COMPUTER NETWORKS

- Chapter4 Medium Access Control Sublayer 2

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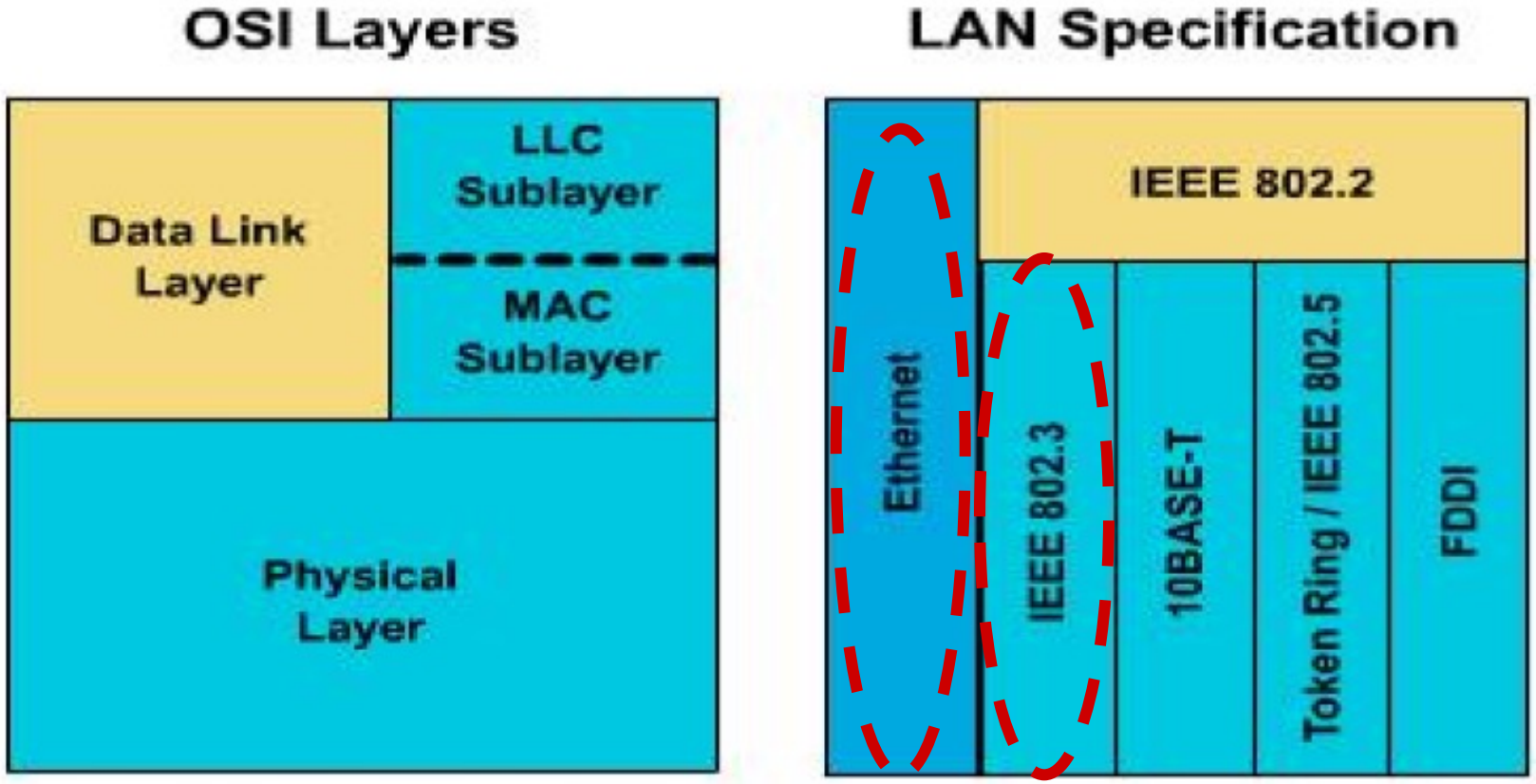
Contents of this lecture

- **Learn** IEEE802 standard
- **Master Ethernet**/IEEE802.3 principle
- **Master Ethernet**/IEEE802.3 frame format
- **Learn characteristics of Ethernet**

