic
  - Wireless
- Although fiber optics provide very large capacity, transmission costs still high
  - Hence interest in efficiency improvements

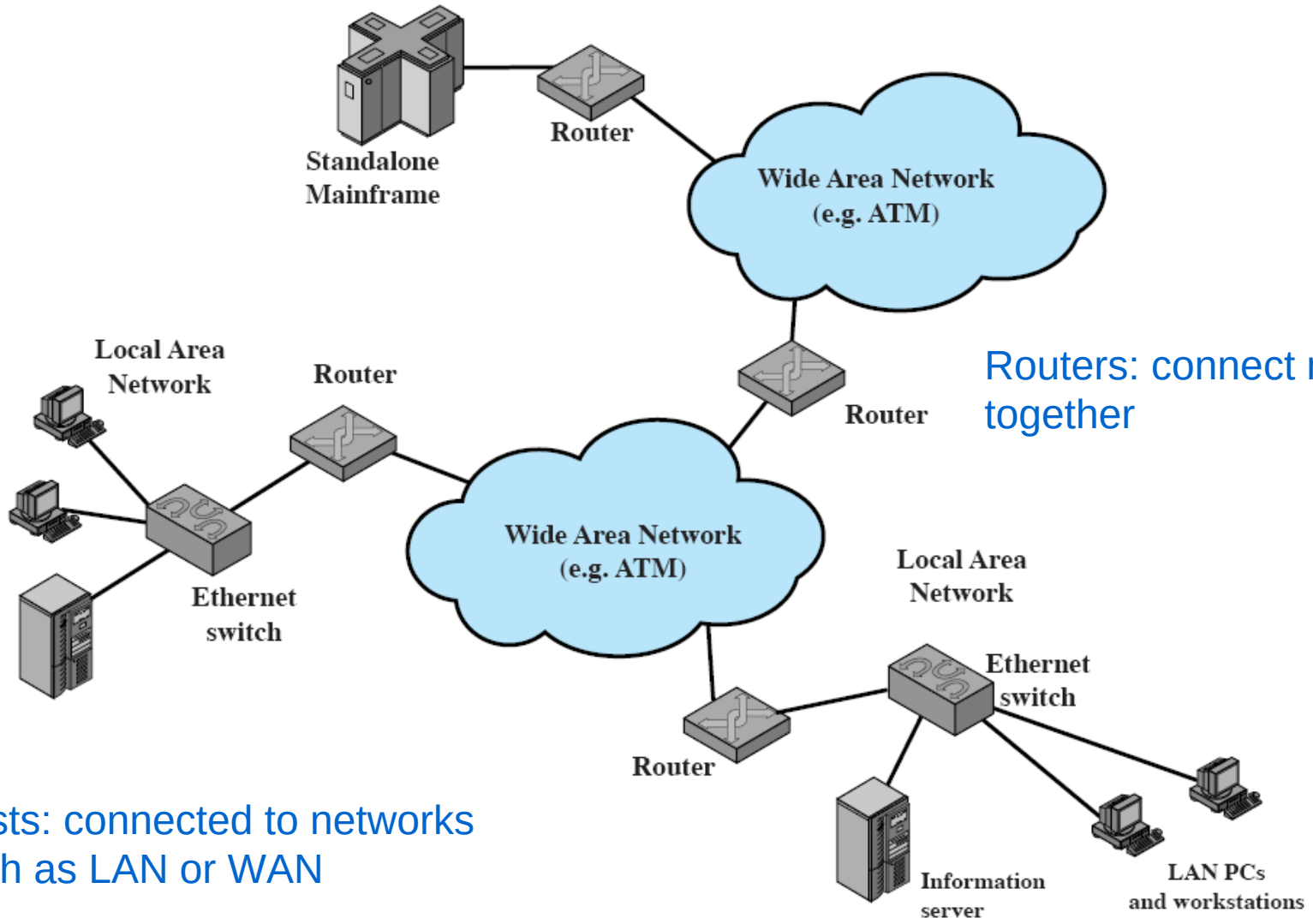
Networking

- Growth of number and power of computers is driving need for interconnection
  - Users want to be able to communicate with any other user
- Need communication software (e.g. Internet protocols) as well as communication network technologies
- Rapid integration of voice, data, image and video technologies
- Two broad categories of communications networks:
  - Wide Area Network (WAN)
    - Cover large geographical area (cities, countries)
    - Operated by carriers
  - Local Area Network (LAN)
    - Cover buildings, homes and small campuses
    - Usually owned and operated by organization that owns end devices
    - High end-user data rates than WAN

