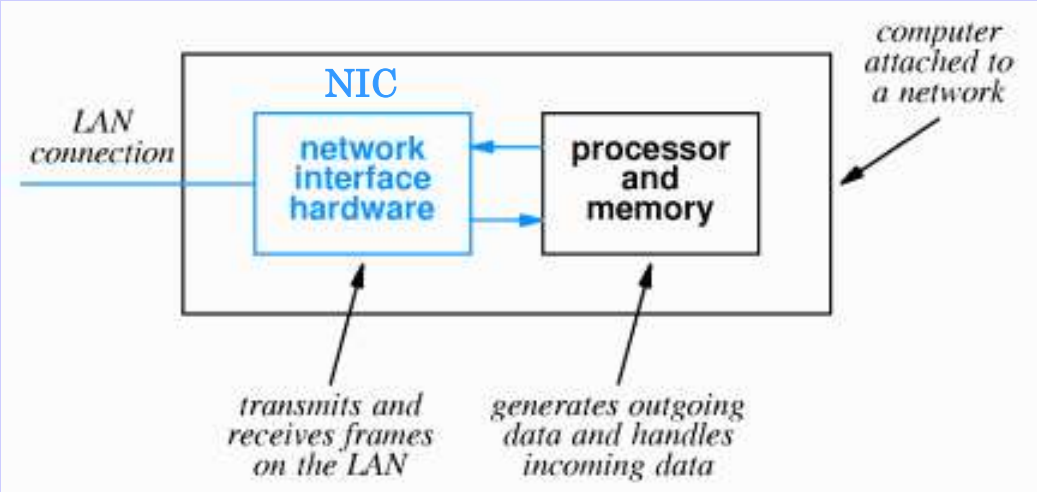
Wired & Wireless LAN Connections

- **Network Interface Card (NIC)**
- **Ethernet Wiring**
  - Thick Ethernet
  - Thin Ethernet
  - Star (Hub) Ethernet
- **Extending LAN**
  - Fiber Modem
  - Repeater
  - Bridge
  - Switch
- **Short Range Wireless Networks**
  - WLAN, WPAN, WBAN, RFID, Sensor Newtorks

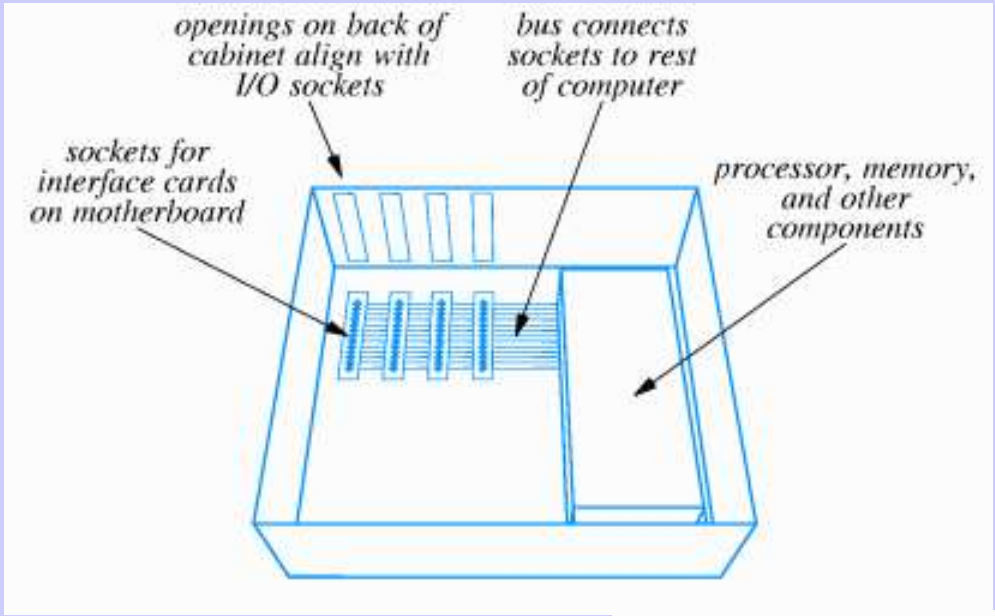
Network Interface Card (NIC)



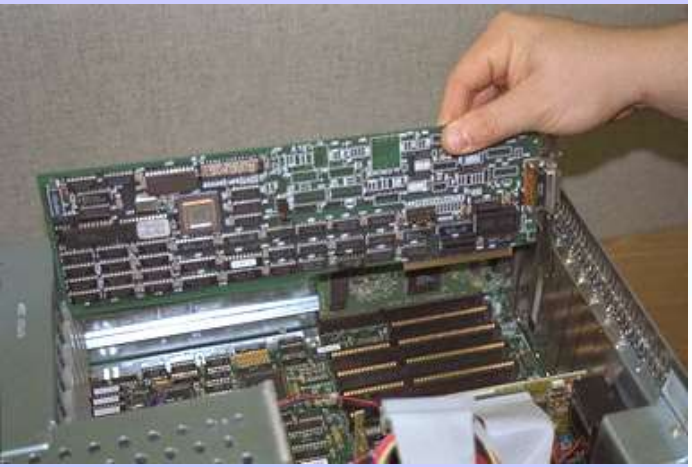
NIC (Network Interface Card or Network Adapter)

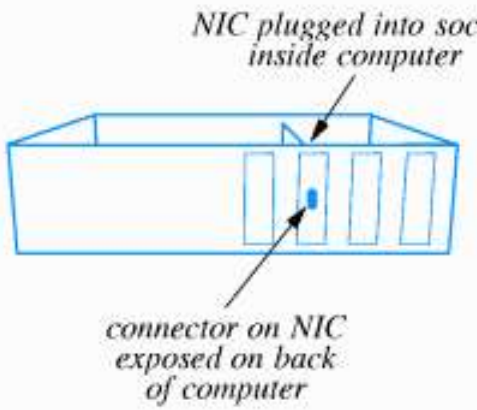
- Interface between a computer and a LAN
- CPU can't process binary data at network speeds (10Mbps, 100Mbps, 1GMbps)
- NIC contains sufficient hardware to process data independent of system CPU
  - System CPU forms message request
  - Sends instructions to NIC to transmit data
  - Receives interrupt on arrival of incoming data
- NIC is built for one kind of physical network
  - Ethernet interface can't be used with token ring
  - ATM interface can't be used with FDDI

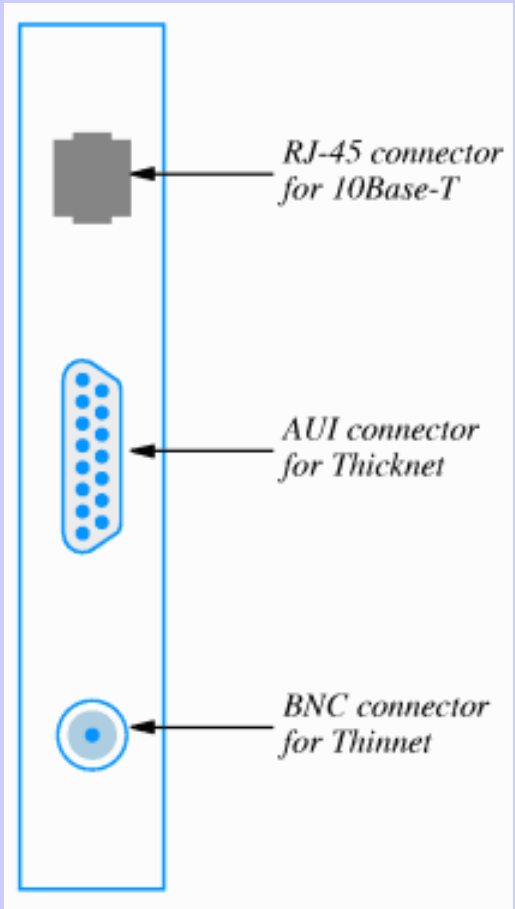
NIC Example in Desktop Computer



Some NIC can be used with different but similar networks: thick, thin and 10Base-T Ethernet, Fast Ethernet



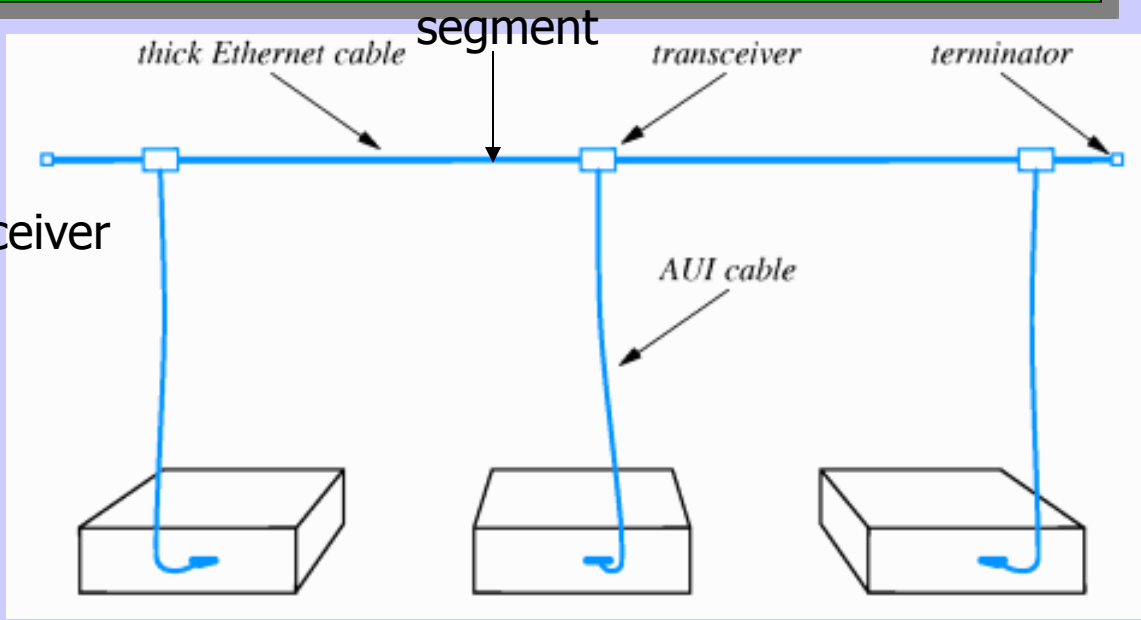




Ethernet Wiring

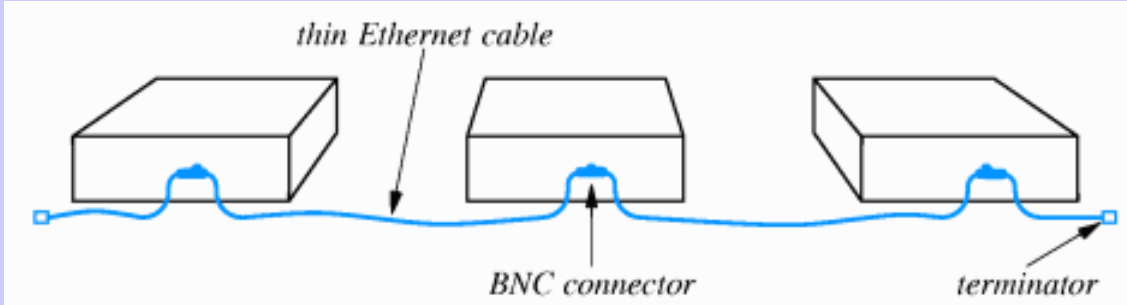
Thick Ethernet wiring (Thicknet)

- the first generation
- use thick coax cable (1cmD)
- AUI cable connects NIC to transceiver
- digital signal in AUI
  (Attachment Unit Interface)
- analogy signal in coax
- *10Base5*
  10Mbps
  max segment: 500m
  computer spacing: 2.5m