IEEE802.3/Ethernet & OSI RM

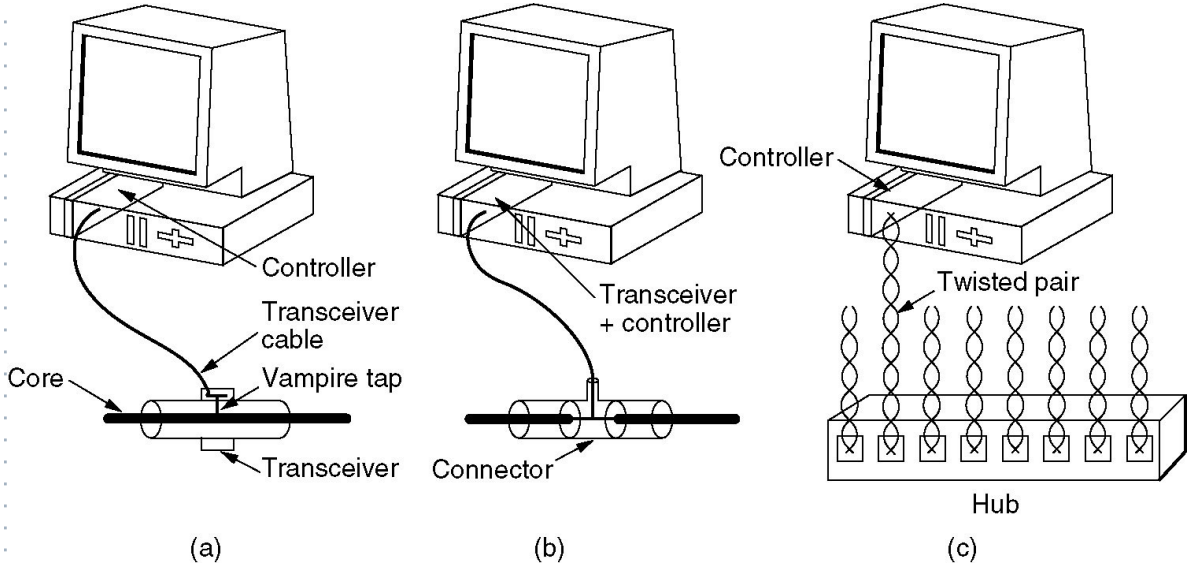


IEEE Ethernet naming rule

- 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**

Ethernet cabling

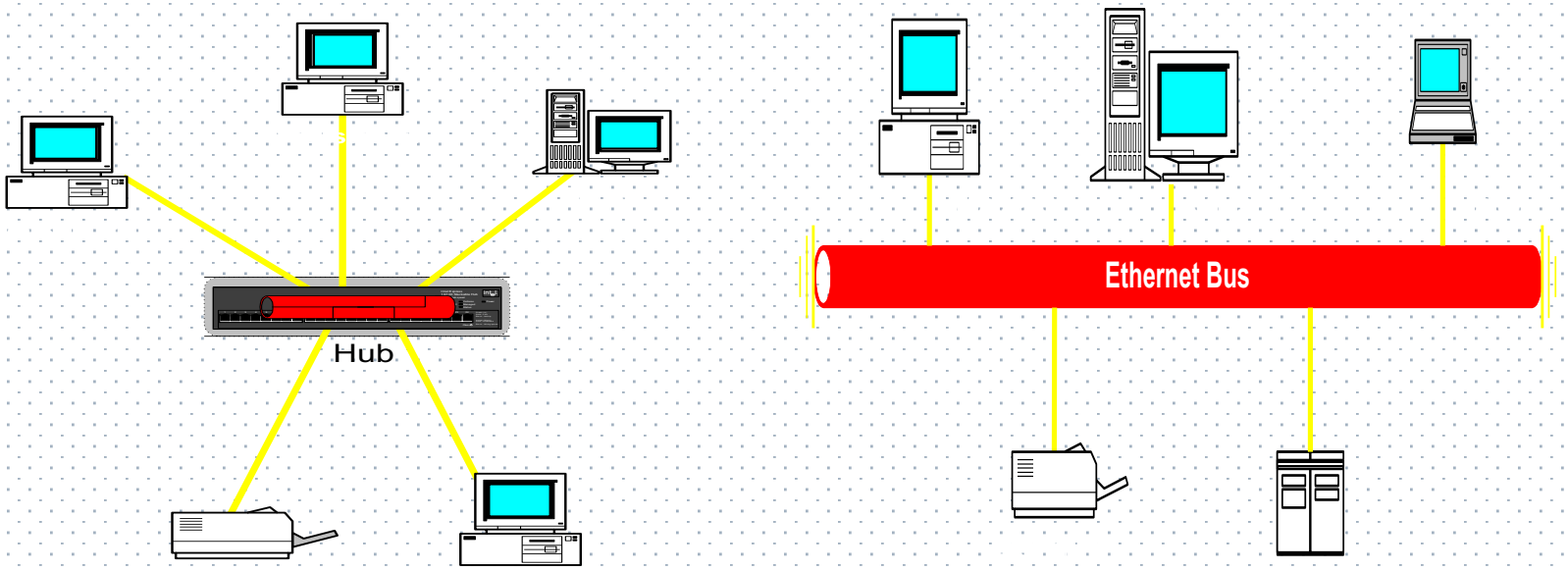
Name	Cable	Max. seg.	Nodes/seg.	Advantages
10Base5	Thick coax	500 m	100	Original cable; now obsolete
10Base2	Thin coax	185 m	30	No hub needed
10Base-T	Twisted pair	100 m	1024	Cheapest system
10Base-F	Fiber optics	2000 m	1024	Best between buildings



