The Medium Access Control Sublayer

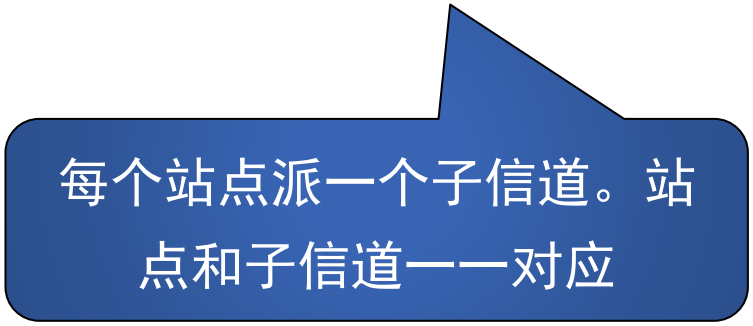
Chapter 4

4.1 Channel Allocation Problem

- Static channel allocation
- Assumptions for dynamic

Static Channel Allocation

- Static channel allocation
  - Allocating a single channel among multiple competing users, such as FDM and TDM, each user is statically allocated the bandwidth or time slots. There is no interference between users.
  - Both FDM and TDM cannot work well with burst traffic. Dividing the single available channel into static subchannel is inherently inefficient. When users are quiescent, the bandwidth is simply wasted.



Static Channel Allocation

- Poor performance, shown by Poisson arrival and service time:
  - $T = 1/(\mu C - \lambda)$, where T is mean time delay, C is channel capacity, λ is arrival rate, μC is service rate
  - $T_{FDM} = 1/(\mu C/N - (\lambda/N)) = N/(\mu C - \lambda) = NT$

划分信道后，单个信道的平均延时比不分的情况差N倍。

适合的场景是什么？

计算机流量是突发的。

适合于用户较少，数目基本固定，各用户的通信量都较大的情况；e. g. 超市、食堂

缺点：无法灵活地适应站点数及其通信量的变化。e. g. 快餐、银行等

Assumptions for Dynamic Channel Allocation

- **Assumptions:**
  - **Independent traffic**, which consists of N independent stations, each with a program or user generates frames for transmission
  - **Single Channel**, a single channel is available for all communications.
  - **Observable Collision**, if two frames are transmitted simultaneously, they overlap in time and the resulting signal is garbled. And the collision is observable.
  - **Continuous time**, or **slotted time**
  - **Carrier sense**, and **no carrier sense**.
- All discussion is based on the above assumptions

4.2 Multiple Access Protocols

- ALOHA
- Carrier Sense Multiple Access
- Collision-free protocols
- Limited-contention protocol
- Wireless LAN protocols

动态分配主要有以下三种方法：

1，冲突协议

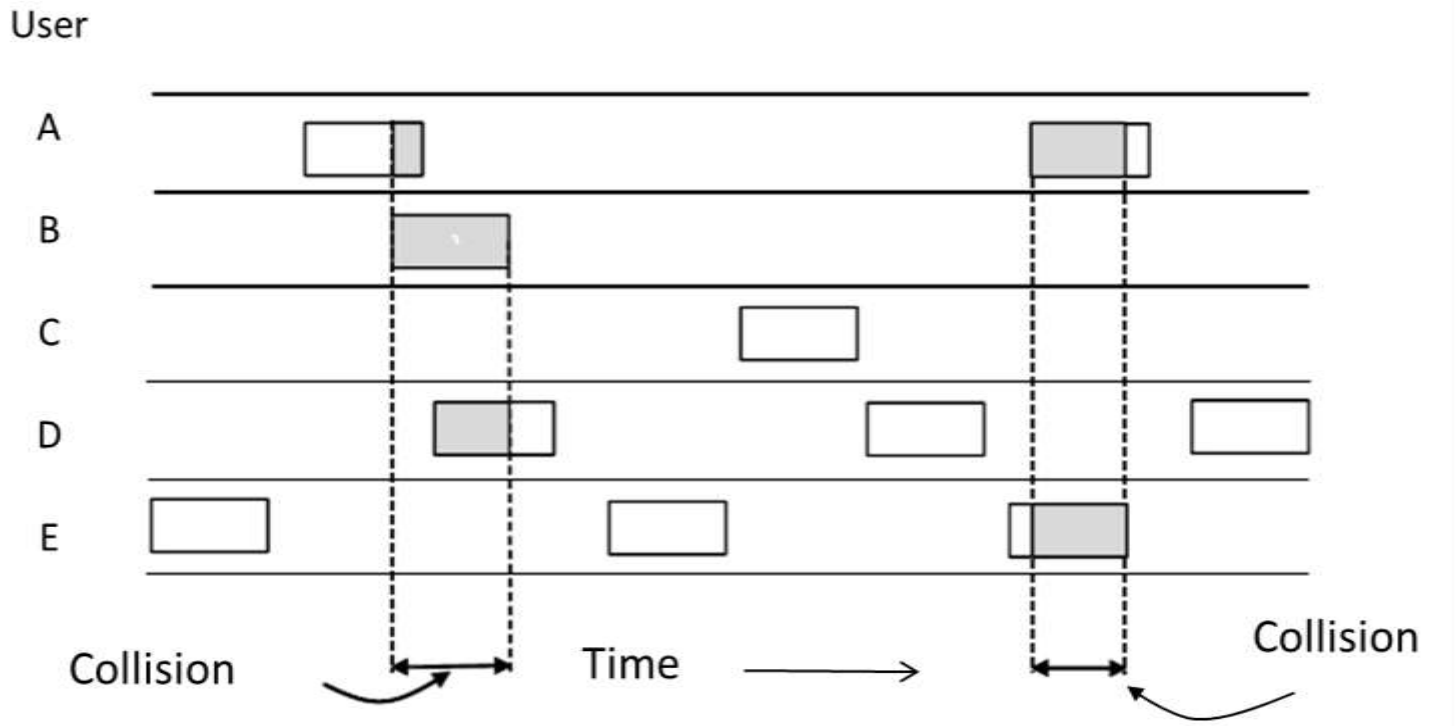
2，无冲突协议

3，有限冲突协议

e. g. 上课提问

ALOHA (1)

- **Principle**: if you want to send a frame, **just do it**. If a collision occurs, the colliding frame will be destroyed. Finish your current transmission and retry later.



