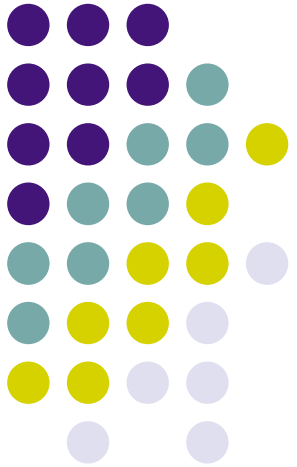
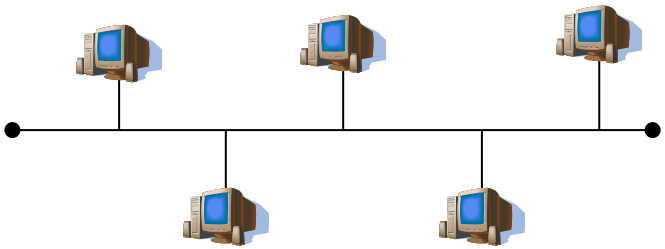
Lecture 5
LAN: Local Area Network

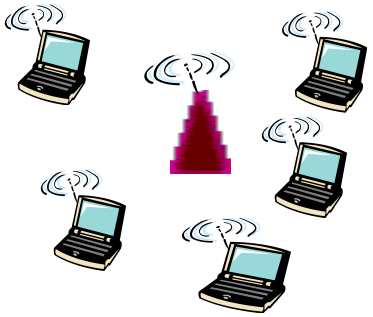
Reading: 4.3 Computer Networks, Tanenbaum



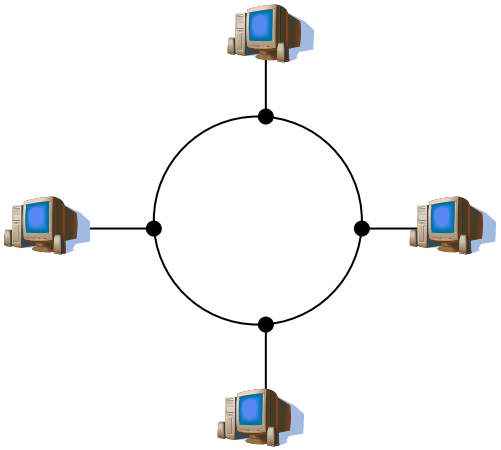
LAN topology



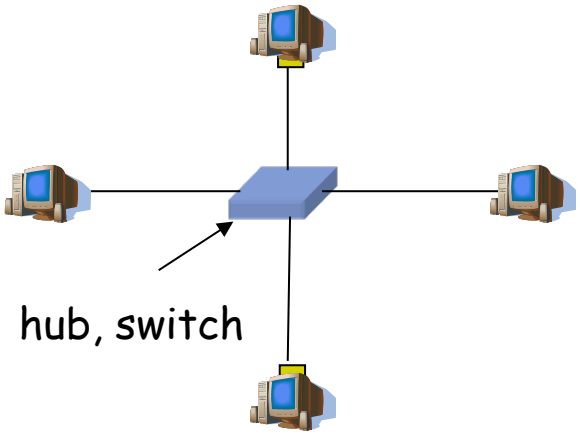
Traditional bus topo



WLAN

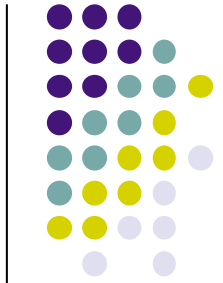


Ring



Star

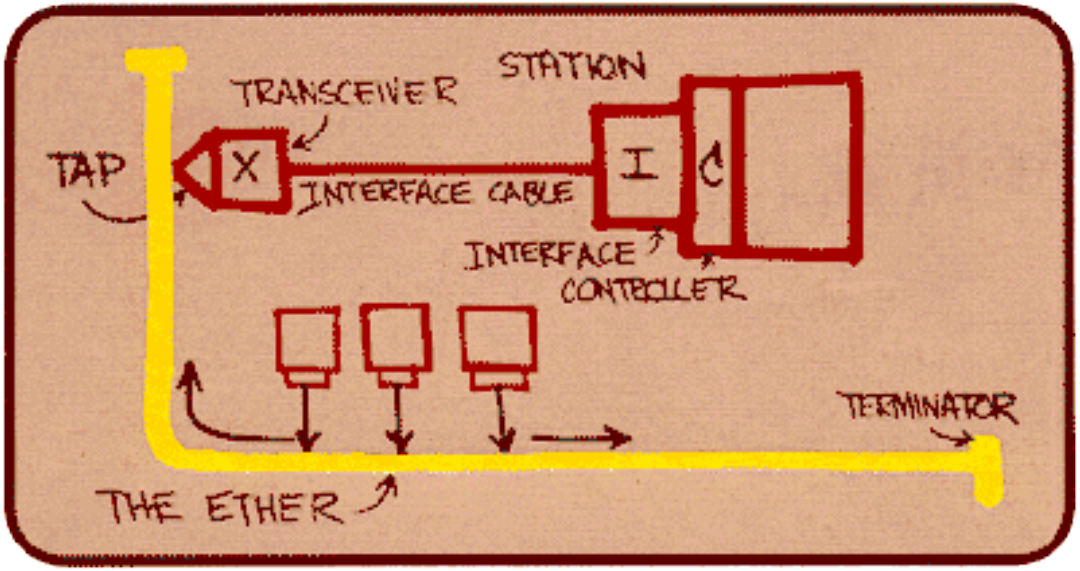
LAN Standards



- IEEE 802 contains many standards for LAN technology.
  - 802.3: Ethernet
  - 802.4: Token bus
  - 802.5: Token ring
  - 802.11 a/b/g/n: Wireless LAN (Wifi)
  - 802.16: WiMax.

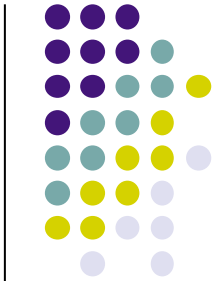
Ethernet LAN

- Layer 2 technology for communication in LAN, invented in 1976
- Standardized in IEEE 802.3
- Ethernet LAN could have different speeds: 3 Mbps – 10 Gbps
  - Ethernet: 10BaseT, 10Base2…

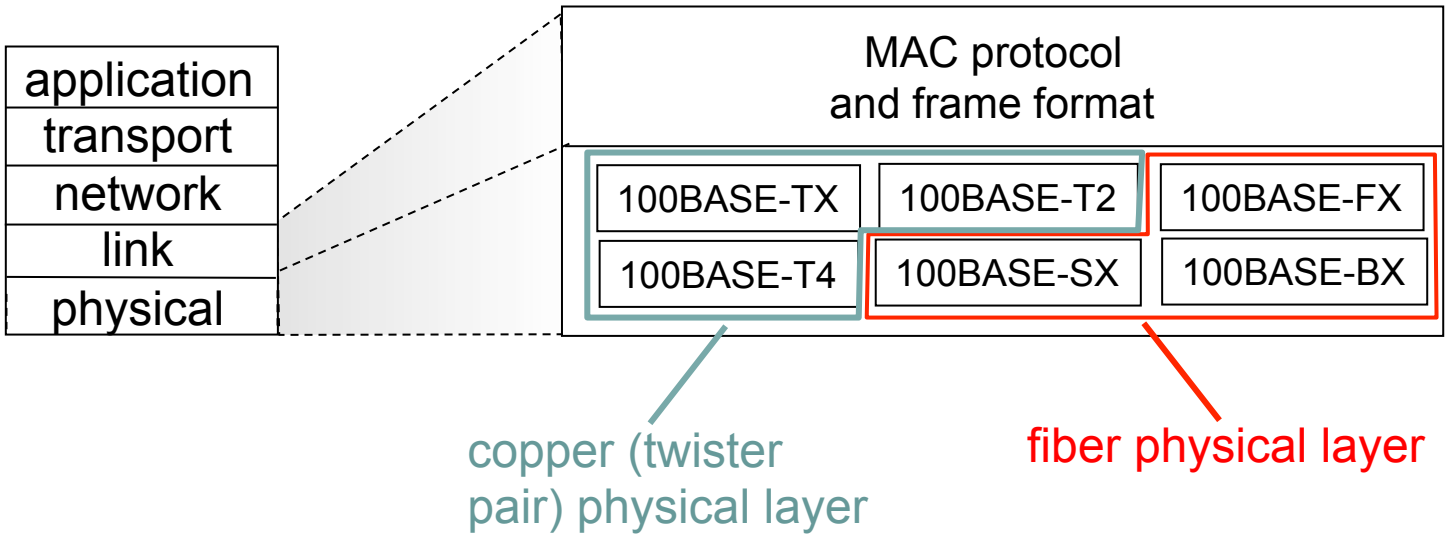


Metcalfe's Ethernet sketch

IEEE 802.3 and Ethernet Standards

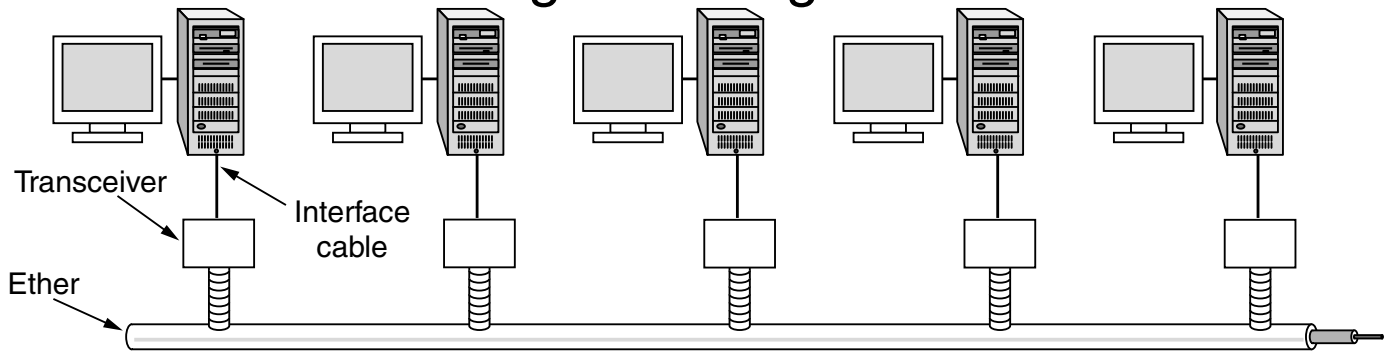


- Datalink & Physical Layers
- Datalink= LLC + MAC
- MAC: CSMA/CD in classical Ethernet
- Several type of Ethernet
  - Same MAC and frame structure
  - Different rate: 2 Mbps, 10 Mbps, 100 Mbps, 1Gbps, 10G bps
  - Different cable: Optical fiber, coaxial, twisted pair



Classical Ethernet

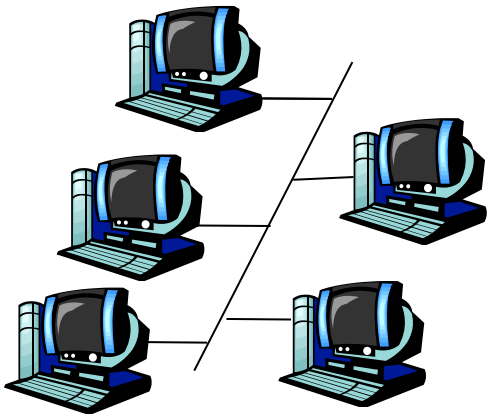
- Bus topology was popular in the past
- All nodes share the same communication medium. Could used a central hub for connecting nodes.
- Use CSMA/CD for media access control.
- Use Manchester encoding at Physical layer
- Use coaxial cable
- Thick Ethernet: Max segment length 500m without converter
- Thin Ethernet: Max segment length 185m without converter



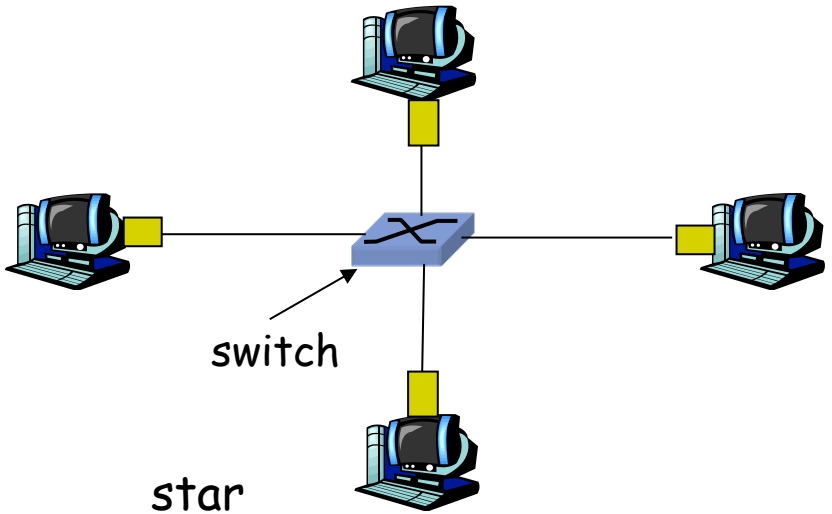
Ref: Computer Network, Tanenbaum

Switched Ethernet

- Switched Ethernet (nowdays):
  - Star topology,
  - Use a central switch Ethernet
  - The switch outputs a frame only to the port linking to the destination ➔ independent connection for each pair of two nodes
  - No collision
  - No media access control is needed.

