EE450, Fall 2015, Zahid

lecture #1

Thursday, Aug 27

Network Applications

- E-mail
- WWW
- Instant messaging
- Remote login
- P2P file sharing
- Multi-user network games
- Streaming audio/video
  - You Tube, Hulu, Netflix
- Voice over IP (e.g. Skype)
- Real-time video conferencing
- Grid computing
- On-line Social Network
  - Facebook, Twitter, etc…
- E-Commerce
- Distributed Databases
- Search

Note: different applications may have different
- Requirements (delay, loss, Throughput, jitter bounds, security)
- Number of participants (unicast, multicast, broadcast, etc…)
- Architecture (client-server, p2p, flat, hierarchical, hybrid, etc…)
- All applications can communicate over a single shared network

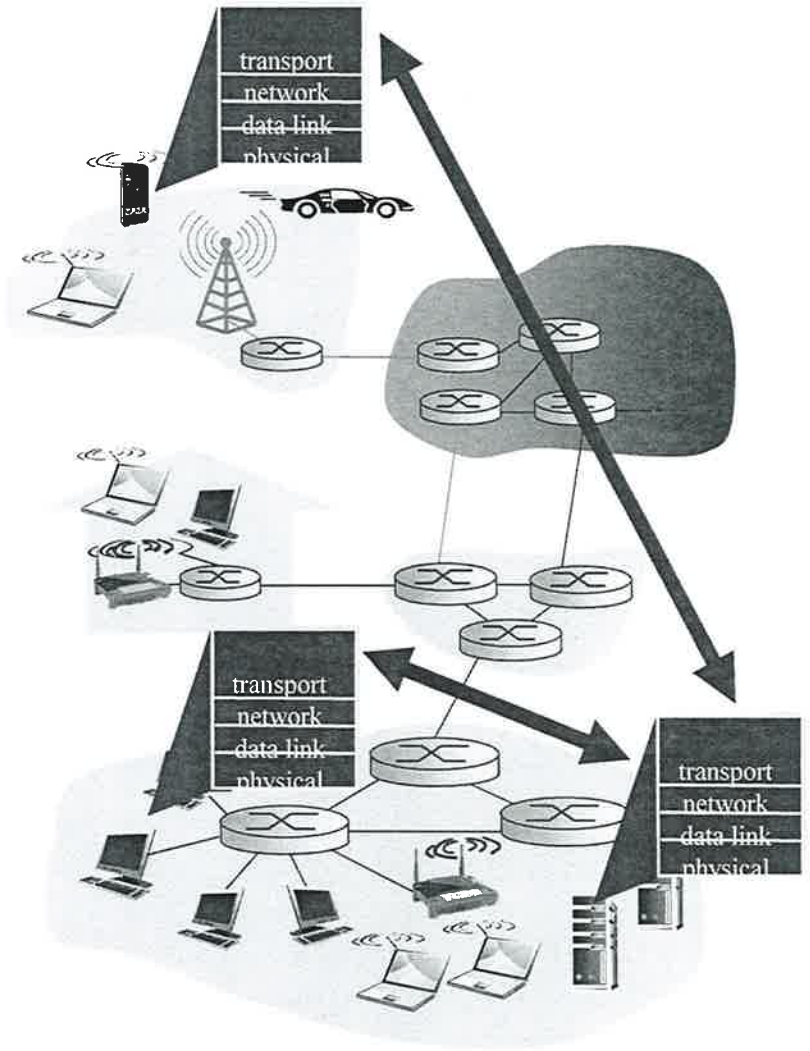
Creating a Networked Application

Write programs that:

- run on (different) end systems
- communicate over network
- e.g., web server software communicates with browser software

No need to write software for network-core devices

- network-core devices do not run user applications
- applications on end systems allows for rapid application development



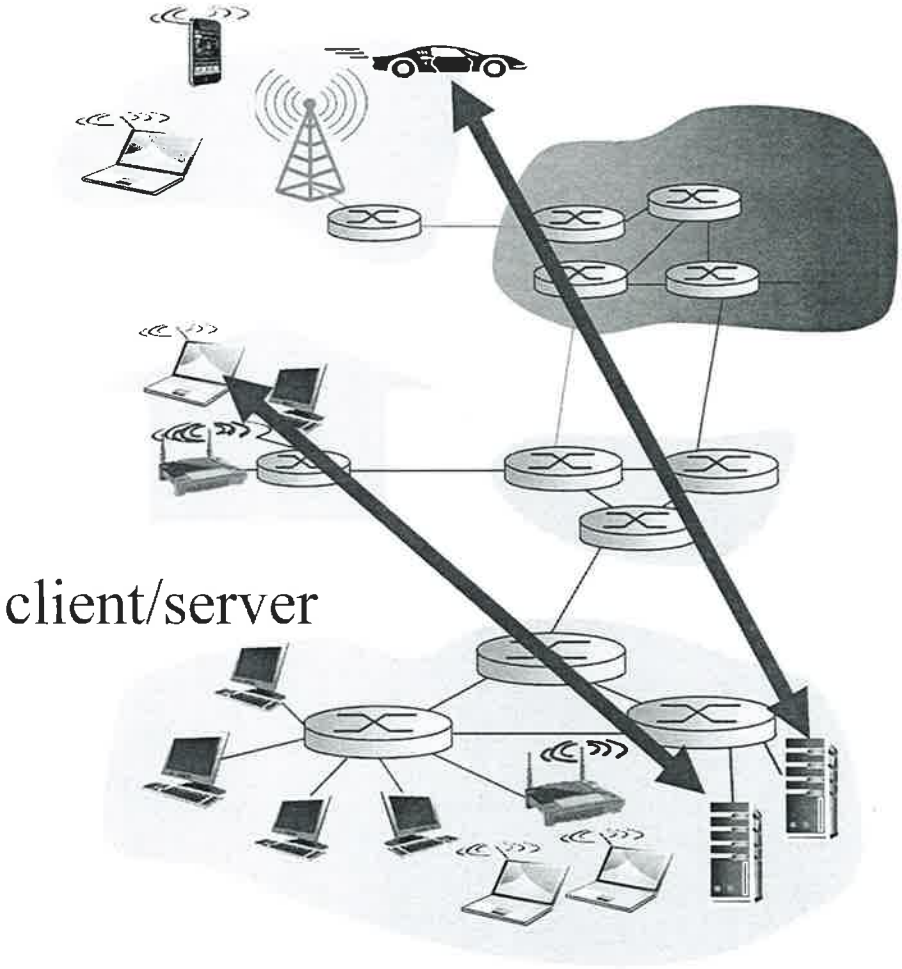
Client Server Architecture

Server:

- Always-on host
- Permanent IP address
- Data centers for scaling

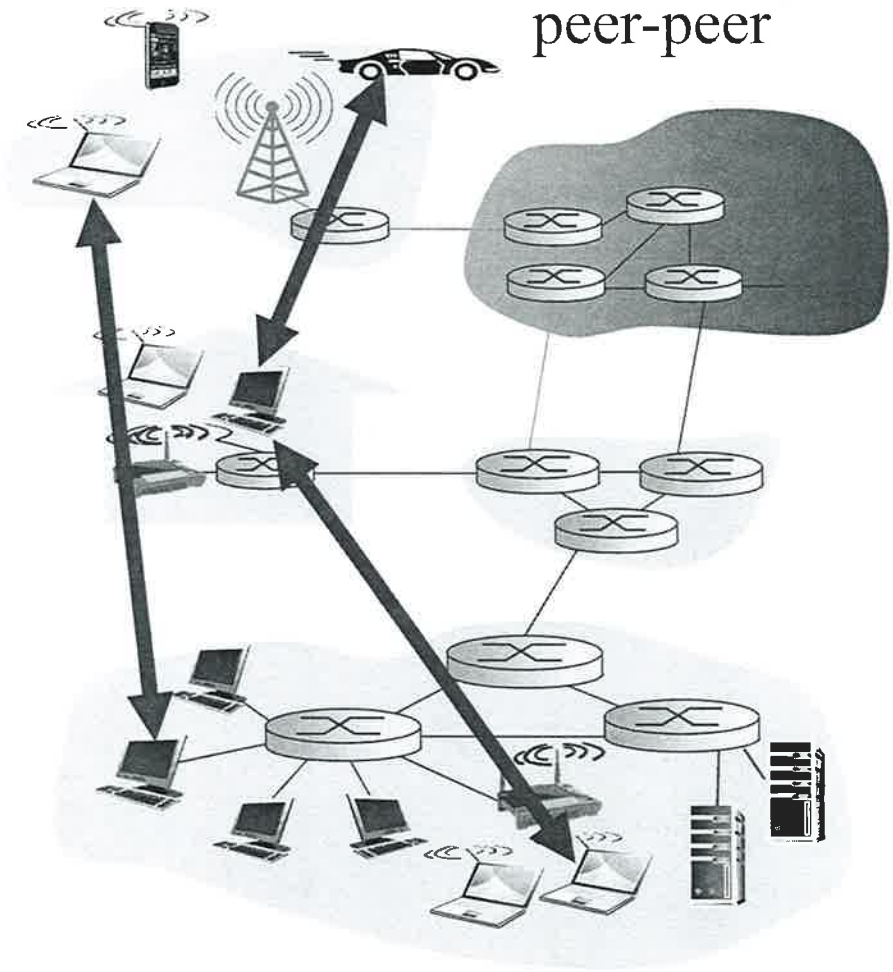
Clients:

- Communicate with server
- May be intermittently connected
- May have dynamic IP addresses
- Do not communicate directly with each other



P2P Architecture

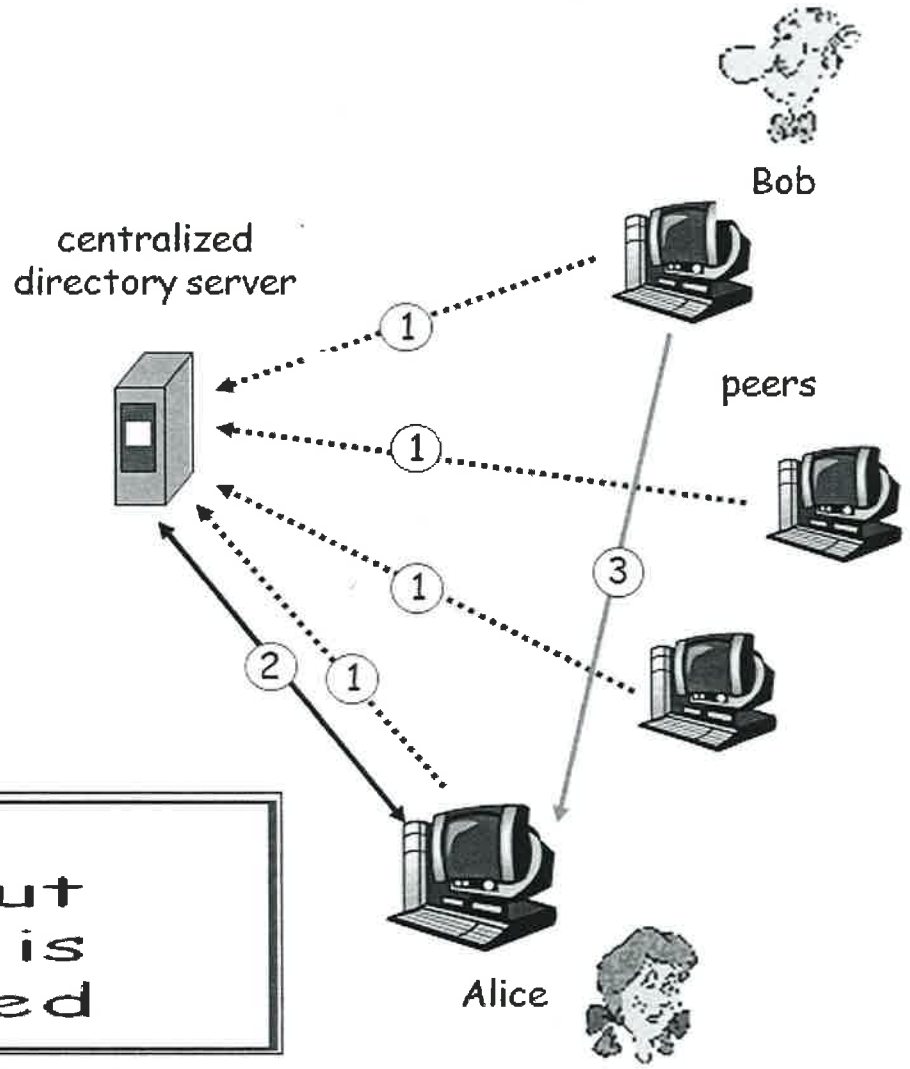
- No always-on server
- arbitrary end systems directly communicate
- Peers request service from other peers, provide service in return to other peers
  - self scalability – new peers bring new service capacity, as well as new service demands
- Peers are intermittently connected and change IP addresses (e.g. Gnutella)
  - complex management



P2P: Centralized Directory

original "Napster" design

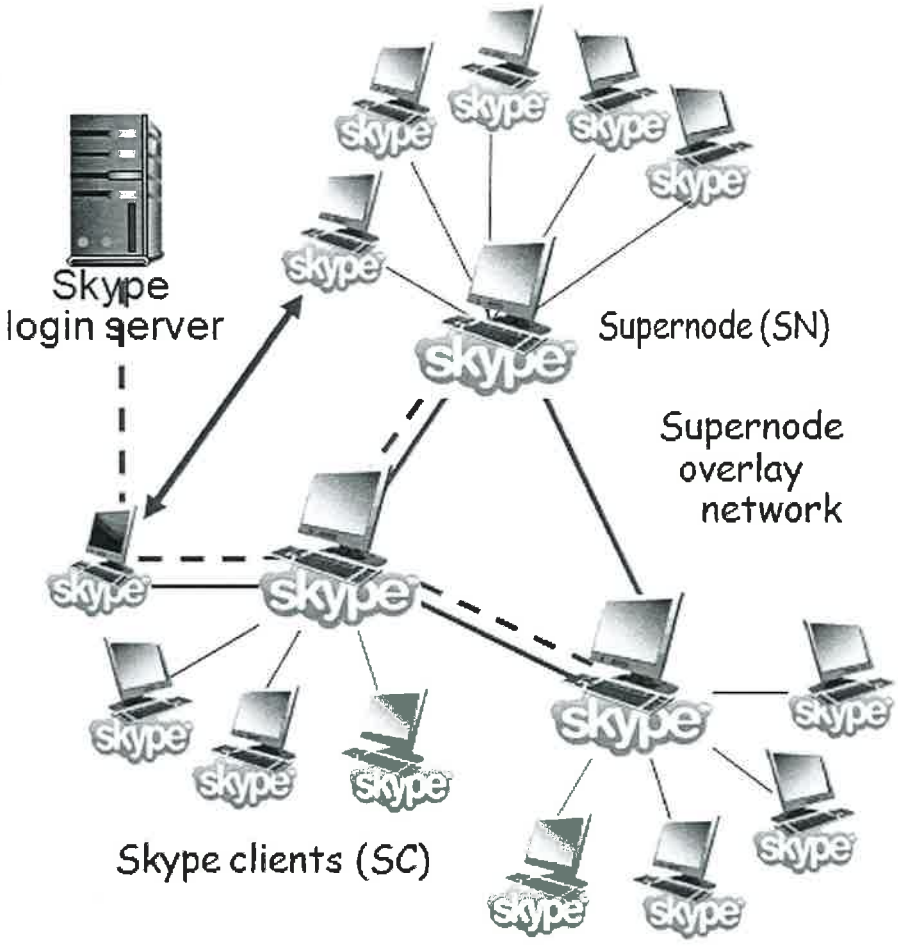
1) when peer connects, it informs central server:
   - IP address
   - content
2) Alice queries for "Hey Jude"
3) Alice requests file from Bob



file transfer is decentralized, but locating content is highly centralized

P2P Case Study: Skype Architecture

- Proprietary application-layer protocol with encrypted msgs
- Skype Peers connect to each other for a VoIP call
- Super Nodes are Skype Peers with special functionality (Usernames-to-IP Address mappings)
- SN Overlay Network
- Skype Login Server



Cloud Computing (EE542)

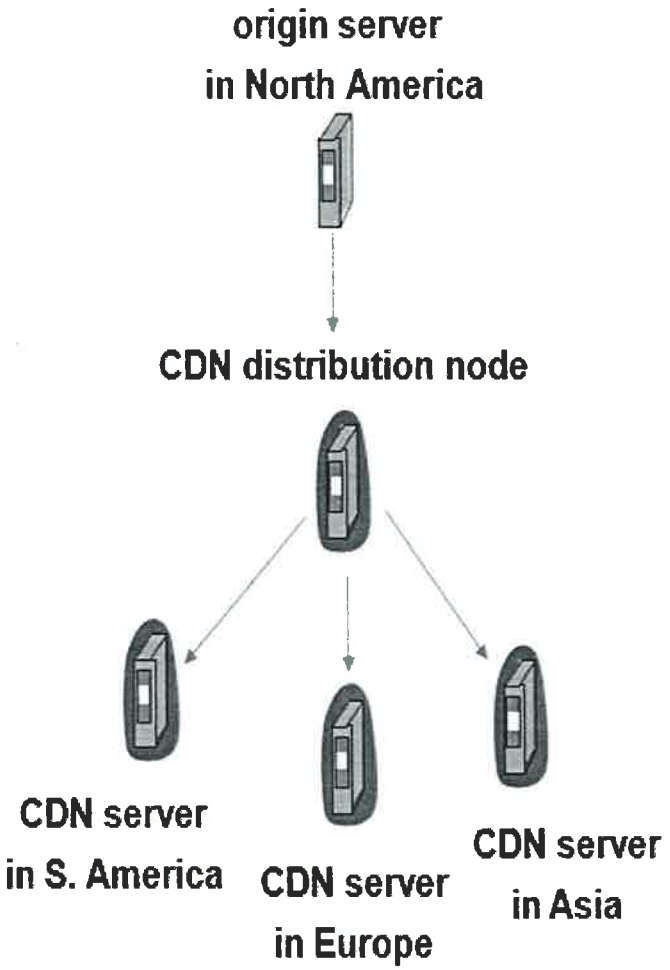
- **Elastic resources**
  - Expand and contract resources
  - Pay-per-use
  - Infrastructure on demand
- **Multi-tenancy**
  - Multiple independent users
  - Security and resource isolation
  - Amortize the cost of the (shared) infrastructure
- **Flexible service management**