The Internet

- The Internet evolved from a US Department of Defence research network: ARPANET, developed in 1969
  - Used packet switching technology
    - Same technology was also applied to packet radio and satellite communication used by US DoD
  - Development and standardization of the Internet suite of protocols: TCP/IP
- What is the Internet?
  - Collection of networks connected together using common software: Internet Protocol (IP)
  - Although network technologies differ, any computer can communicate with any other computer (providing they are using IP)

Internet Elements

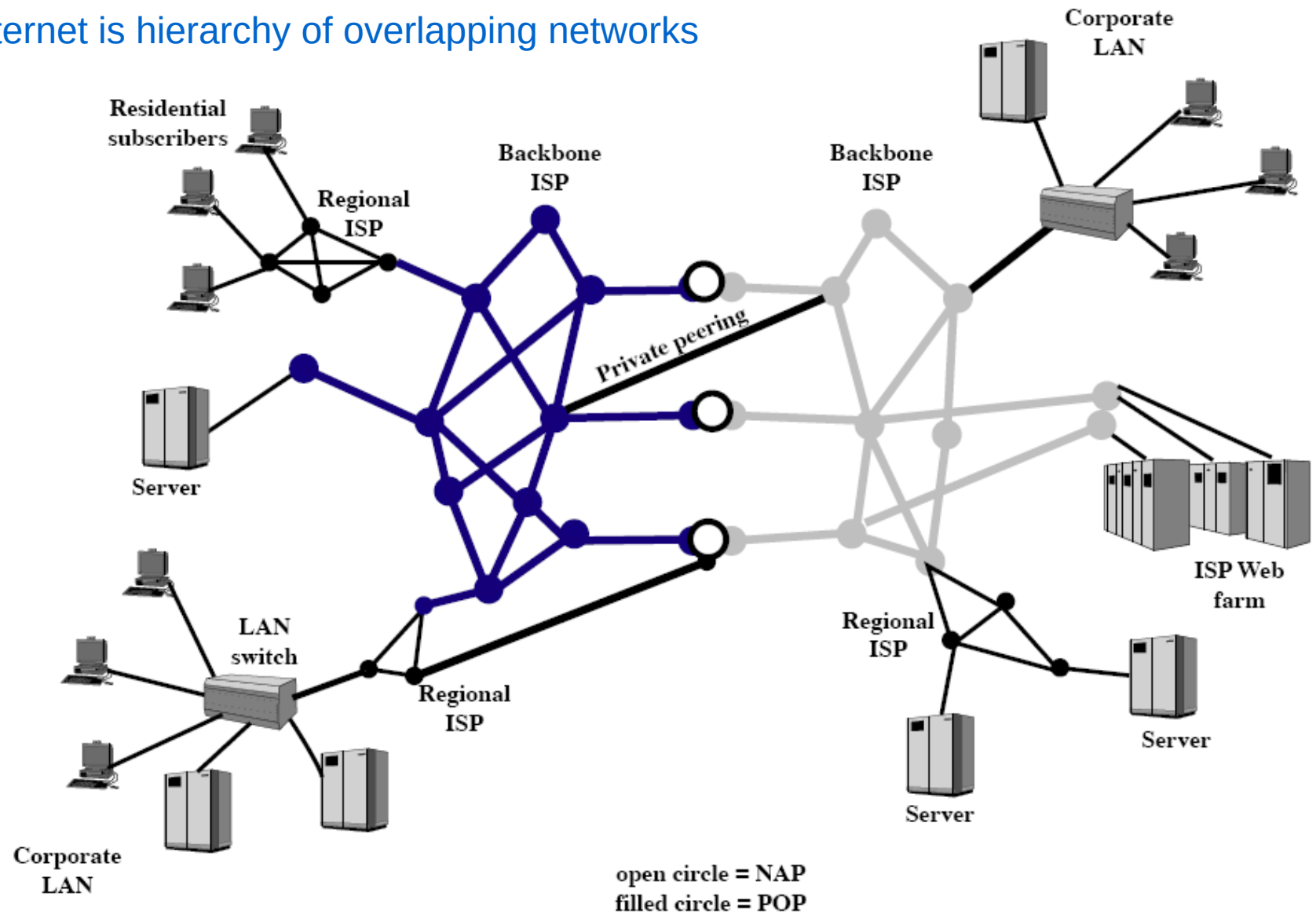


Routers: connect networks together

Hosts: connected to networks such as LAN or WAN

Internet Architecture

Internet is hierarchy of overlapping networks



Example Configuration