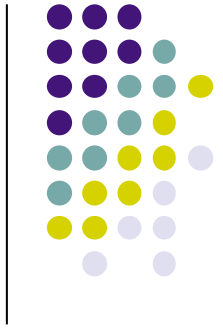


bus: coaxial cable



star

Classical Ethernet



- Ethernet frame

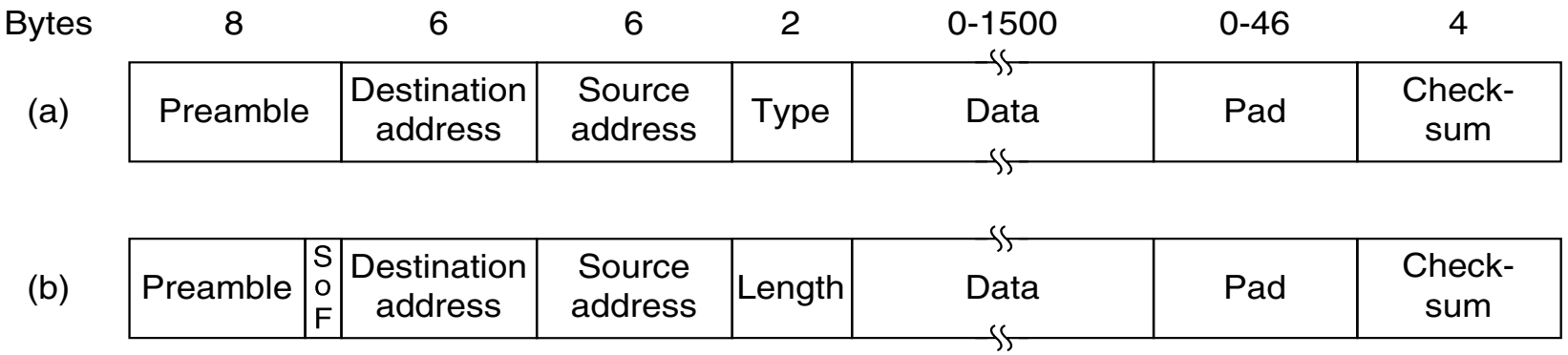
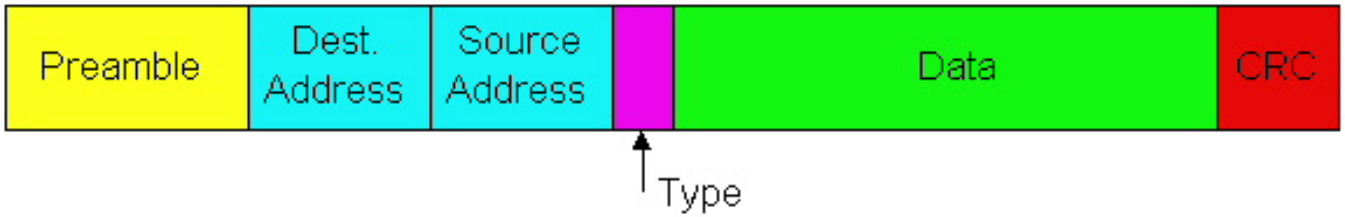


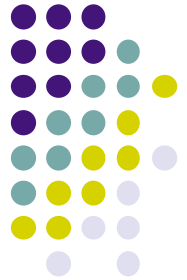
Figure 4-14. Frame formats. (a) Ethernet (DIX). (b) IEEE 802.3.

Structure of Ethernet frame



- Preamble: Marking the starting of a frame
- Address: Physical addresses of source and destination
  - 6 bytes
- Type: Uppper layer protocol (IP, Novell IPX, AppleTalk, …)
- Checksum: Error detection code. CRC??

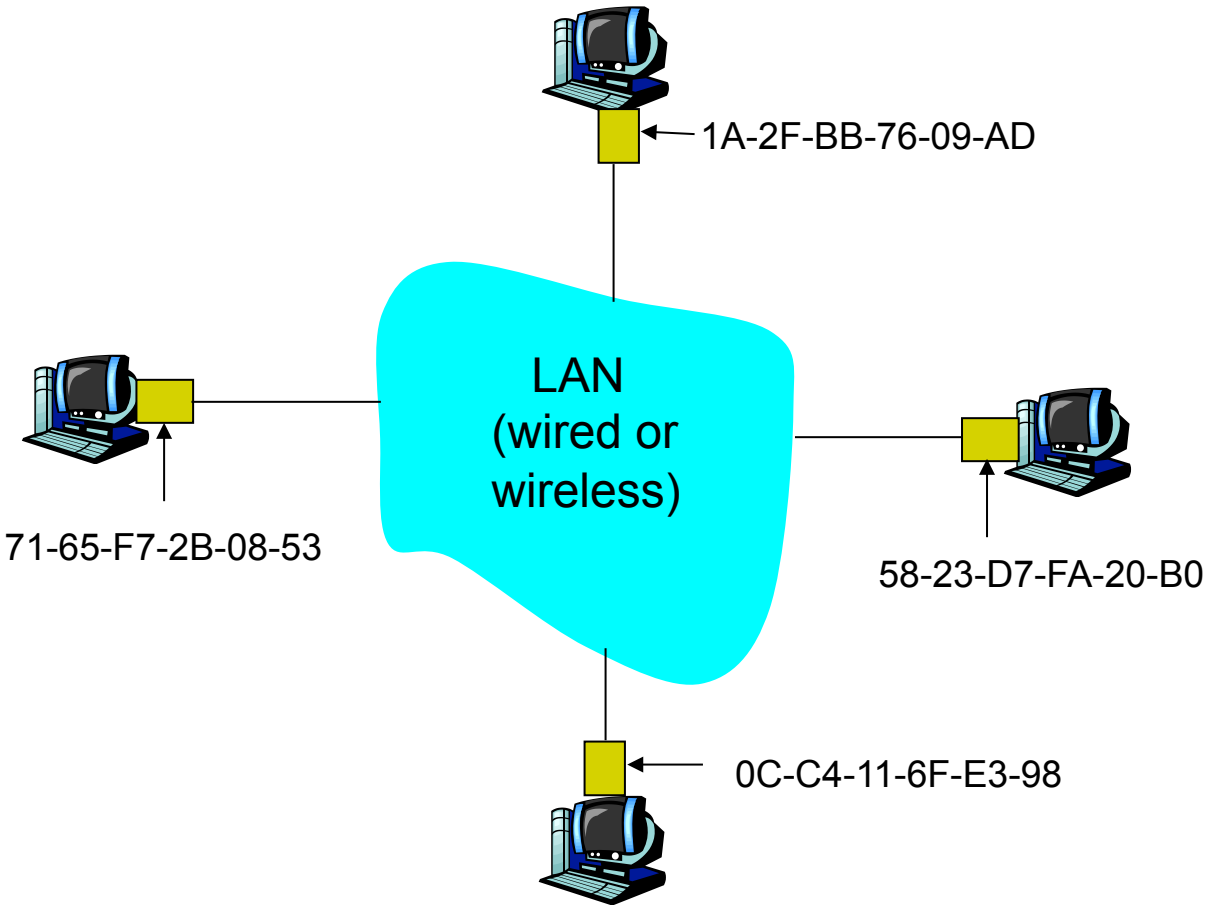
MAC address and ARP



- IP Address :
  - 32-bit
  - Used in Network layer
- MAC address:
  - Used in Data link layer
  - 48 bit

ARP and MAC address

Each network adapter has a MAC address

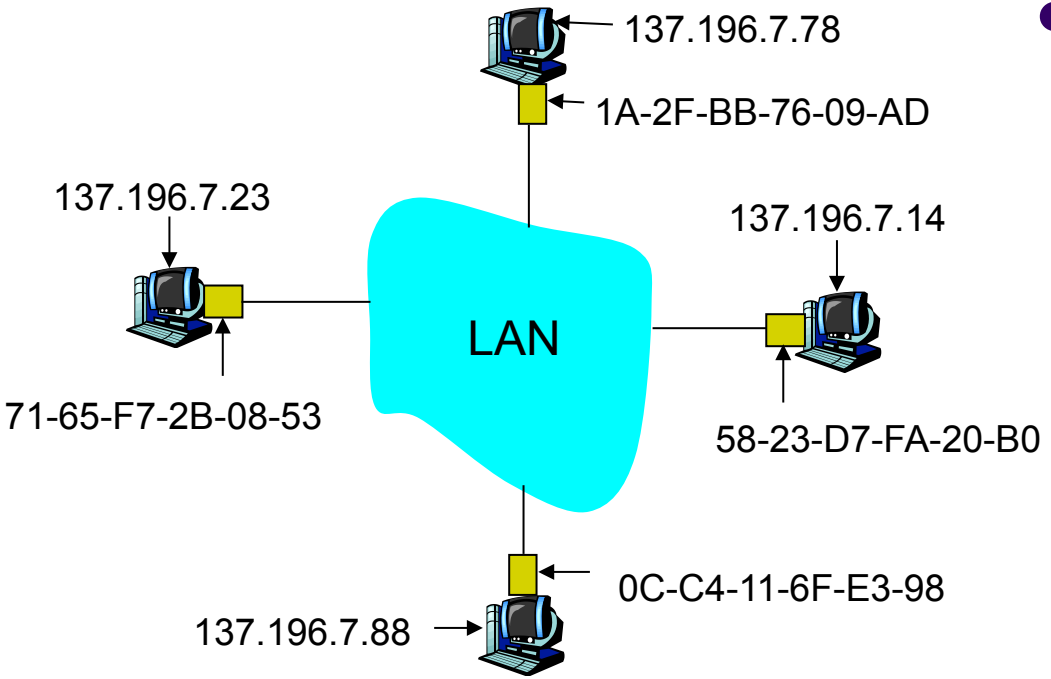


Broadcast address =
FF-FF-FF-FF-FF-FF

= adapter

ARP: Address Resolution Protocol

Question: Identify MAC address from an IP address



- Each network node (host, router) has an ARP table
- ARP table: contain mapping IP/MAC of some nodes

< IP address; MAC address; TTL>

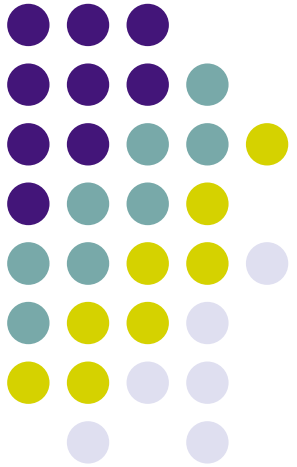
  - TTL (Time To Live): ~20 min.

ARP : Work on a network segment

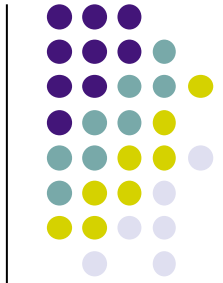
- A wants to send data to B on datalink layer but do not know MAC of B
- A broadcast an ARP package stating the IP address of B
- B receives the package with is address and reply to A with MAC of B
- A saves the MAC address of B

LAN (cont.)