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)**

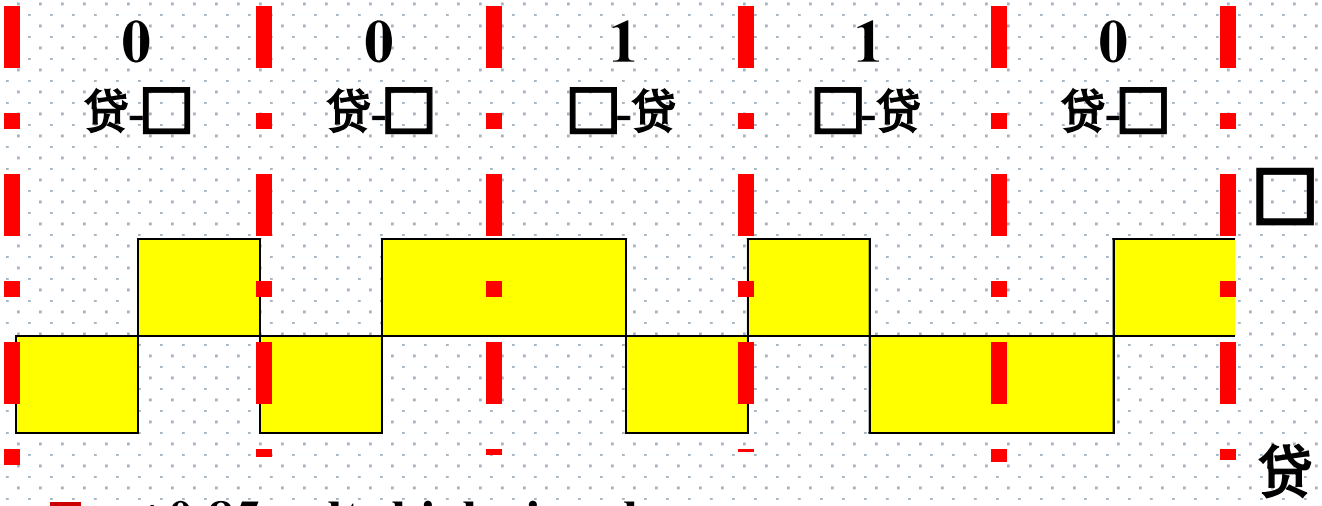
Ethernet encoding

- 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

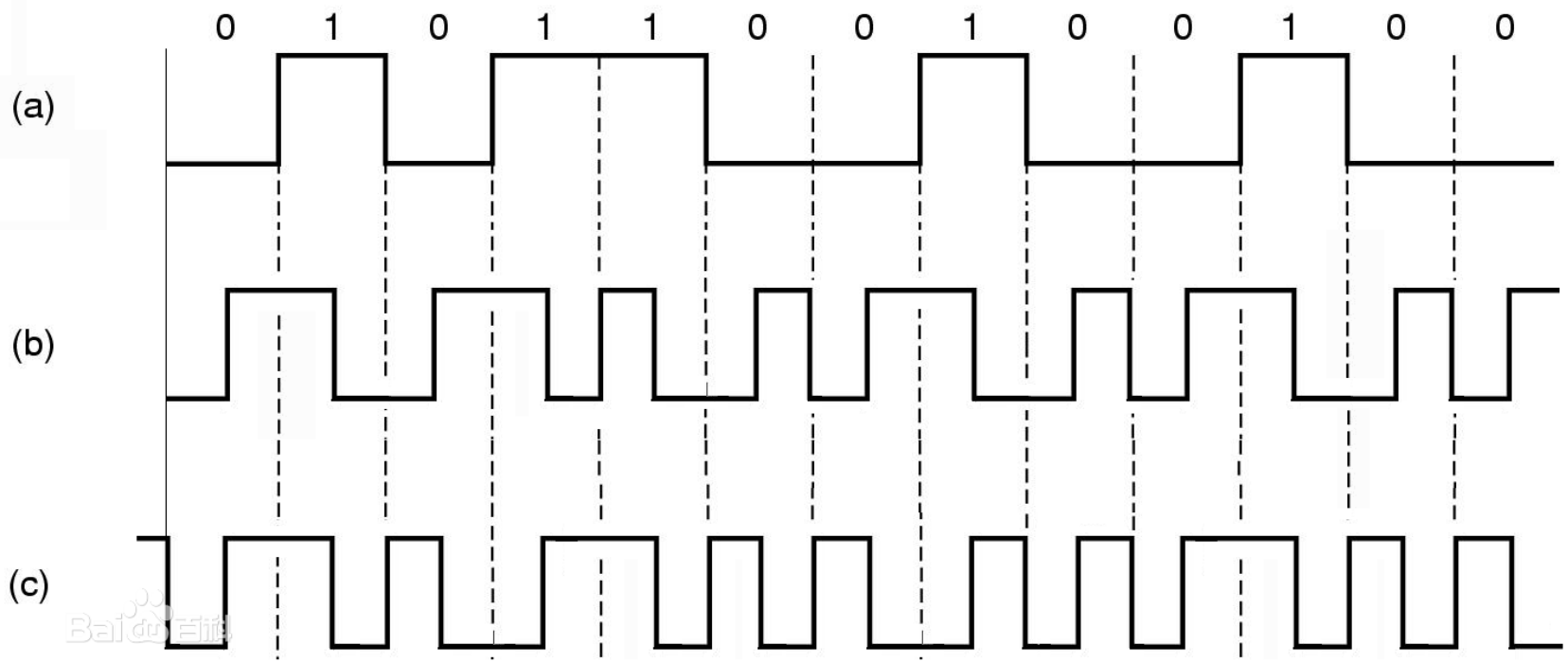
Manchester encoding



- +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)

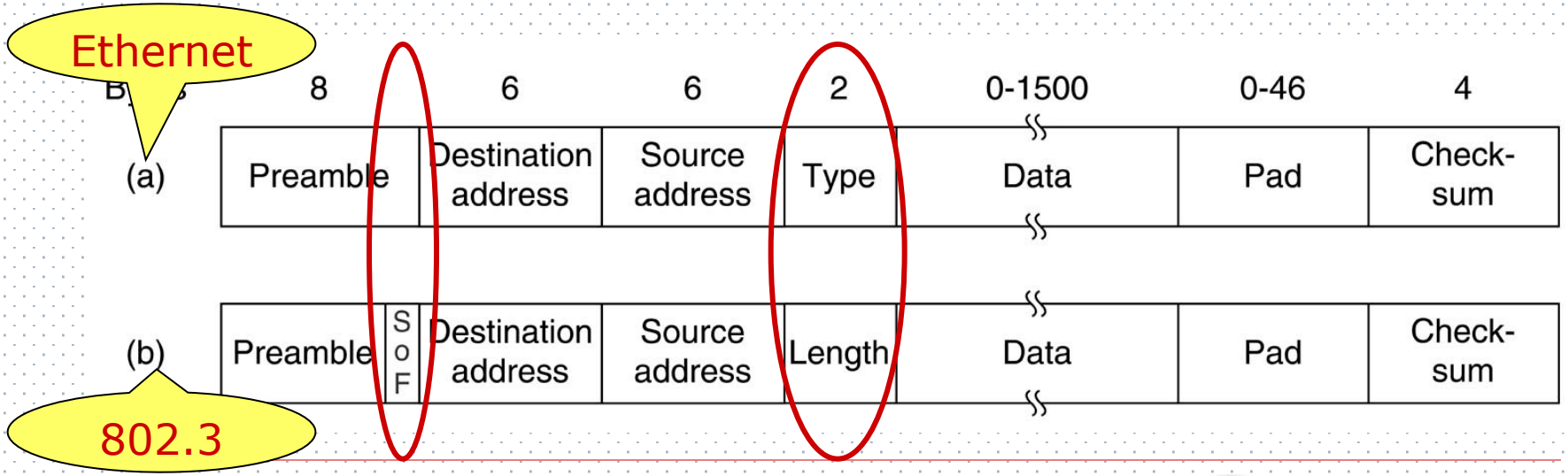
Number	Topic
802.1	Overview and architecture of LANs
802.2 ↓	Logical link control
802.3 *	Ethernet
802.4 ↓	Token bus (was briefly used in manufacturing plants)
802.5	Token ring (IBM's entry into the LAN world)
802.6 ↓	Dual queue dual bus (early metropolitan area network)
802.7 ↓	Technical advisory group 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