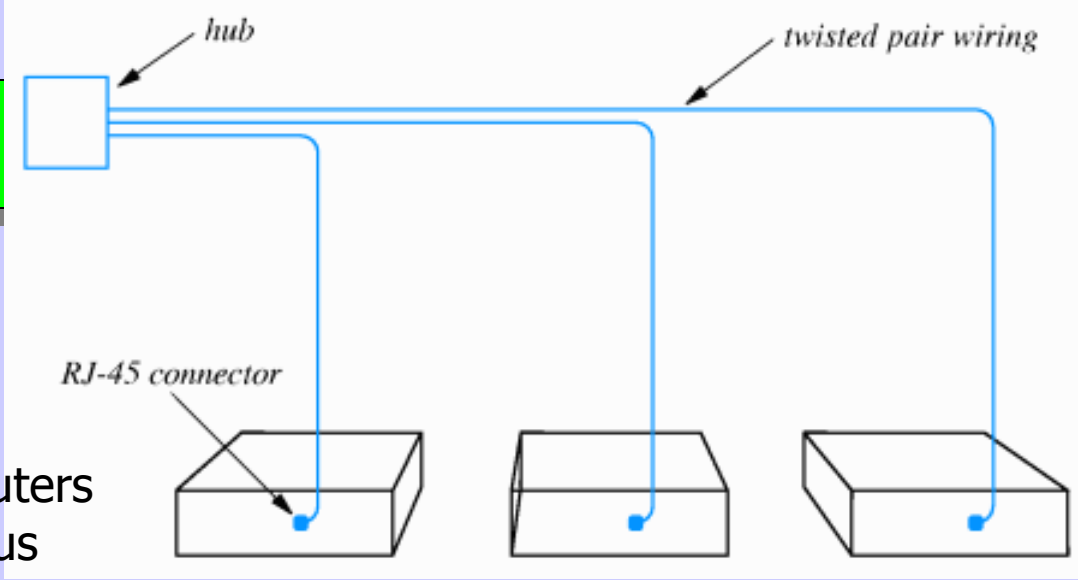
Thin Ethernet wiring (Thinnet)

- the second generation
- use thin coax cable (0.5cmD)
- BNC connects to thin cable
- *10Base2*
  10Mbps
  max segment: 185m
  computer spacing: 0.5m



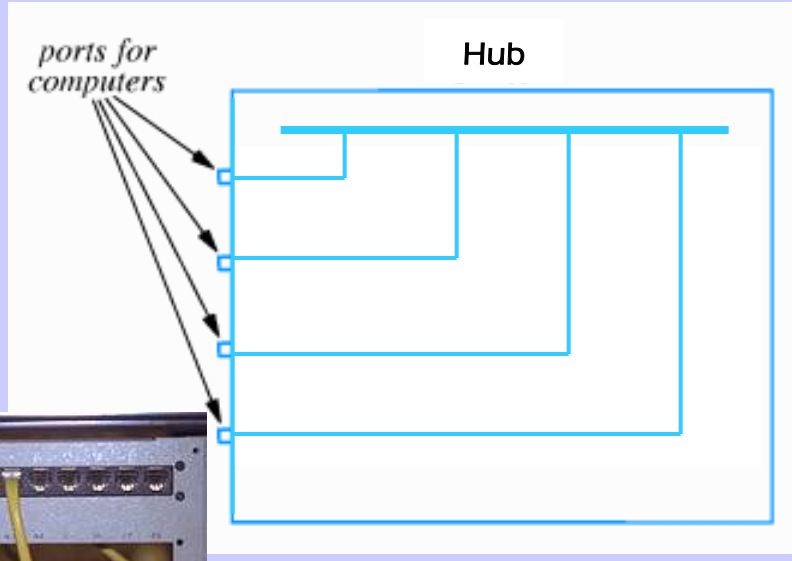
Ethernet

Ethernet Wiring (cont)



Hub Ethernet wiring
- the third generation, most popular
- use **hub**
  a device with connections to computers
  physically star topology, logically bus
  same frame format, follow CSMA/CD
  → "*Ethernet-in-a-box*"

- *10Base-T*
  10Mbps, twisted pair, RJ-45 connector
  max wire length: 100m
  number of computers: port number
- *100Base-Tx/T4*
  100Mbps, twisted pair
  max wire length: 100m
- *1000Base-T/CX*
  1000Mbps, twisted pair
  max wire length: 25m
- *1000Base-SX/LX*
  1000Mbps, optical fiber
  max fiber length: 550m



Twisted Pair

Register Jack (RJ)

Project 802.3

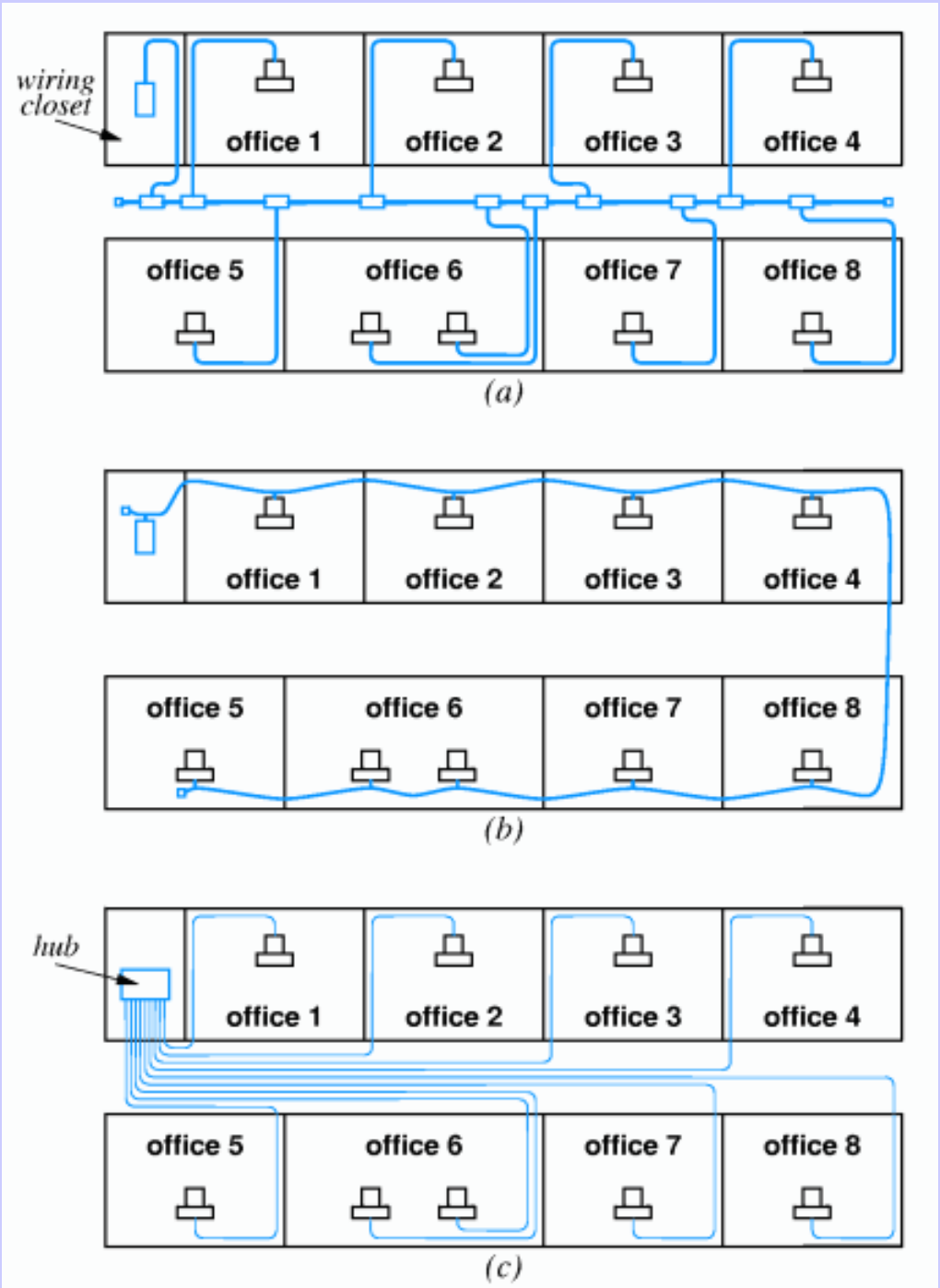
Comparison of Wiring Schemes

Thicknet

Thinnet

Hub Ethernet

-Hybrid Wiring in practical-



Extending LAN

Distance and computer number Limitation of LAN

- Thicknet: 500m, Thinnet: 185m, 10/100Base-T: 100m
- Thicknet: 100 computers, Thinnet: 30 comp, 10/100Base-T: <100
- Signal attenuation and noise across long distance
- CSMA/CD can't work across arbitrary distance for Ethernet
- Long circulation time for token passing in Token Ring and FDDI

Motivation to extend LAN

- Large organization has many computers in different places

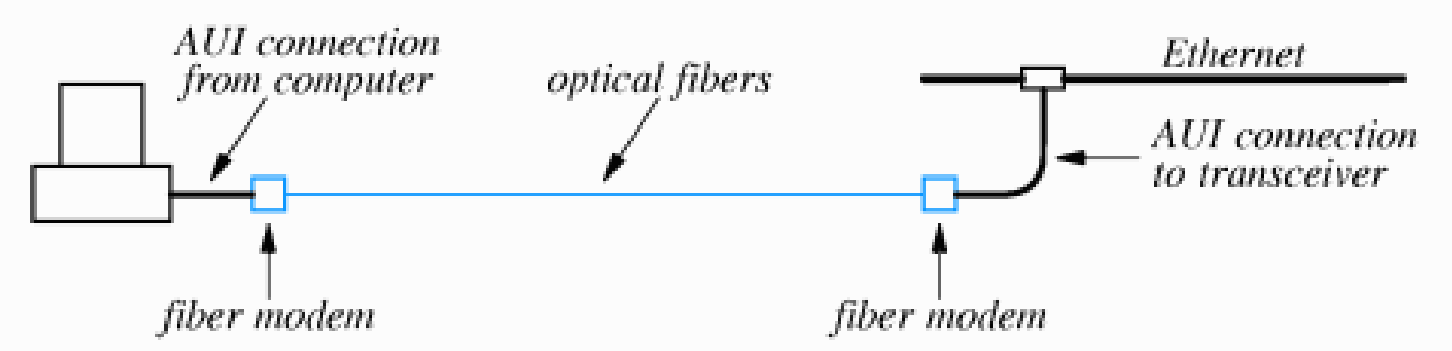
Requirement in extending LAN

- Must not violate designs assumptions in original LANs

Methods and hardware in extending LAN

- Optical fiber and fiber modem
- Repeater or hub
- Bridge
- Switch

Fiber Optical Extension

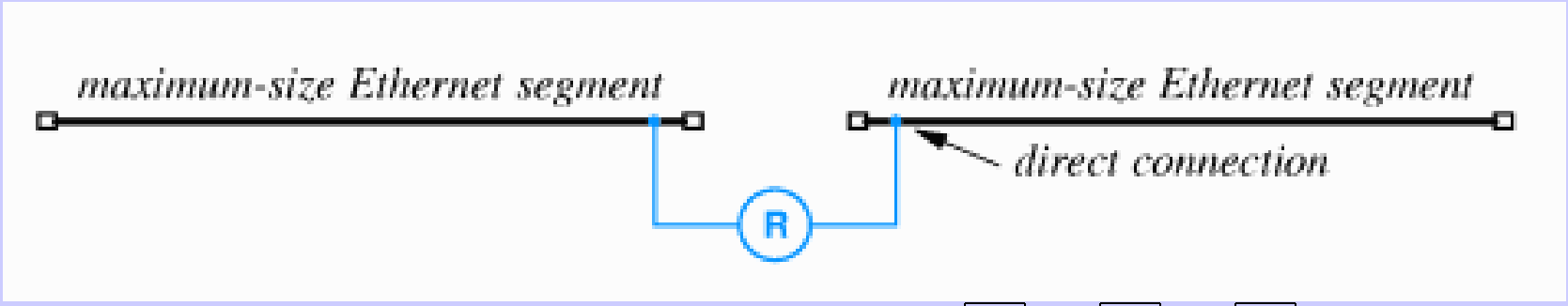


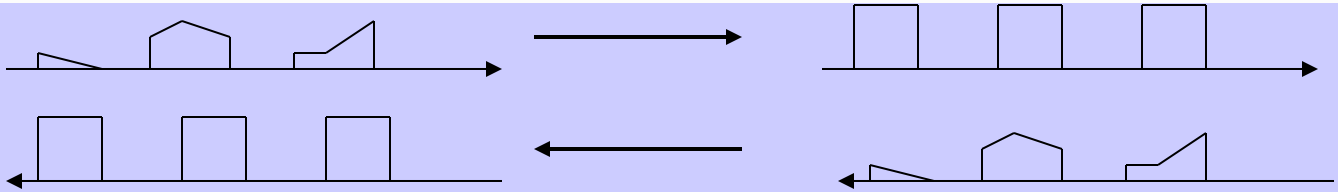
Optical fiber has high bandwidth and low delay
- connect one computer to a far LAN
- connect two LANs in certain distance (e.g., 2 LANs in two buildings)

