Chapter4 Medium Access Control Sublayer(2)

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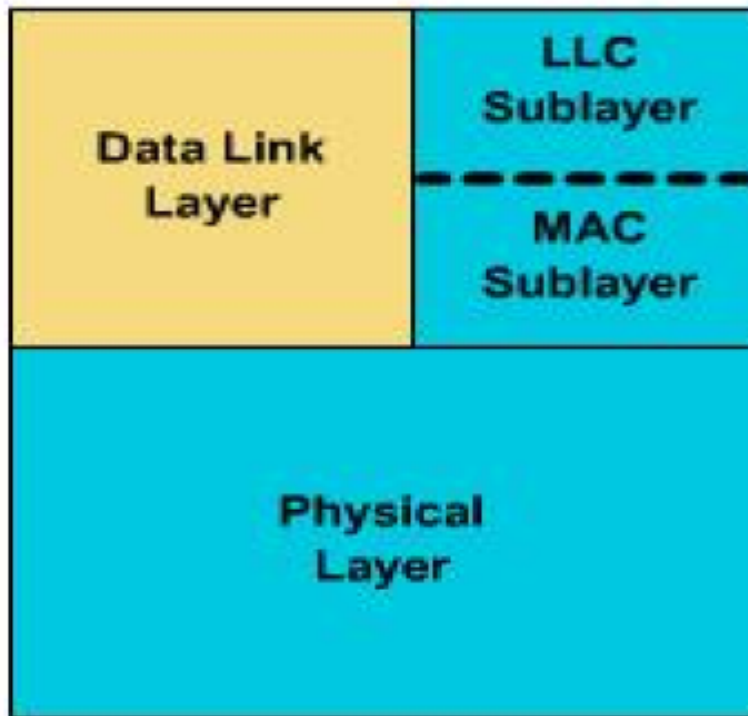
School of Computer Science & Engineering ,SCUT

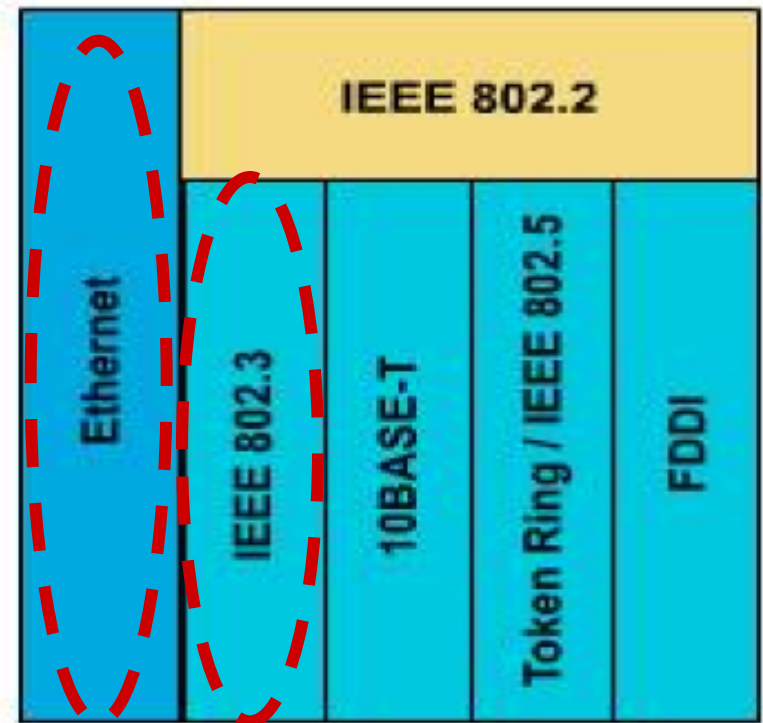**Communication & Computer Network key-Lab of GD**

Contents of this lecture

- ☐ **Learn** IEEE802 standard

- ☐ **Master Ethernet**/IEEE802.3 principle

- ☐ **Master Ethernet**/IEEE802.3 frame format

- ☐ **Learn characteristics of Ethernet**

IEEE802.3/Ethernet & OSI RM

IEEE Ethernet naming rule

☐ 10Base2（IEEE 802.3a）

■ –10：**baseband（unit: Mbps）**

■ –Base：**baseband transmission (基带传输)**

■ –2（或5）：**support segment （100米为单位，四舍五入）**

☐ 10Base-TX（IEEE 802.3X）

■ –T：**copper UTP**

■ –F：**fiber**

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Ethernet cabling

Name	Cable	Max. seg.	Nodes/seg.	Advantages
10Base5	Thick coax	500 m	100	Original cable; now obsolete
10Base2	Thin coax	185 m	30	No hub needed
10Base-T	Twisted pair	100 m	1024	Cheapest system
10Base-F	Fiber optics	2000 m	1024	Best between buildings

Controller

Transceiver cable

Vampire tap

Core

Transceiver

(a)