Hub, Switch, Bridge

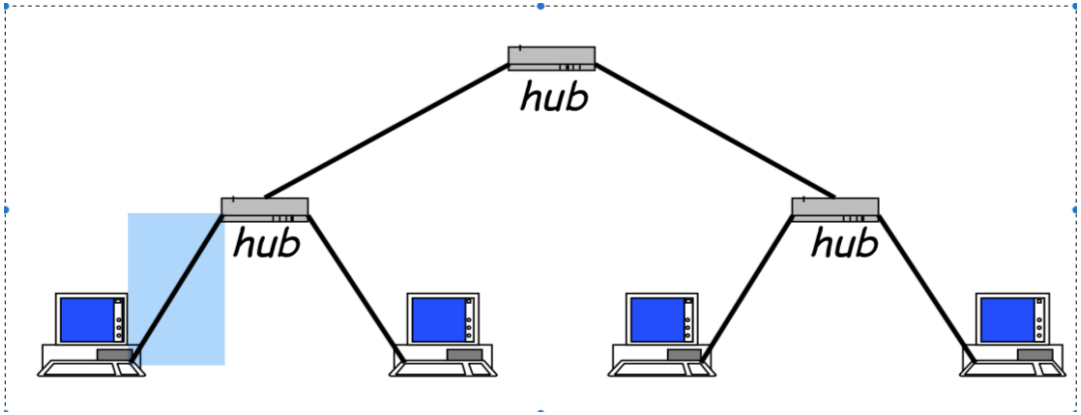


Devices of LAN



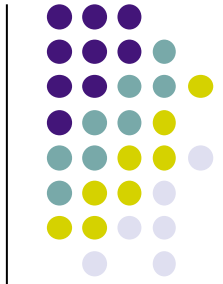
- Repeater, Hub, bridge and switch
  - All are LAN devices with many ports
- Repeater:
  - Repeats the bits received in one port to the other port
  - One network with repeaters = one collision domain
  - Repeater is a physical layer system.
- Hub:
  - Receive the signal from one port (amplify) and forward to the remaining ports
  - Do not offer services of datalink layer
  - Layer 1 intermediate system

Hub



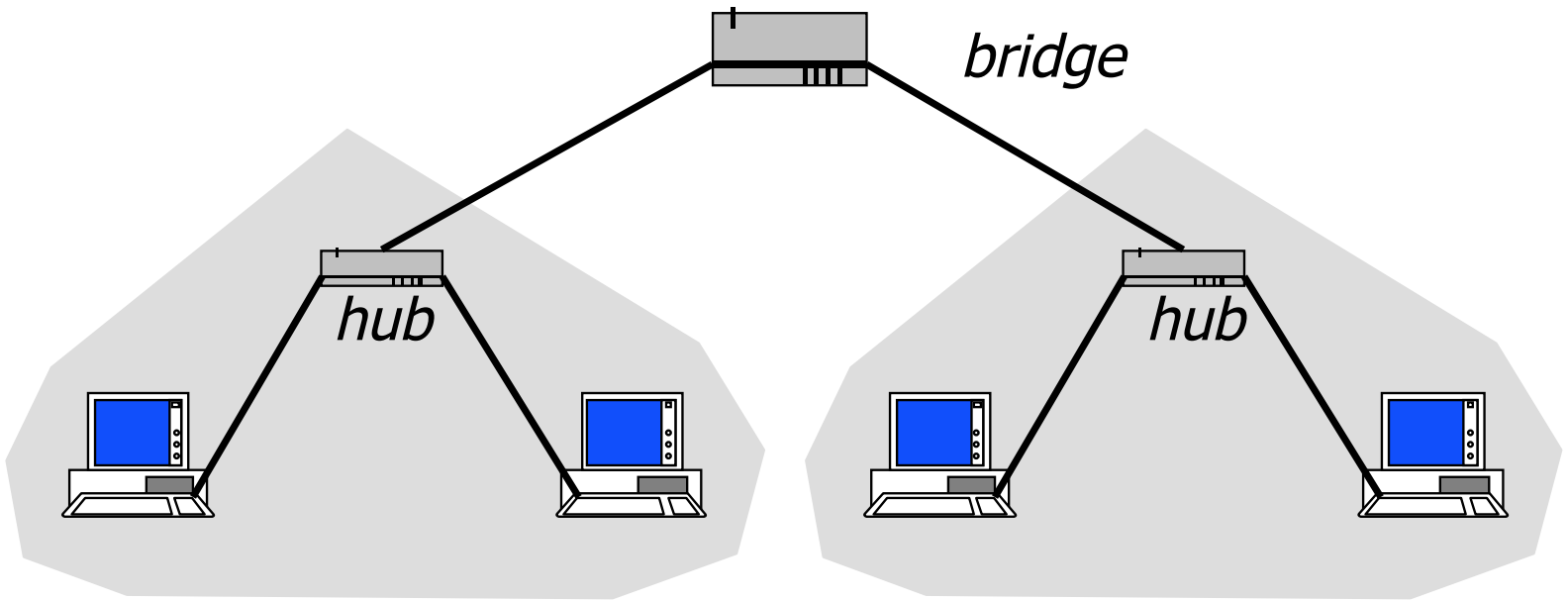
Hub=Multiple port repeater
Single collision domain

Devices of LAN (cont.)



- Bridge
  - More intelligent than hub
  - Can store and forward data (Ethernet frame) according to MAC address.
  - Bridge breaks the network into two collision domains.
  - Layer 2 intermediate system
- Switch
  - More ports than bridge
  - Can store and forward data according to MAC address
    - Receive full frame, check error, forward

Bridge

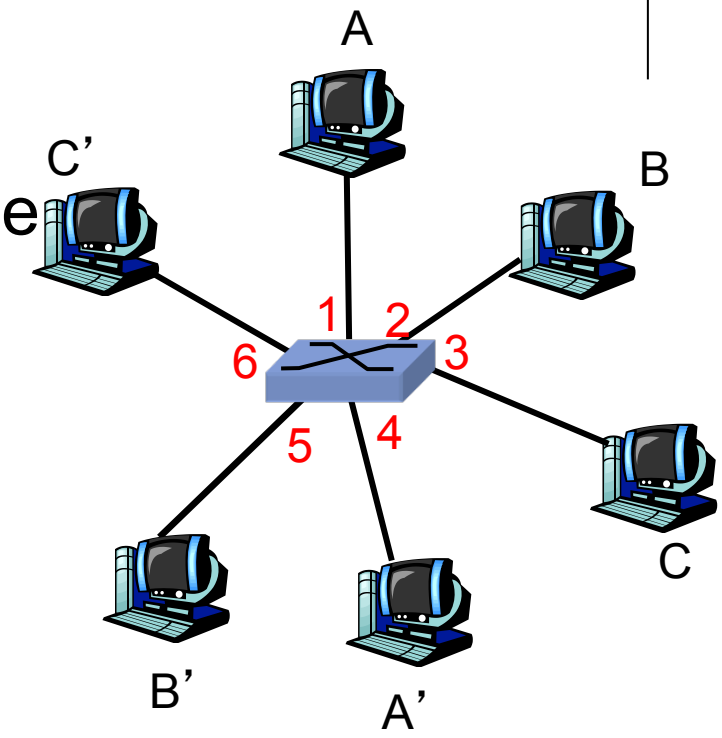


Two ports systems

- Forward MAC frame from one port to the other based on MAC address
- Create two collision domains

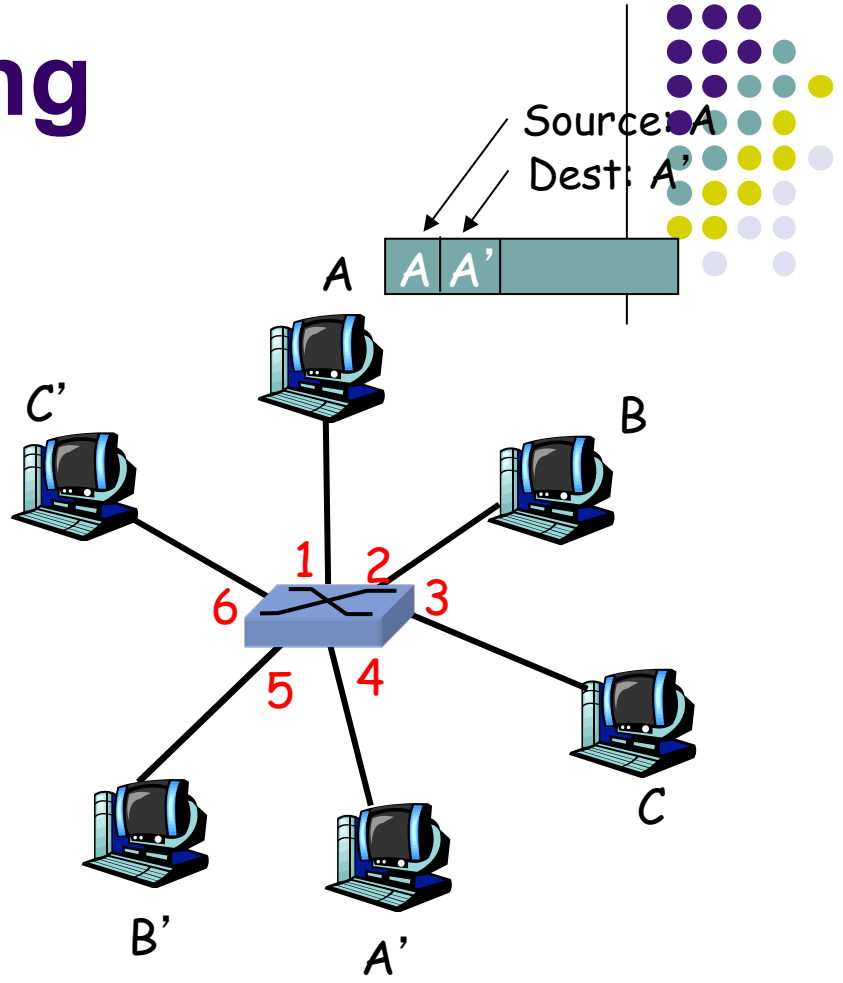
Switch

- Allows multiple node pairs sending data in the same time
  - E.g. A-to-A’ and B-to-B ‘ without collision
  - Each link is an independant collision domain
- Switch has a table of MAC addresses showing which node connects to which port
  - (MAC address of host, port index, TTL)



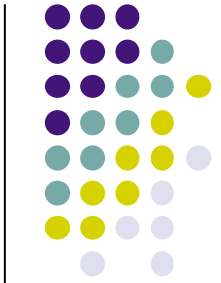
Switch: Self learning mechanism

- Switch learns the MAC address of all hosts connected to the switch
- Forwarding table



MAC addr	interface	TTL
A	1	60

Switch: forwarding mechanism



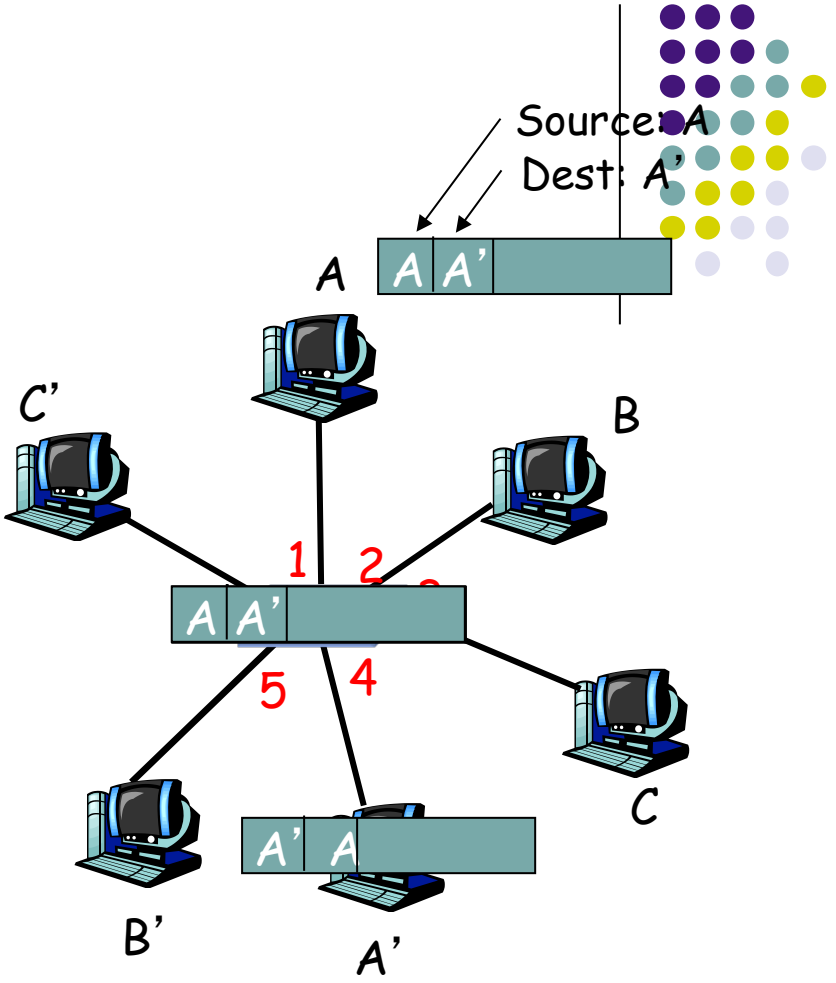
When receiving a fram

1. The incomming port and MAC associated is learnt
2. Looking for outgoing port based on destination MAC and forwarding table
3. **if** outgoing port is found
   then {
   if incomming port== outgoing port
   then destroy the frame
   else forward the frame to outgoing port
   }
   else broacast the frame