Fiber modem
- convert electronic signal in LAN cable into light signal in fiber

Note: can't use telephone line modem to directly connect a computer to a remote LAN because its low speed (34/56Kbps)

Repeater



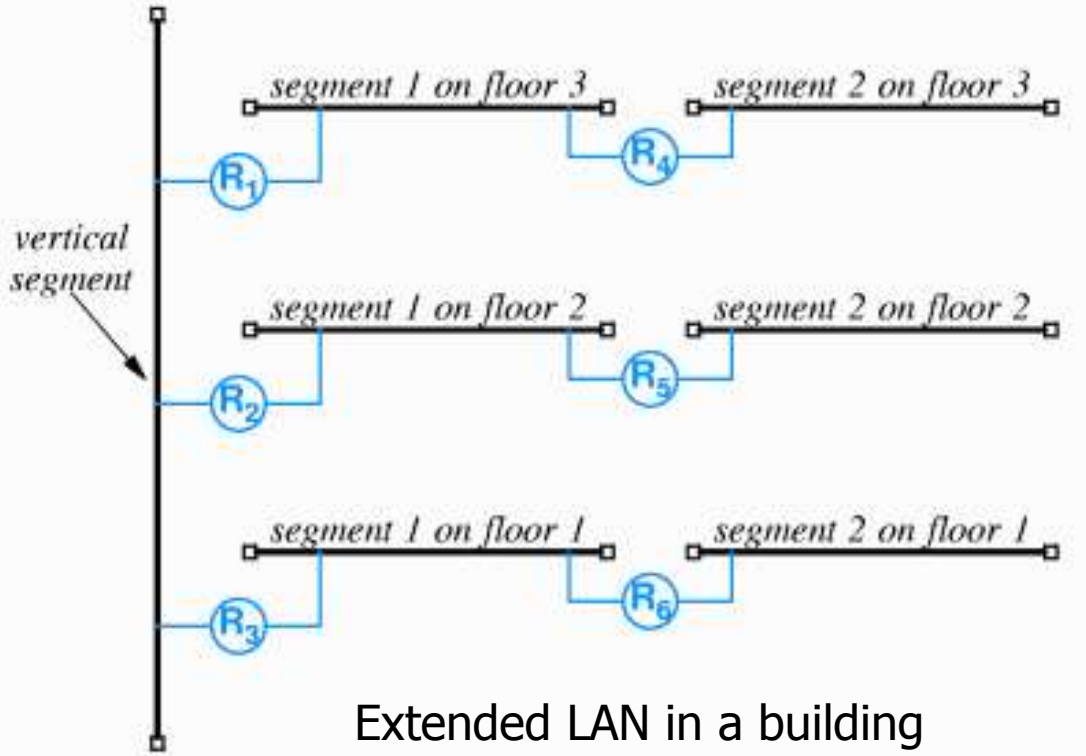


Ethernet Extender

Repeater:

- A bi-directional device connect two LAN segments
- Doubles Thicknet segment from 500m to 1000m
- Accepts attenuated and noise signal and output reconstruct signal
- Does not understand frame format and have no hardware address
- Propagates error bits and collisions

Application of Repeater and Its Limit

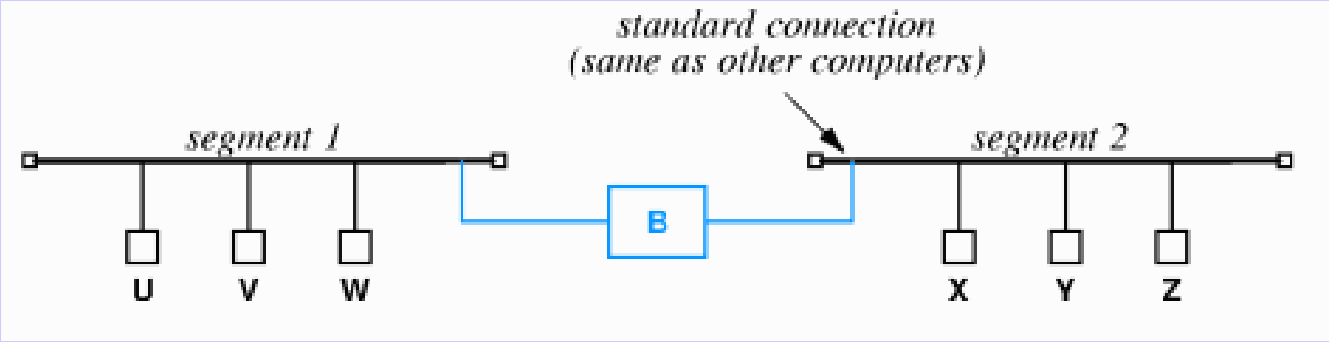


Extended LAN in a building

Animation

- Can't extend Ethernet with repeaters infinitely
- CSMA/CD won't work if medium is too long and has large delay
- Maximum **4** repeaters between any two Ethernet computers
- A hub can connect other hub(s) and it functions as a repeater
  Be careful in such connection !!

Bridge



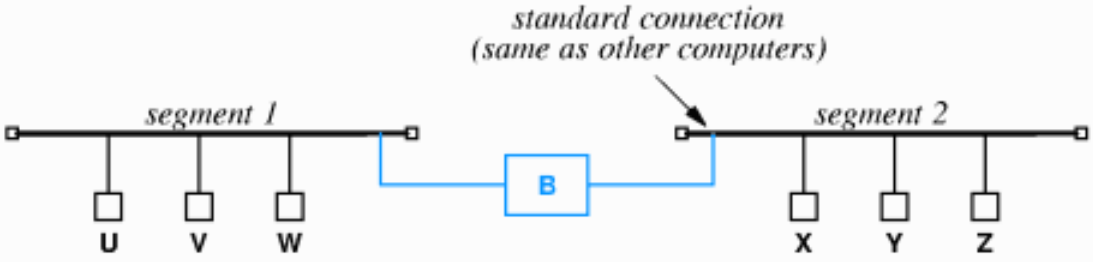
Network Bridge

Animation

Bridge

- A hardware device with NIC to connect two LAN segments
- Handles both bit reconstruction like repeater and complete frame
- Knows which computer is attached to which segment using a table
- Checks packet destination address and forward it if necessary
- Forwards all broadcast and multicast packet
- Does not forward error packet and collision
- Allows concurrent use of different segments if traffic is local
- U and V can exchange frame at the same time X and Y exchange

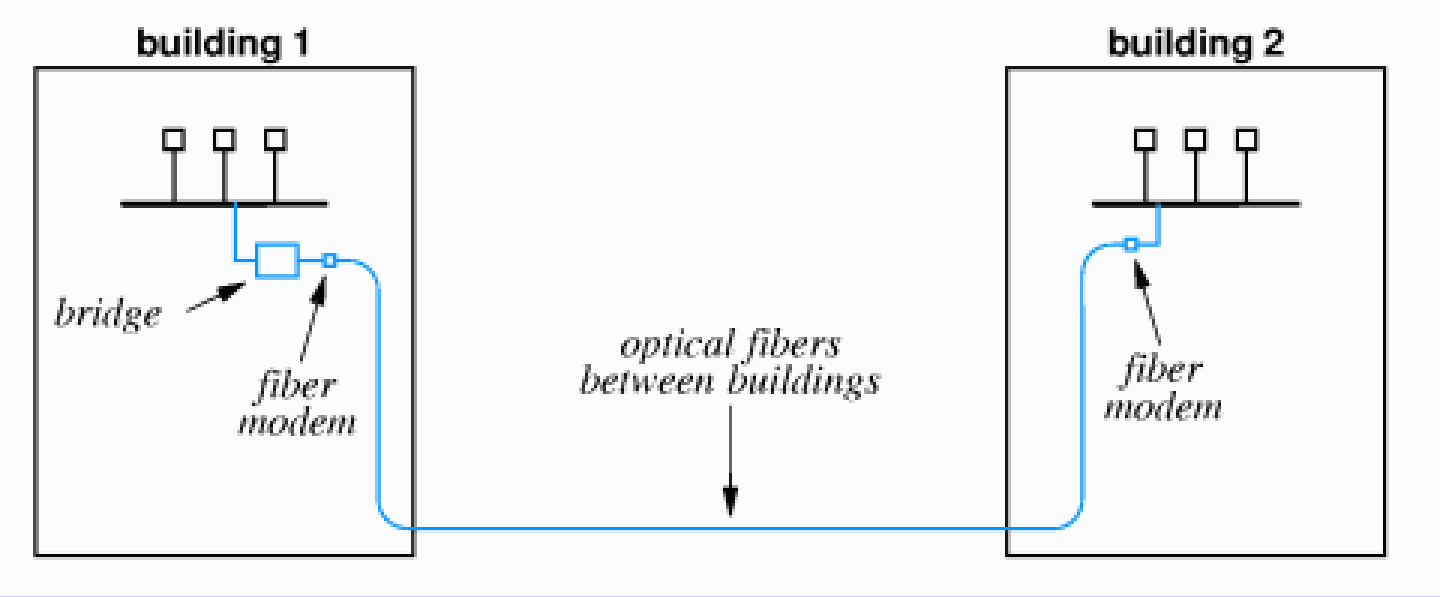
Set Up Bridge Table



Event	Segment 1 List	Segment 2 List
Bridge boots	–	–
U sends to V	U	–
V sends to U	U, V	–
Z broadcasts	U, V	Z
Y sends to V	U, V	Z, Y
Y sends to X	U, V	Z, Y
X sends to W	U, V	Z, Y, X
W sends to Z	U, V, W	Z, Y, X