Transceiver + controller

Connector

(b)
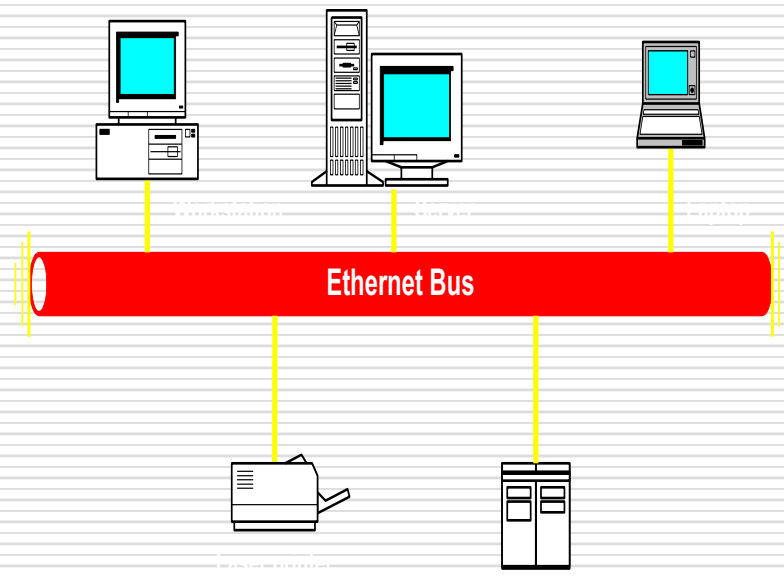
Controller

Twisted pair

Hub

(c)
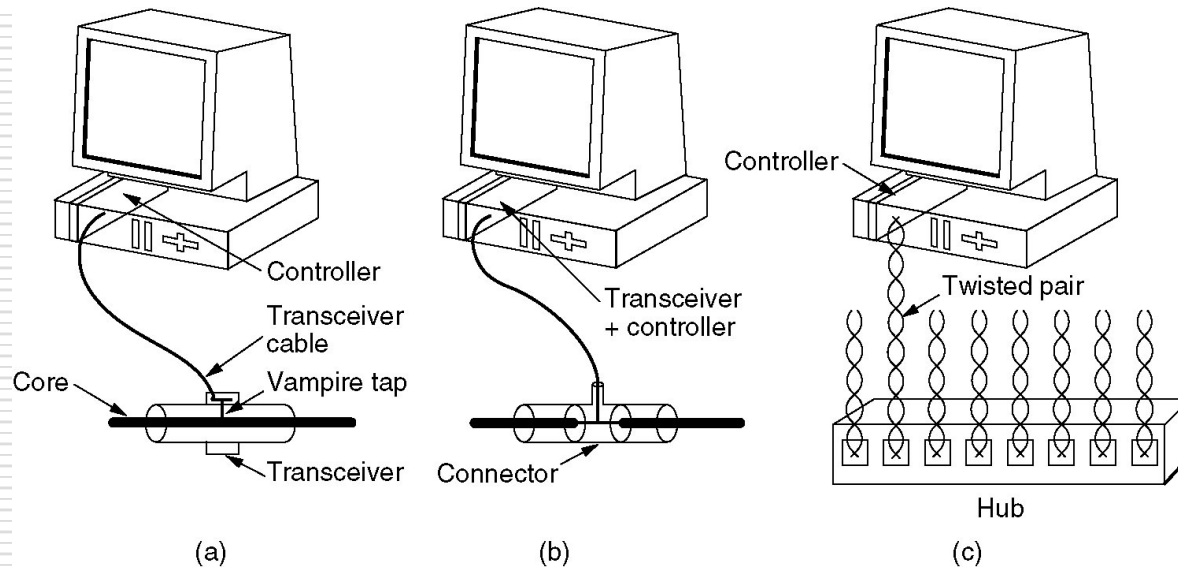
Detecting problem in thick or thin coax

☐ **Detecting cable breaks, excessive length (超长), bad taps， or loose connector can be a major problem with thick coax or thin coax.**

☐ **time domain reflectometry （时间域反射计）**

  ■ **Send pusle**

  ■ **Timing the interval between sending and receiving the echo**

  ■ **Localize the origin of the echo**

Topology of 10Base-T
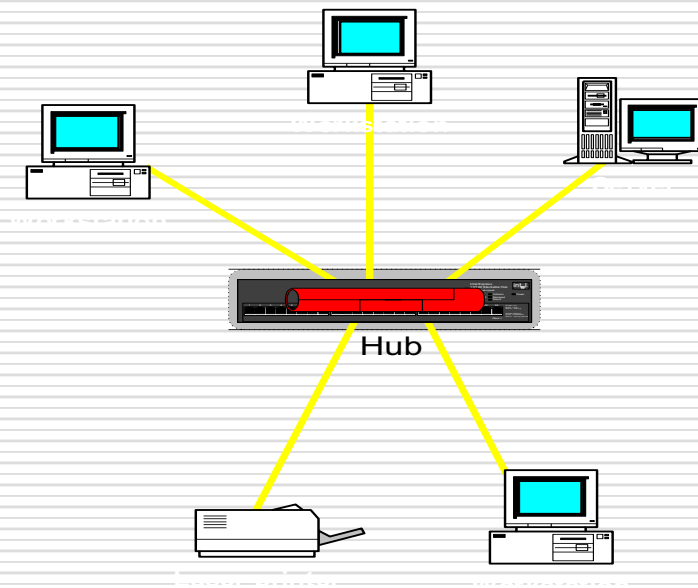
Physical topology   **Logical topology**

- ☐ **Physical topology is star**
- ☐ **Logical topology is bus（compete the bus）**