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.



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 X 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

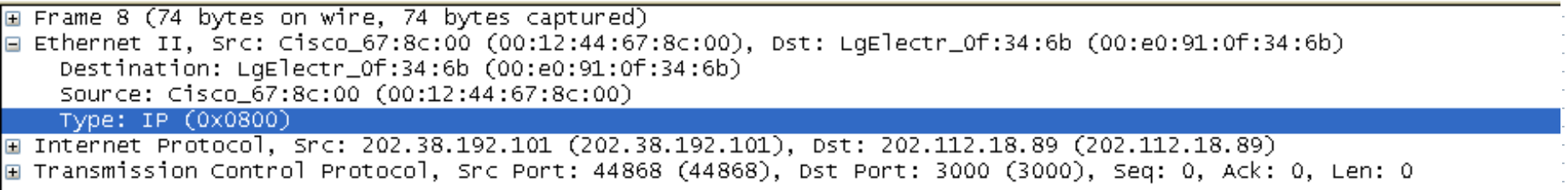
  IBM 08-00-5A

- **An example**

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

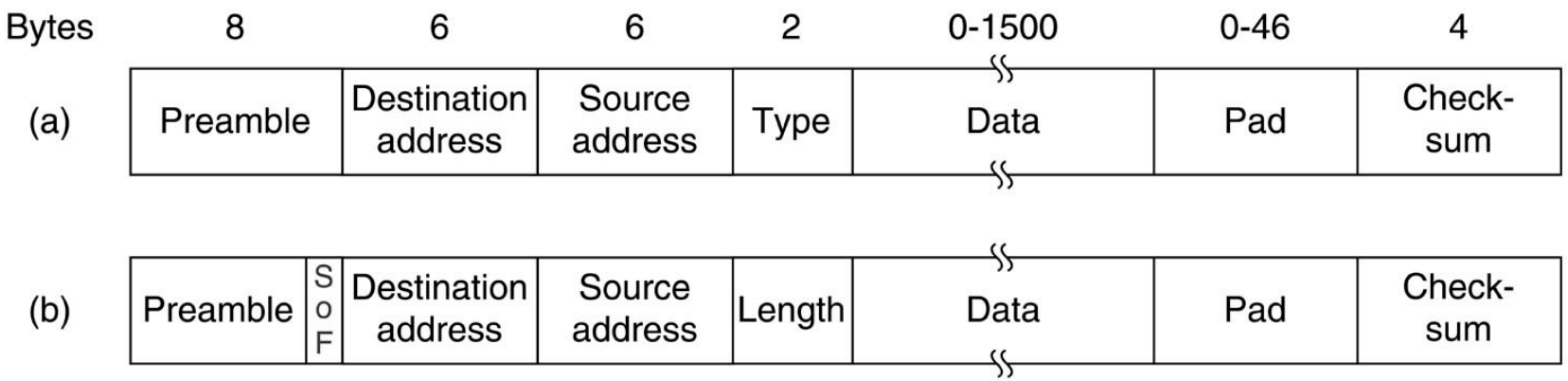
The Type/Length Field

- 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.