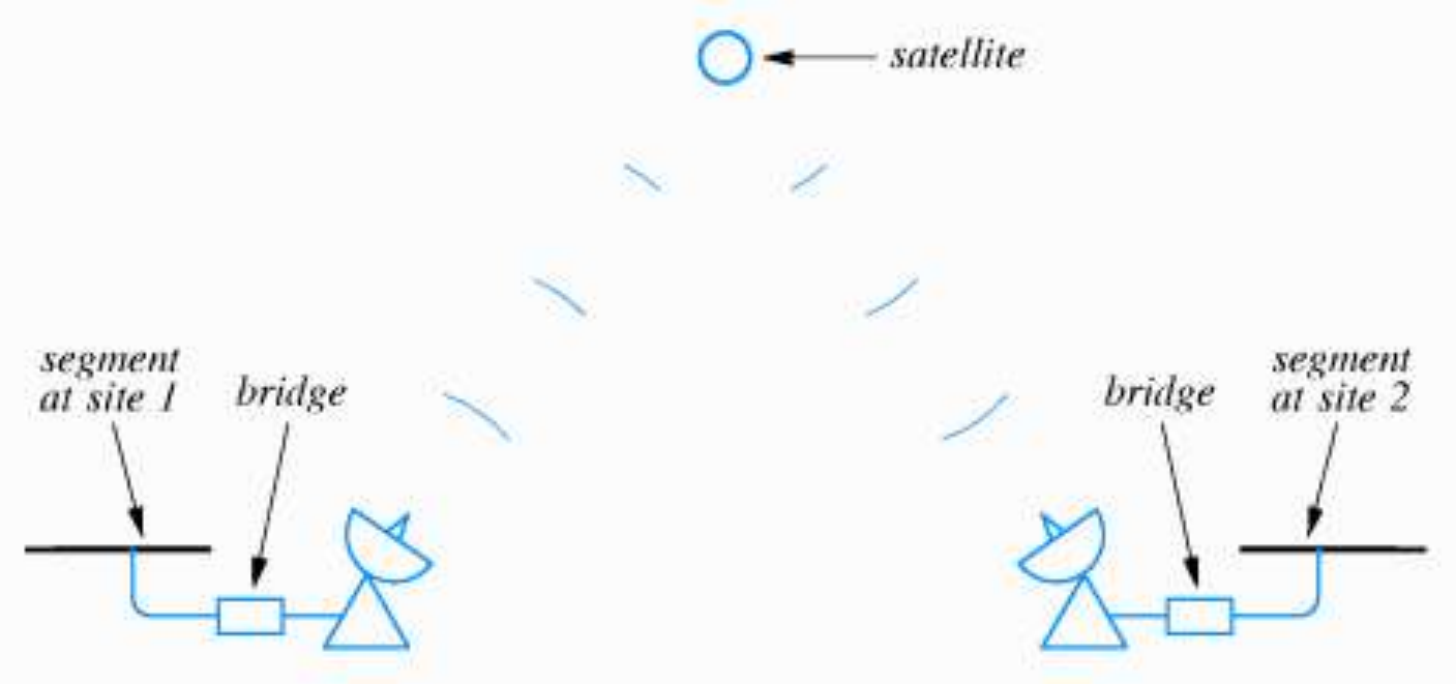
- Initially, the forwarding table in a bridge is empty.
- Bridge uses source address to learn location of each computer
- Learning is completely automated and fast
- Examines source address in each frame, add entry to list for a segment

Optical Fiber Bridging between Buildings



- Similar to extending AUI with fiber modems
- Can put a bridge in one building with a long connection to other LAN segment in different building
- Avoids extended AUI connection for each computer in remote building

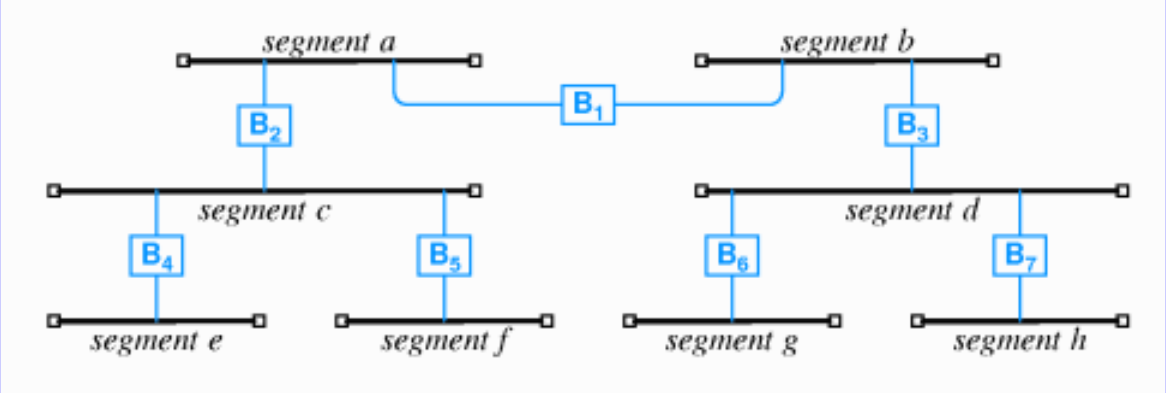
Bridging Across Longer Distance



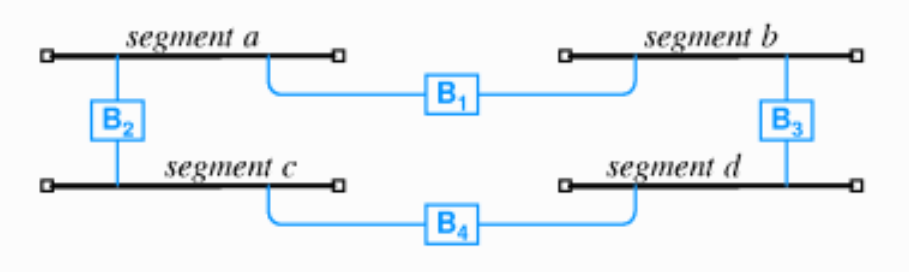
- Can use leased line, microwave, laser or satellite to connect two LANs
- Using two bridges instead of one
- Filters at *both* ends, reducing traffic across slow link
- Provides buffering at both ends, matching dissimilar transmission speeds

Bridge Tree and Bridge Cycle

Bridge tree



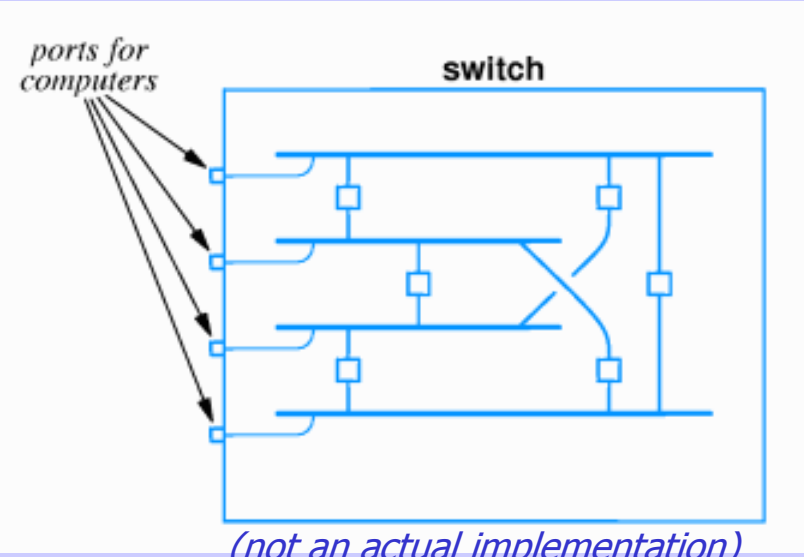
Bridge cycle



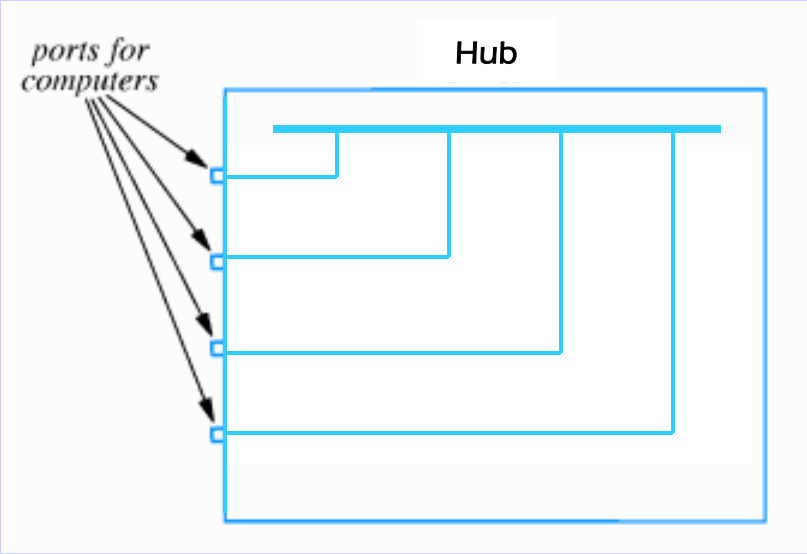
Bridge Tree: Use multiple bridges to connect LANs to form a large network
e.g., campus network, concurrent transmissions in each LAN

Bridge Cycle: Several bridges form a loop
- A computer receives two copies of a same packet
- A broadcast packet results in infinite packets in the loop
- A loop is hard to avoid in a large and dynamic network
- Spanning Tree Algorithm (IEEE 802.1 Group)

Ethernet Switch and Hub



(not an actual implementation)



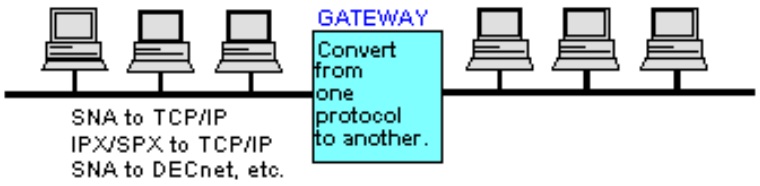
Switch - A device interconnects computers or LANs
- Physically similar to a hub and logically similar to a bridge array
- One LAN segment per host and bridges interconnect segments
- Operates on packets, understand addresses, only forward if necessary
- Permits concurrent/simultaneous transmissions
- Higher cost than hub per port

Hub and Switch

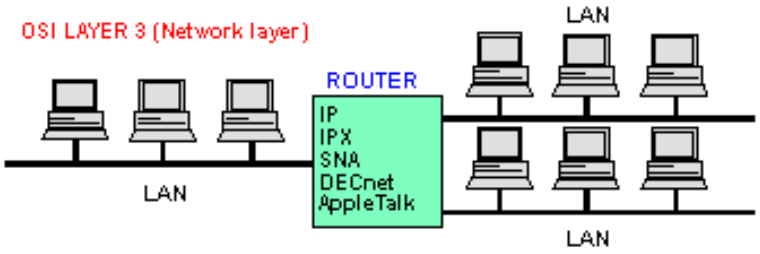
Hub, Switch and Router

LAN Hardware

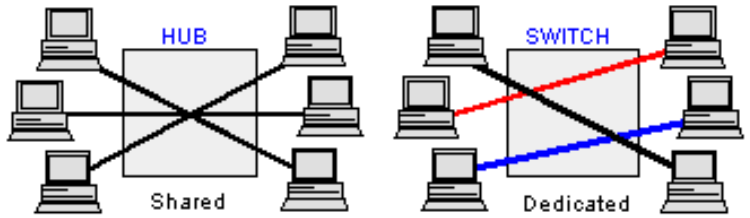
OSI LAYER 4 (Transport layer) and higher



OSI LAYER 3 (Network layer)

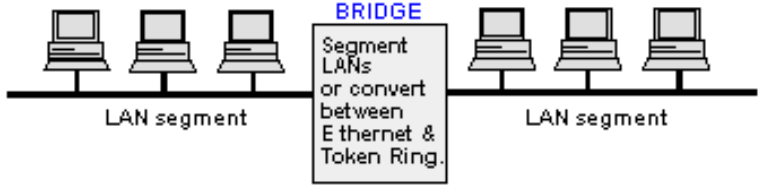


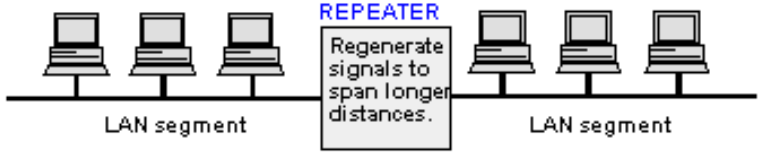
OSI LAYERS 1 & 2 (Data link layers)