Cloud Computing Service Models

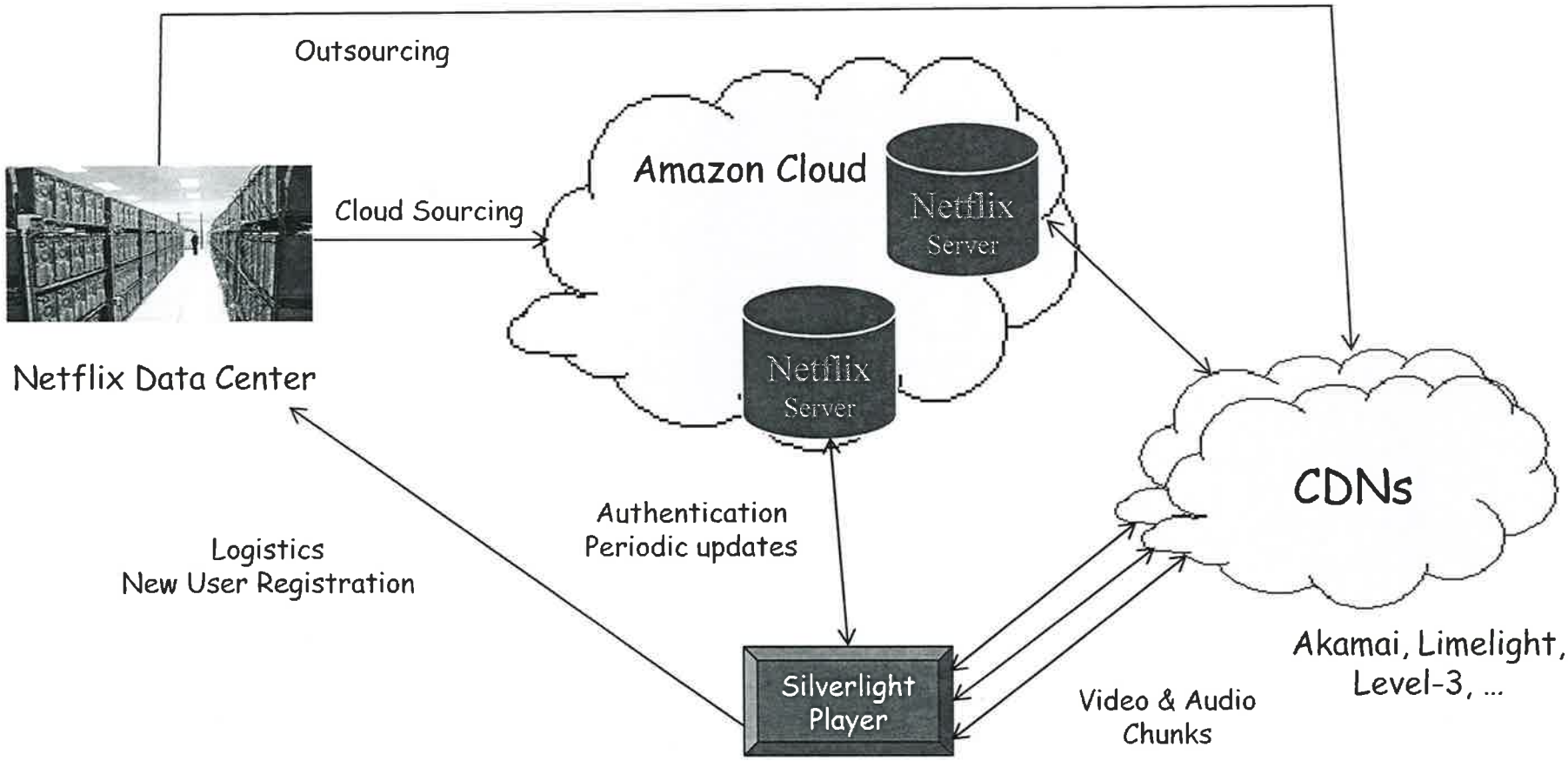
- Software as a Service
  - Provider licenses applications to users as a service
  - E.g., customer relationship management, e-mail, ..
  - Avoid costs of installation, maintenance, patches..
- Platform as a Service
  - Provider offers platform for building applications
  - E.g., Google's App-Engine
  - Avoid worrying about scalability of platform
- Infrastructure as a Service
  - Provider offers raw computing, storage, and network
  - E.g., Amazon's Elastic Computing Cloud (EC2)
  - Avoid buying servers and estimating resource needs

CDN: Content Delivery Networks

- Proactive content replication
  - Content provider (e.g., CNN) contracts with a CDN
- CDN replicates the content
  - On many servers spread throughout the Internet
- Updating the replicas
  - Updates pushed to replicas when the content changes



Case Study: Netflix Architecture



- Netflix is the single largest source of Internet Traffic
- Consume ~ 30% of Peak Downlink Traffic

Network Software (I)

- NOS include special functions for connecting hosts into a network
- NOS manages network resources and services
- NOS provide network security for multiple users
- Most common Client/Server NOS include:
  - UNIX
  - Microsoft NT/Windows 2000
  - Novell Netware
  - LINUX
  - OS/2
  - Others

Network Software (II)

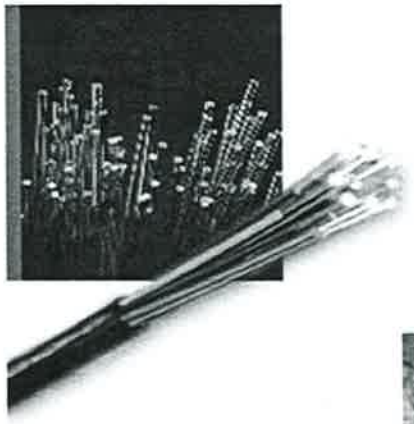
- Network hosts communicate through the use of client software called "Shells, Redirectors, Requesters"
- Network Protocols (such as TCP/IP, SPX/IPX, NETBEUI, etc..) enables data transmission across the network
- Client software resides on top of the network protocols.

Network Hardware

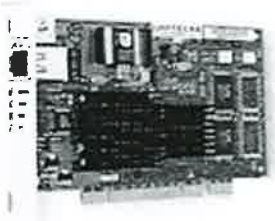
- Users accessing network resources must have a Pathway to those resources.
- Host connect to networks using expansion cards known as Network Interface Cards (NICs), a.k.a. Adapter Cards.
- Network cards communicate by sending signals through the medium (Twisted pair, Coax, Fiber, Radio, etc..)

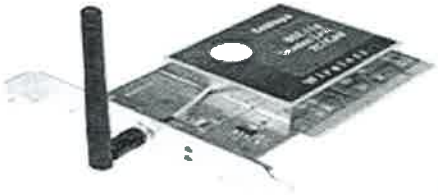
Links: Medium + Adapter Cards

Communication Medium



Network Adapter

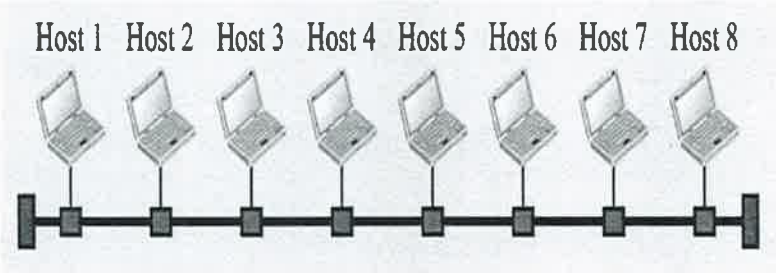




Network Classifications

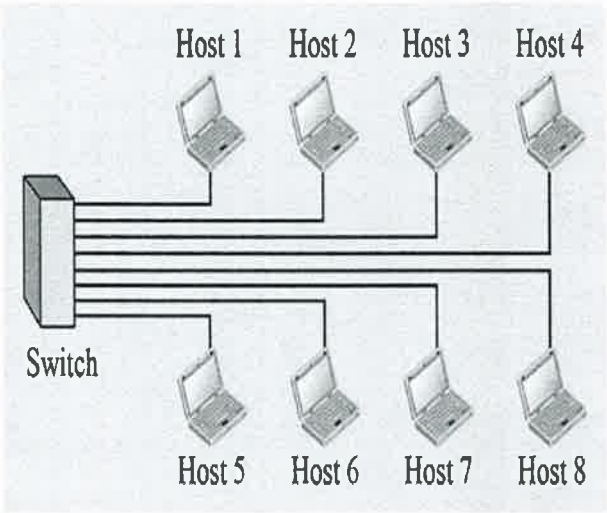
- Networks can be classified based on Coverage into
  - LANs: Local Area Networks
  - WANs: Wide Area Networks
  - Others including MAN (Metropolitan Area Networks, PAN (Personal Area Networks), Home Networks, etc...
- Networks could also be classified as Switched or Shared (Broadcast) networks
- Networks could also be classified based on their functionalities for example Backbone Networks, Content Delivery Networks, Overlay Networks, etc..