In pure ALOHA, frames are transmitted at completely arbitrary times

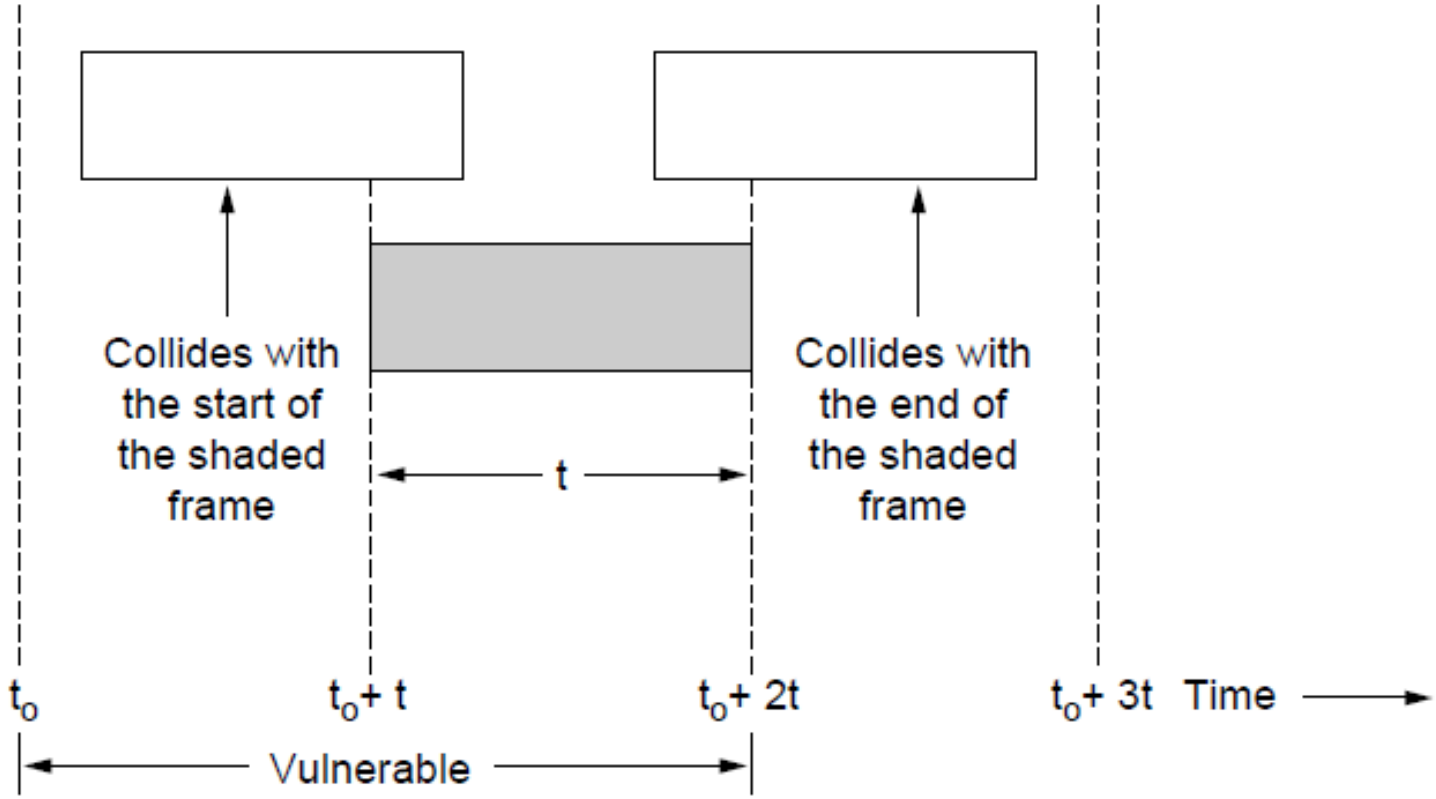
ALOHA (补充)

- aloha是夏威夷语，指爱慕、恋慕、同情、怜悯、再见、你好等类似的意思。在夏威夷被特别用来作迎接和道别。在有的情况下也被用作致意问候。Aloha kakahiaka 是早上好的意思。Aloha auinala 是下午好的意思。Aloha ahiahi 是晚上好的意思。Aloha kakou 被用作欢迎所有人的普遍形式。Aloha也是夏威夷州的昵称。

- 几十年来，aloha这个词被人与一种复杂的心理状态联系起来，称为Aloha精神。Aloha精神通常被描述为一种关心和接纳周围的人，并尊重他们的人格，即使在面对有压力的环境、场合甚至人物。

- 最近这个词开始在美国以外的地区流行起来。出生于檀香山的流行艺人、百老汇明星、好莱坞演员Bette Midler 经常在全国亮相时用这个词来打招呼。电视剧《夏威夷5-O》里也经常用这个词。Aloha精神也是基于夏威夷的背景的著名迪斯尼系列影视《Lilo和Stitch》的主要创作理念。

ALOHA (2)



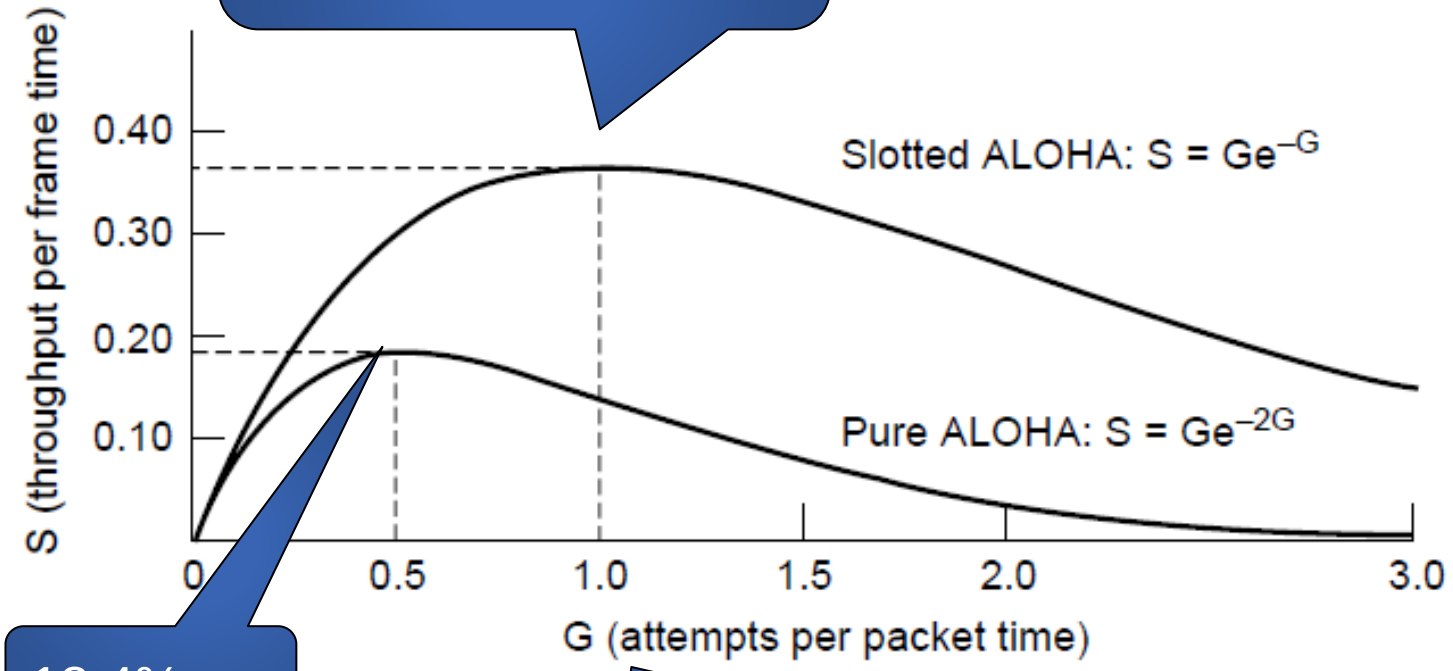
Vulnerable period for the shaded frame.

ALOHA (2)

- **Slotted ALOHA**
  - We can improve a bit by removing some randomness. In **Slotted ALOHA**, frame transmission can only start at fixed times.
  - Split time into pieces(slots), each slot equals to frame transmission time. Arrived frame can only be sent at the beginning of next slot. Vulnerable time is no longer $2t_0$, but t_0. The probability of success increases one time.

ALOHA (3)

The channel efficiency is then 36.8%.



18.4%

G：每帧时的平均帧数

Throughput versus offered traffic for ALOHA systems.

Carrier Sense Multiple Access Protocols

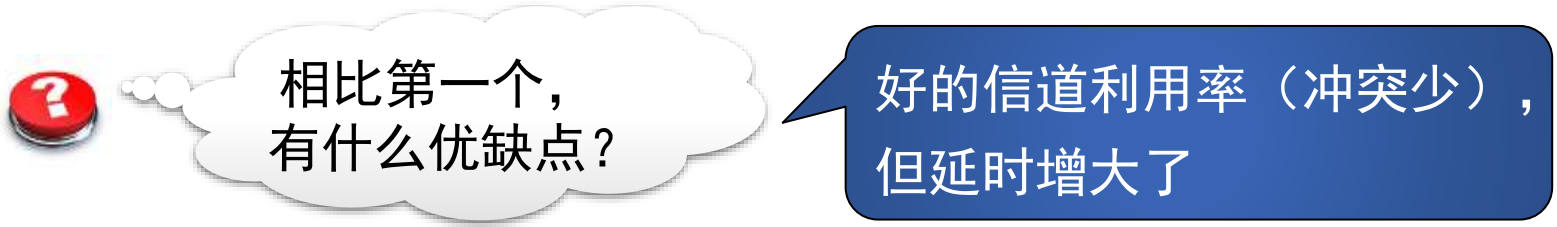
- CSMA (**Carrier Sense Multiple Access**)
  - Protocols do better than ALOHA: you **monitor the channel** before and/or during transmission. Listen for a carrier and act accordingly, that is carrier sense.
- Persistent and Non-persistent CSMA
  - **1-persistent:** Listen whether the channel is idle before transmitting. If busy, wait until it becomes idle and then immediately start your transmission with probability 1.