Characteristics of 10Base-T

☐ **Advantage**

- ■ **Installation-cost is lower than coax**

- ■ **Plug and play, constructing network is flexible**

- ■ **Star topology, easy to separate trouble**

- ■ **open**

☐ **Problem**

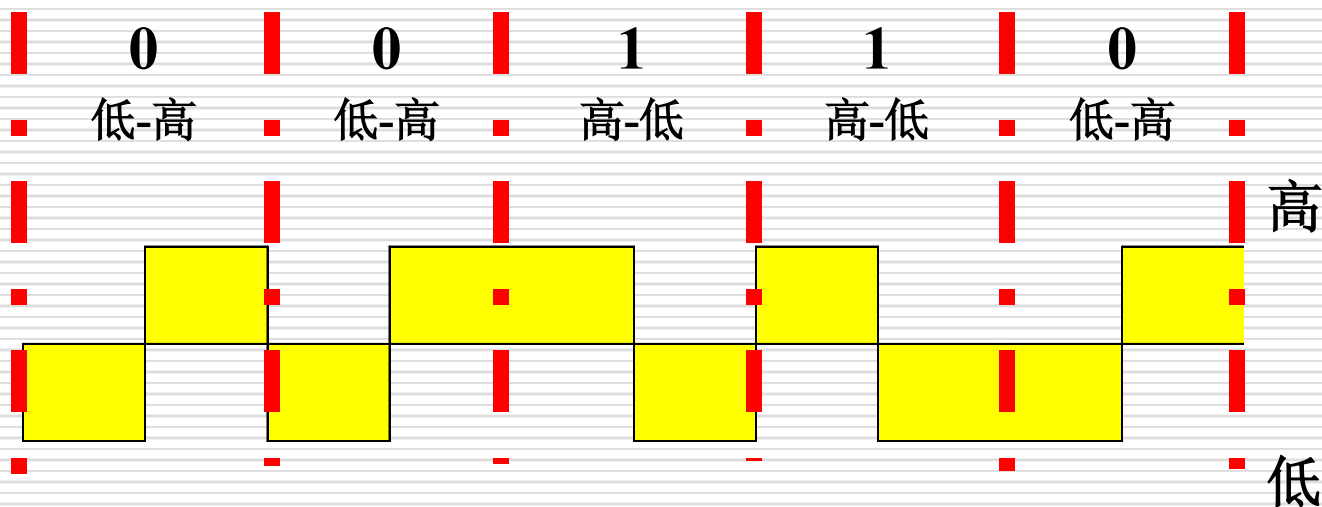- ■ **Many users share a 10M bus (channel)**

Ethernet encoding

- **None of the Ethernet versions use straight binary encoding with 0 volts for a 0 bit and 5 volts for a 1 bit since it leads to ambiguities: it cannot tell the difference between an idle sender (0 volts) and a 0 bit (0 volts).**

- **We can use -1 volts for a 0 and +1 volts for a 1, but this also runs into trouble if the receiver samples the line at a slightly different rate than the sender is sending the data.**

- **What is needed is a way for receivers to unambiguously determine the start, end, or middle of each bit without reference to an external clock.**

Ethernet encoding(cont'd)

☐ **Do not use binary encoding**

☐ **All Ethernet do use Manchester encoding**

■ **Each bit period is divided into two equal intervals.**

■ **A binary 1 bit is sent by having the voltage set high during the first interval and low in the second one.**

■ **A binary 0 is just the reverse: first low and then high.**

■ **Every bit period has a transition in the middle, making it easy for the receiver to synchronize with the sender.**

■ **But requires twice as much bandwidth as straight binary encoding.**

☐ **Differentia Manchester encoding**

■ **802.5 does use**

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Manchester encoding

0	0	1	1	0
低-高	低-高	高-低	高-低	低-高

高

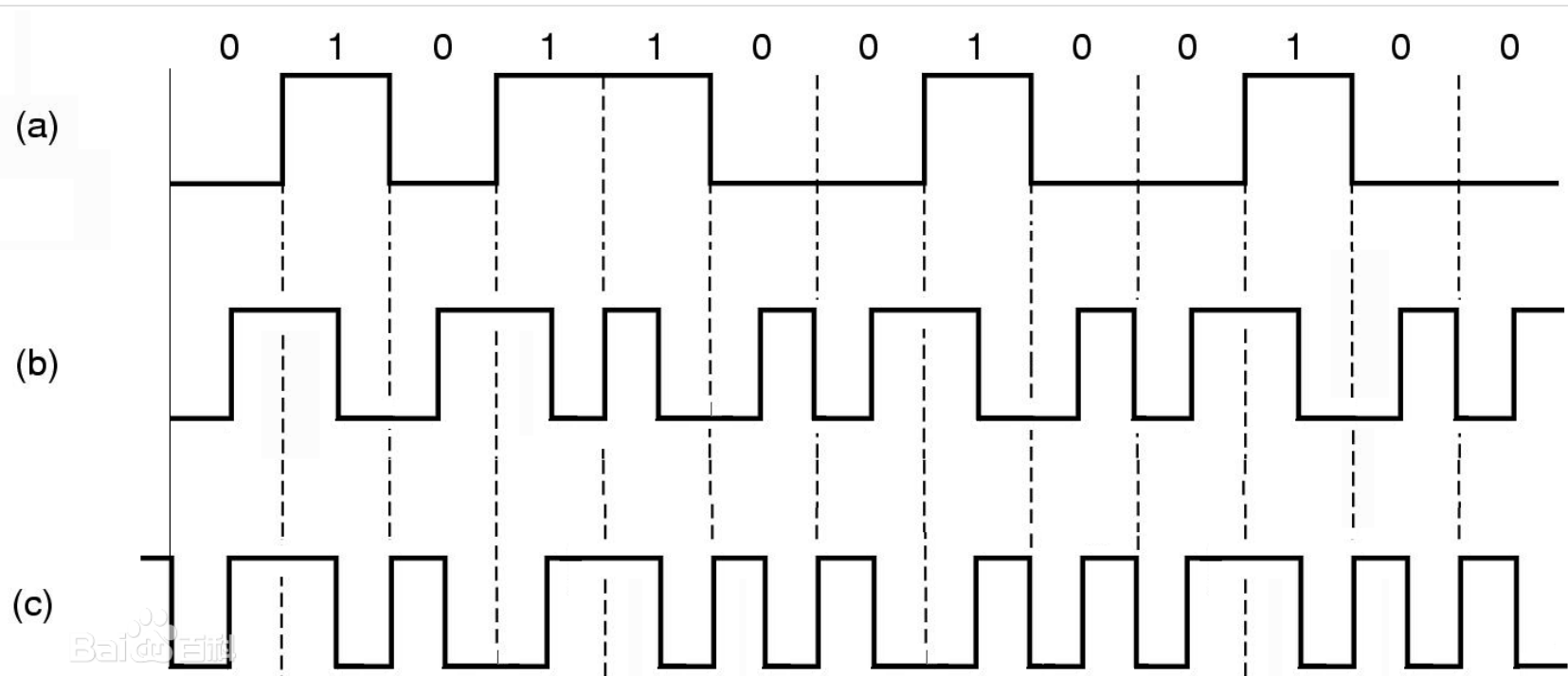低

- ■ +0.85 volt: high signal
- ■ -0.85 volt: low signal
- ■ 0 volt: DC value
- ☐ Bit rate: b = 10 Mbps
- ☐ Baud: B = 20 MHz（信号的变化频率）