Switched vs. Broadcast Networks

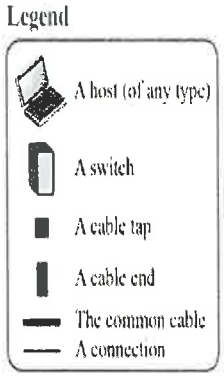


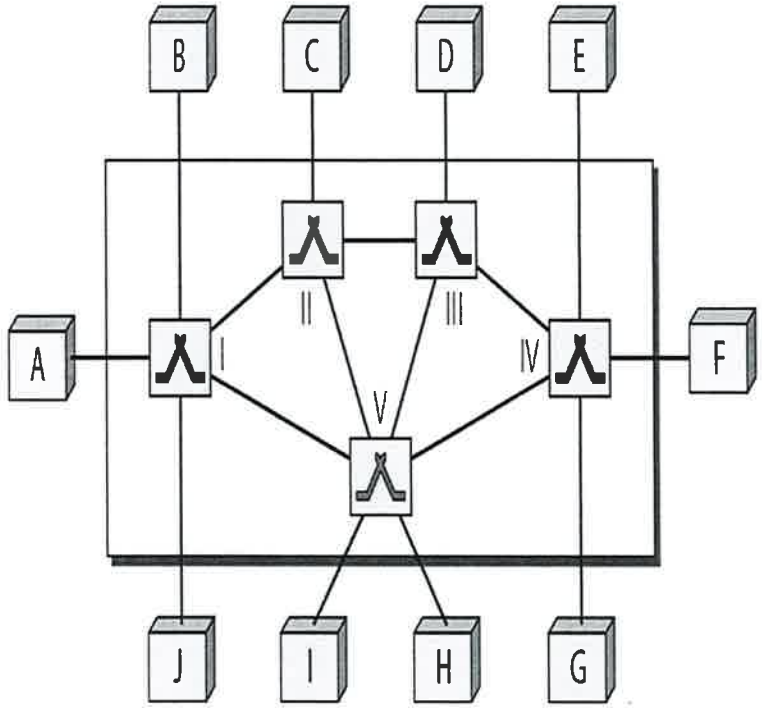
a. LAN with a common cable (past)

Broadcast



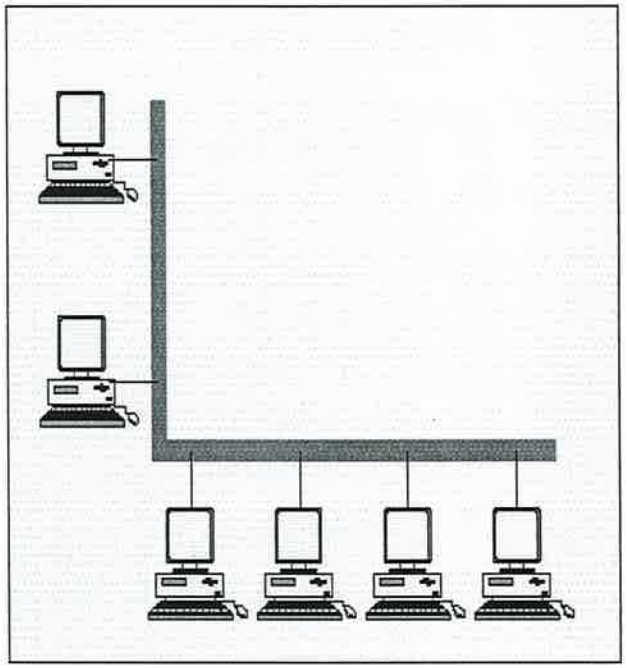
b. LAN with a switch (today)



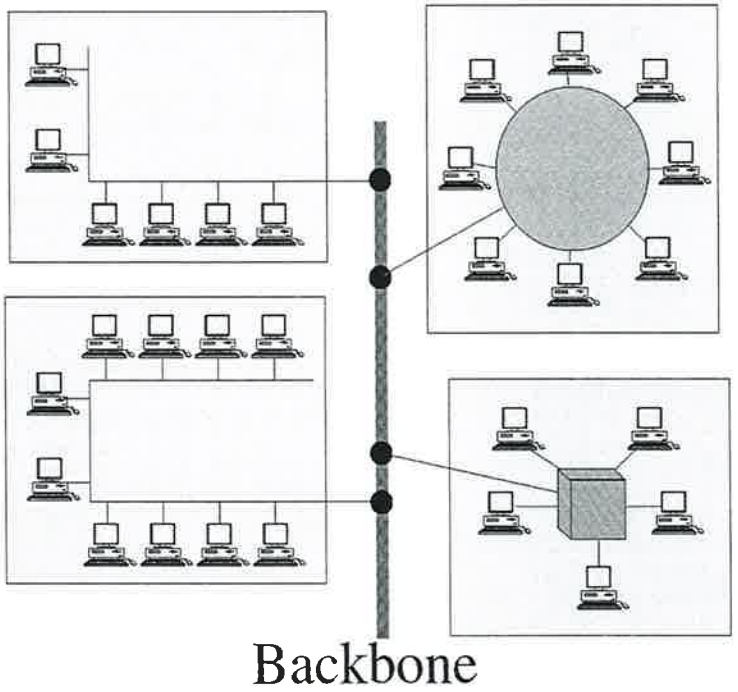


Switched

Local Area Networks (I)