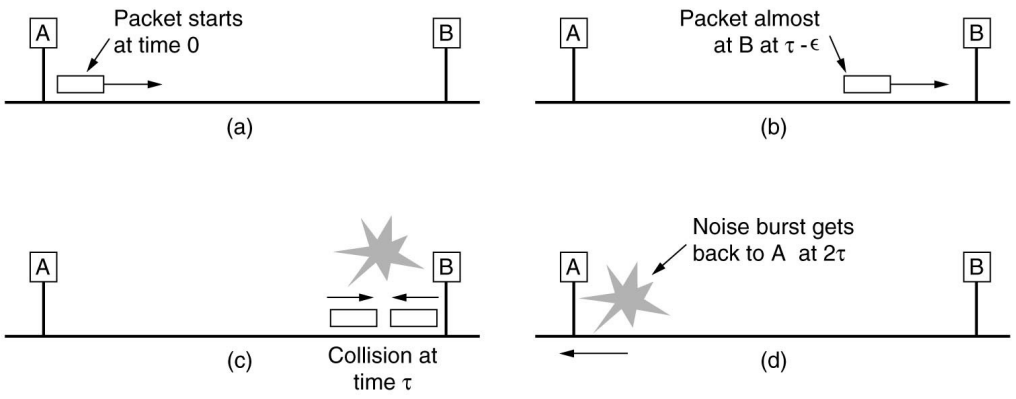
Data field

- 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,



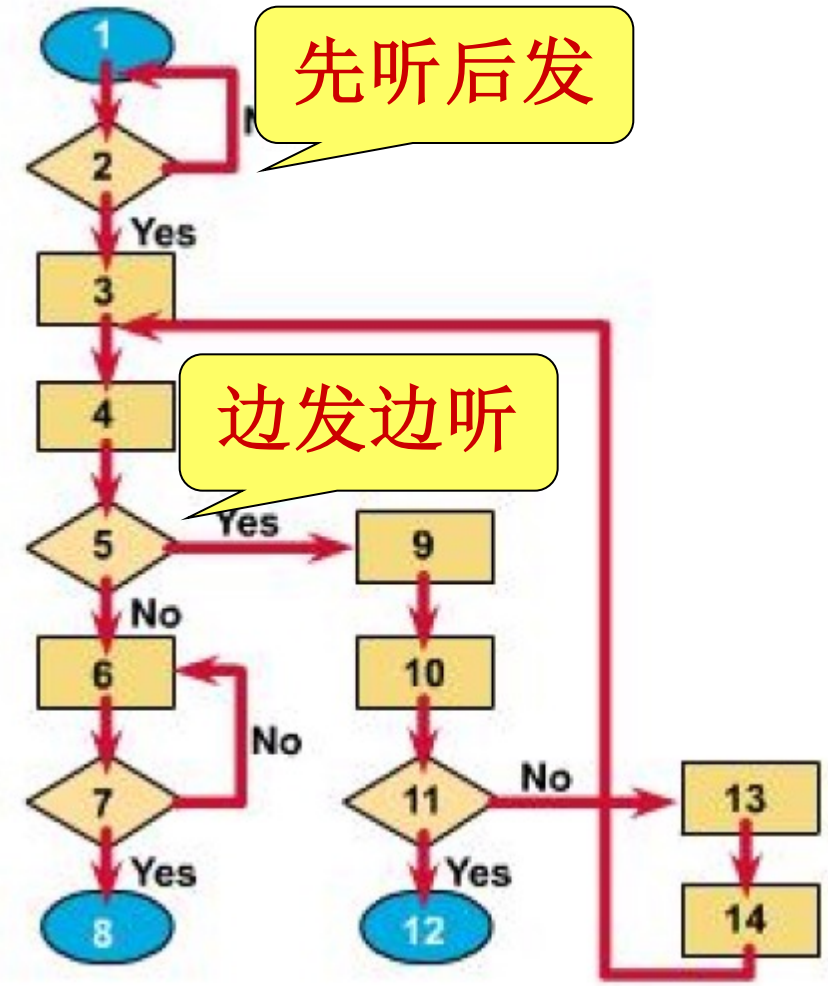
Why length≥ 64 Byte?