Manchester encoding

IEEE 802 standard (chapter 1)

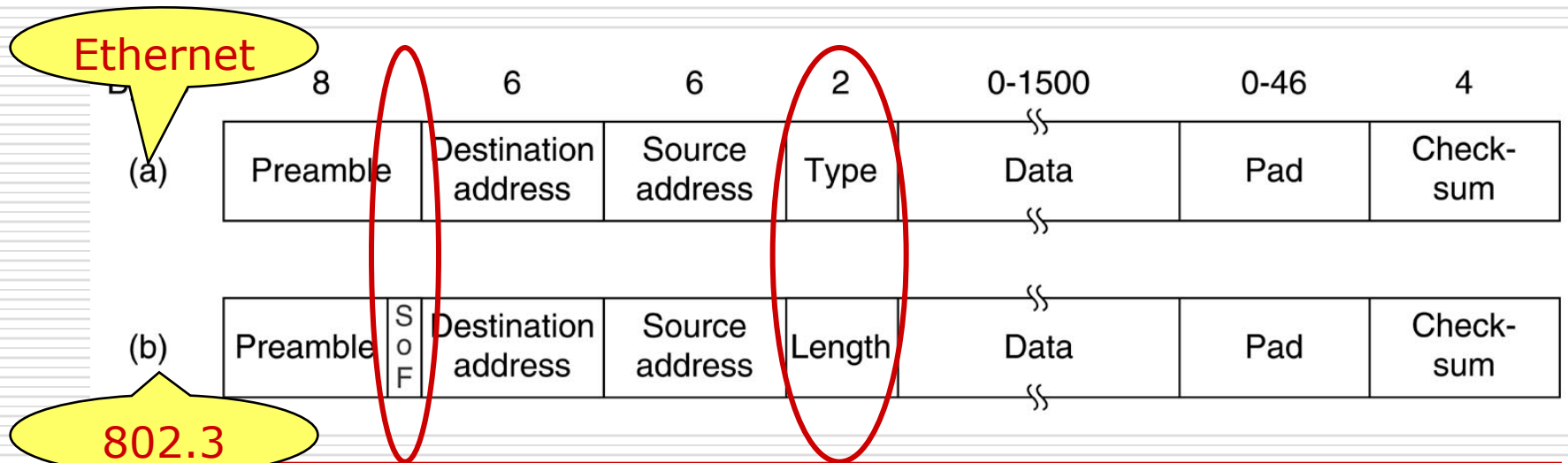| Number	Topic
802.1	Overview and architecture of LANs
802.2 ↓	Logical link control
802.3 *	Ethernet
802.4 ↓	Token bus (was briefly used in manufacturing plants)
802.5	Token ring (IBM's entry into the LAN world)
802.6 ↓	Dual queue dual bus (early metropolitan area network)
802.7 ↓	Technical advisory group on broadband technologies
802.8 †	Technical advisory group on fiber optic technologies
802.9 ↓	Isochronous LANs (for real-time applications)
802.10 ↓	Virtual LANs and security
802.11 *	Wireless LANs
802.12 ↓	Demand priority (Hewlett-Packard's AnyLAN)
802.13	Unlucky number. Nobody wanted it
802.14 ↓	Cable modems (defunct: an industry consortium got there first)
802.15 *	Personal area networks (Bluetooth)
802.16 *	Broadband wireless
802.17	Resilient packet ring

Ethernet MAC sublayer protocol

☐ **There are two different MAC sublayer protocols:**

- **DIX (DEC, Intel, Xerox)**

  - ☐ **was introduced first**

  - ☐ **was most widely used**

- **IEEE 802.3**

  - ☐ **was introduced later**

  - ☐ **was not so widely used (due to the de facto DIX standard and abundance of available hardware)**

- **They are close enough that it makes little difference**

事实标准

Comparison of IEEE 802.3 and Ethernet frame

☐ **(a)** **Preamble** **of 8 bytes, each with the bit pattern 10101010. For synchronization between the sender and the receiver.**

☐ **(b)** **Preamble** **of 7 bytes and a** **Start of frame** **(SOF) byte containing 10101011 to denote the start of the frame, and it is useful for compatibility with 802.4 and 802.5.**

Ethernet

	8		6	6	2	0-1500	0-46	4
(a)	Preamble		Destination address	Source address	Type	Data	Pad	Check-sum
(b)	Preamble	S O F	Destination address	Source address	Length	Data	Pad	Check-sum

802.3

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Destination/Source address

- **10-Mbps baseband standard use only the 6-byte addresses.**

  - **Ordinary address**: the high-order bit value is 0.

  - **Multicast address**: the high-order bit value is 1.

  - **Broadcast address**: all bits have a value of 1.

  - **Local address**: assigned by local network administrator, distinguished by the second high-order bit (46) value 0.

    - For bit 47, 0 means single station address and 1 means group stations address

  - **Global address** (about 7×10^{13}): assigned by IEEE to ensure world wide uniqueness, distinguished by the second high-order bit (46) value 1.