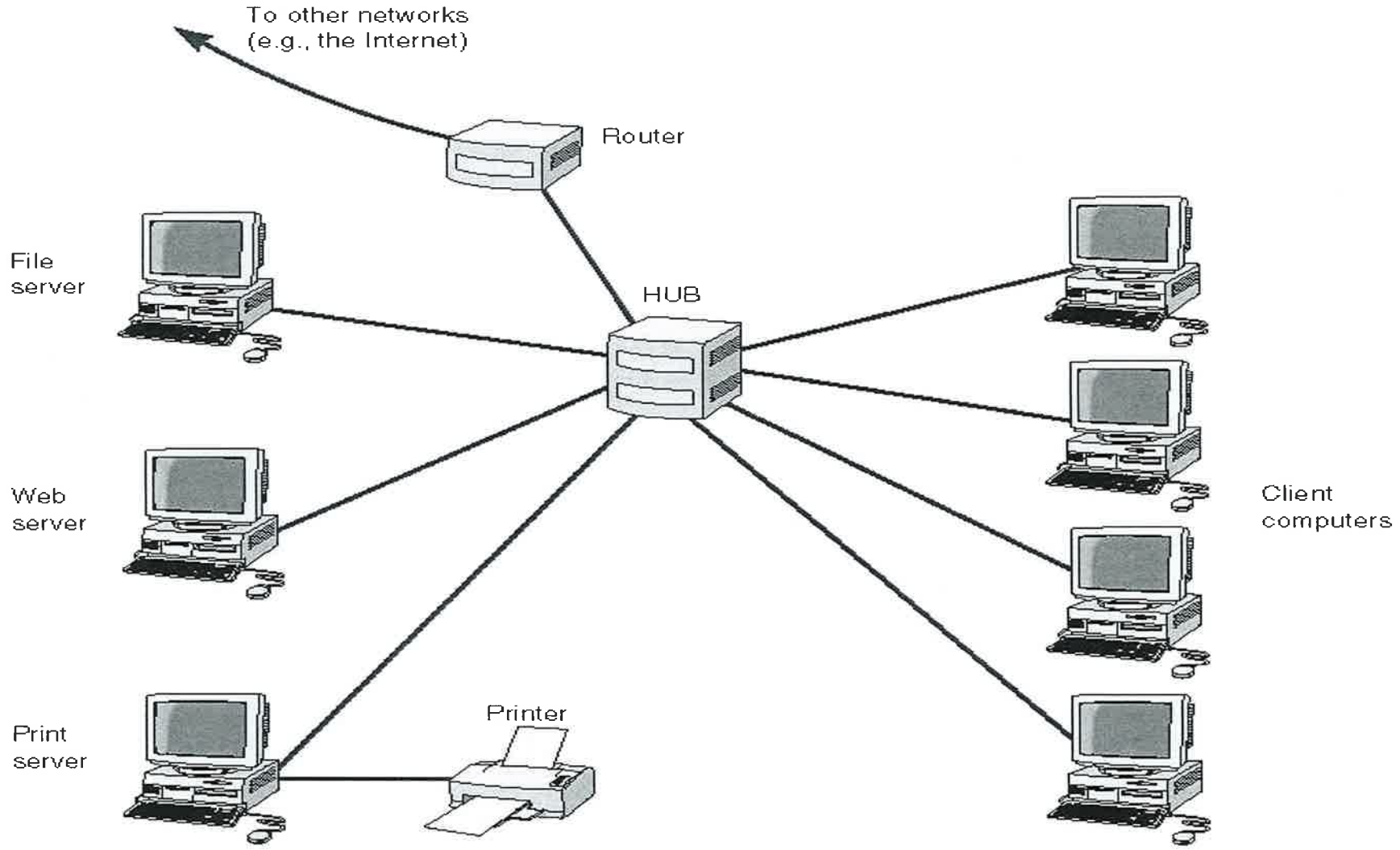


Single building LAN

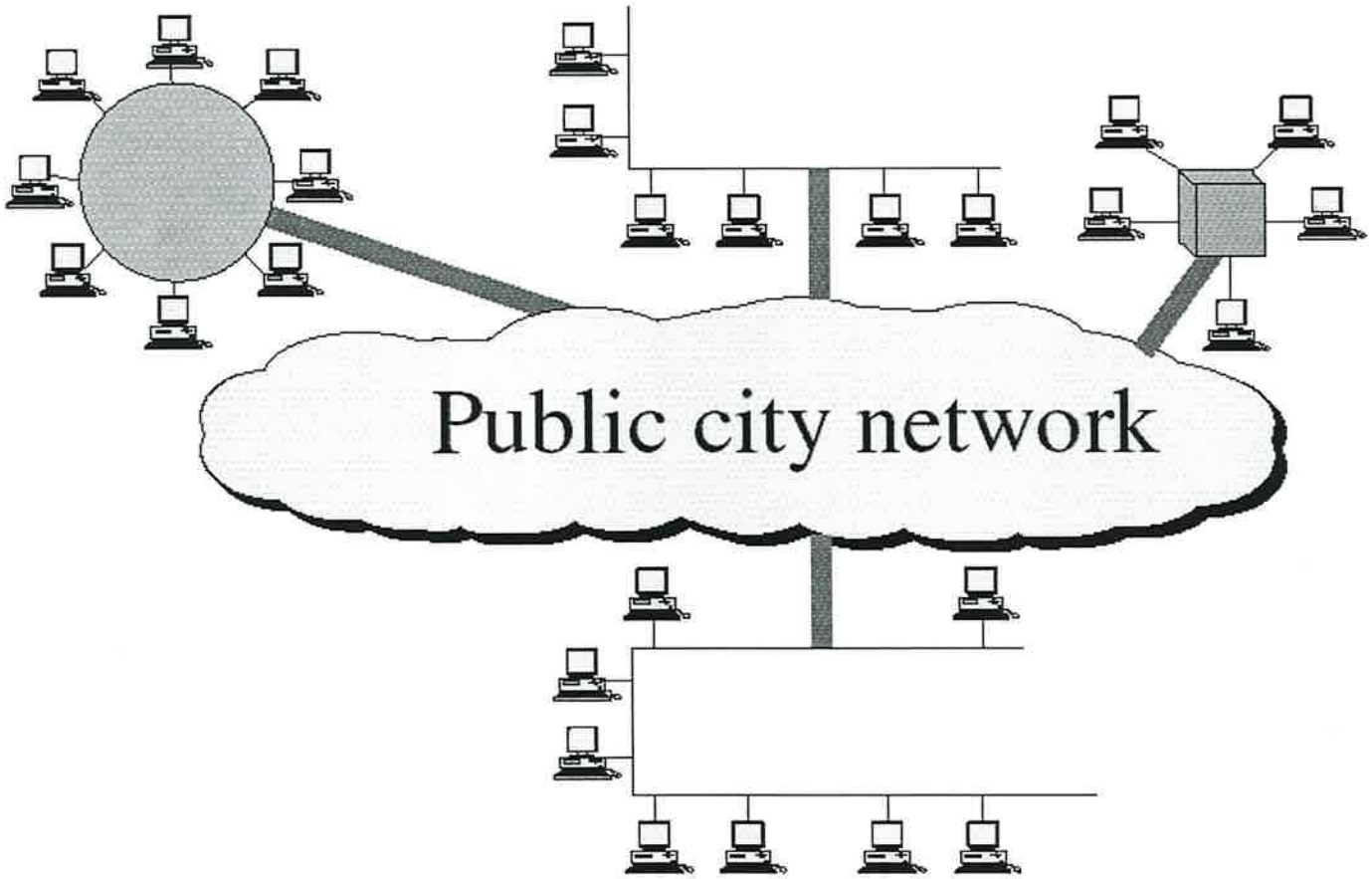


Multiple building LAN

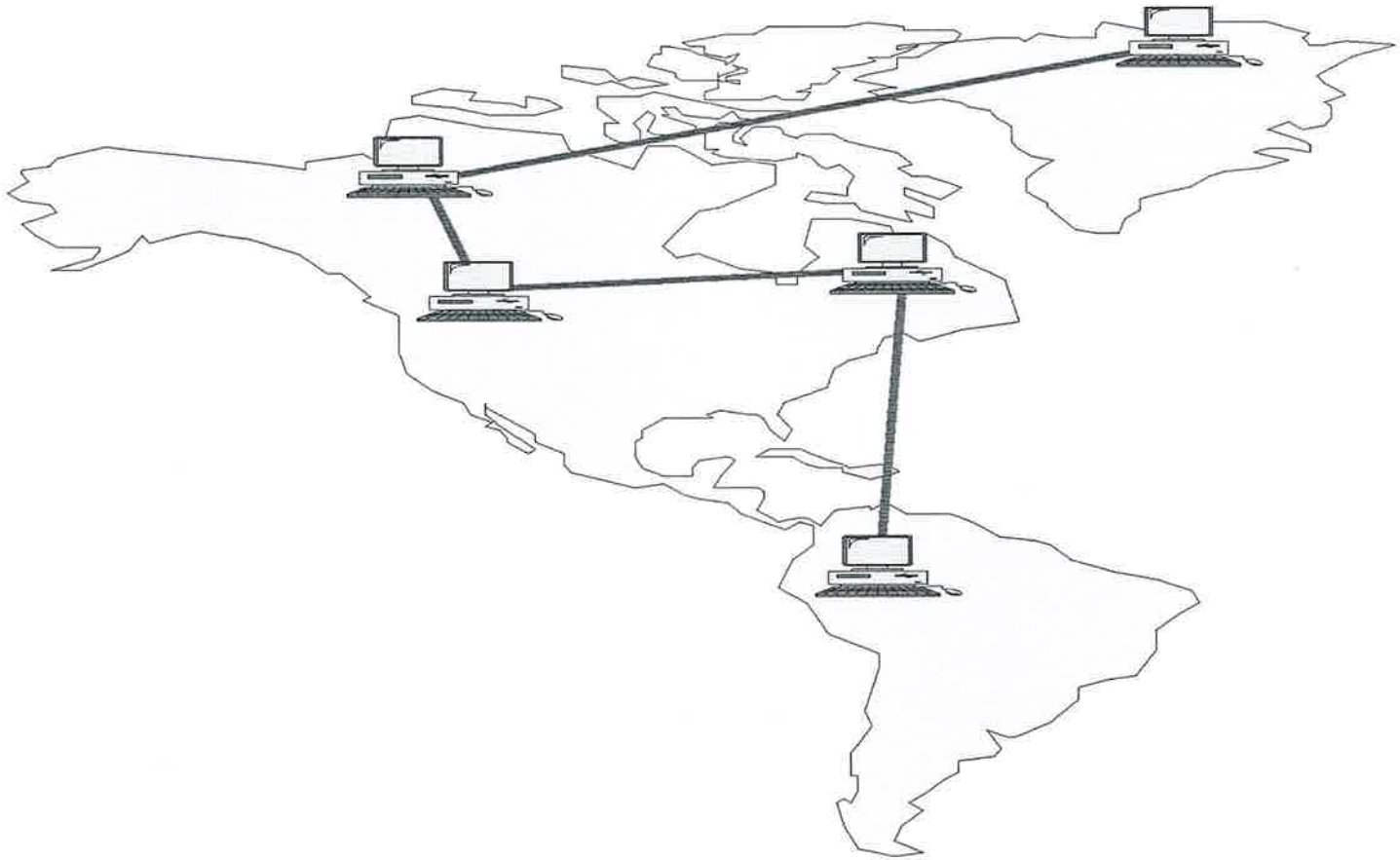
Local Area Networks (II)