E thernet, Token Ring

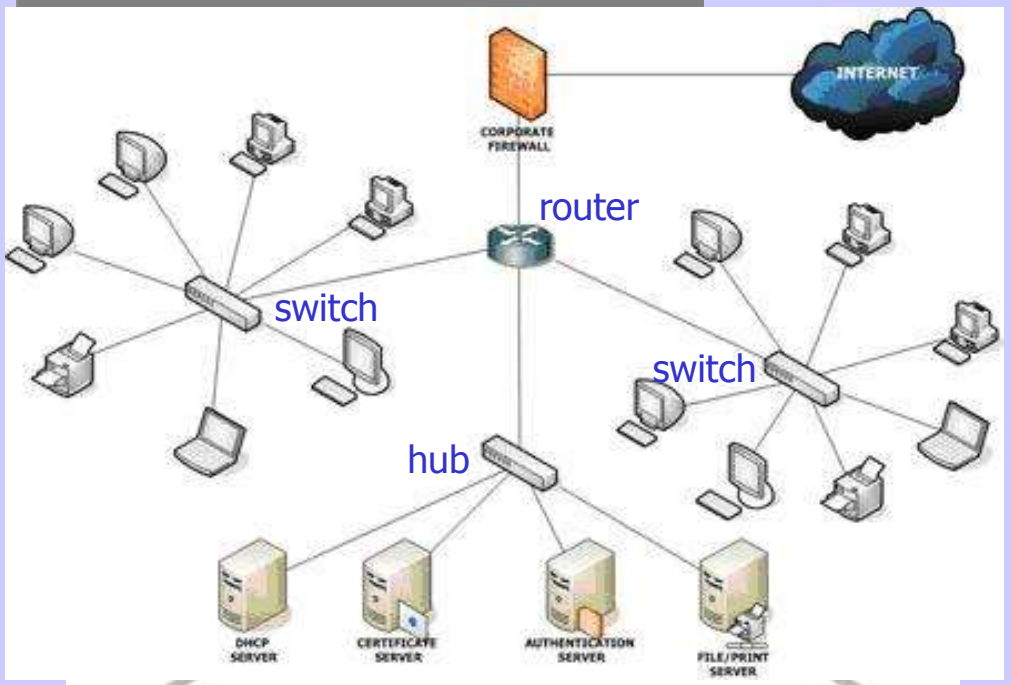
Switched E thernet, Switched Token Ring, ATM