MAC address (physical address)

- **Ethernet MAC Address = Manufacture ID (OUI, Organizationally Unique Identifier) + NIC ID=24bit + 24bit**

- **First 24 bits：**

     Cisco   00-00-0c

     Novell   00-00-1B、00-00-D8

     3Com   00-20-AF、00-60-8C

     IBM   08-00-5A

- **An example**

   00-60-8C-01-28-12

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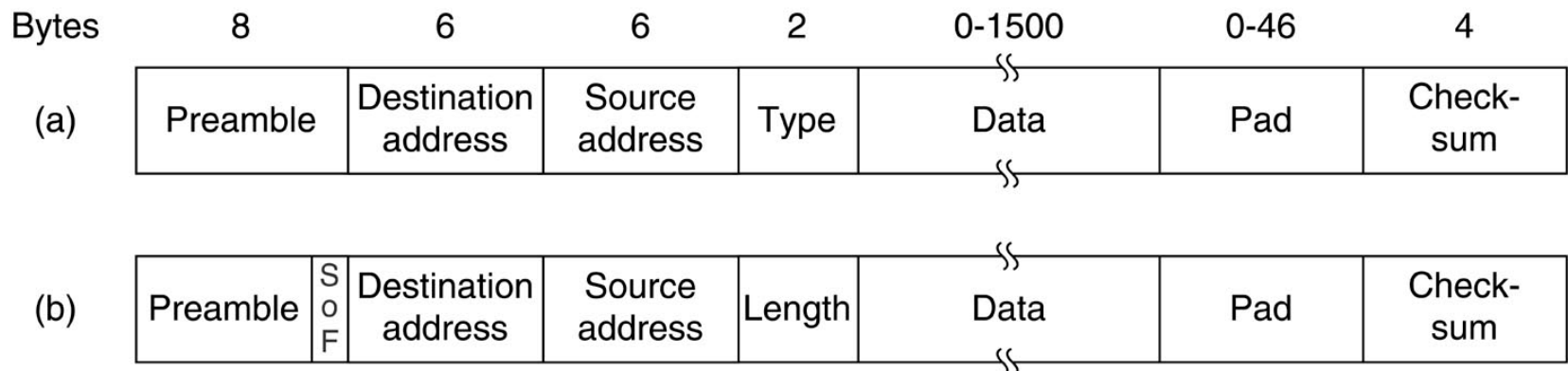
The Type/Length Field

☐ **In DIX, the type field specifies which network-layer process to give the frame to (for supporting multi-protocols at network-layer).**

  ■ **But DIX is the format commonly used, and the field is often used as a type field.**

☐ **In IEEE 802.3, the length field is the length of the data field.**

☐ **How to distinguish this field?**

  ■ **Any number in the field less than or equal to 1536(0x600) can be interpreted as Length, and any number greater than 1536 can be interpreted as Type.**

```
⊞ Frame 8 (74 bytes on wire, 74 bytes captured)
⊟ Ethernet II, Src: Cisco_67:8c:00 (00:12:44:67:8c:00), Dst: LgElectr_0f:34:6b (00:e0:91:0f:34:6b)
    Destination: LgElectr_0f:34:6b (00:e0:91:0f:34:6b)
    Source: Cisco_67:8c:00 (00:12:44:67:8c:00)
    Type: IP (0x0800)
⊞ Internet Protocol, Src: 202.38.192.101 (202.38.192.101), Dst: 202.112.18.89 (202.112.18.89)
⊞ Transmission Control Protocol, Src Port: 44868 (44868), Dst Port: 3000 (3000), Seq: 0, Ack: 0, Len: 0
```

Data field

- ☐ **Data field: <= 1500 bytes.**

- ☐ **Ethernet requires that valid frames must be at least 64 bytes long.**

  - ■ **Keeping a minimum frame length will result in the sender being able to detect if a collision has occurred by forcing the transmission to take more than 2τ in time.**

  - ■ **where round trip time ~= 50 μsec (the line rate is 10Mbps and the maximum distance is 5km)**

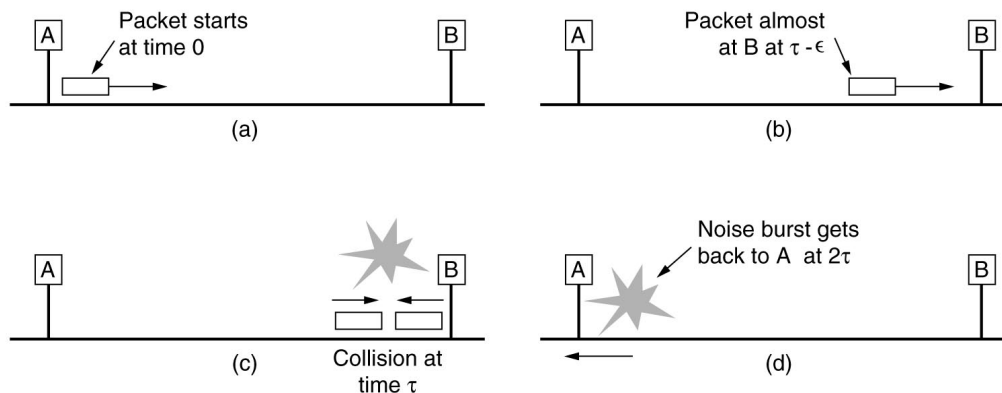- ☐ **If the data portion of a frame is less than 36 bytes,**

Bytes	8	6	6	2	0-1500	0-46	4
(a)	Preamble	Destination address	Source address	Type	Data	Pad	Check-sum

(b)	Preamble	S O F	Destination address	Source address	Length	Data	Pad	Check-sum

Why length$\geq$ 64 Byte?