Metropolitan Area Network



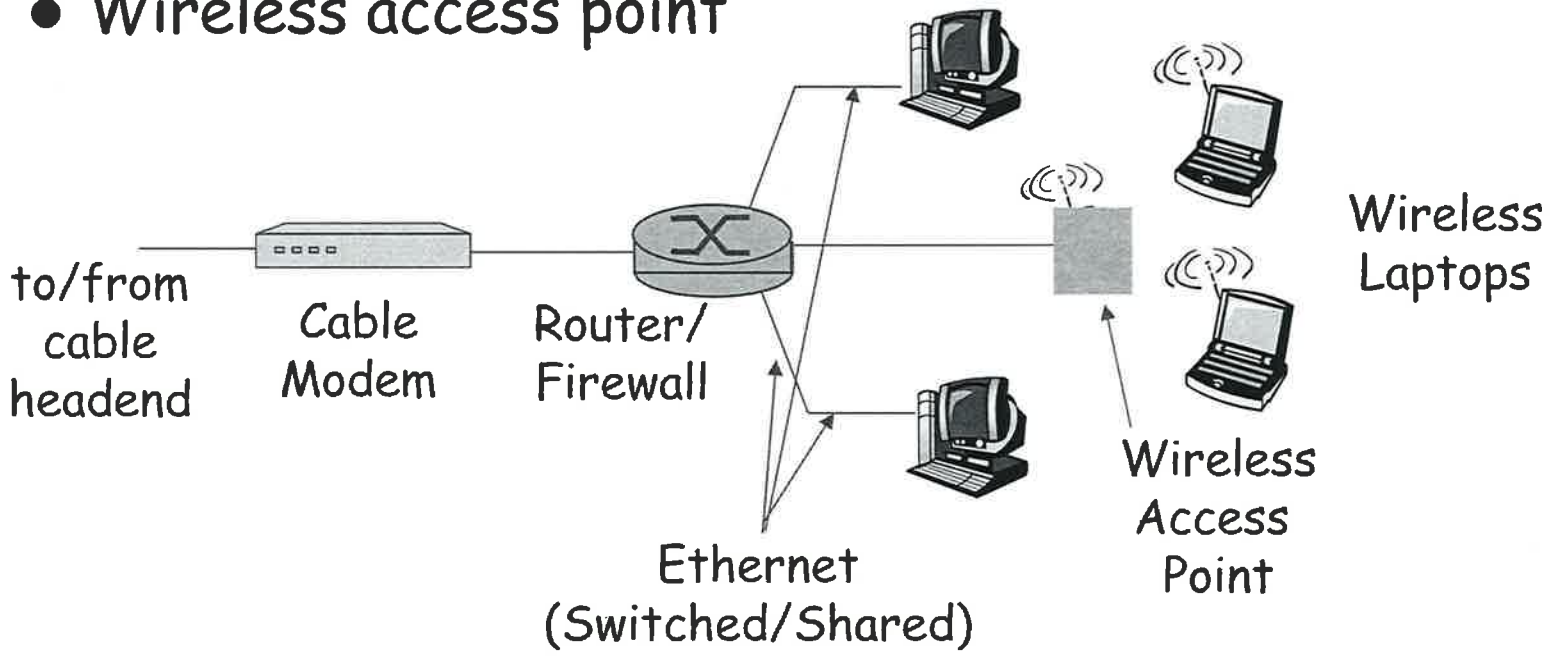
Wide Area Networks



Home Networks

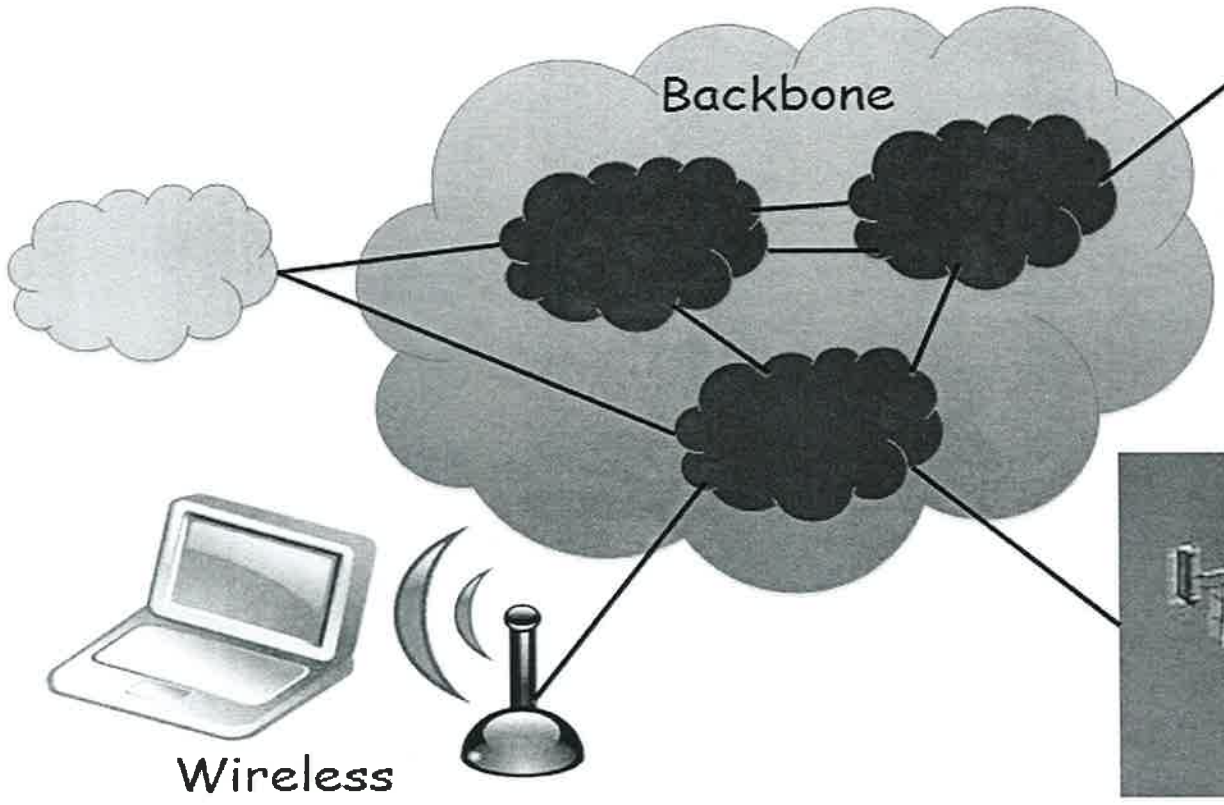
Typical home network components

- ADSL or cable modem
- Router/firewall/NAT
- Ethernet
- Wireless access point



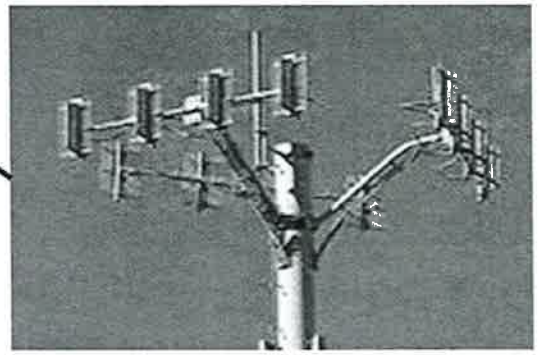
Backbone Networks

Provide Transit Service for customers
Glue that holds the Internet together



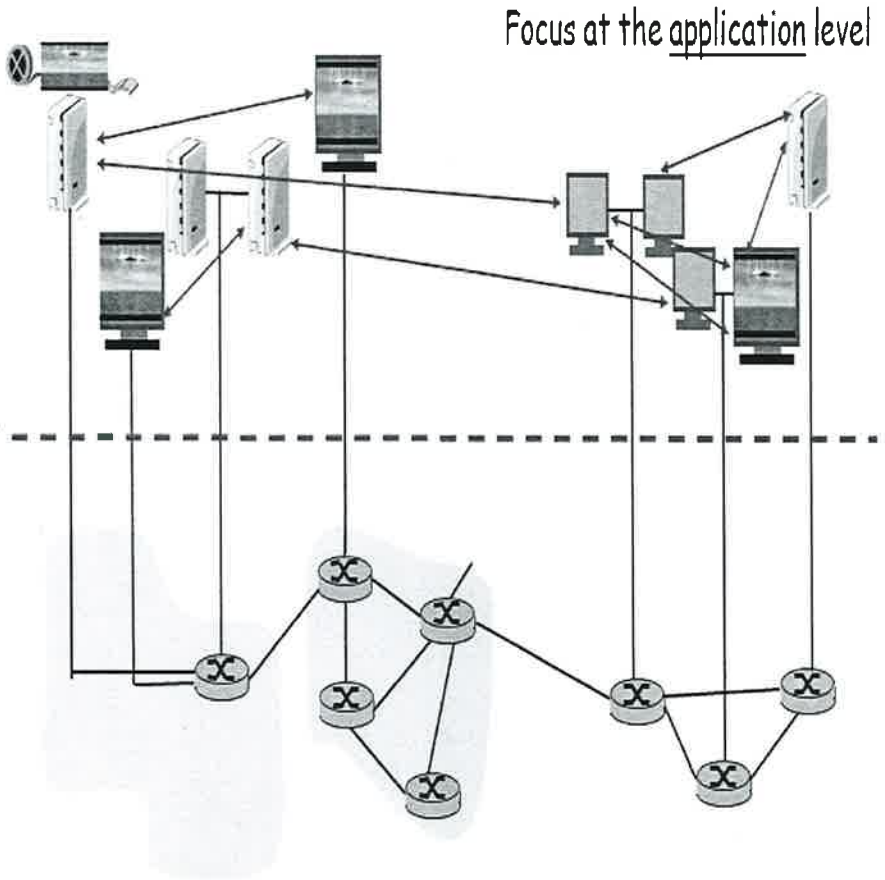
Data Center

Cellular

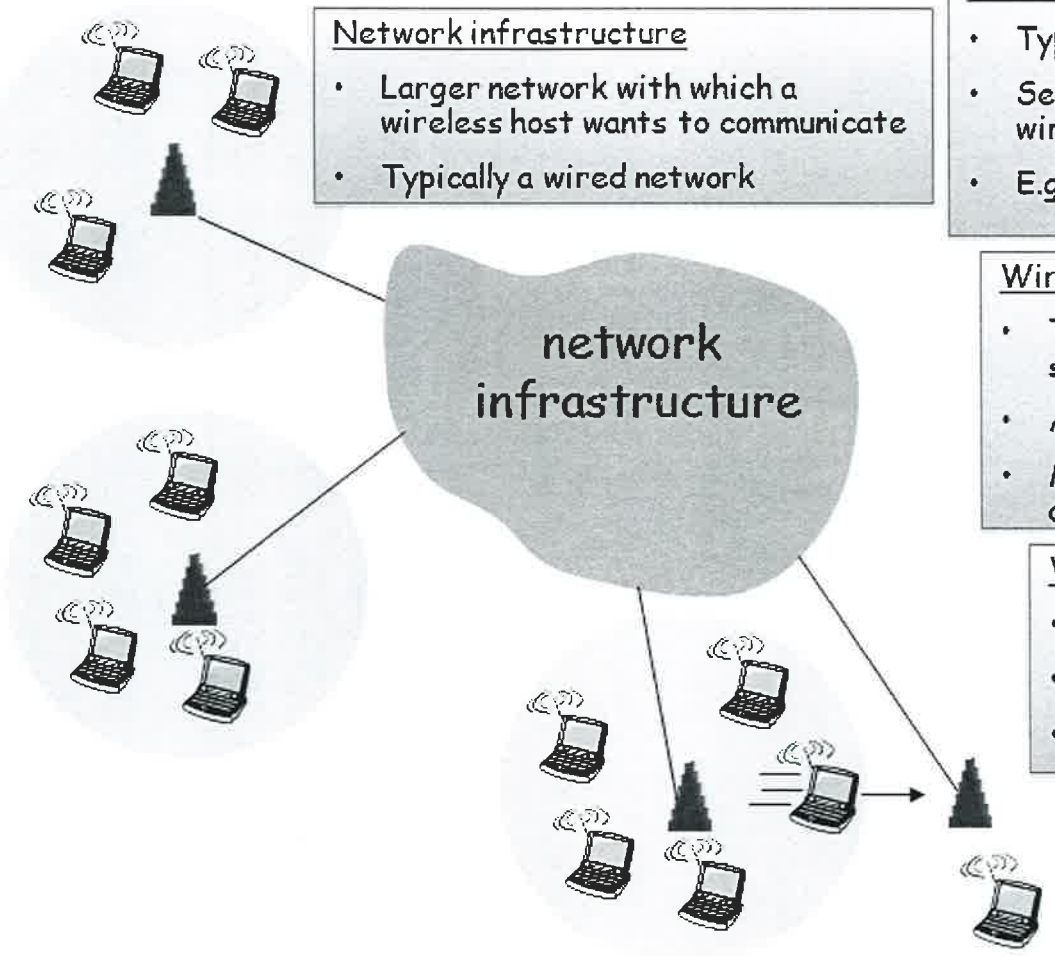


Overlay Networks

- Logical network built on top of physical network
  - Overlay link is tunnel through underlying network
- Many logical networks may coexist at once
  - Over the same underlying network
- Nodes are often end hosts
  - Acting as intermediate nodes that forward traffic
- Who controls the nodes providing service?
  - The party providing the service