有没有可能冲突？

1）两个站以为空闲同时发；
2） 传播的时延造成的误会。

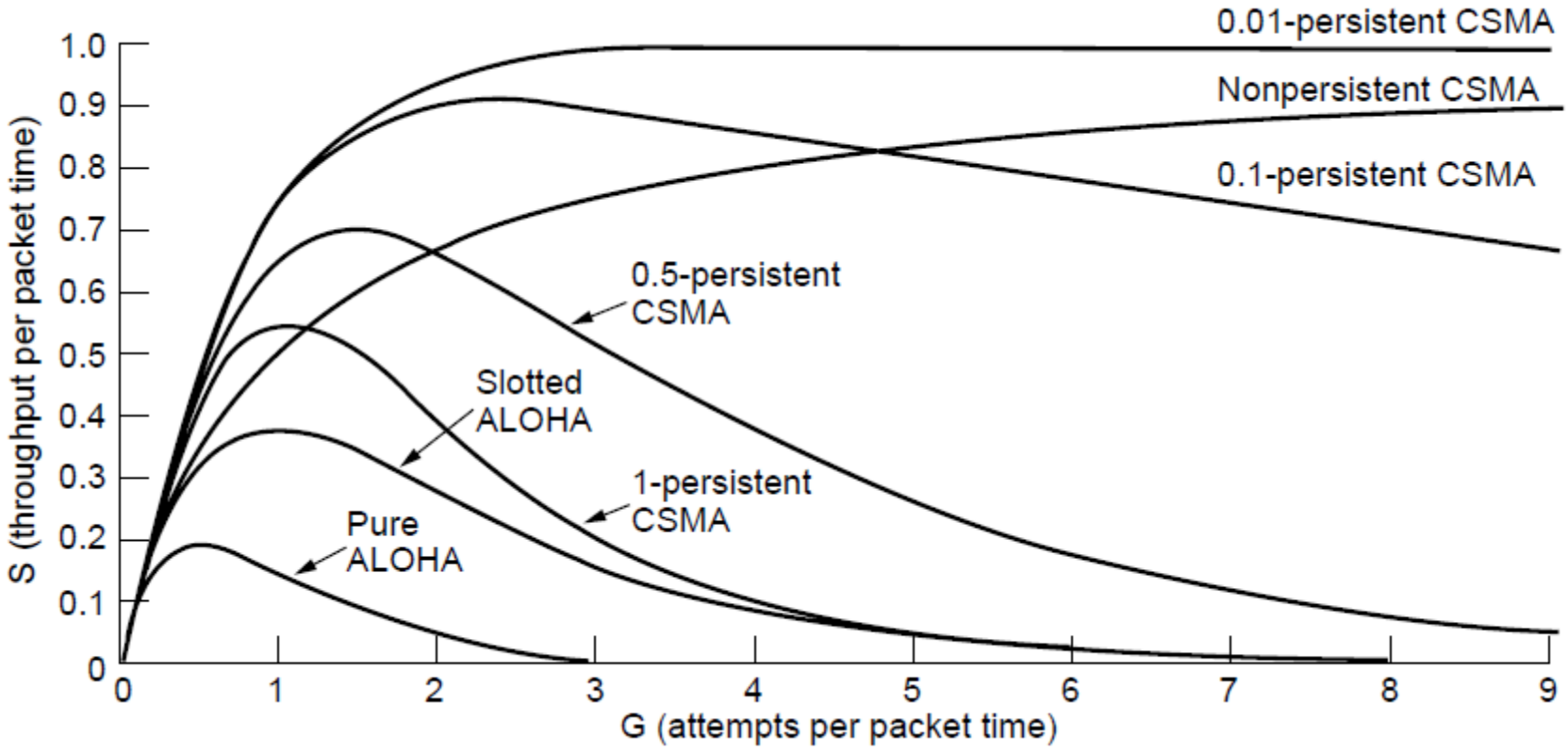
Carrier Sense Multiple Access Protocols

- **Non-persistent:** Less greedy – when the channel is busy, wait a random period of time before trying again.



- **p-Persistent:** Used with **slotted systems**. If you find the channel idle during the current slot, you transmit with probability *p*, and defer until next slot with probability 1-*p* . *p*=1 is not really good, *p*=0 makes you *really* polite.

Persistent and Nonpersistent CSMA



Comparison of the channel utilization versus load for various random access protocols.

CSMA with Collision Detection

- **Improvement**: sense the channel, but **immediately stop transmission** when you detect a collision. **Ethernet** works like this:

1. Listen to see whether the channel is free. Transmission is delayed until the channel is no longer used.
2. During transmission, keep listening in order to detect a collision. If a collision occurs, transmission immediately stops.
3. If a collision occurred, wait a random period of time, and proceed with the first step again.

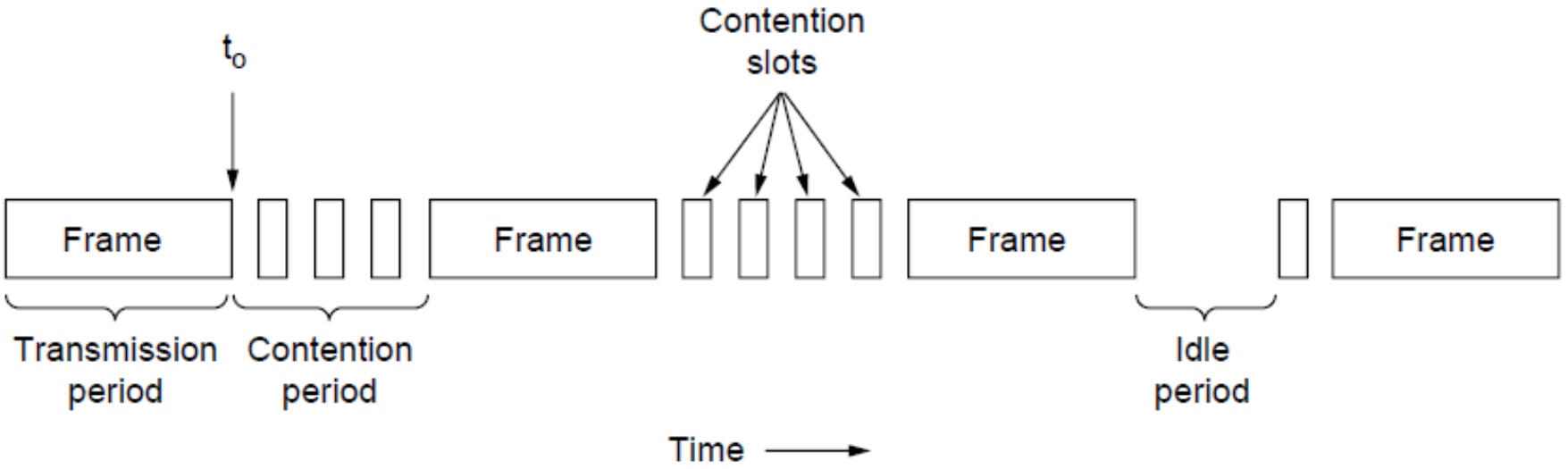
CSMA with Collision Detection

信道利用率、延时

	空闲	忙碌	冲突
ALOHA	发	发	冲突、等随机的时间
1坚持CSMA	发	不发，等着发	冲突、等随机的时间
非坚持CSMA	发	不发，等随机的时间	冲突、等随机的时间
P坚持CSMA	概率P发	不发，等着发(下一个时隙)	冲突、等随机的时间
CSMA/CD	发	不发，等着发	终止发送、等随机的时间