- **CSMA/CD require**
  - **Sending time the frame need ≥ 2τ**
- **Ethernet（802.3），10Mbps LAN**
  - **Time slot：2τ = 51.2μs**
  - **The shortest frame：10Mbps× 2τ/8 = 64 Byte**
    - **或者：（51200/100ns）/8=64Byte**



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



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.

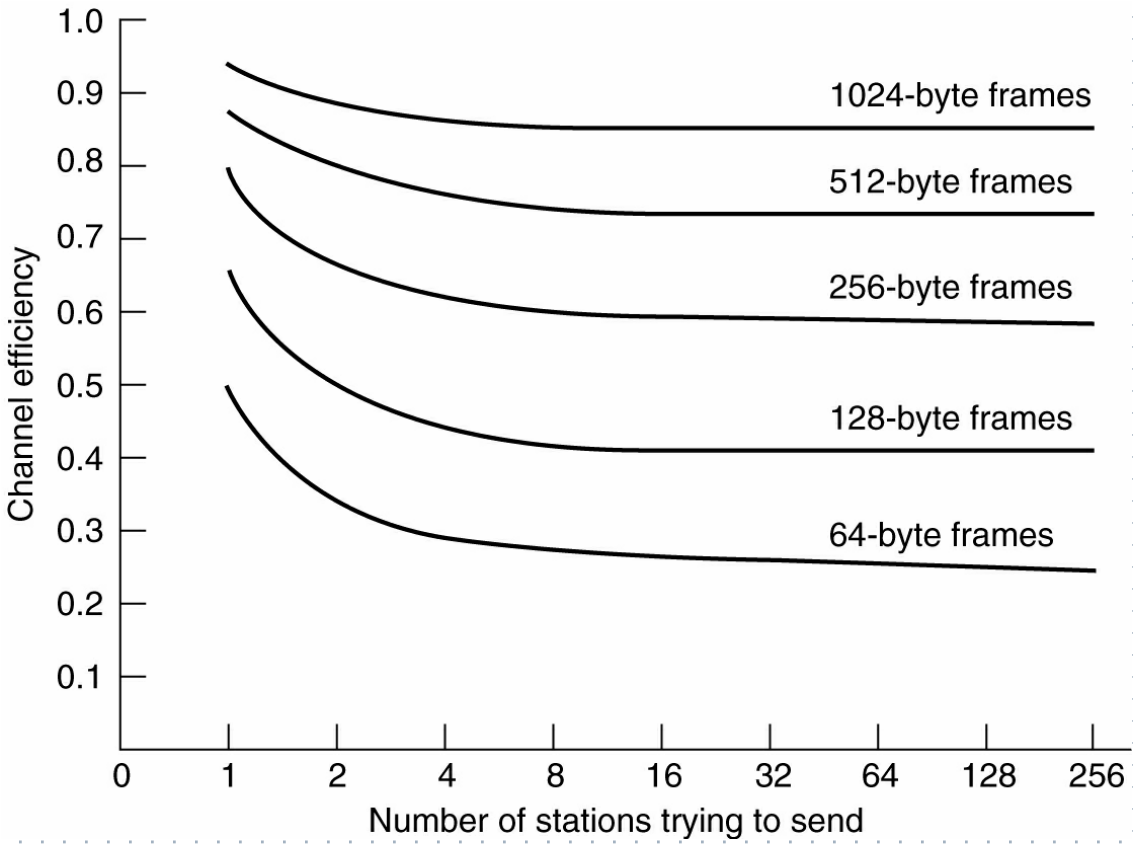
Random time

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 **ith 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