Ex:

- Outgoing port unknown: *Broadcast*
- Know A:

Direct transfering

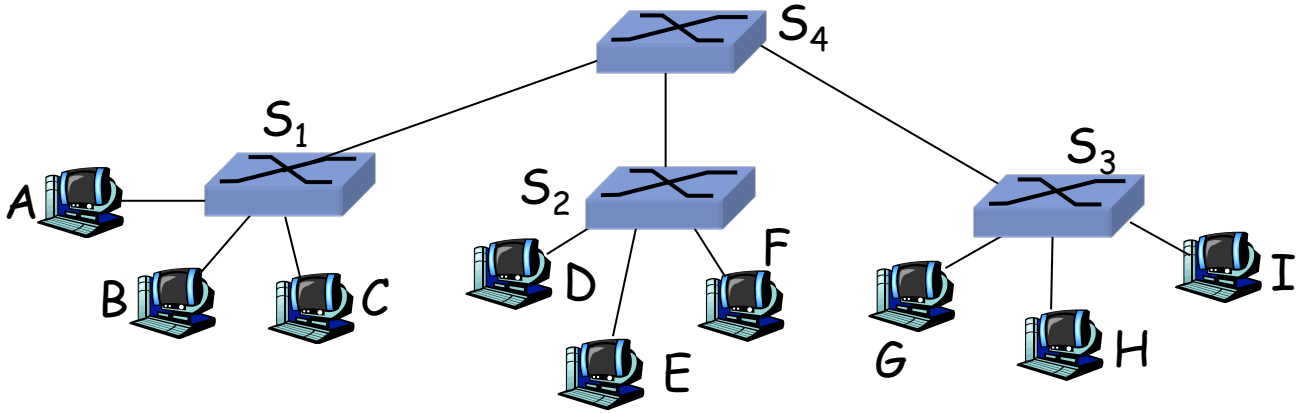


MAC addr	interface	TTL
A	1	60
A'	4	60

Forwarding table (empty initially)

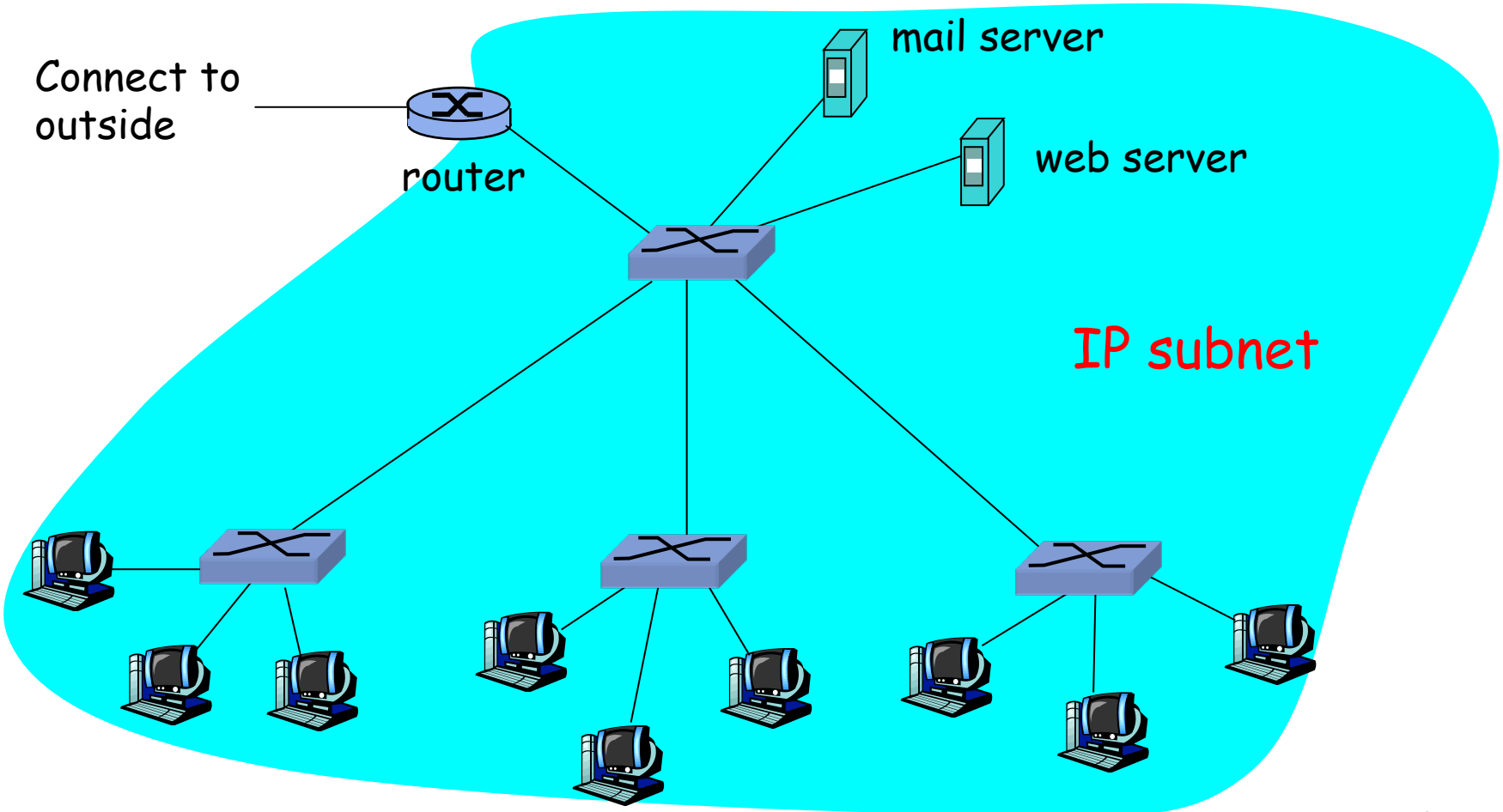
Connecting switch in cascade

- Switches could be connected to eachother

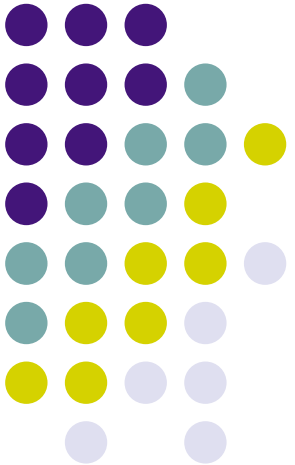


- Switches in cascade uses also self learning mechanism

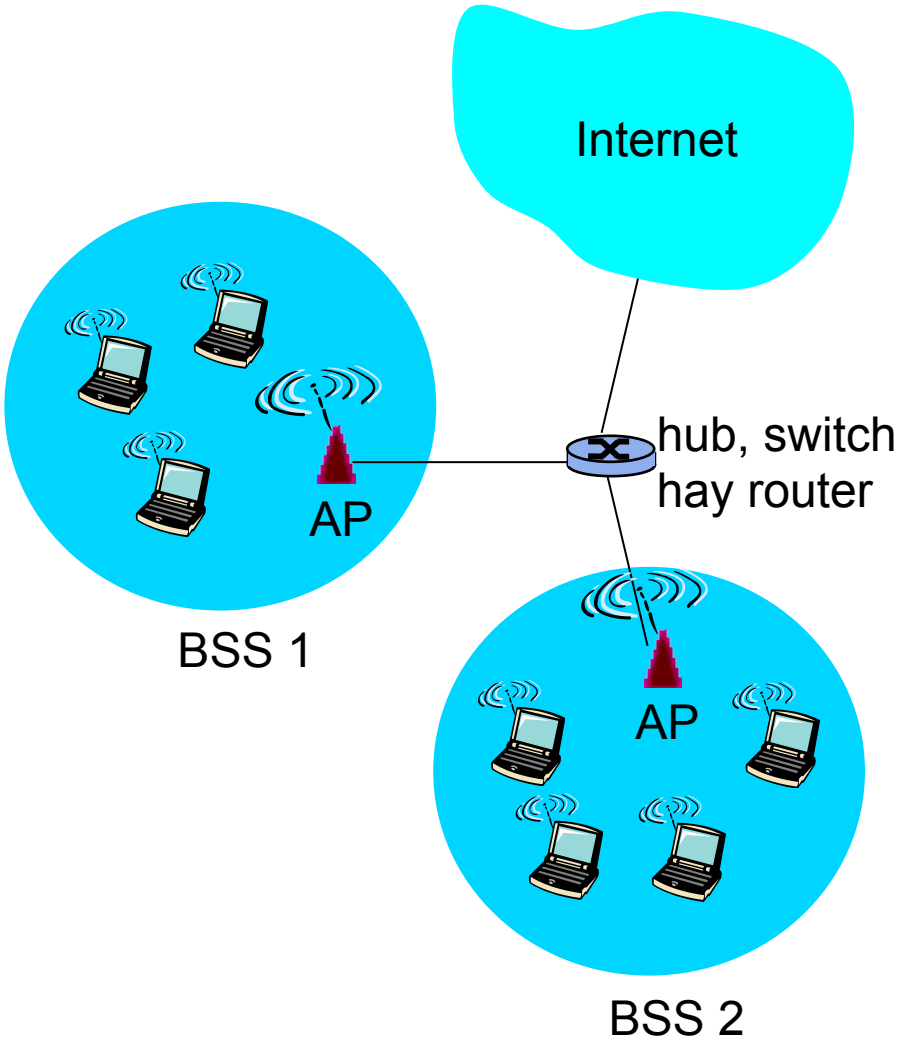
A typical LAN



Wireless LAN



Overview of 802.11 LAN



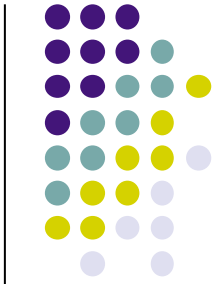
- Include base station = access point) and stations with wireless network interfaces
- Base station mode
  - Basic Service Set (BSS)
    - wireless hosts
    - access point (AP): base station
- Ad hoc mode:
  - Stations pay also the role of AP

Standards

- 802.11b
  - Band 2.4-5 GHz (unlicensed spectrum)
  - Maximum speed 11 Mbps
- 802.11a
  - Band 5-6 GHz
  - Maximum speed 54 Mbps
- 802.11g
  - Band 2.4-5 GHz
  - Maximum speed 54 Mbps
- 802.11n: use multiple antennas (MIMO)
  - Band 2.4-5 GHz
  - Maximum speed 200 Mbps

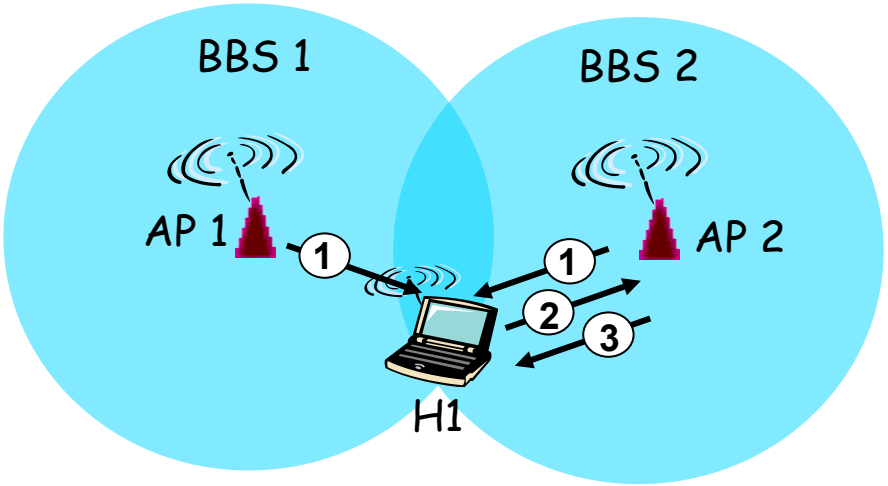
- Employ CSMA/CA for multiple access control
- Working in 2 modes : base-station and ad hoc

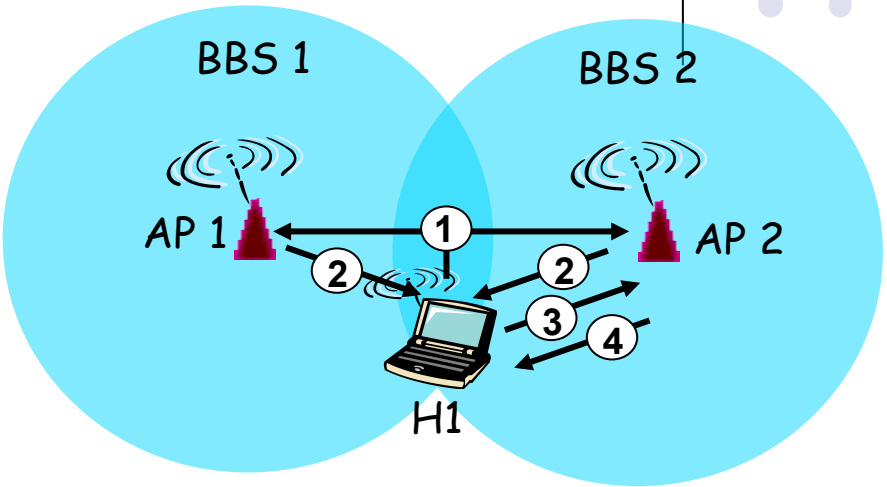
802.11: Chanel and connection



- Band is divided into 14 chanels spaced 5MHz apart. Europe uses 13 channels, America uses 11 channels, Japan uses 14 channels.
  - Admin chooses a working frequency for AP (may leave AP to choose automatically)
- Station: need to connect to an AP
  - Scan channels, listen to initial frames (*beacon frames)* containing the ID (SSID) and MAC address of the AP
  - Choose one AP.