- **CSMA/CD require**

  - **Sending time the frame need $\geq 2\tau$**

- **Ethernet（802.3）， 10Mbps LAN**

  - **Time slot：2τ = 51.2μs**

  - **The shortest frame：10Mbps$\times$ 2τ/8 = 64 Byte**

    - 或者：（51200/100ns）/8=64Byte

(a) Packet starts at time 0

(b) Packet almost at B at $\tau - \epsilon$

(c) Collision at time τ

(d) Noise burst gets back to A at 2τ

CSMA/CD

1. Host wants to transmit
2. Is carrier sensed?
3. Assemble frame
4. Start transmitting
5. Is a collision detected?
6. Keep transmitting
7. Is the transmission done?
8. Transmission completed
9. Broadcast jam signal
10. attempts =
    attempts + 1
11. attempts >
    too many?
12. Too many collisions;
    abort transmission
13. Algorithm calculates backoff
14. Wait for t seconds
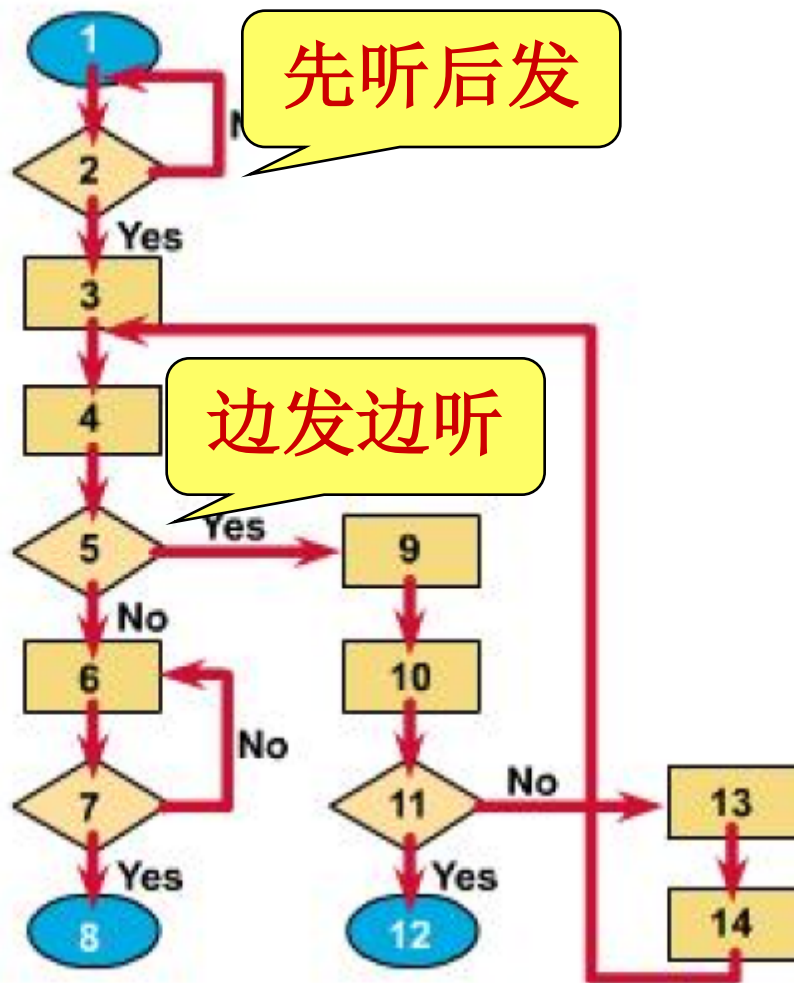
先听后发

边发边听

Binary Exponential Backoff

- 二进制指数回退算法
- **After a collision, the station waits for a random time and try again. How the randomization is done ?**
- **Time is divided into discrete slots whose length is equal to the worst case round trip propagation time (2τ).**
  - **After the first collision, each station waits either 0 or 1 slot time at random.**
  - **After the second collision, each station waits either 0, 1, 2, or 3 slot times at random.**
  - **After i collisions, a random number between 0 and $2^i - 1$ is chosen, and that number of slots is skipped.**
  - **After 10 collisions have been reached, the randomization interval is frozen at 1023 slots.**
  - **After 16 collisions, the controller gives up and reports failure.**

Random time

Retry	Random Time Range	Retry	Random Time Range
1	$2^1-1 = 0....1 \times 51.2_{\mu sec}$	9	$2^9-1 = 0...511 \times 51.2_{\mu sec}$
2	$2^2-1 = 0....3 \times 51.2_{\mu sec}$	10	$2^{10}-1 = 0....1023 \times 51.2_{\mu sec}$
3	$2^3-1 = 0....7 \times 51.2_{\mu sec}$	11	$2^{11}-1 = 0....1023 \times 51.2_{\mu sec}$
4	$2^4-1 = 0...15 \times 51.2_{\mu sec}$	12	$2^{12}-1 = 0....1023 \times 51.2_{\mu sec}$
5	$2^5-1 = 0....31 \times 51.2_{\mu sec}$	13	$2^{13}-1 = 0....1023 \times 51.2_{\mu sec}$
6	$2^6-1 = 0....63 \times 51.2_{\mu sec}$	14	$2^{14}-1 = 0....1023 \times 51.2_{\mu sec}$
7	$2^7 -1= 0....127 \times 51.2_{\mu sec}$	15	$2^{15}-1 = 0....1023 \times 51.2_{\mu sec}$
8	$2^8 -1= 0...255 \times 51.2_{\mu sec}$	16	$2^{16}-1 = 0....1023 \times 51.2_{\mu sec}$