CSMA with Collision Detection

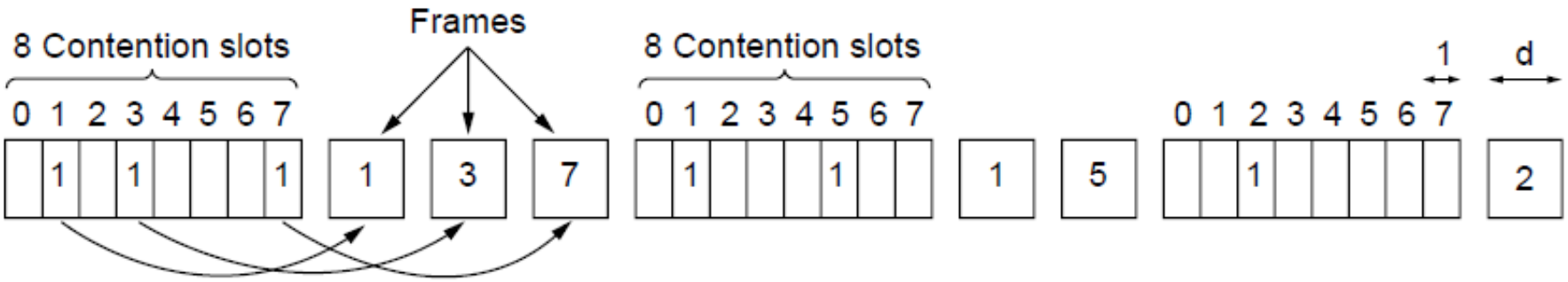
- At t_0, a station finished transmitting, any other station having a frame to send may now try to do so. If two or more decide to transmit simultaneously, there will be a collision. After a station detected a collision, it aborts its transmission, waits for a random period time, and then tries again. Thus, this model consists of alternating contention and transmission period, with idle periods.



CSMA/CD can be in one of three states: contention, transmission, or idle.

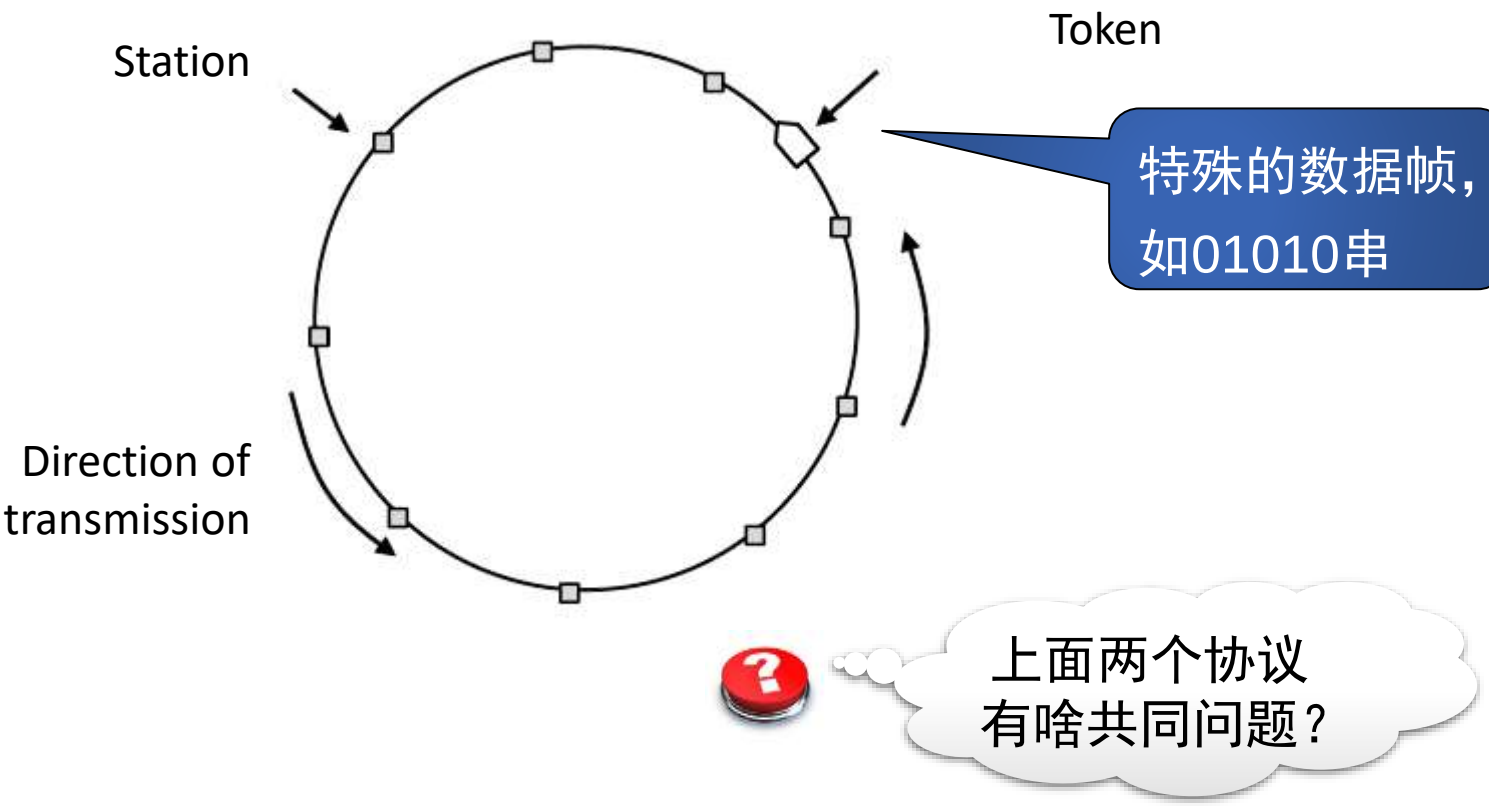
Collision-Free Protocols (1)

- **A Bit-Map Protocol:** The contention period contains N slots. If station k wants to transmit a frame, it transmits a 1 during the k^{th} slot. The highest-numbered station goes first. It is a reservation protocol.
- **The channel efficiency:**
  - Low load: $d/(N+d)$ d: data bits, N: overhead
  - High load: $d/(d+1)$



The basic bit-map protocol.

Collision-Free Protocols (2)



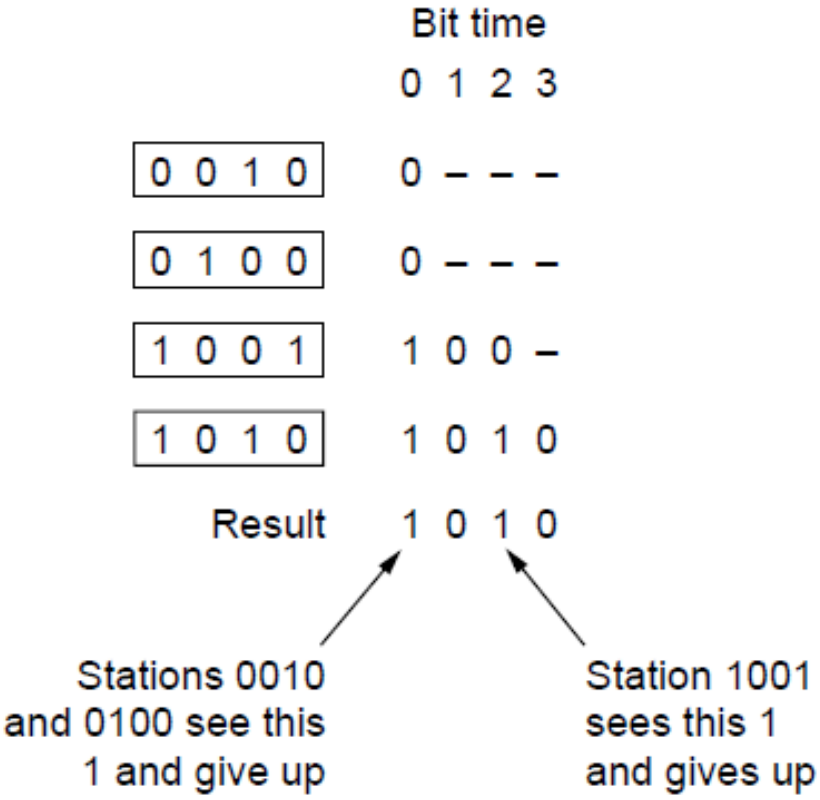
Token ring.