Scanning mechanism: active/passive





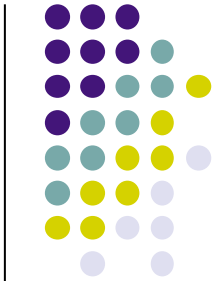
Passive Scanning:

(1) Beacon frames are sent from APs
(2) H1 send a connection request to AP2
(3) AP2 accepts the request

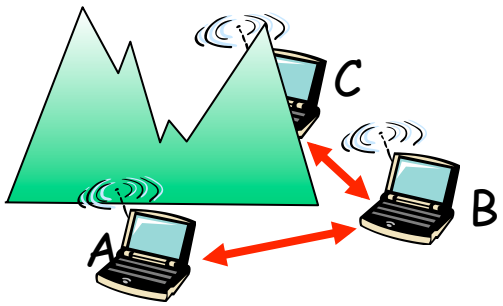
Active Scanning:

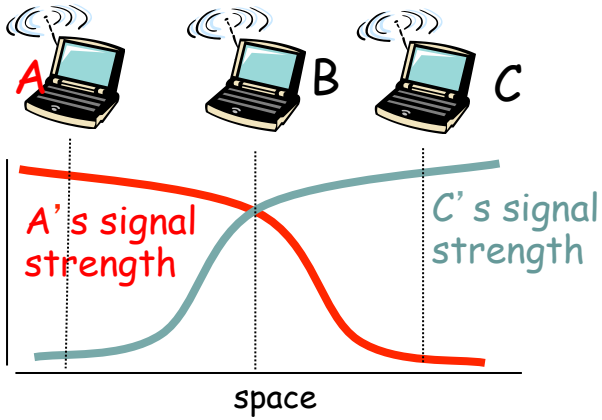
(1) H1 broacast the request to find an AP
(2) APs reply with their information
(3) H1 send a connection request to AP2
(4) AP2 accepts the requests

IEEE 802.11: Multiple access control



- 802.11: CSMA
- 802.11: CA – Collision Avoidance
  - It is difficult to implement Collision detection (CD) in wireless environment.
  - In some cases, it is even impossible to detect the collision : hidden terminal, fading





IEEE 802.11 MAC Protocol: CSMA/CA

Sender

1 If the channel is available during **DIFS** time then

Send the entire frame (no CD)

2 if channel is busy then

Starting random back-off (waiting)

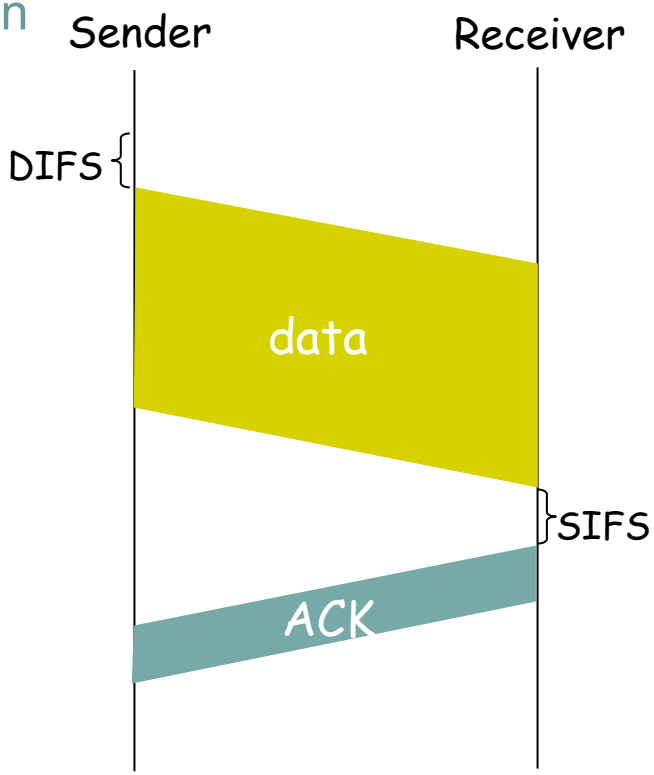
At the end of back-off time, send data

If no ACK is received, double the back-off time and try again.

Receiver

- If receive well a frame then

reply by an ACK after **SIFS**



DIFS: Distributed Inter Frame Space

SIFS: Short Inter Frame Space

Why need ACK?

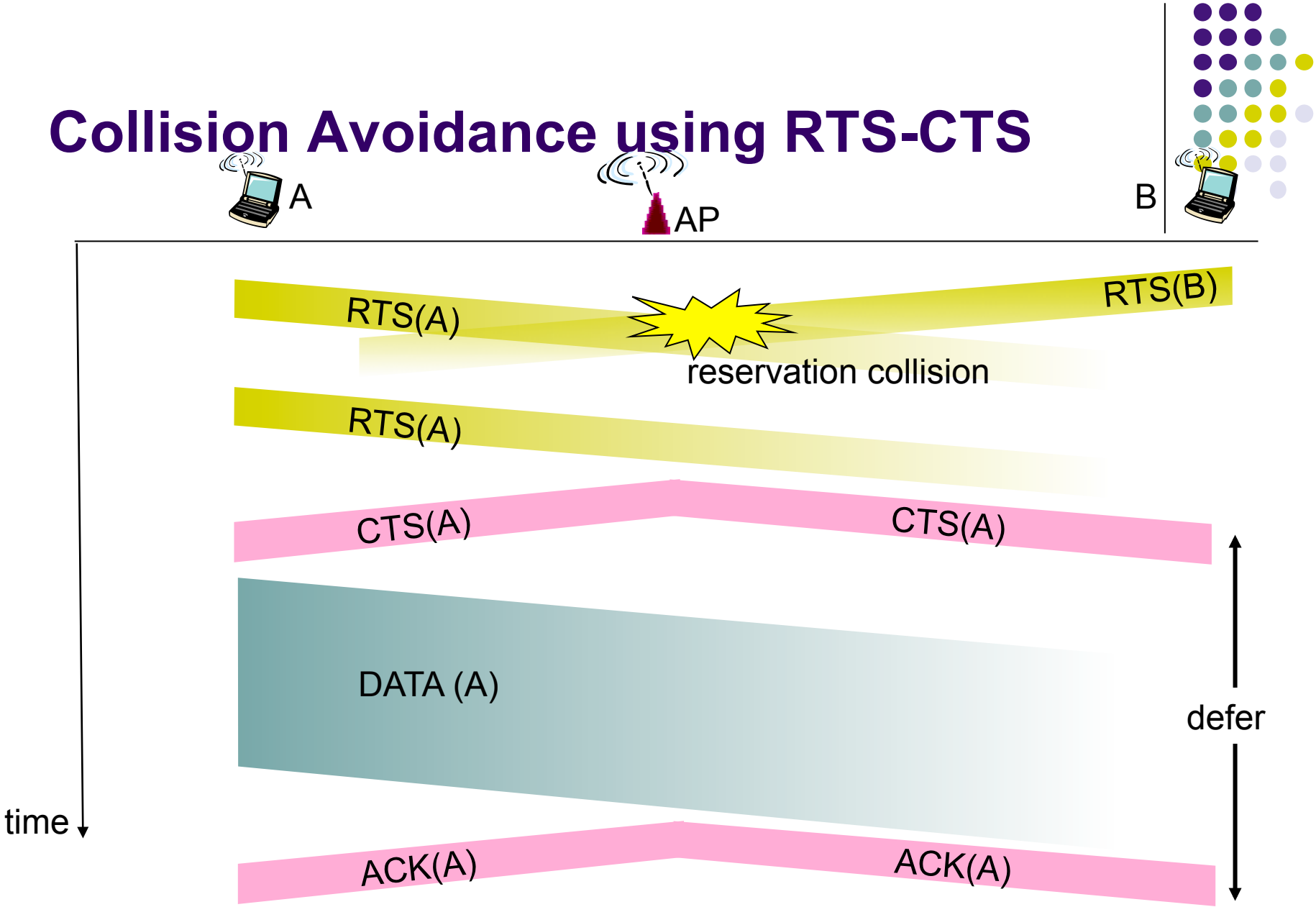
Avoid Collision mechanism

Idea: Sender can reserve channel without random access→ avoid collision for long frame

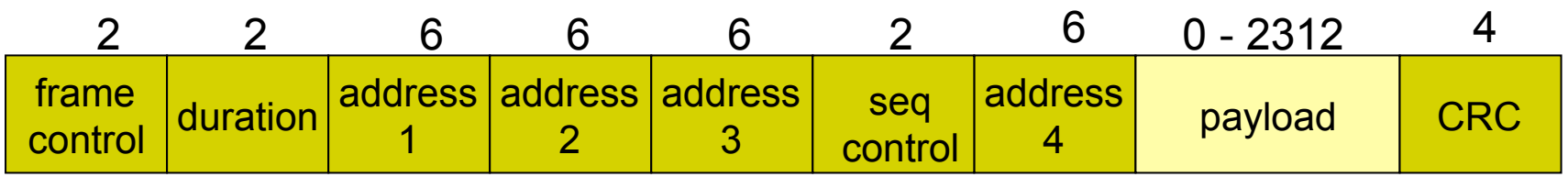
- Sender send frame RTS (request-to-send) to BS using CSMA
  - RTS may meet a collision (with low probability because the frame is short)
- BS broadcast the frame CTS (clear-to-send CTS) to answer
- All stations receive CTS
  - Sender send data frame
  - All other stations has to cancel the intention to send frames.