Pay attention

☐ After i**th collision**：

- When $0 < i \leqq 10$ ， **wait** $(0\sim 2^i-1) \times 2\tau$

- When $10 < i < 16$ ， **wait**（**0**~1023） $\times 2\tau$

- When $i > 16$ ， give up sending

Ethernet performance
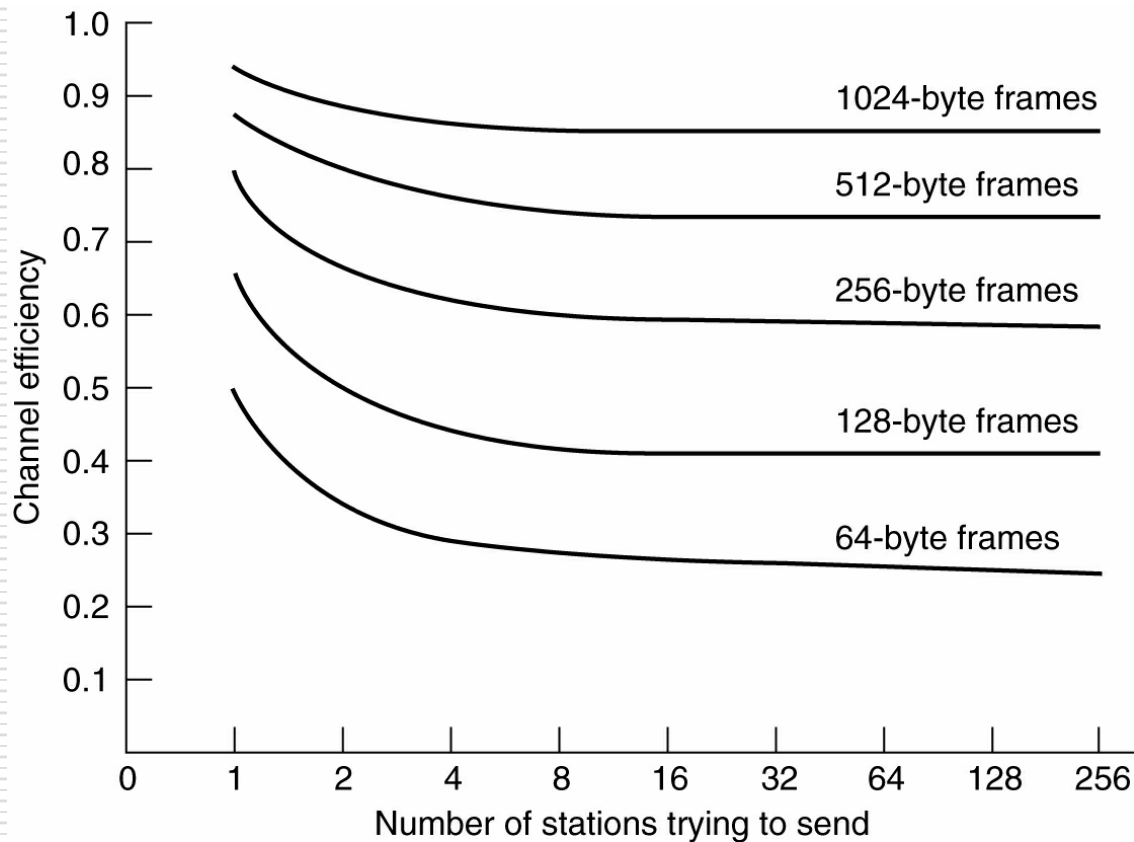
Typical Ethernet

☐ **10base2**

☐ **10base5**

☐ **10base-T**

☐ **Improve performance**

  ■ **Up to 100Mbps**

  ■ **Switched network**

Switched Ethernet

- **The heart of the system is a switch containing a high-speed (typically over 1 Gbps) backplane and room for multiple plug-in cards (typically 4 to 32)**

- **The plug-in card checks to see if the frame is destined for one of the other stations connected to the same card.**

  - **If so, the frame is copied to the destination station.**

  - **If not, the frame is sent over the high-speed backplane to the destination station's card.**
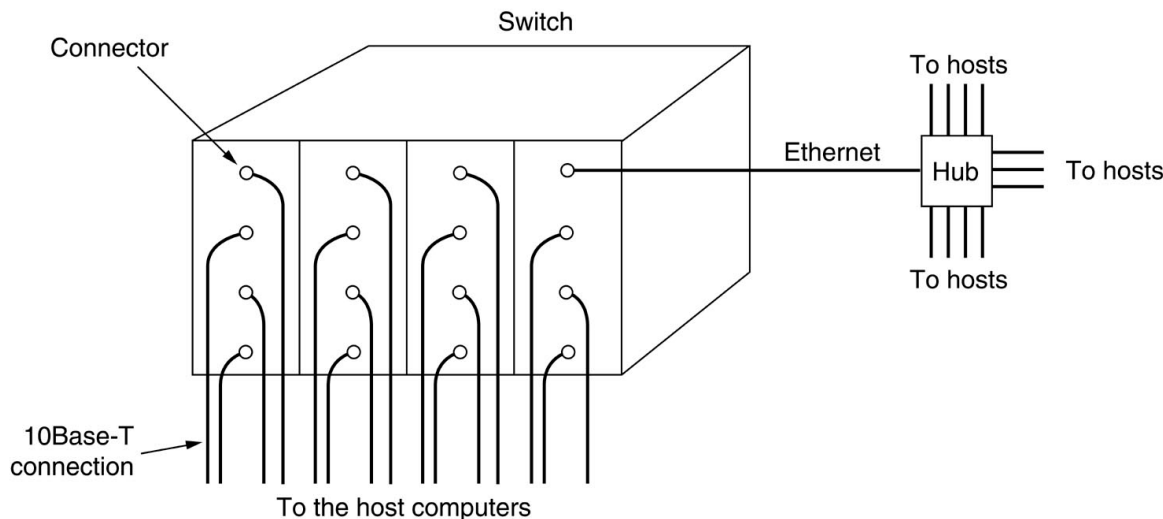
Switched Ethernet (cont'd)

- ☐ **What happens if two machines attached to the same plug-in card transmit frames at the same time ?**