  - Distributed collection of end users



Wireless Networks



Network infrastructure

- Larger network with which a wireless host wants to communicate
- Typically a wired network

Base station

- Typically connected to wired network
- Sending packets between wired network and wireless host(s)
- E.g., cell towers, 802.11 access points

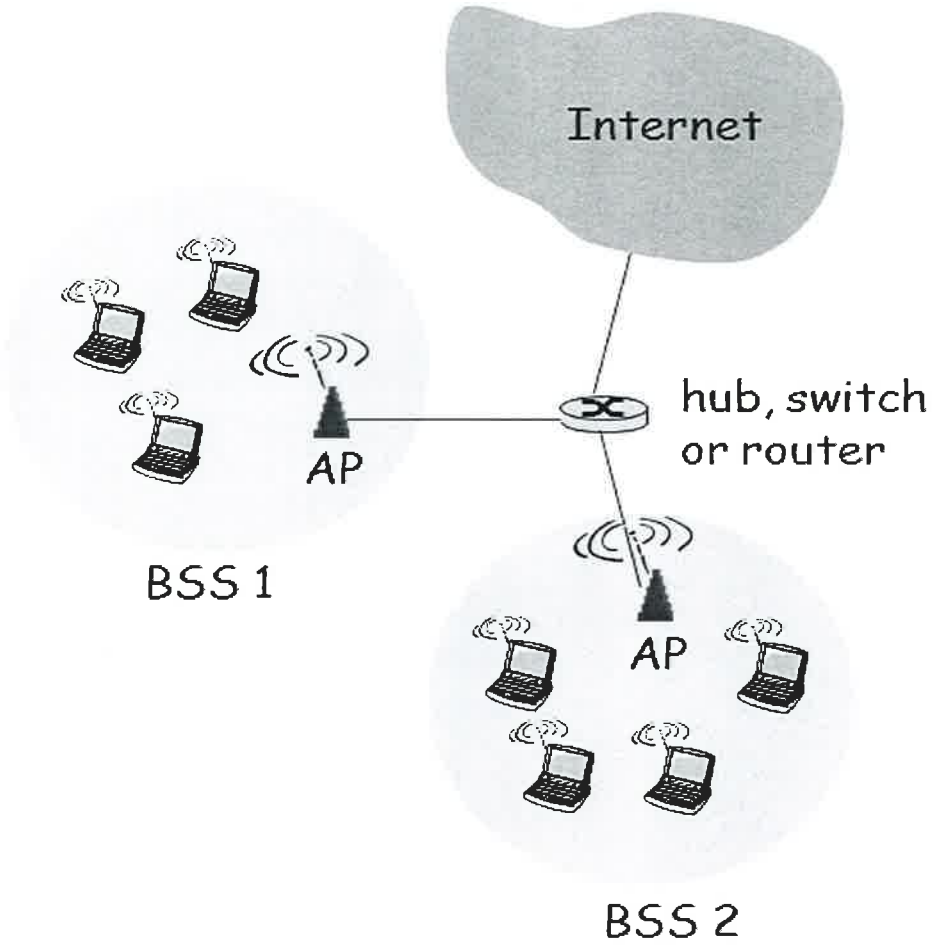
Wireless link

- Typically used to connect mobile(s) to base station
- Also used as backbone link
- Multiple access protocol coordinates link access

Wireless host

- Laptop, smartphone
- Run applications
- May be stationary or mobile

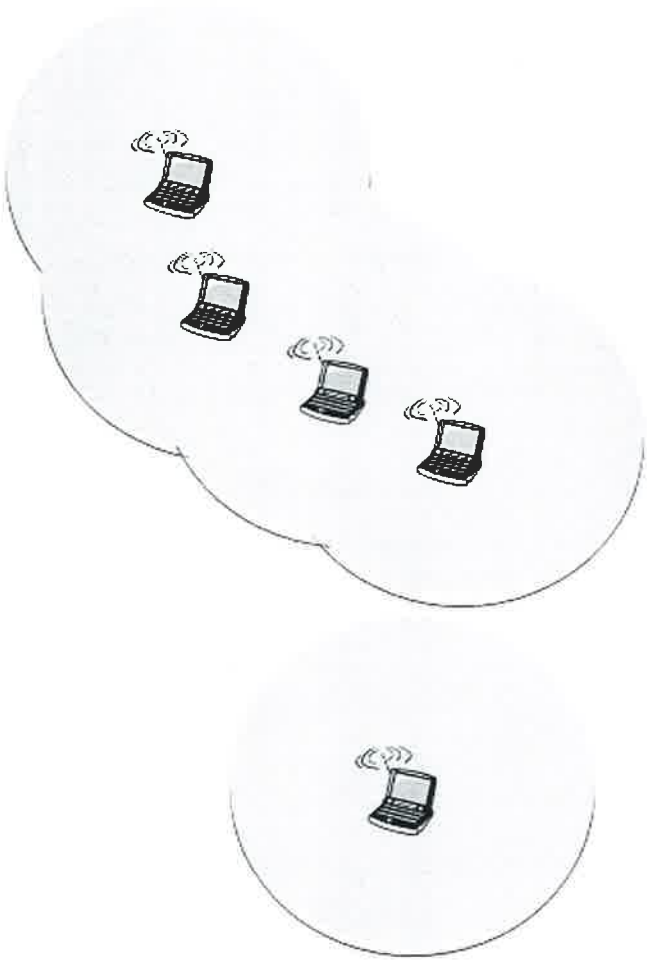
Wireless LANs (802.11)



- Access Point (AP)
  - Base station that communicates with the wireless hosts
- Basic Service Set (BSS)
  - Coverage of one AP
  - AP acts as the master
  - Identified by an "network name" known as an SSID