Avoid collision thanks to the reservation made by small size control frames

Collision Avoidance using RTS-CTS



802.11 frame: Addressing



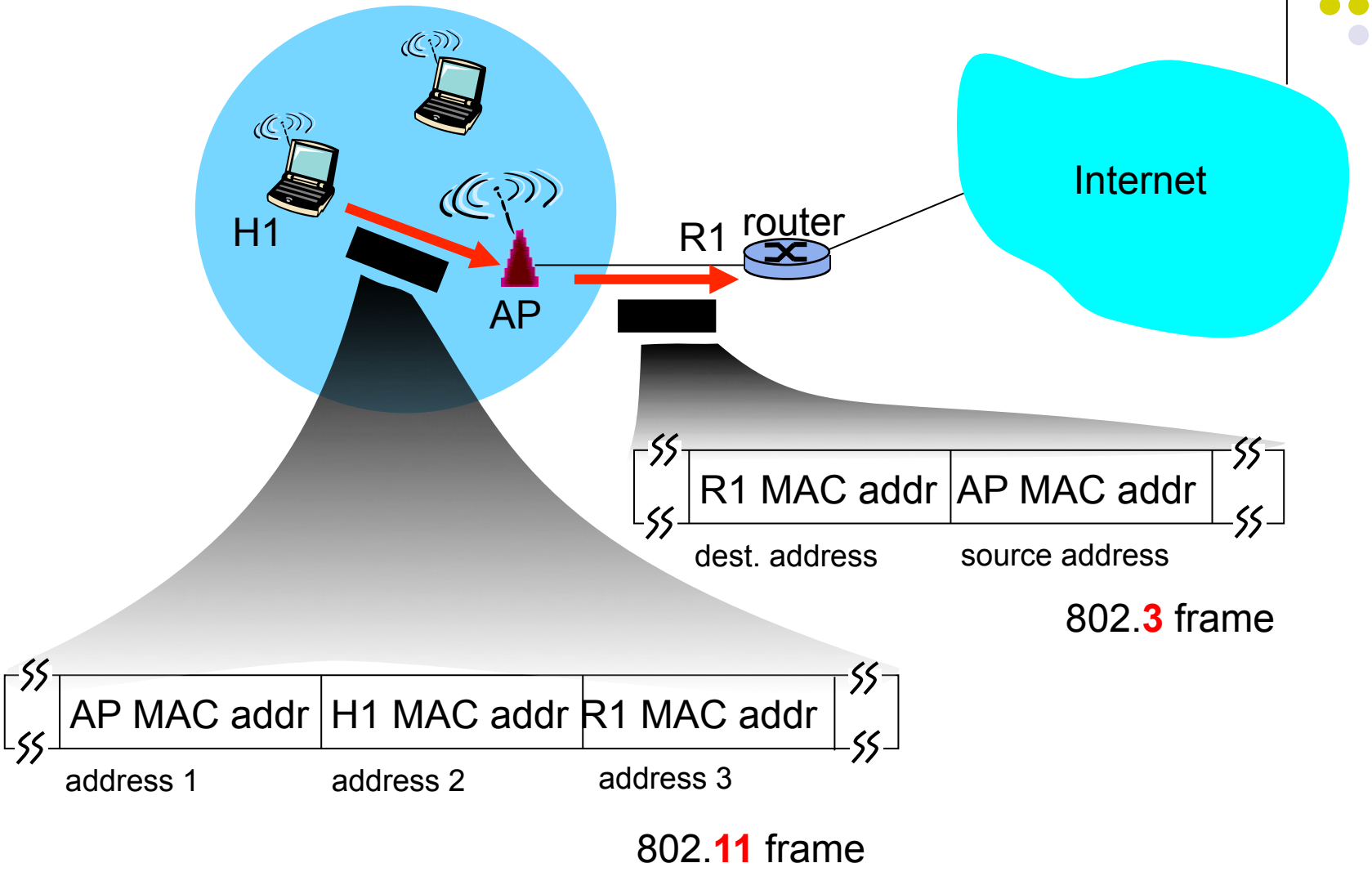
Address 1: address of the destination

Address 2: address of the source

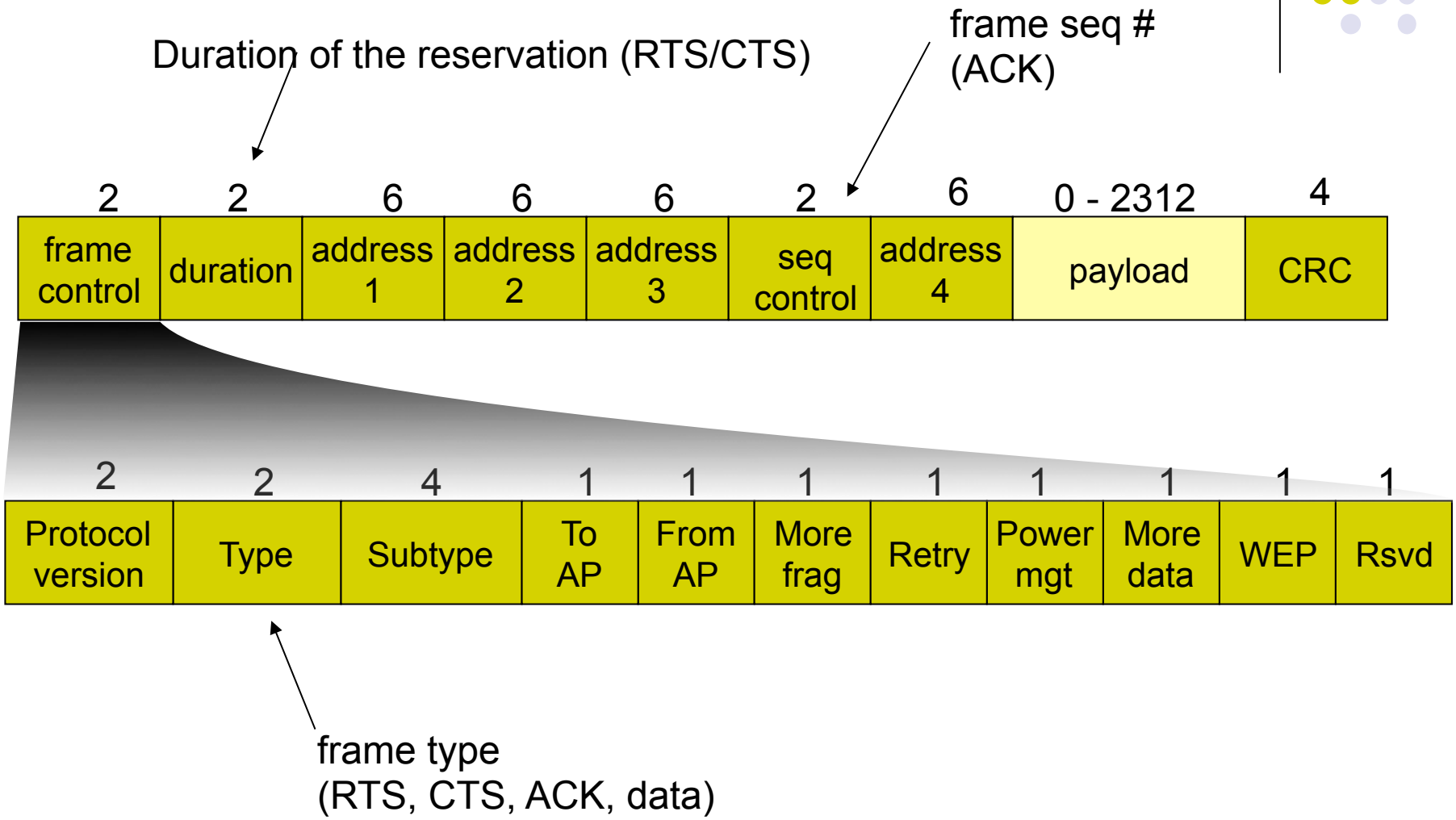
Address 3: MAC address of the router attached to the AP

Address 4: Using in adhoc mode

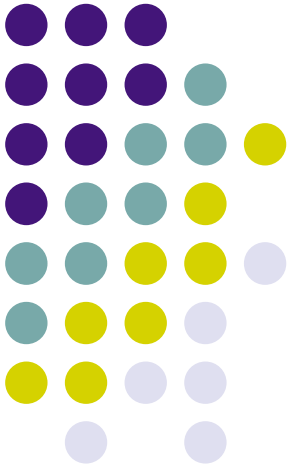
802.11 frame: Addressing



802.11 frame


Duration of the reservation (RTS/CTS)
frame seq # (ACK)
2
2
6
6
6
2
6
0 - 2312
4
frame control
duration
address 1
address 2
address 3
seq control
address 4
payload
CRC
2
2
4
1
1
1
1
1
1
1
1
Protocol version
Type
Subtype
To AP
From AP
More frag
Retry
Power mgt
More data
WEP
Rsvd
frame type (RTS, CTS, ACK, data)

Mạng truy nhập sử dụng cáp quang



Mạng truy nhập

- Mạng truy nhập thu thập dữ liệu từ phía người dùng và cung cấp cho mạng lõi
- Các dịch vụ phổ biến từ phía người dùng
  - Điện thoại
  - Mạng tryền hình cáp
  - Truyền dữ liệu. Ví dụ trên nền đường truyền điện thoại (xDSL) hoặc cáp quang.

Kiến trúc của mạng truy nhập

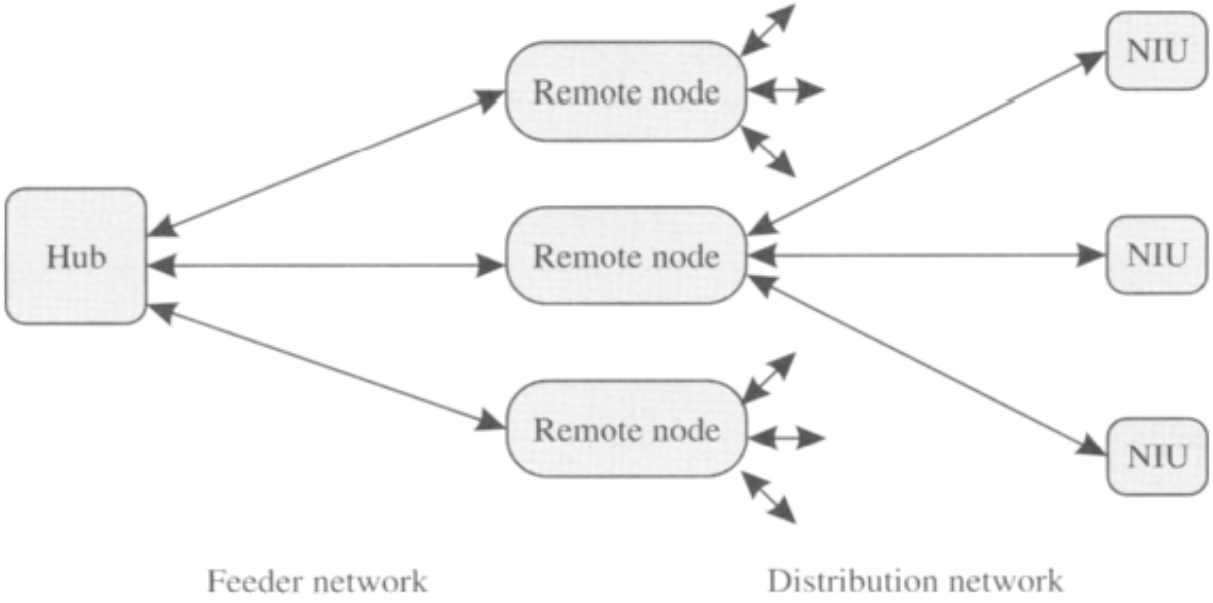
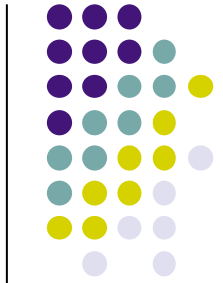


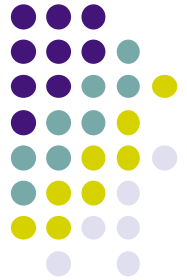
Figure 11.1 Architecture of an access network. It consists of a hub, which is a telephone company central office or cable company head end, remote nodes deployed in the field, and network interface units that serve one or more individual subscribers.

Kiến trúc mạng truy nhập



- Hub
  - Nằm phía nhà cung cấp
- NIU: Network Interface Unit
  - Nằm phía người sử dụng
  - Nối với 1 người dùng hoặc 1 doanh nghiệp
- Remote Node
  - Trong mạng broadcast, RN phân phối dữ liệu từ Hub đến mọi NIU
  - Trong mạng switched, RN nhận dữ liệu từ Hub và phân phối các luồng khác nhau đến các NIU

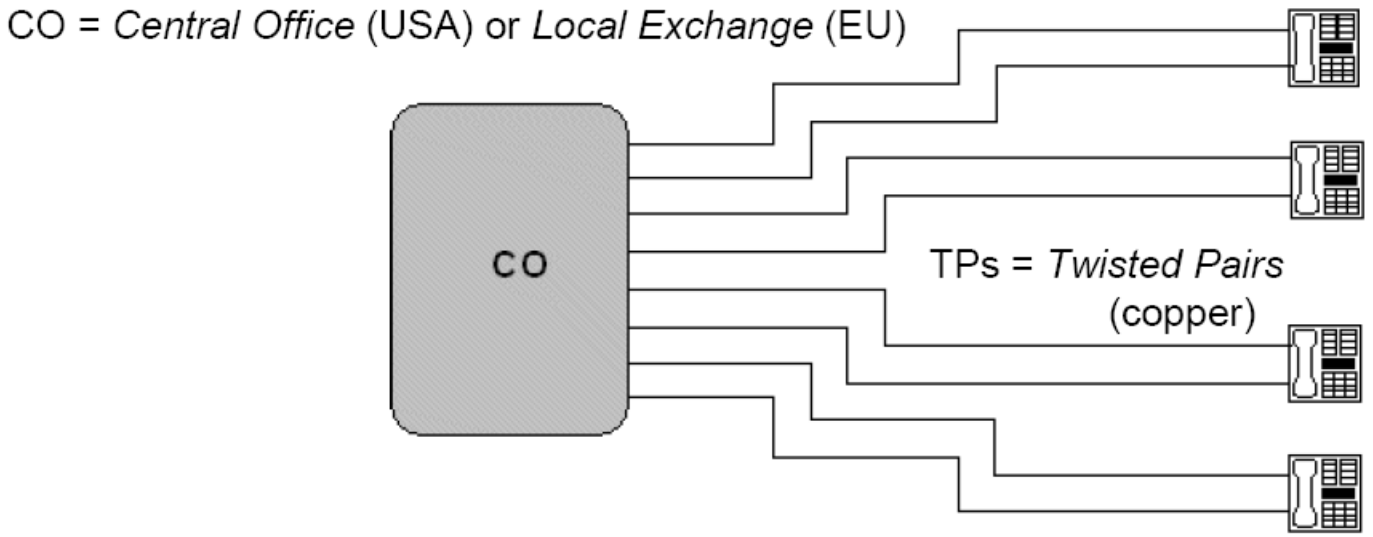
Phân loại mạng truy nhập



- Các loại mạng truy cập phổ biến:
  - Mạng điện thoại
  - Mạng truyền hình cáp
  - Mạng dữ liệu sử dụng cáp quang