- ☐ **Case 1: all the ports on the card are wired together to form a local on-card LAN:**
  - ■ **At any instant, only one transmission per card is permitted, but all the cards can be transmitting in parallel.**
  - ■ **Each card forms its own collision domain, independent of the others.**

- ☐ **Case 2: each input port can buffer incoming frames in the card's on-board RAM.**
  - ■ **All input ports can receive (and transmit) frames at the same time - parallel and full-duplex.**
  - ■ **Each port is a separate collision domain, so collisions do not occur.**

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100Mbps Ethernet—802.3u

- Fast Ethernet (**IEEE 802.3u**) was officially approved by IEEE in June 1995.
    - **backward compatible**
        - The old packet formats, interfaces, and procedural rules are kept
    - **Faster**
        - The bit time is reduced from 100 (10 Mbps) nsec to 10 nsec (100 Mbps).
- Fast Ethernet uses hubs or switches to wire up computers, just like 10Base-T wiring.
- Fast Ethernet allows the following three types of wire.

Name	Cable	Max. segment	Advantages
100Base-T4	Twisted pair	100 m	Uses category 3 UTP
100Base-TX	Twisted pair	100 m	Full duplex at 100 Mbps (Cat 5 UTP)
100Base-FX	Fiber optics	2000 m	Full duplex at 100 Mbps; long runs

Gigabit Ethernet（吉比特以太网）

- **Gigabit Ethernet (IEEE 802.3z) was ratified by IEEE in 1998.**
    - **backward compatible**
    - **faster than the existing 802.3 and 802.3u standards.**
- **All configurations of Gigabit Ethernet are point-to-point rather than multidrop.**
- **Gigabit Ethernet supports two different modes of operation**
    - **full-duplex: switch-based connection**
    - **half-duplex: hub-based connection**
- **Gigabit Ethernet supports flow control: one end can send a special control frame to the other end telling it to pause for some period of time**

How to solve？

- **carrier extension（载荷扩充）**

    - **padding the frame to 512 bytes (8)**

    - **So，the maximum distance can be 200m=25*8**

    - **disadvantage：line utility is low ，just 9%（46/512）**

- **frame bursting （帧串）**

    - **transmit multiple frames in a single transmission**

    - **Improve line utility**

IEEE802.2

- ☐ LLC run on top of Ethernet and the other 802 protocols.
- ☐ LLC hides the differences between the various kinds of 802 networks by providing a single format and interface to the network layer.
- ☐ LLC provides three service options:
  - ■ unreliable datagram service,
  - ■ acknowledged datagram service
  - ■ reliable connection-oriented service.
- ☐ The LLC header contains three fields:
  - ■ a destination access point
  - ■ a source access point
  - ■ a control field.

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Logical Link Control
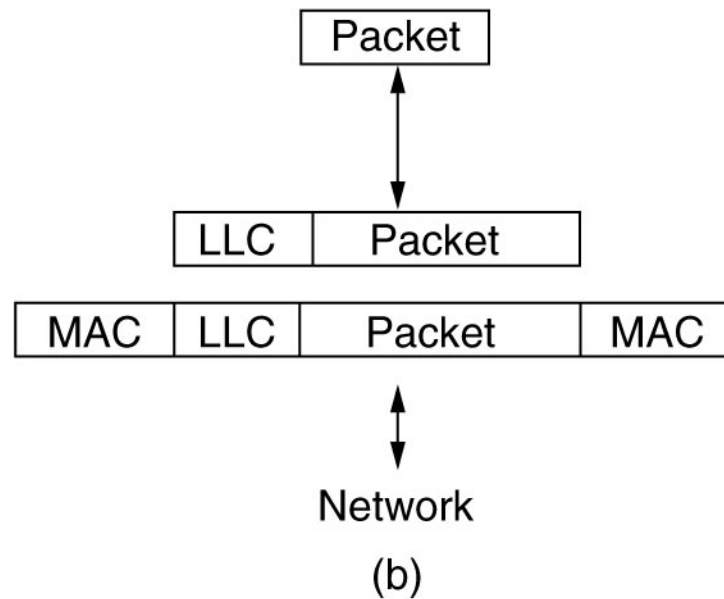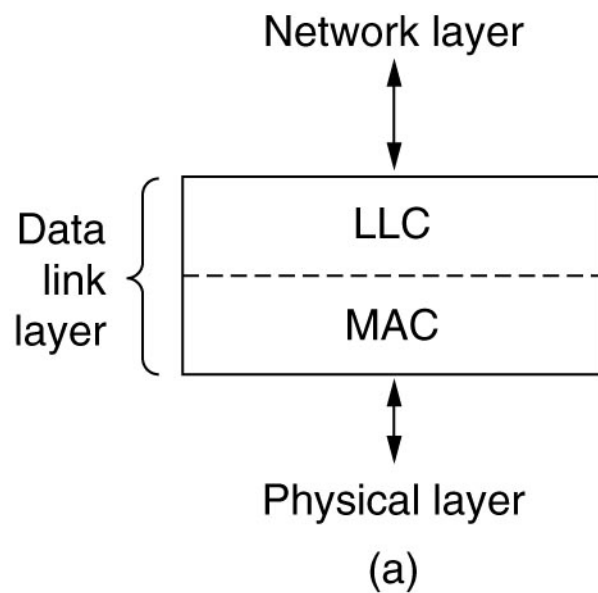
Summary

- **Learn** IEEE802 standard

- **Master Ethernet**/IEEE802.3 MAC principle
    - **Binary exponential backoff**

- **Master Ethernet**/IEEE802.3 frame format
    - **Difference**
    - **64byte~1518byte**

- **Learn characteristics of Ethernet**
    - **10Base-T**
    - **Faster Ethernet**

Thanks !

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