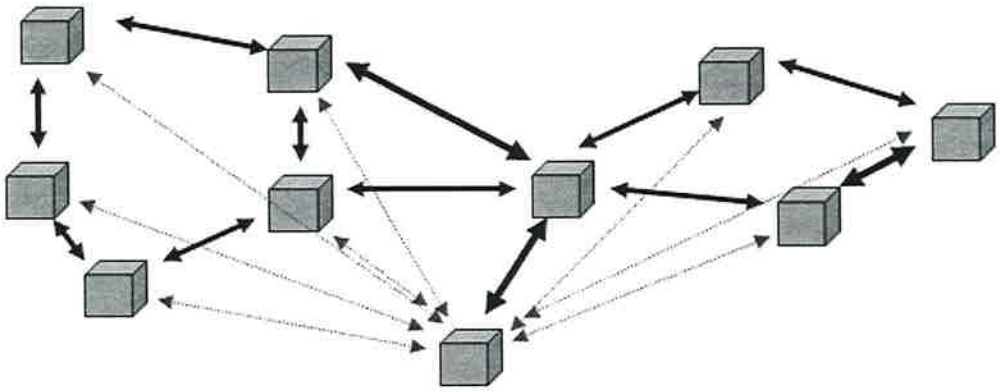
SSID: Service Set Identifier

Ad-Hoc Wireless Mesh

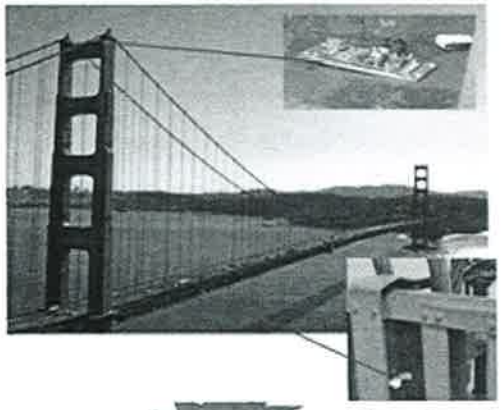


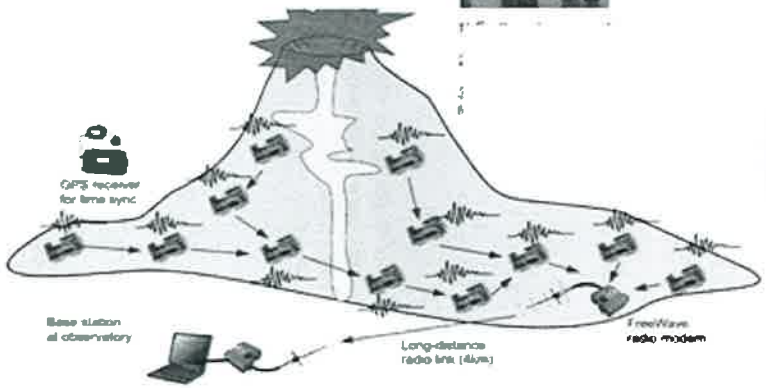
Ad hoc mode

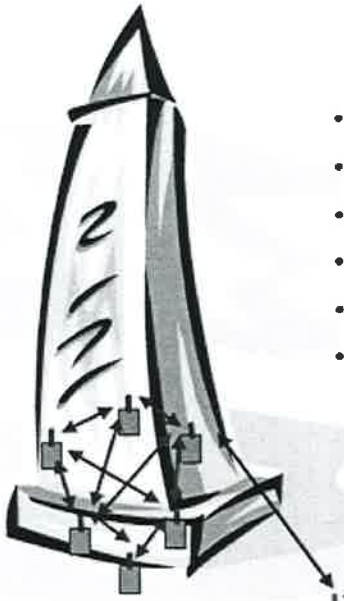
- No base stations
- Nodes can only transmit to other nodes within link coverage
- Nodes self-organize and route among themselves
- Can create multi-hop wireless networks, instead of a wired backend



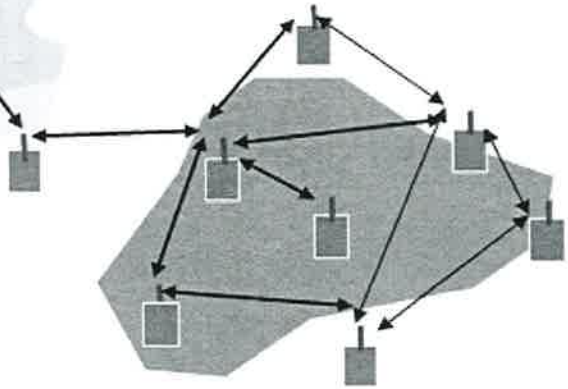
Sensor Networks





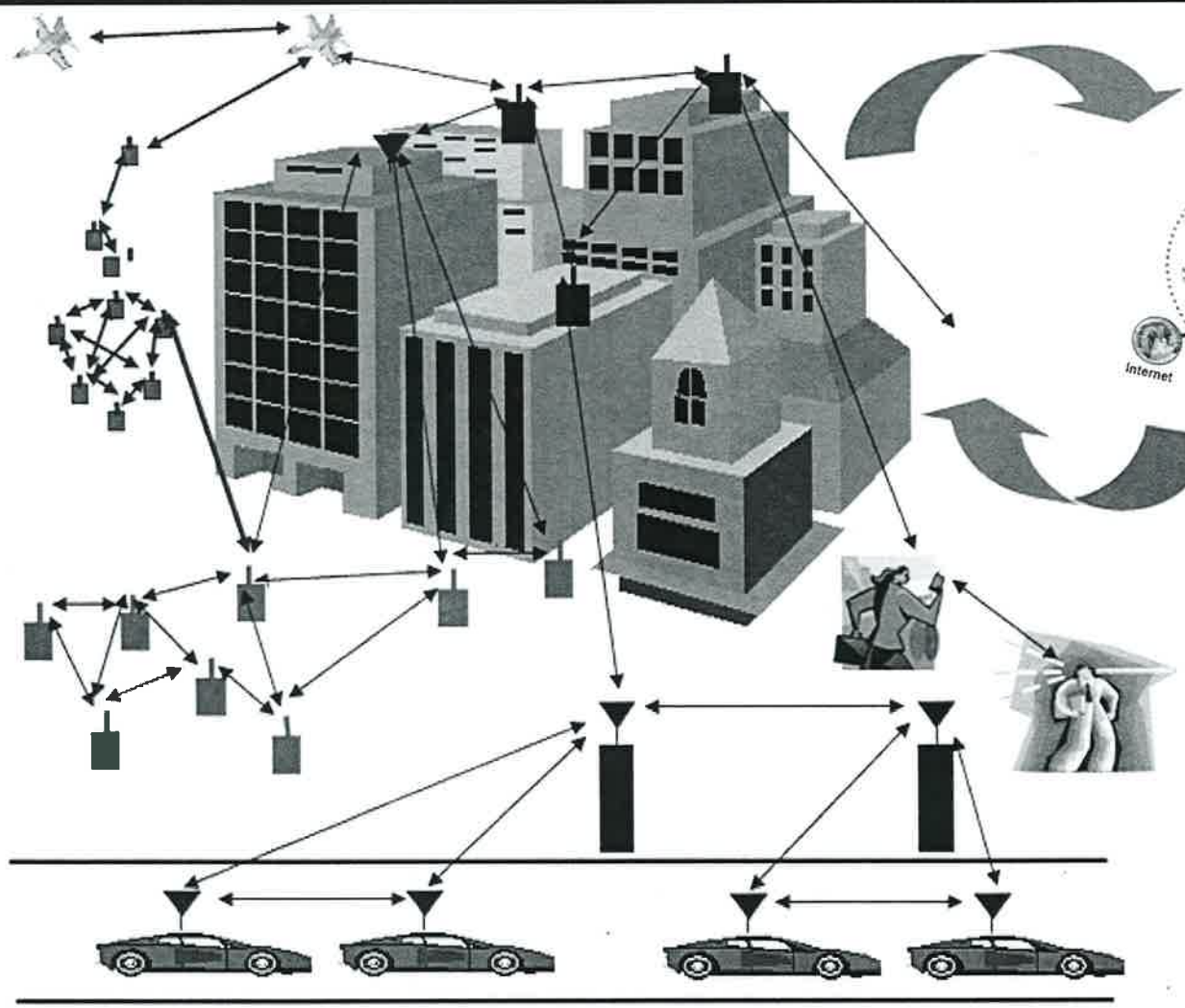


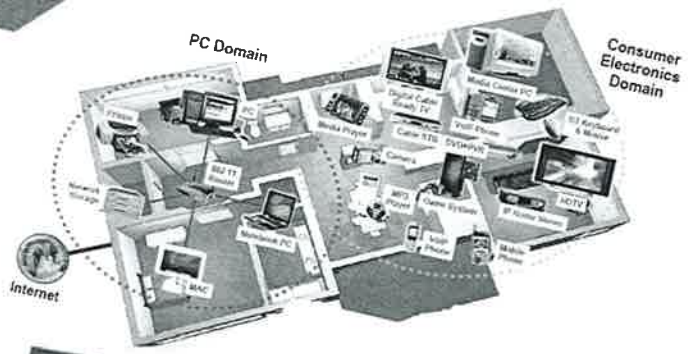
- Smart homes/buildings
- Smart structures
- Search and rescue
- Homeland security
- Event detection
- Battlefield surveillance



- Energy (transmit and processing) is driving constraint
- Data flows to centralized location
- Low per-node rates but tens to thousands of nodes
- Intelligence is in the network rather than in the device

Future Wireless Networks





Next-generation Cellular
Wireless Internet Access
Wireless Multimedia
Sensor Networks
Smart Homes/Spaces
Automated Highways
In-Body Networks
All this and more …

Ubiquitous Communication Among People and Devices