Binary Countdown 二进制倒计数

- In the contention period a total of $\log_2 N$ bits can be transmitted. Each station transmits its number (bit by bit), and stops as soon as it detects a higher-numbered contender

- **假设传输延时可以忽略不计-同时看到地址宣告；**
- **优先级；**
- **设计帧格式，使得地址和帧内第一个字段一致，则可以开销为0；**

有朝一日或有用武之地。



Limited-Contention Protocols

- **Contention** systems are good when there's not much going on – a station can immediately transmit a frame. We do some repairing when things go wrong.

低负载下的延迟低的优点，但是高负载下冲突导致信道利用率低。

- **Collision-free** systems are good when there's generally a lot of traffic – a station first has to get the channel explicitly before frame transmission. We do a lot of work avoiding collisions.

优缺点？

低负载下的延迟高，但是高负载下冲突少，信道利用率高。

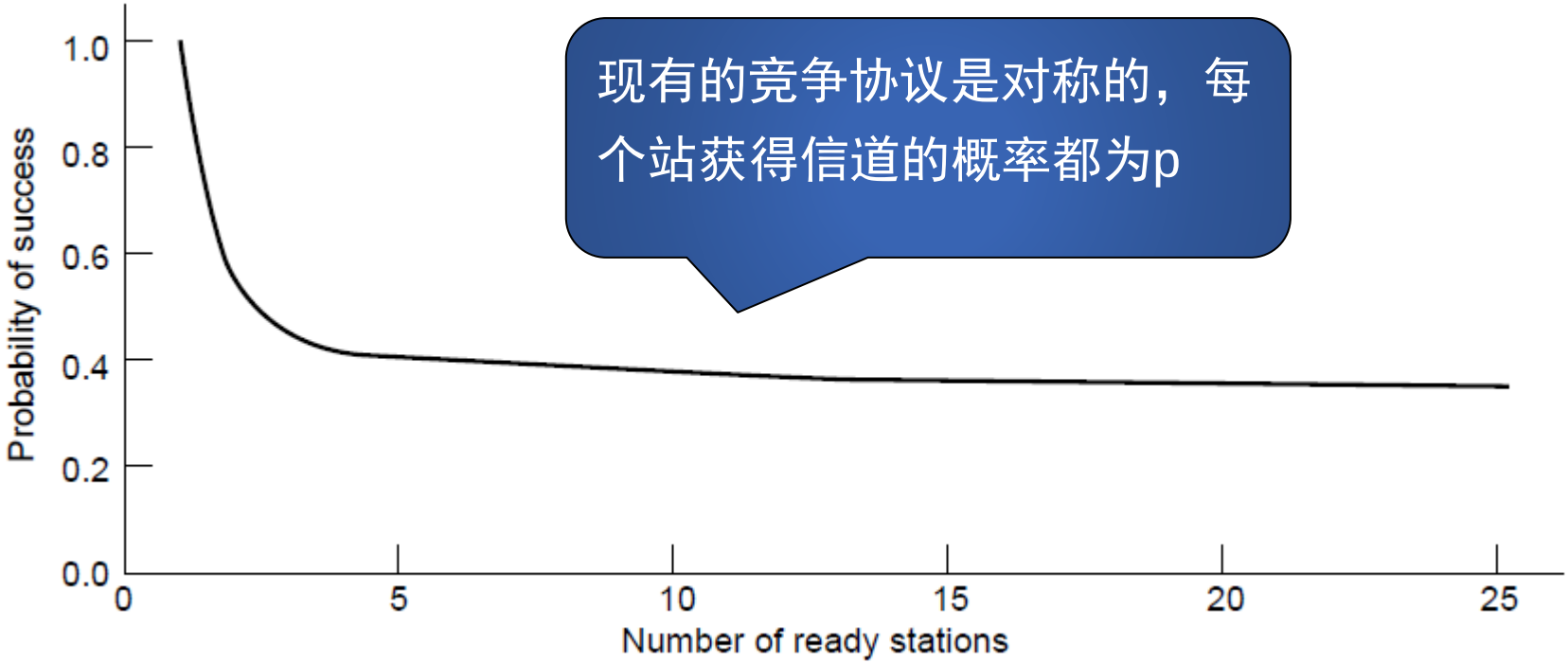
Limited-Contention Protocols

信道利用率、延时

- **Limited-Contention Protocols:** uses contention at low loads to provide low delay; uses a collision-free technique at high load to provide good channel efficiency.

Limited-Contention Protocols

现有的竞争协议是对称的，每个站获得信道的概率都为p



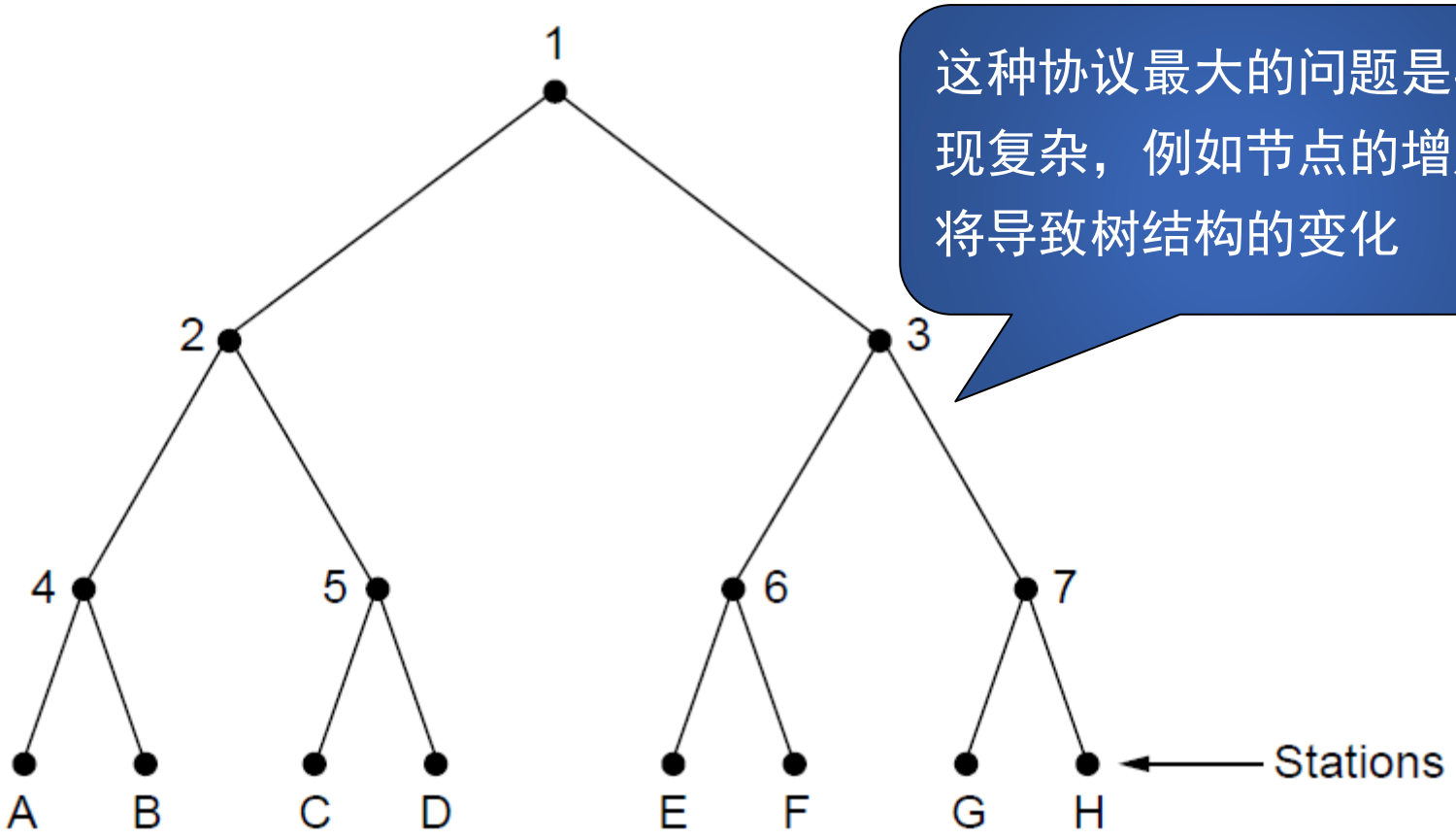
Acquisition probability for a symmetric contention channel.