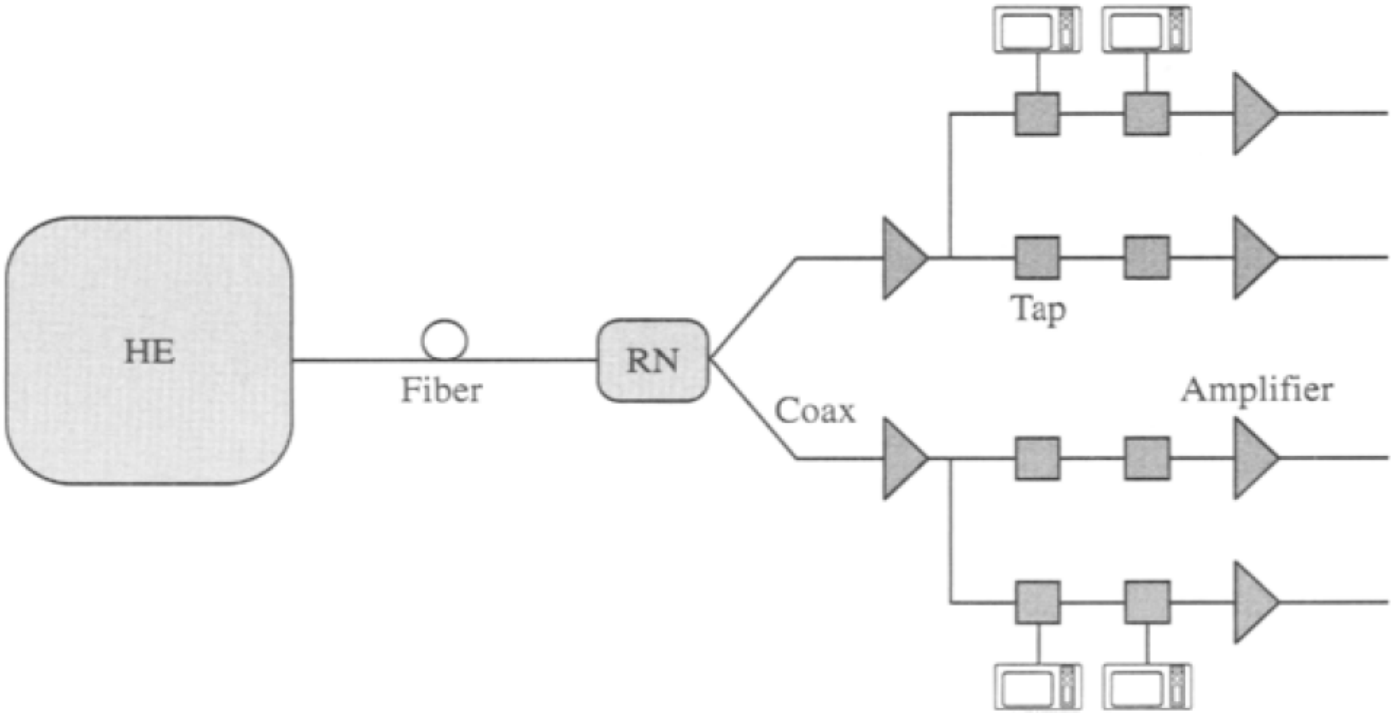
Mạng điện thoại nội bộ

- Sử dụng cáp xoắn



Mạng truyền hình cáp

- Dùng cả cáp đồng trục và cáp quang
  - Hybrid Fiber Coaxial cable: HFC
- HE: headend



Mạng truy nhập quang: FTTx

- Dữ liệu được truyền trên cáp quang trong mạng phân phối (distribution network) cho đến ONU (Optical Network Unit)
  - Mong muốn: Cáp quang đến gần thuê bao nhất
- **FTTCab** (*Fiber To The Cabinet*): Cáp quang kết thúc ở một cabinet, dưới 1km cuối đến thuê bao dùng mạng phân phối cáp đồng.
- **FTTC** (*Fiber To The Curb*) / **FTTB**(*Fiber To The Building*); ONU phục vụ một số thuê bao (8 to 64); từ ONU đến NIU dùng cáp đồng (dưới 100m)
- **FTTH** (*Fiber To The Home*); ONUs thực hiện chức năng của NIUs;

Mạng truy nhập quang: FTTx

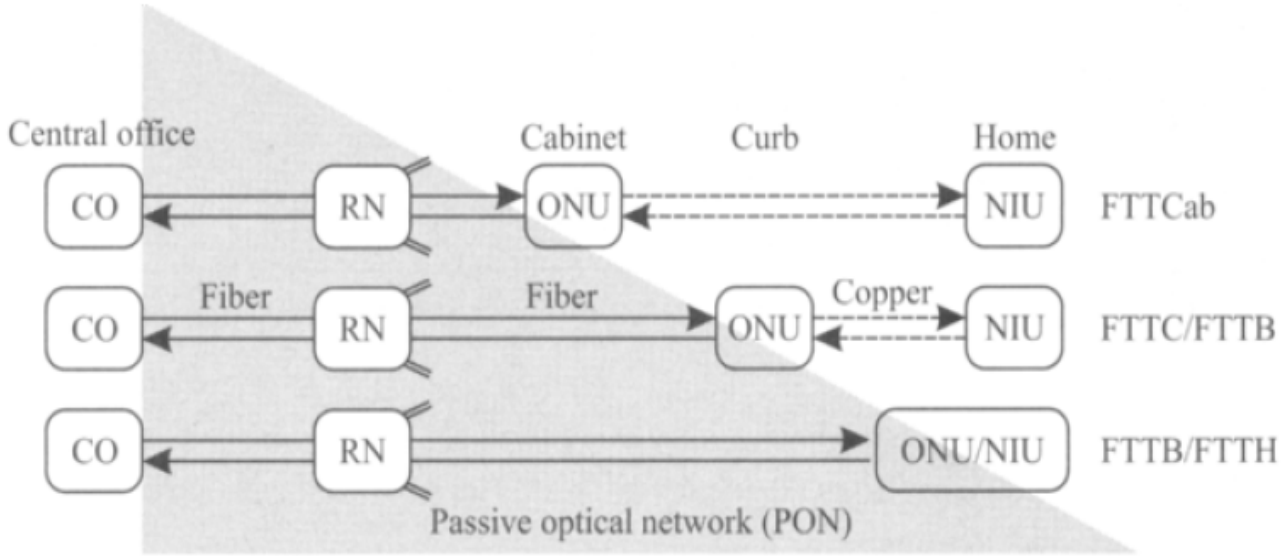
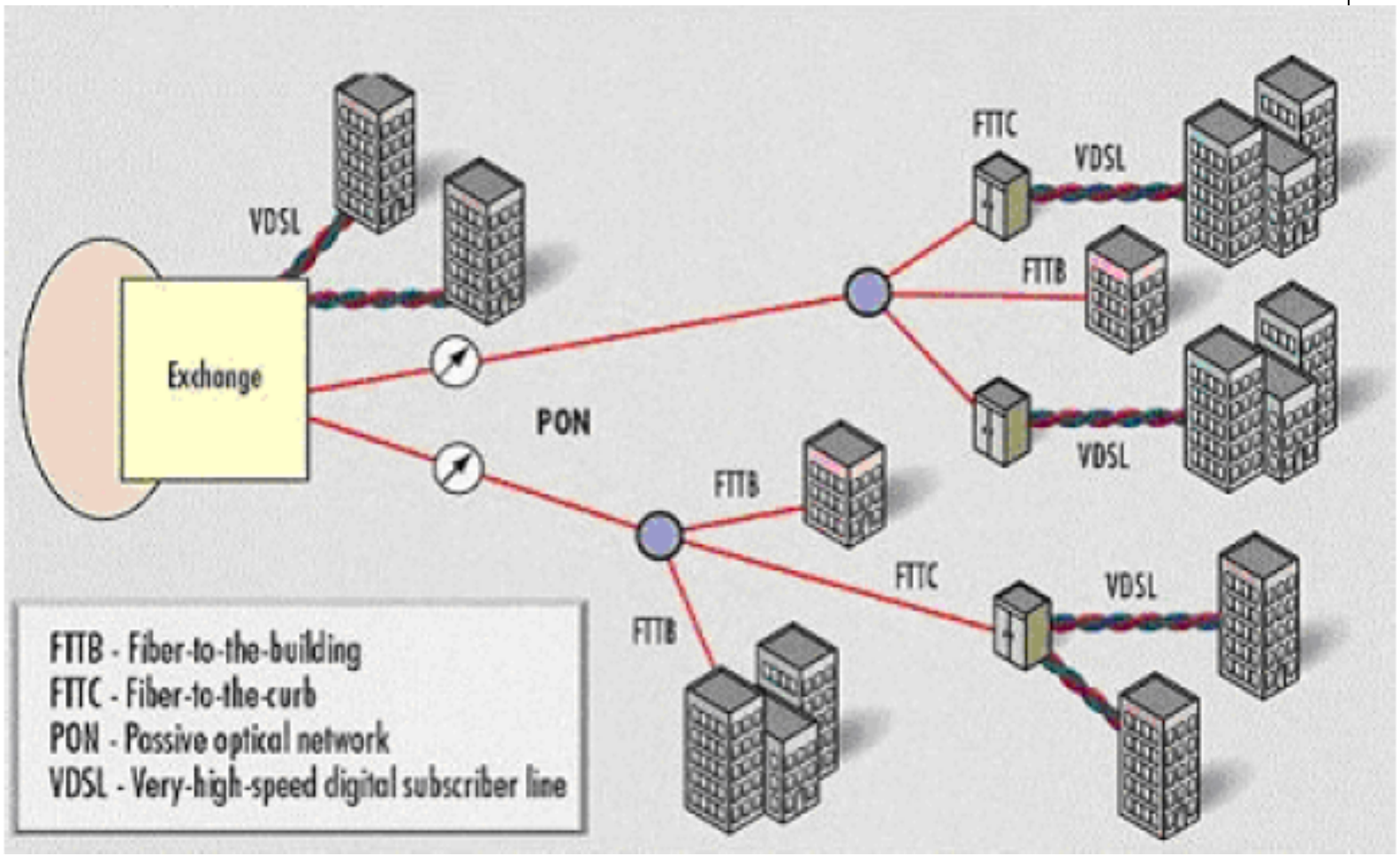


Figure 11.5 Different types of fiber access networks, based on how close the fiber gets to the end user. In many cases, the remote node may be located at the central office itself. The ONUs terminate the fiber signal, and the links between the ONUs and the NIUs are copper based.

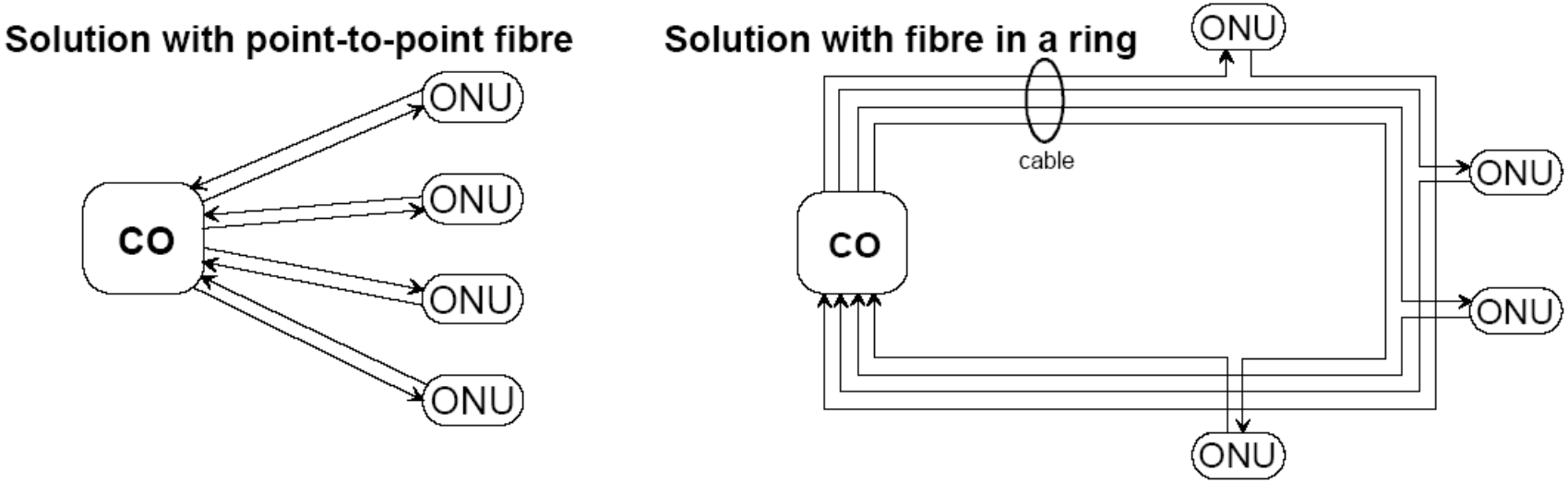
- PON: Passive Optical Network: giữa CO và ONU
- ONU: có thể là modem quang.