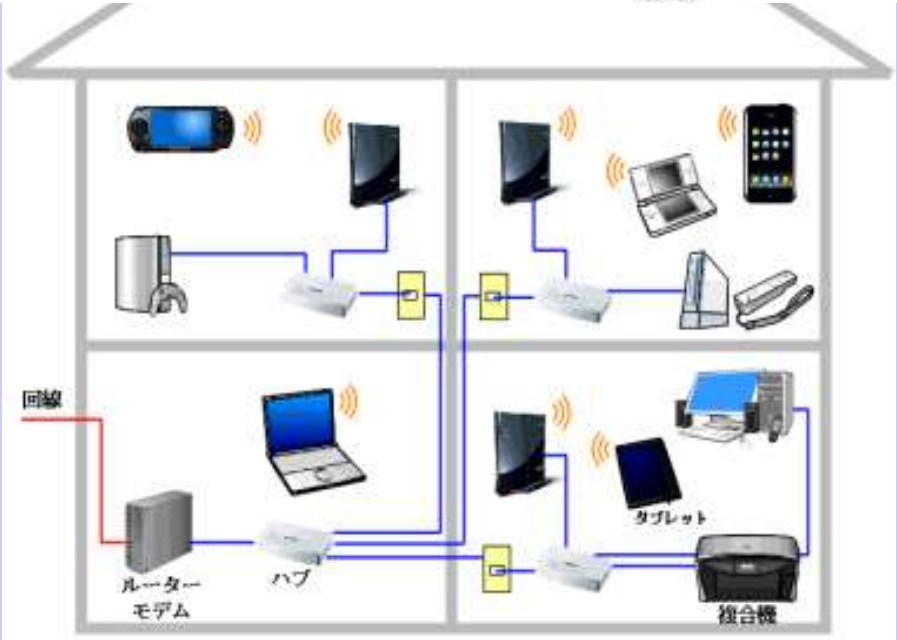




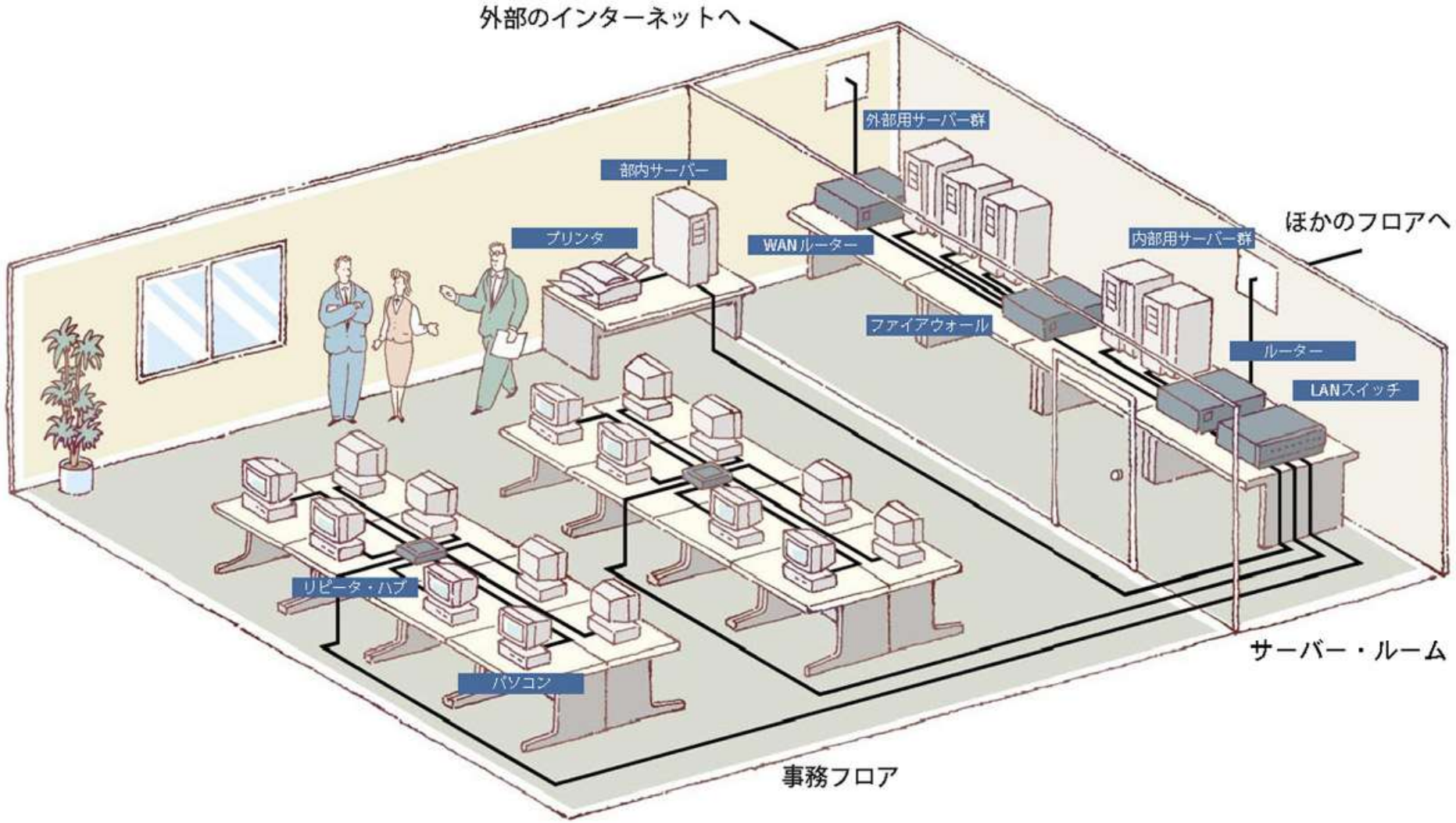
LAN Connections

Lecture 5

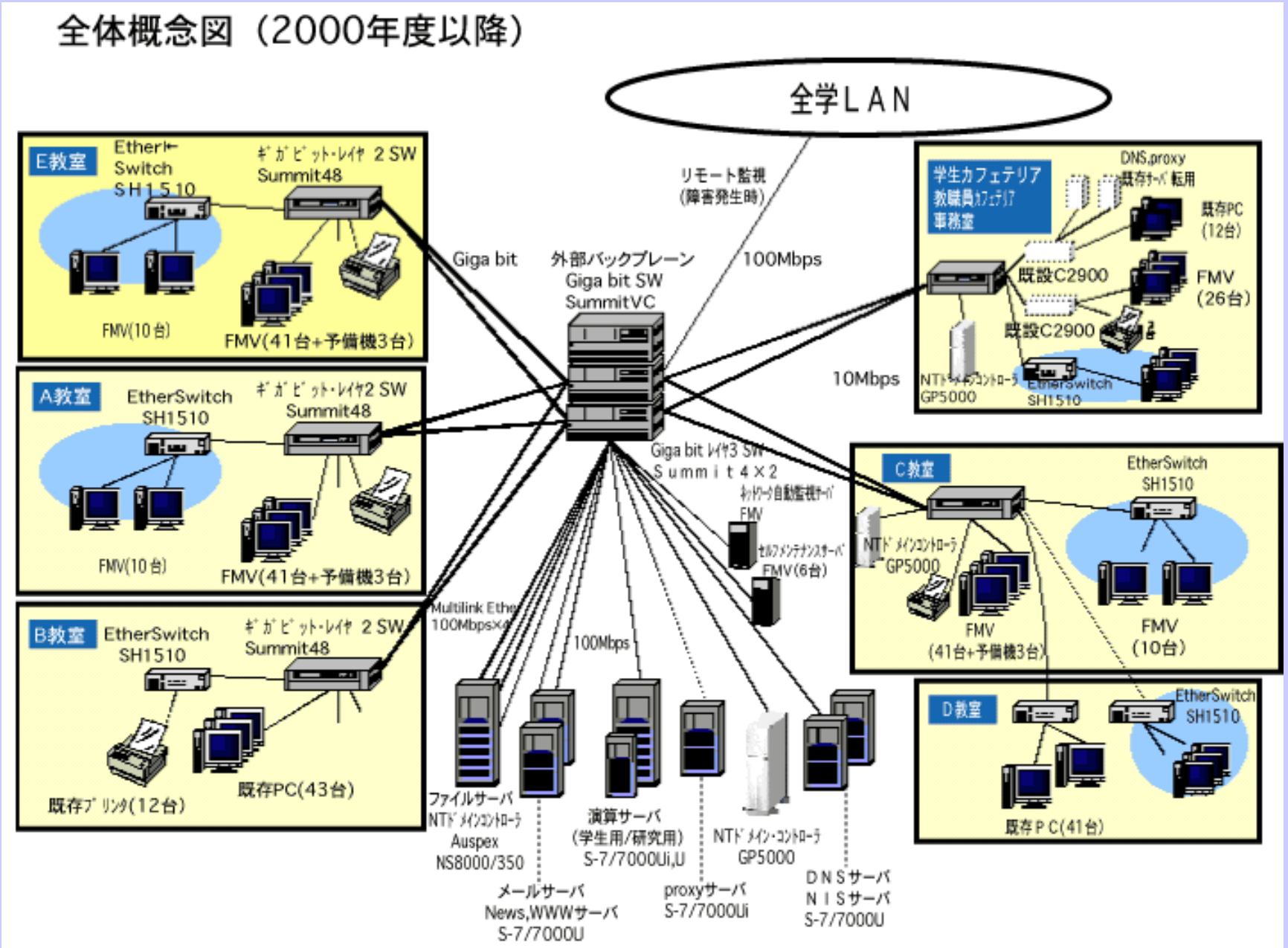




LAN Connection Example



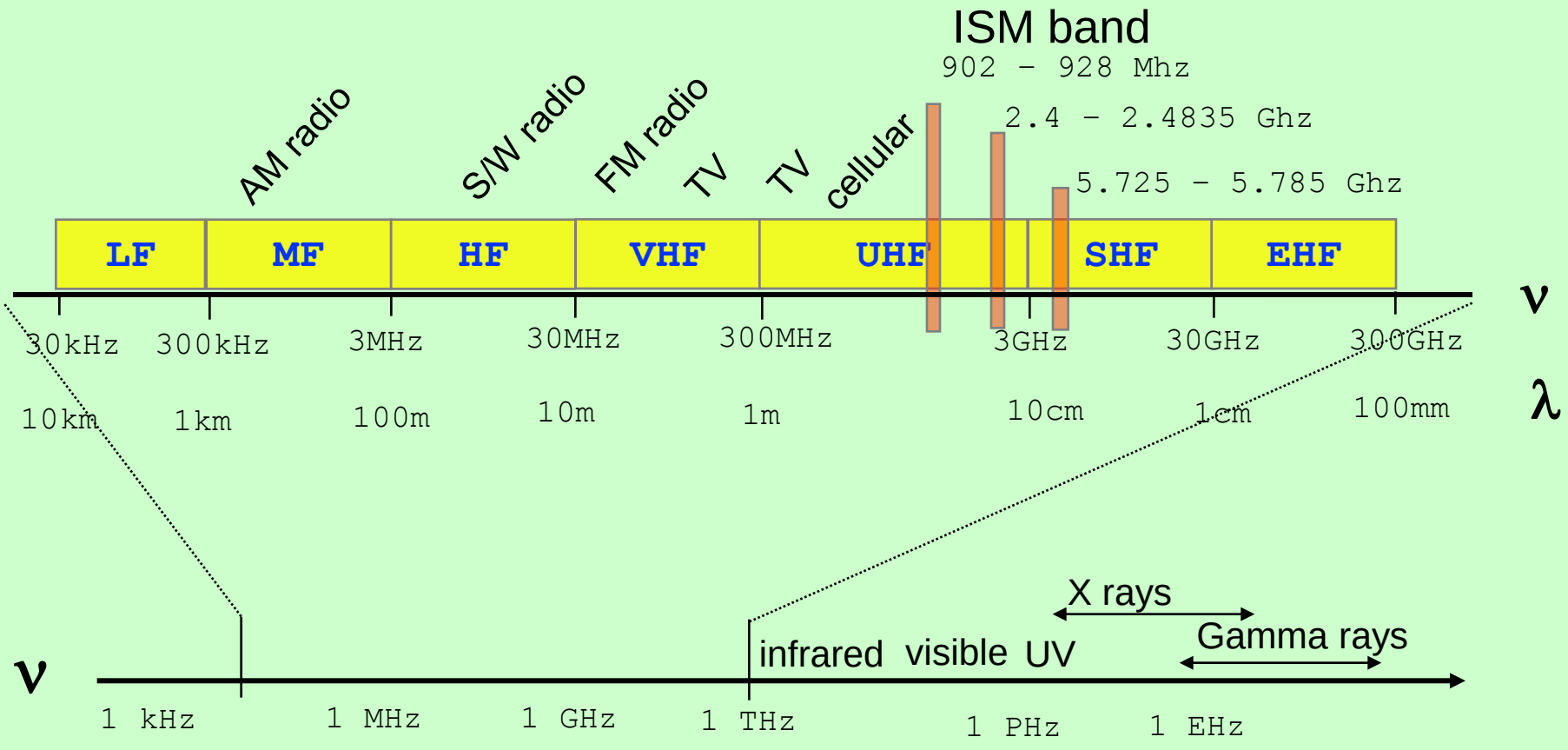
Hosei Campus Network



Short Range Wireless Networks

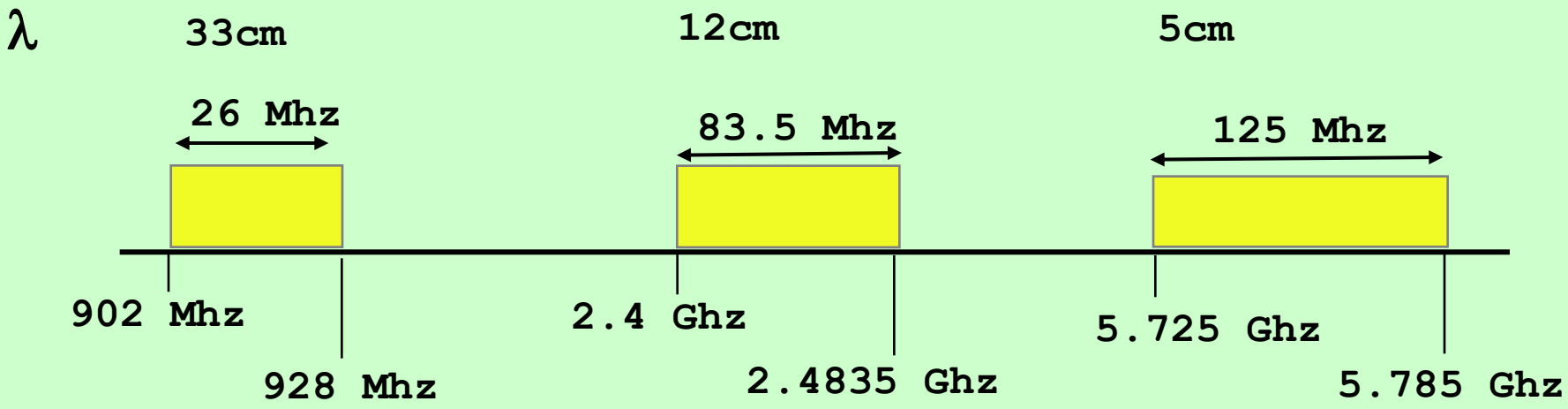
- **Wireless LAN (WLAN)**: small range (< 100m)
  - IEEE 802.11a/b/g/x (Wi-Fi, similar to Ethernet)
    - Speed: 2Mbps (infrared), >10Mbps (Microwave, 2.4/5.2GHz)
  - HomeRF
    - Speed: 10Mbps (2.4GHz), support both data, voice and streaming
- **Wireless PAN** (WPAN, Personal Area Network)
  - Bluetooth
    - Speed: 1M~10bps, defined by Bluetooth Special Interest Group (SIG, industry)
  - ZigBee
    - Speed: 10K-1Mbps, defined by ZigBee Alliance
  - IrDA
    - Speed: 10K-10Mbps, infrared communication with limited directions
  - **UWB** (Ultra Wide Band, very high speed)
- **Wireless BAN** (WBAN, Wireless Body Area Network)
  - Speed: 100-1Mbps, emerging
- **RFID** (Radio Frequency ID, varied speeds)
- **Wireless Sensor Network**
  - Speed: varied greatly

Frequency and Spectrum



Propagation characteristics are different in each frequency band

Unlicensed Radio Spectrum



cordless phones
baby monitors
Wireless LANs
ZigBee

802.11
Bluetooth
ZigBee
Microwave oven

High-speed
WLAN/UWB

IEEE 802.11, WLAN and WiFi

Victor Hayes

- born July 31, 1941 Surabaya, Dutch East Indies
- a Senior Research Fellow at the DUT, US
- “Father of Wi-Fi” due to his role in establishing and chairing the IEEE 802.11for WLAN

IEEE 802.11

A set of physical layer standards for WLAN in 2.4, 3.6, 5 & 60 GHz

http://en.wikipedia.org/wiki/IEEE_802.11

WiFi Alliance

http://en.wikipedia.org/wiki/Wi-Fi_Alliance

IEEE 802.15, WPAN – Personal Area Network

Personal Area Network (PAN)
Body Area Network (BAN)

IEEE 802.15

A WG of IEEE 802 for Wireless Personal Area Network (WPAN)

Task Group 1: WPAN / Bluetooth
Task Group 2: Coexistence
Task Group 3: High Rate WPAN
Task Group 4: Low Rate WPAN
Task Group 5: Mesh Networking
Task Group 6: Body Area Networks
Task Group 7: Visible Light Communication

https://en.wikipedia.org/wiki/IEEE_802.15

Bluetooth and UWB

Jim Kardach
The Man Who Named Bluetooth

https://en.wikipedia.org/wiki/Bluetooth

Robert A. Scholtz and Moe Z.
Pioneer ultra-wide bandwidth (**UWB**)

https://en.wikipedia.org/wiki/Ultra_wideband

IEEE802.16, WiMAX

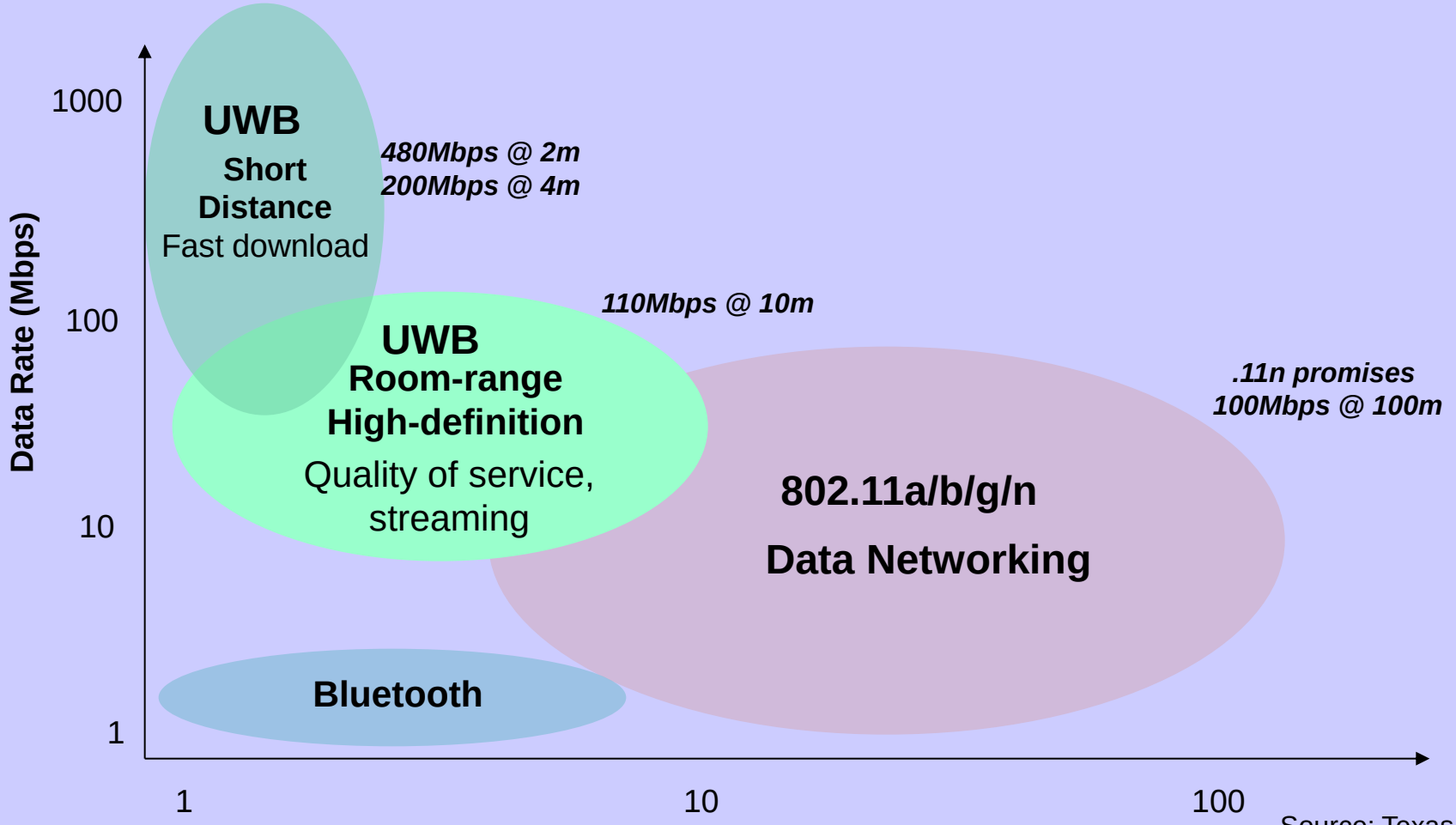
IEEE 802.16

An unit WG of IEEE 802 LAN and MAN standards committee
A series of Wireless Broadband standards for Wireless MAN
http://en.wikipedia.org/wiki/IEEE_802.16