The Adaptive Tree Walk Protocol

自适应树遍历协议

- Stations are located as the leaves of a binary-tree. Protocol assigns contention slot dynamically to stations who has frame to send. Searching algorithm is depth-first. If a collision occurs, the search continues recursively with the node’s left and right children.

The Adaptive Tree Walk Protocol

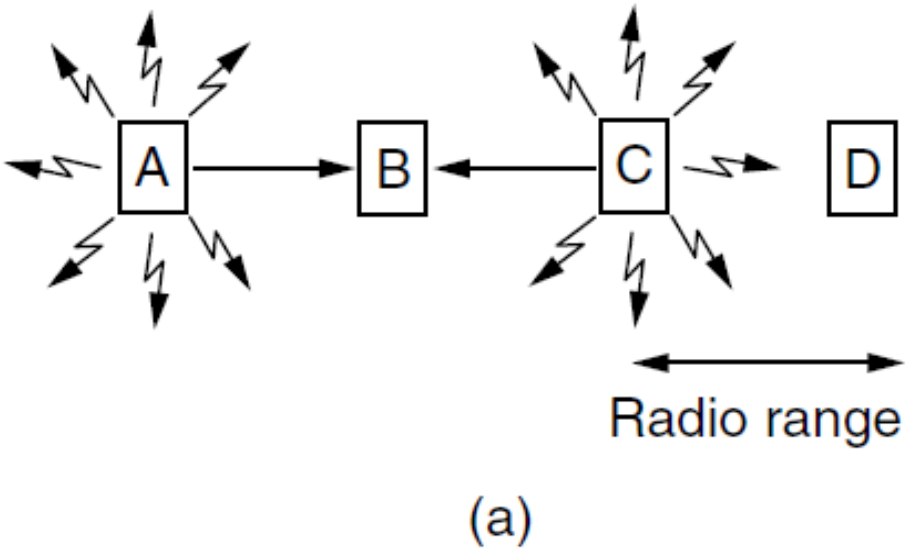


The tree for eight stations

Wireless LAN Protocols (1)

1，因为衰落，很难侦听到传输冲突；
2，站所覆盖的区域有所不同 。

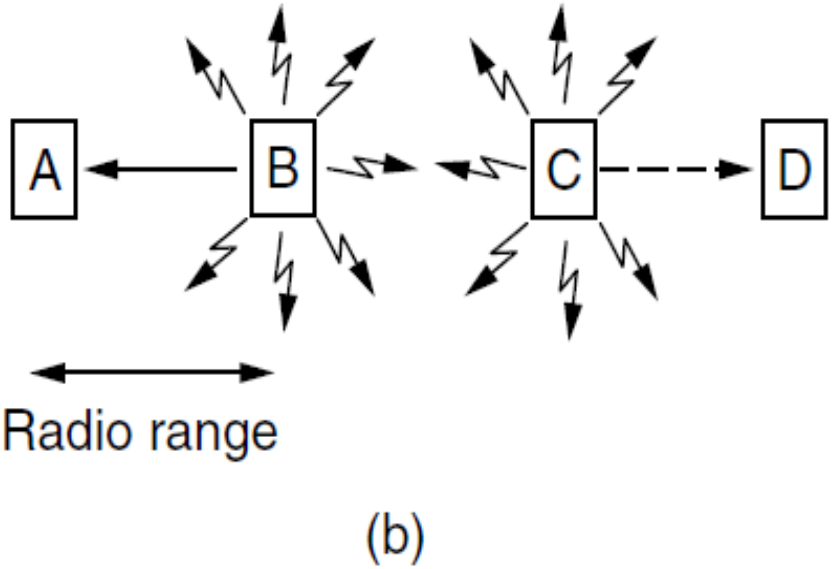
- **hidden station problem**
  How can *C* be prevented from trying to transmit something to *B*? In that case it will ruin any receipt by *B*



A wireless LAN. (a) A and C are hidden terminals when transmitting to B.

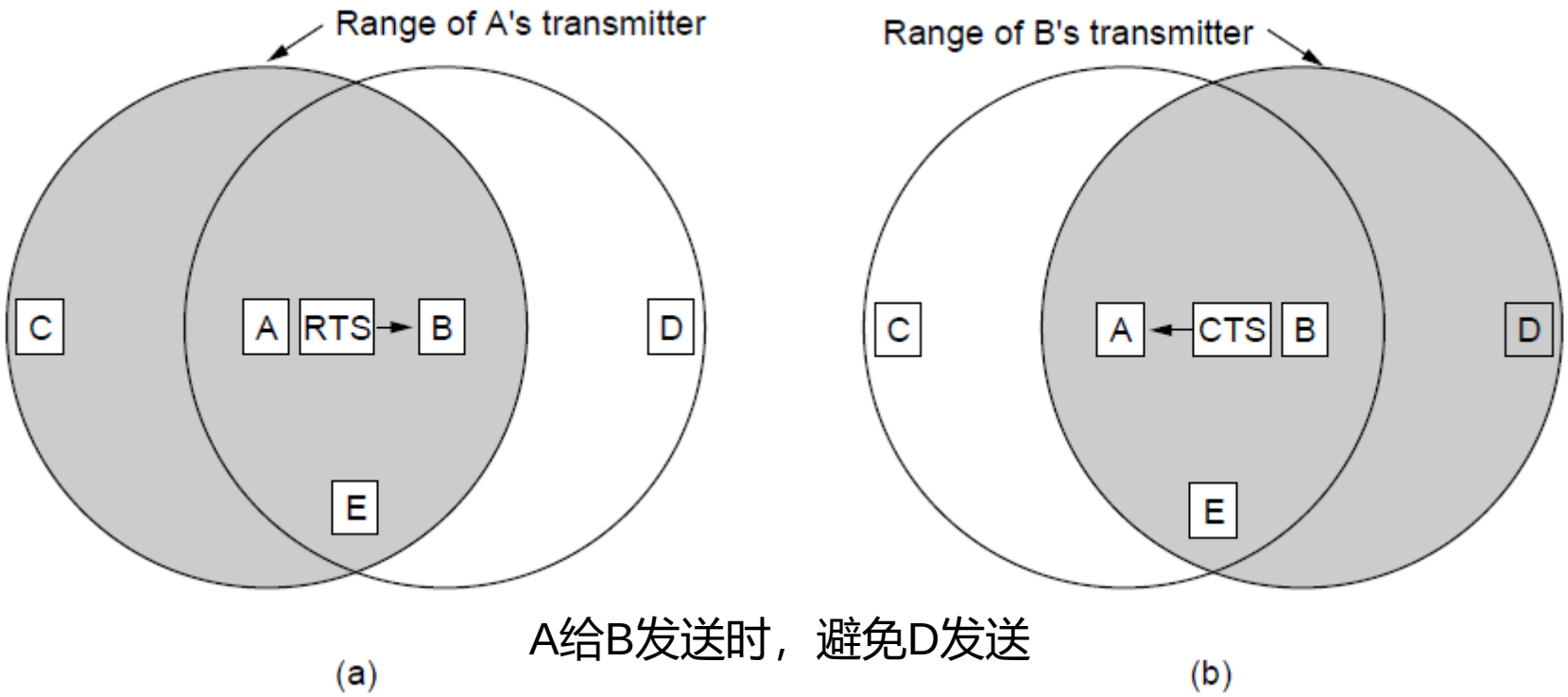
Wireless LAN Protocols (2)

- **exposed station problem**
  How can we tell *C* that it is allowed to transmit to *D*, because this will not interfere with the communication from *B* to *A*?