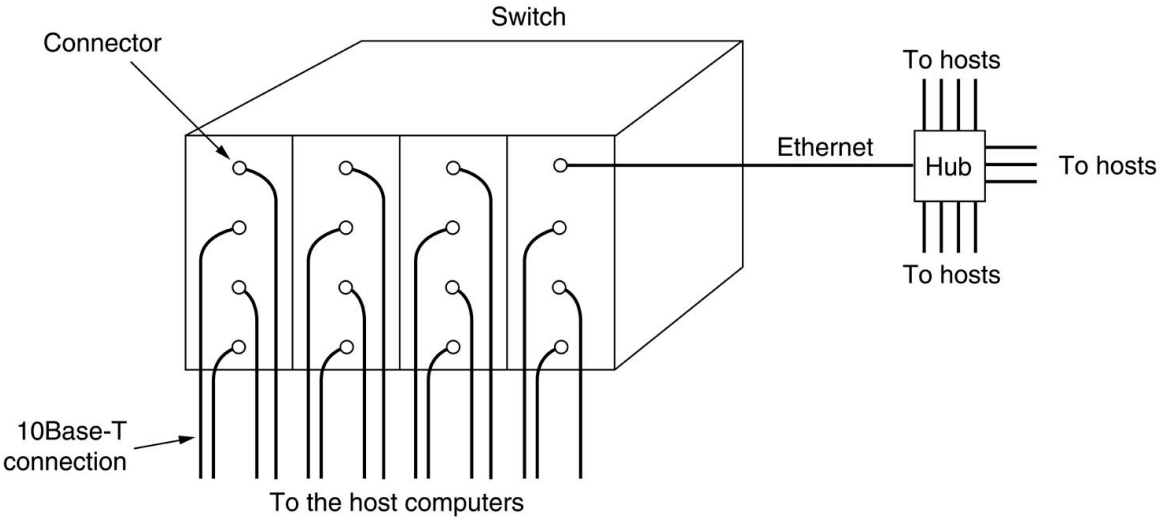


Typical Ethernet

- 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.

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

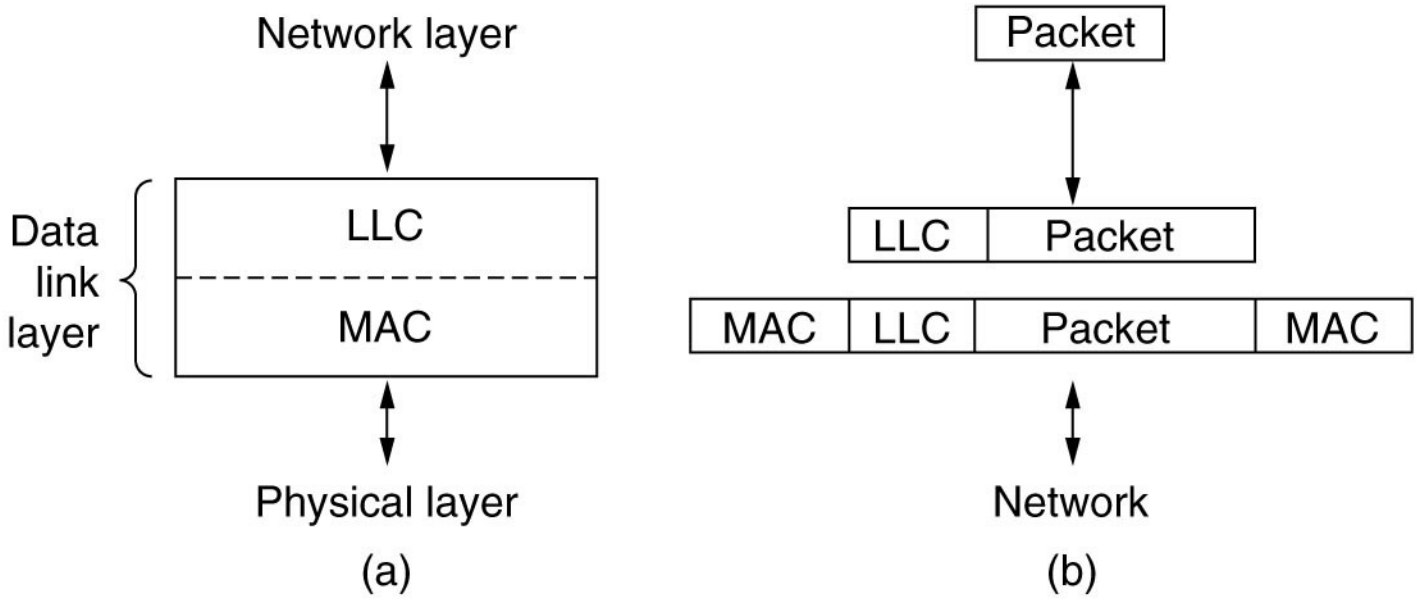
How to solve?

- 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.

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 !