WiMAX

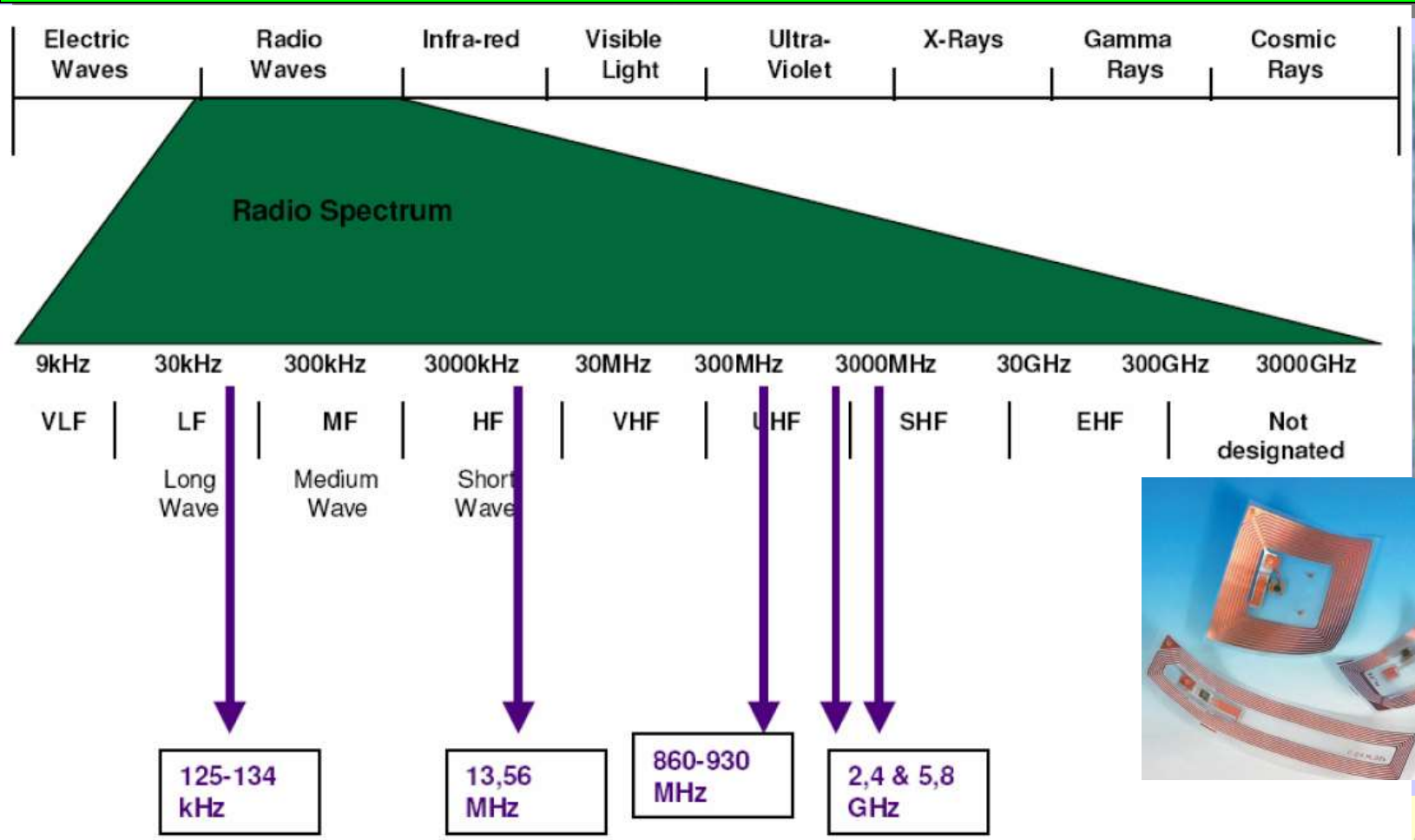
http://en.wikipedia.org/wiki/WiMAX

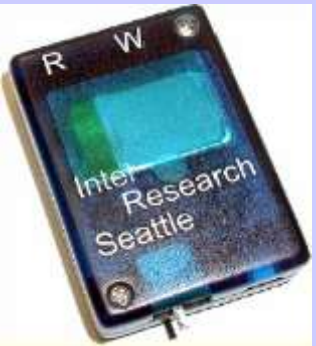
WLAN/WPAN

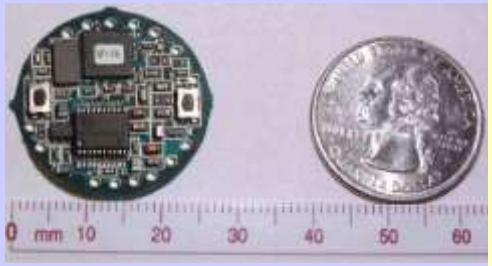


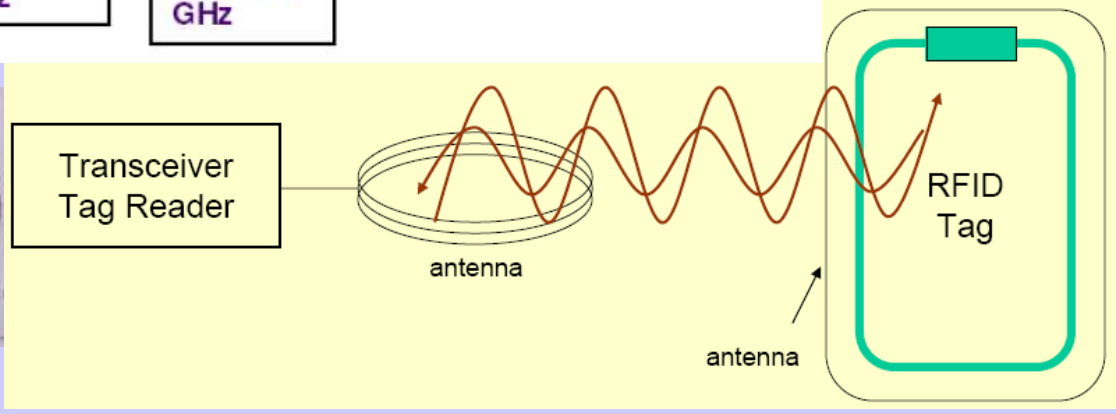
Source: Texas Instruments

Radio Spectrum for RFID

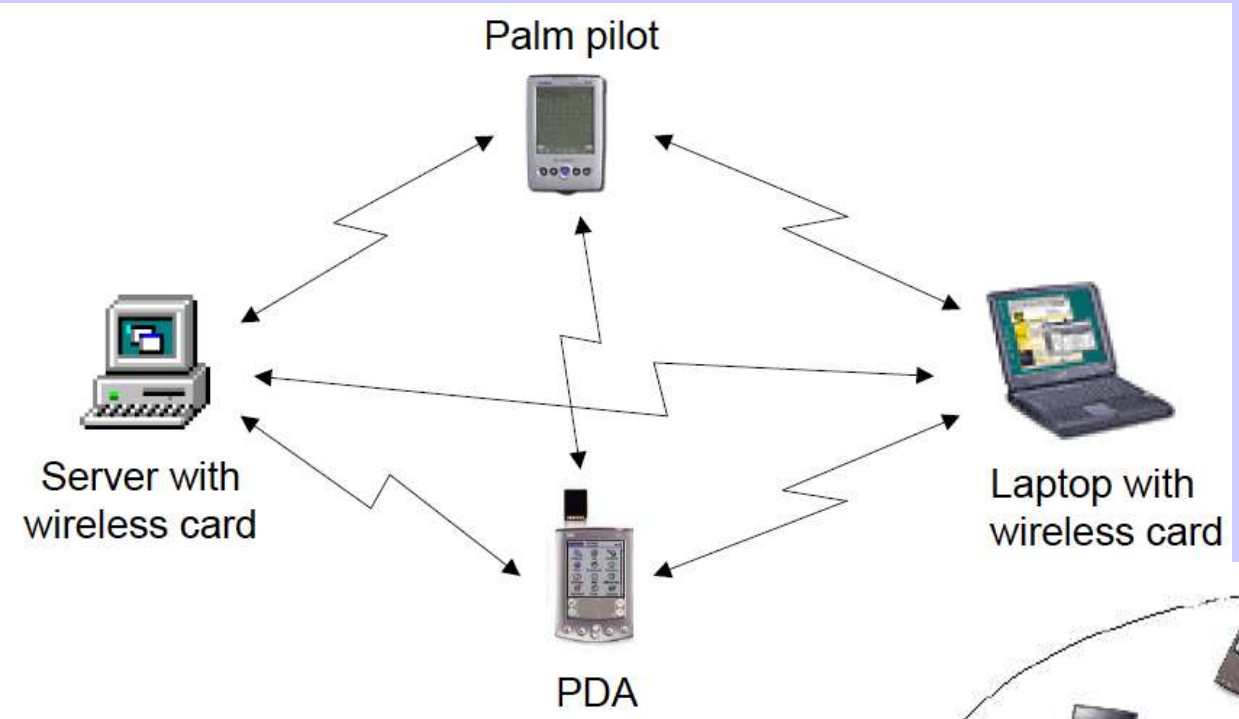


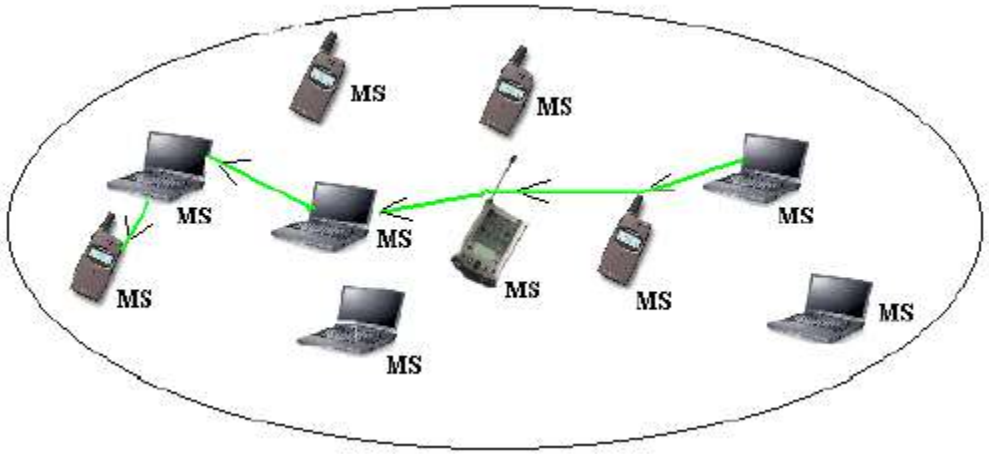






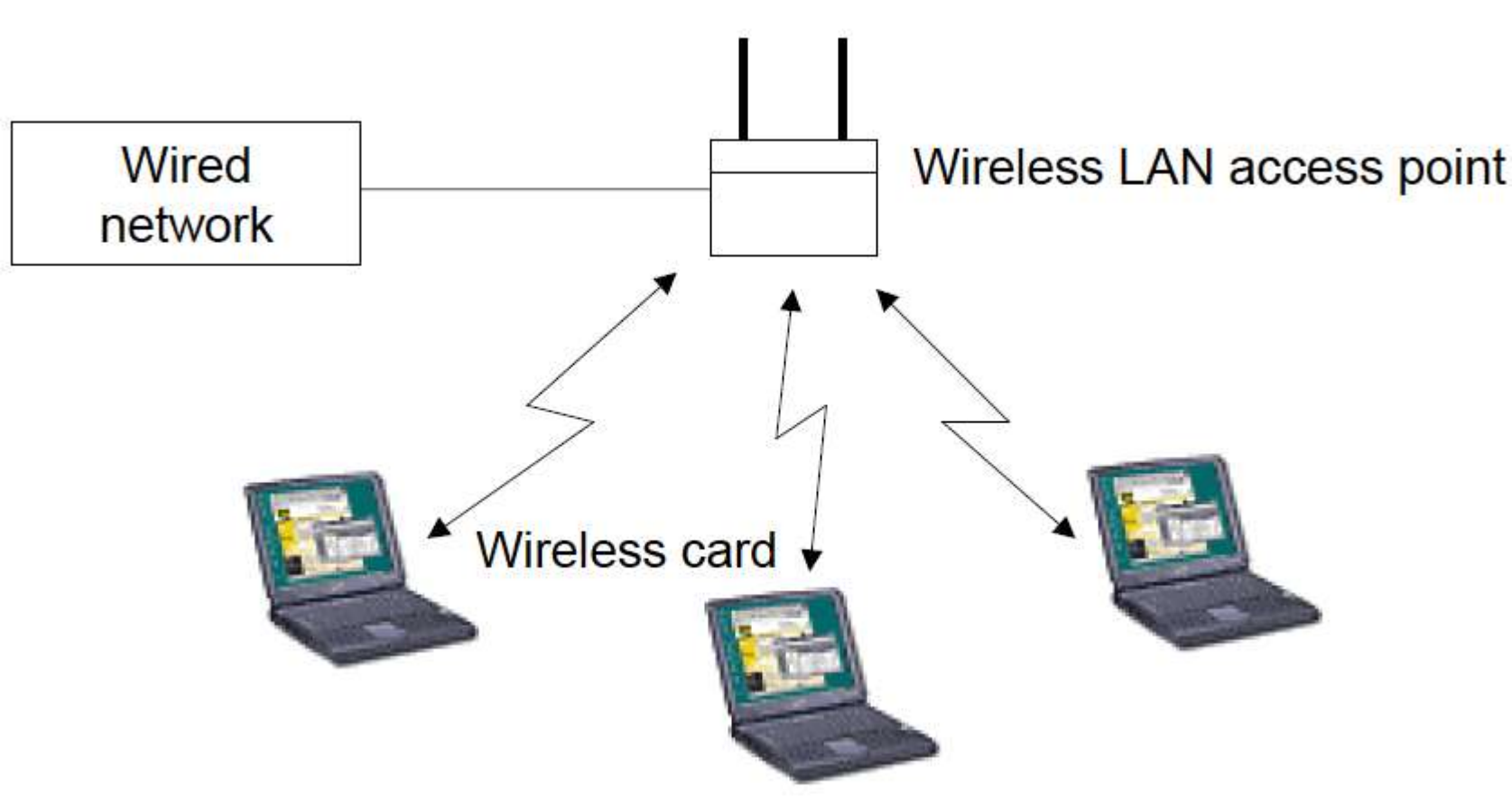
Wireless Connection: Ad Hoc / Peer-to-Peer



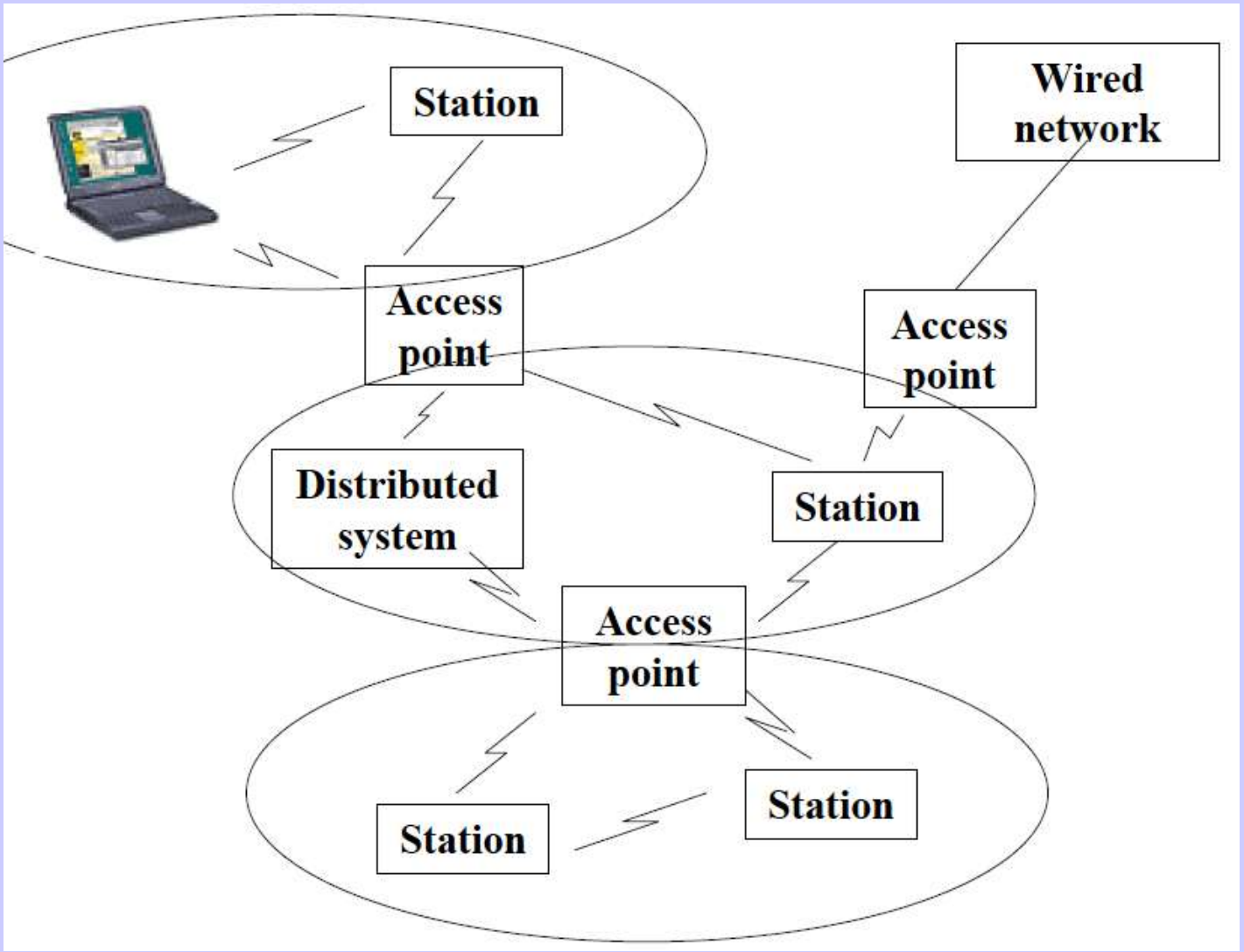


- No backbone infrastructure.
- Routing can be multi-hops. Topology is dynamic.

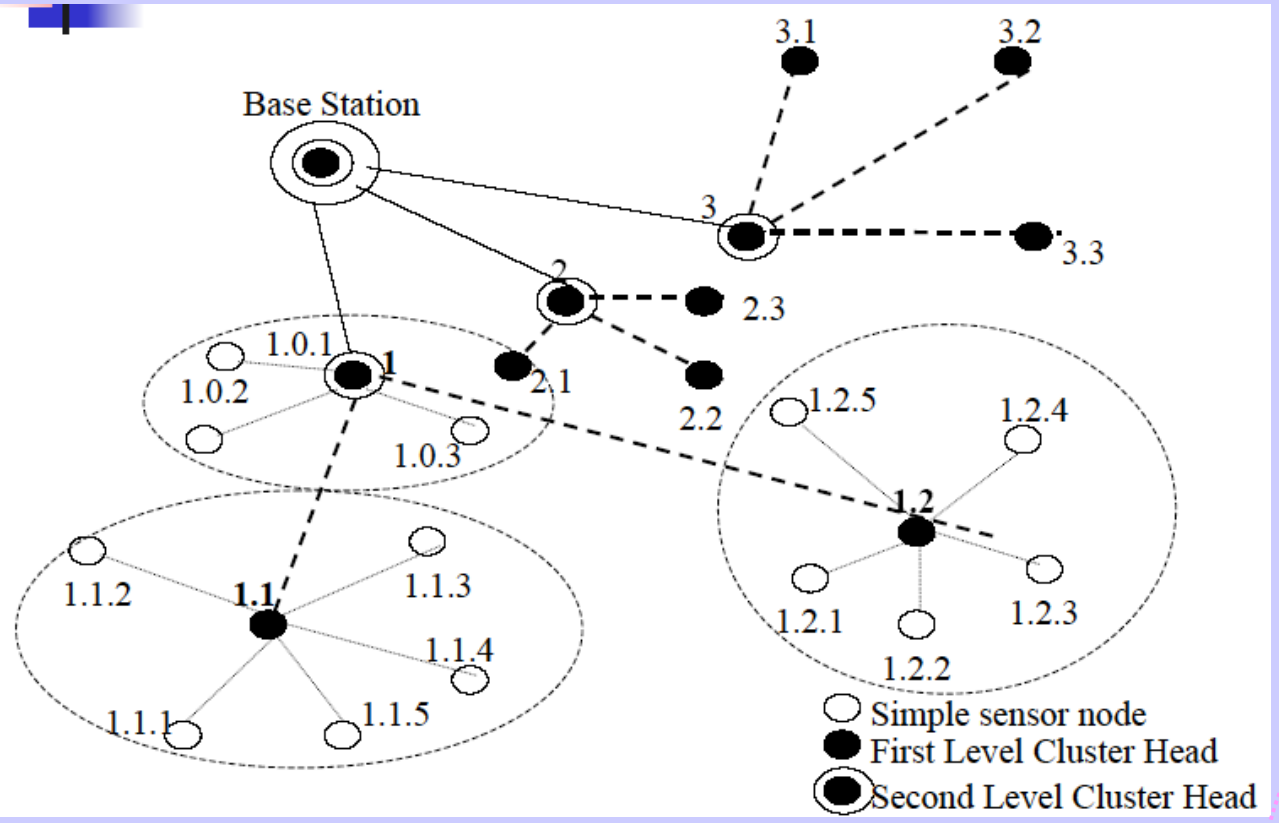
Wireless Connection: Client/Server (Access Point)