A wireless LAN. (b) B and C are exposed terminals when transmitting to A and D.

Wireless LAN Protocols (3)



A给B发送时，避免D发送

The MACA protocol. (a) *A sending an RTS to B. (b) B responding* with a CTS to *A.*

Ethernet (1 of 2)

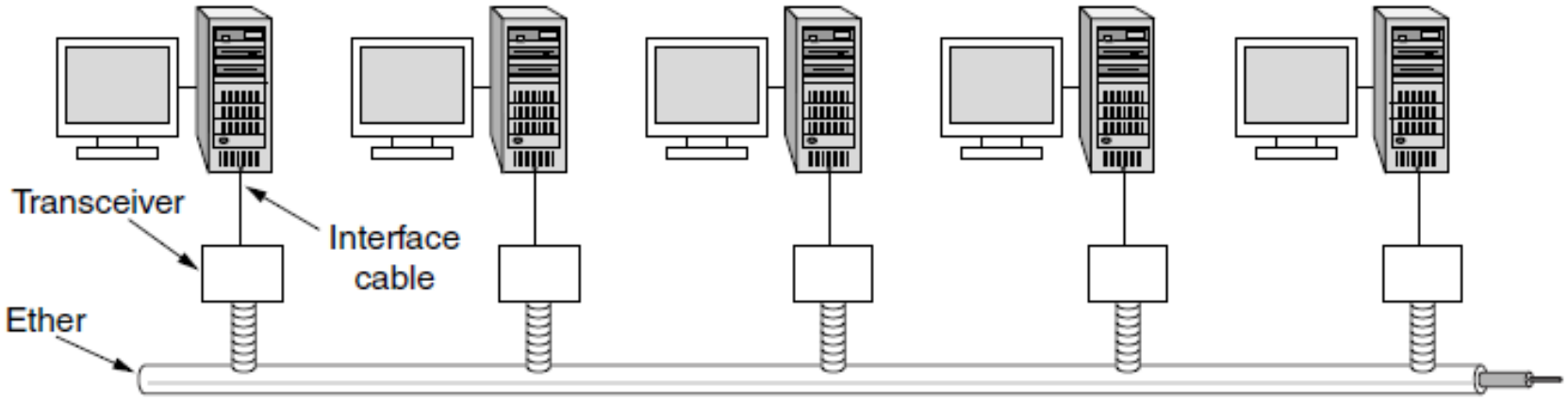
Bob Metcalfe.
Luminiferous ether
发光性乙醚

- Classic Ethernet physical layer
- Classic Ethernet MAC sublayer protocol
  - CSMA/CD with binary exponential backoff
- Ethernet performance
- Switched Ethernet
- Fast Ethernet

Ethernet (2 of 2)

- Gigabit Ethernet
- 10-Gigabit Ethernet
- 40- and 100-Gigabit Ethernet
- Retrospective on Ethernet

Classic Ethernet Physical Layer



Architecture of classic Ethernet

Classic Ethernet Physical Layer

- **Ethernet** stands for a near implementation of the **IEEE 802.3** protocol. It is CSMA/CD based (sense the channel, wait until idle, and back-off when you detect a collision).

Name	Cable	Max. dist.	Nodes/Seg.
10Base5	Thick coax	500 m	100
10Base2	Thin coax	200 m	30
10Base-T	Twisted pair	100 m	1024
10Base-F	Fiber optics	2000 m	1024

- **Note**: 10Base-T is popular as it can make use of telephone lines, and is easy to maintain when it comes to cable breaks (cables go to **hubs**). All four types are widely used

<传输速率 Mb/s> <传输方式> <网段最大长度 (*100m)>

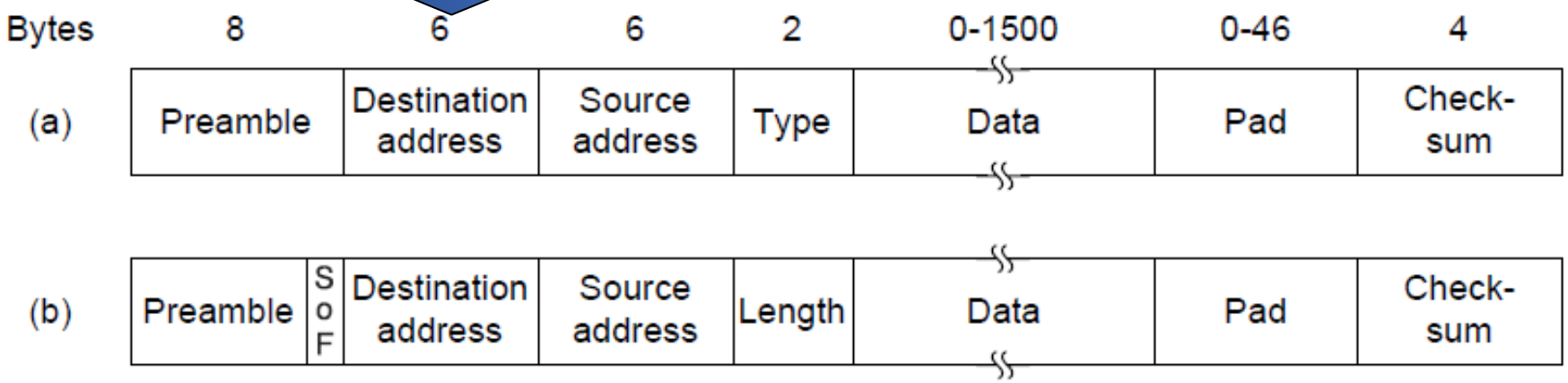
MAC Sublayer Protocol (1)

- IEEE Standard 802.3 and Ethernet
  - 802.3—1-persistent CSMA/CD LAN: When a station wants to transmit, it listens to the cable. If the cable is busy, the station waits until it goes idle; otherwise it transmits immediately. If two or more stations simultaneously begin transmitting on an idle cable, they will collide. All colliding stations then terminate their transmission, wait a random time, and repeat the whole process all over again.

- Ethernet: a specific product that almost implement 802.3 specifications.

MAC Sublayer Protocol (1)

第一位1-组播地址
全1-广播地址



帧的最大最小

1997年之前使用的类型字段都大于1500 (1536 0x600).
0x0800 IPv4 (2048) 1000 0000 0000

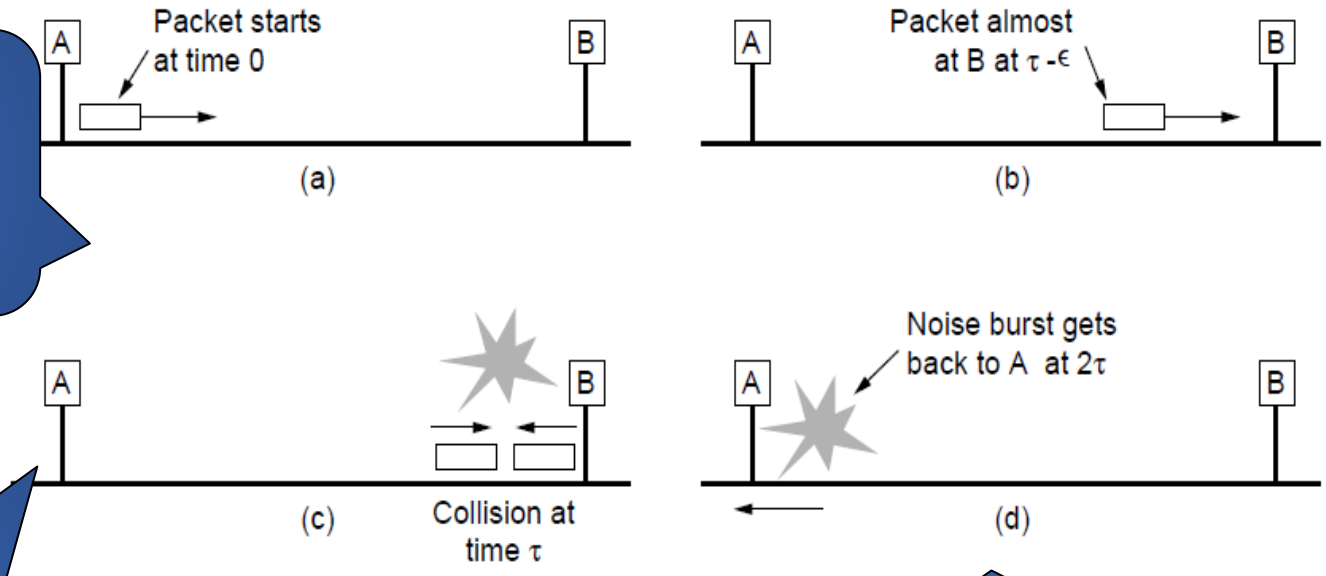
Frame formats. (a) Ethernet (DIX). (b) IEEE 802.3.