Mạng truy cập FTTx



Kiến trúc AF (all fiber)

- Một cặp cáp dành riêng nối CO trực tiếp với mỗi ONU
- Giá thành tỉ lệ với số ONU và chi phí bảo trì cáp
- Sử dụng trong phạm vi nhỏ như doanh nghiệp

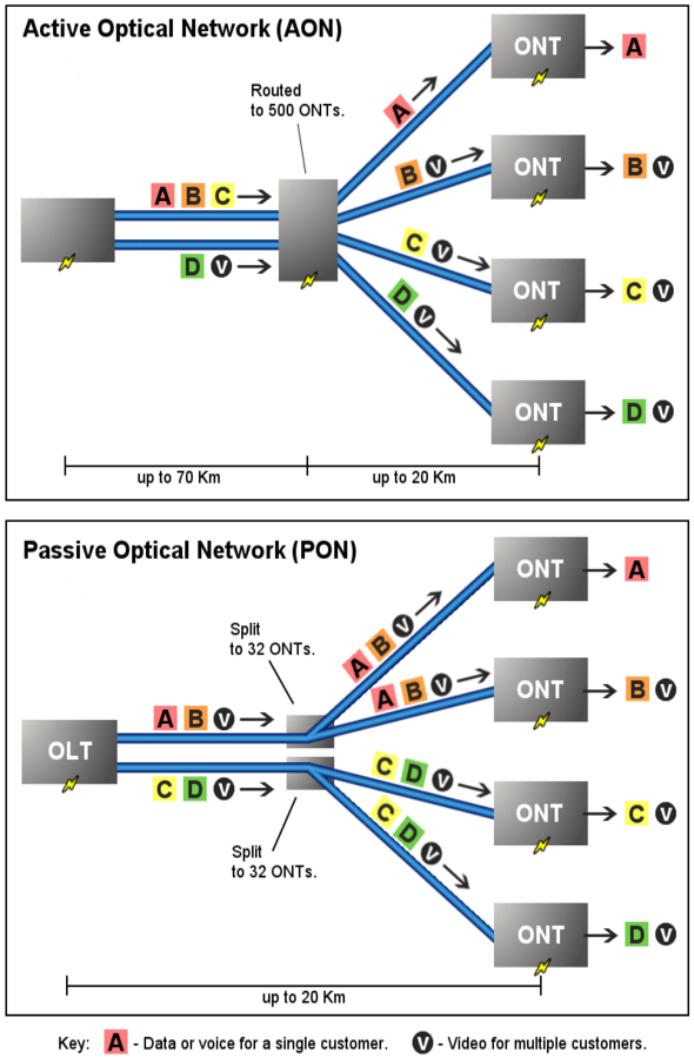


AON vs. PON

Remote Note (Distribution nodes) chia dữ liệu về các đích.

AON: Active Optical Network
- là mạng sử dụng công nghệ chủ động (Remote Node tiêu thụ điện)
- Remote node phân tích và định tuyến riêng các gói tin theo địa chỉ đích
- Khoảng chạy cáp có thể dài đến 100km

PON: PassIve Optical Network
- Là mạng sử dụng công nghệ thụ động, (Remote Node không tiêu thụ điện)
- Remote node (Splitter) không phân tích mà chỉ lặp tín hiệu trên tất cả các cổng ra
- Upstream: MUX từ các nguồn khác nhau bằng TDM (TDM PON) hoặc WDM (WDM PON)
- Khoảng chạy cáp giới hạn 20km



EPON: Ethernet PON

- EPON: PON vận chuyển dữ liệu là các frame Ethernet
  - Chiều xuống (down stream)
    - Quảng bá dữ liệu chung

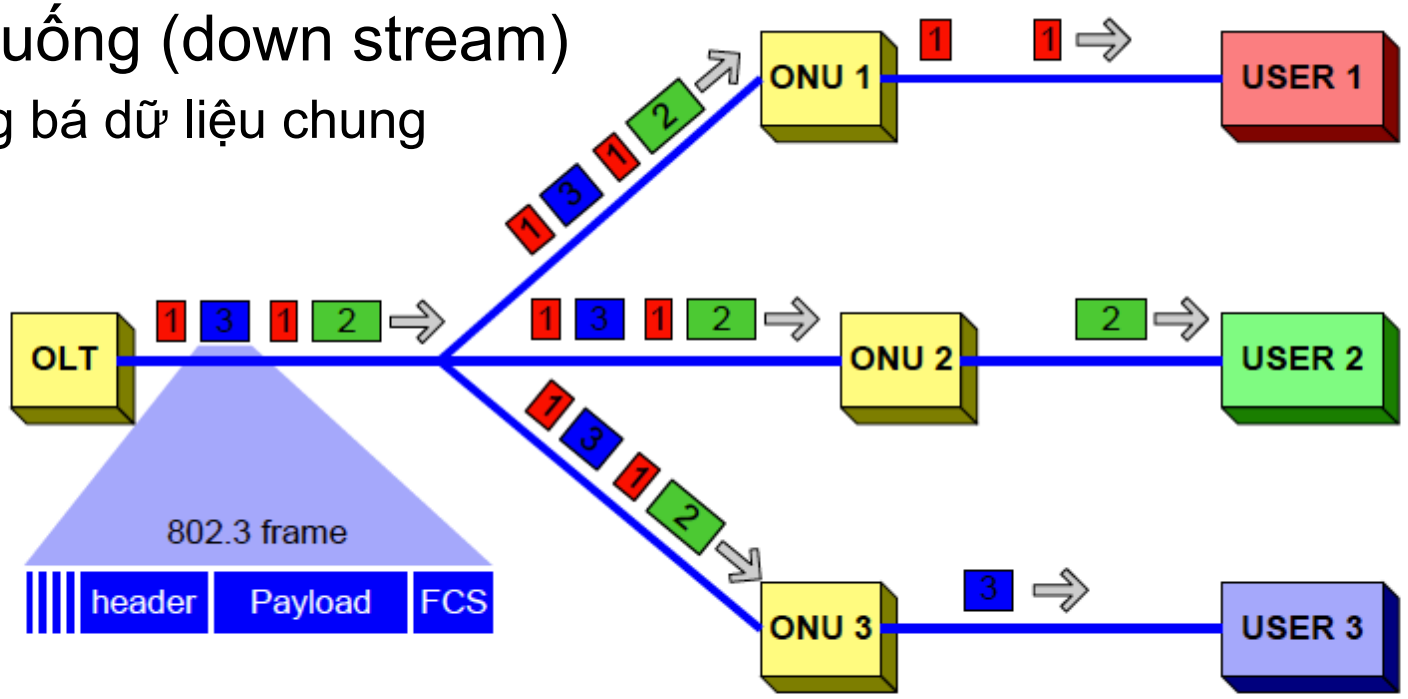


Figure 8-6. Downstream traffic in EPON.

EPON

- Chiều lên (Upstream): dồn kênh theo thời gian (TDM) trực tiếp các gói Ethernet của người dùng từ các nguồn khác nhau vào kết nối chung OLT-RN
- EPON thuộc loại TDM PON

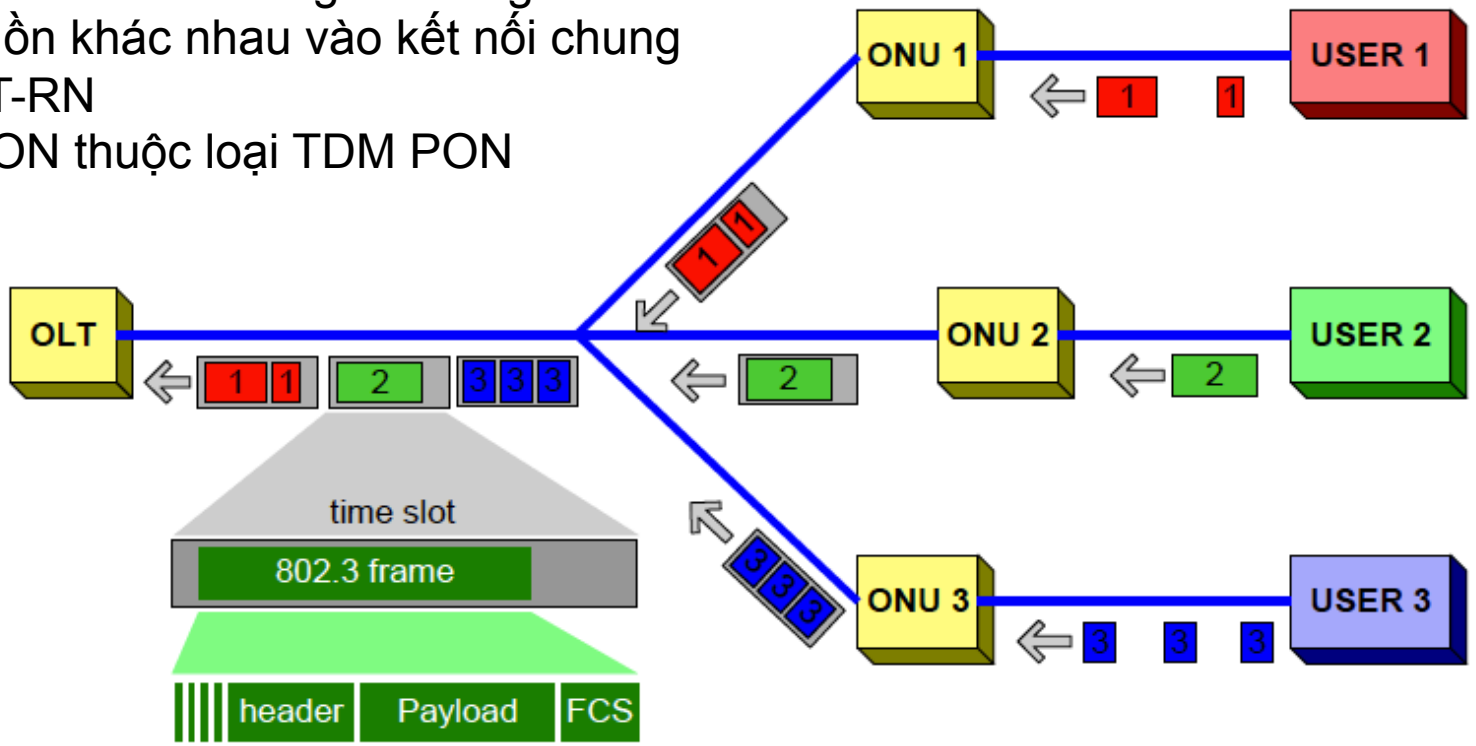
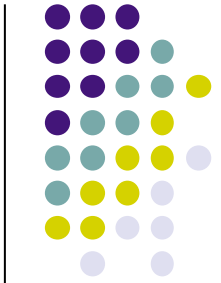


Figure 8-7. Upstream traffic in EPON.

GPON: Gigabit Capable PON



- GPON có thể dùng để tải nhiều dữ liệu khác nhau: Ethernet, ATM, voice …
- Dữ liệu từ OLT đến người dùng chia sẻ kênh chung giữa OLT và RN
  - Downstream broadcast
  - Upstream TDM
  - Các gói được đóng trong khung dữ liệu GPON có trường định danh người nhận (chiều downstream), người gửi (chiều upstream)

WPON (WDM PON)

- Được phát triển bởi các công ty, chưa chuẩn hóa
- Mỗi ONT sử dụng một bước sóng để truyền dữ liệu
- Remote note là AWG thiết bị có khả năng tách ghép các bước sóng, thực hiện MUX/DEMUX theo bước sóng chiều xuống và lên.
- Thuộc loại Wavelength routing PON