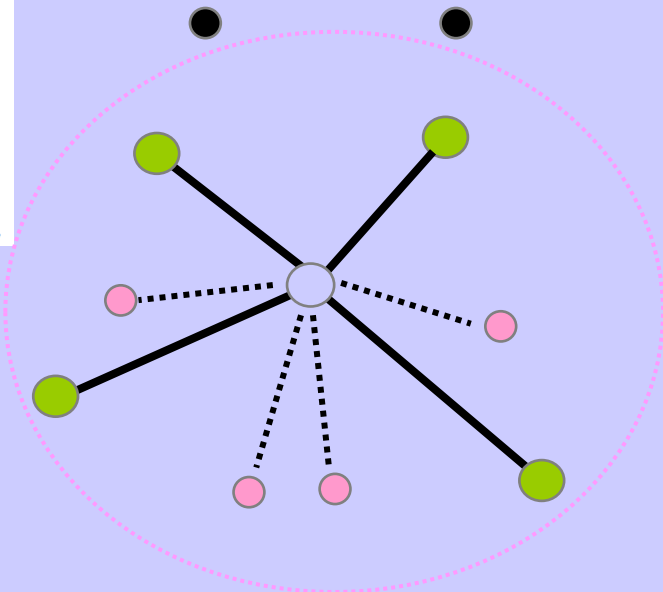


Wireless Connection: Distributed



Wireless Connection: Hierarchy





Master Active Slave

Parked Slave Standby

Exercise 5

1. Explain why a hub Ethernet is logically bus but physically star.

2. 10Base5 uses _____ cable, 10Base2 uses _____,
   10Base-T uses _____, 100Base-T/T4 uses _____,
   1000Base LX/SX uses _____.

3. when we connect two LANs in two buildings, one bridge is used. However, when two LANs are connected by a least line, microwave or satellite, two bridges are used. Why?

4. Explain similarities and differences between a repeater and a bridge.

5. Explain similarities and differences between an Ethernet switch and an Ethernet hub.