MAC Sublayer Protocol

2500米（四个中继器）往返时间 50 微秒。
10M发一个bit 100纳秒

- Collision detection can take as long as 2ζ . Actually 2 ζ=2(total DTE delay + total Repeaters delay + propagation delay)=51.2 μs for 10M Ethernet or 512 bit-time

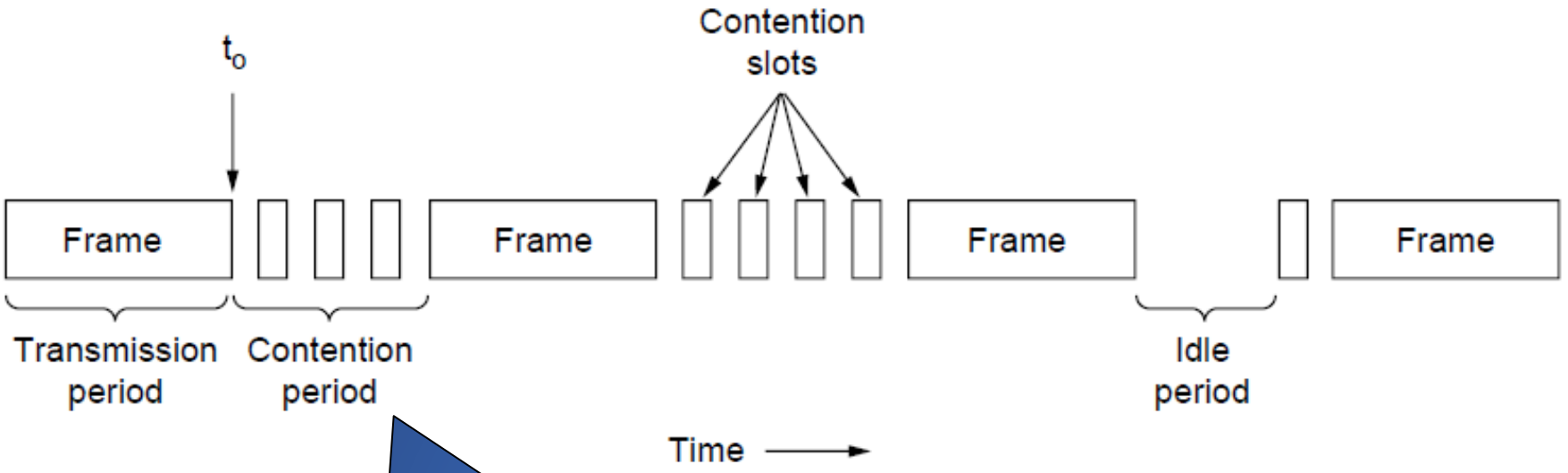
相互制约：
- 传输速率
- 点到点的距离
- 数据帧的长度



每一个检测到冲突的站，都发冲突信号，4-6字节的干扰串。

1） 区分有效帧和垃圾帧，
2） 避免一个短帧还没到达对方的时候，就已经发完了。

Flashback….



发现冲突2T。残缺帧64字节。

有一点点像分槽ALOHA。时间槽：64B

MAC Sublayer Protocol (3)

- After *i* collisions, a random number between 0 and $2^i - 1$ is chosen, and that number is skipped. After 10 collisions have been reached, the randomization interval is frozen at a maximum of 1023 slots. After 16 collisions, the controller throws in the towel and reports failure back to the computer.

Ex: 1st collision, slots selected from 0, 1;

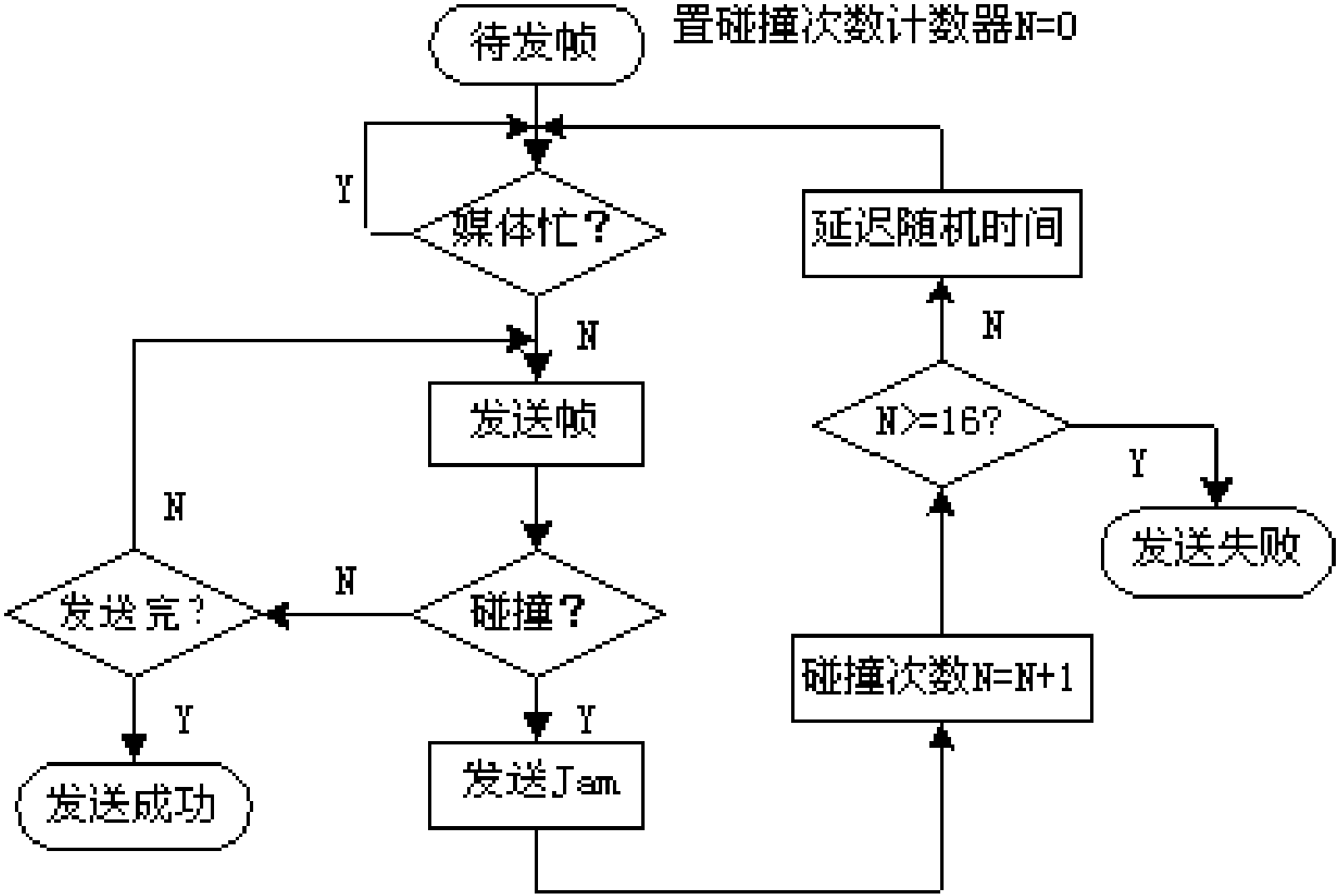
2nd collision, slots selected from 0, 1, 2, 3;

3rd collision, slots selected from 0, 1, … 7;

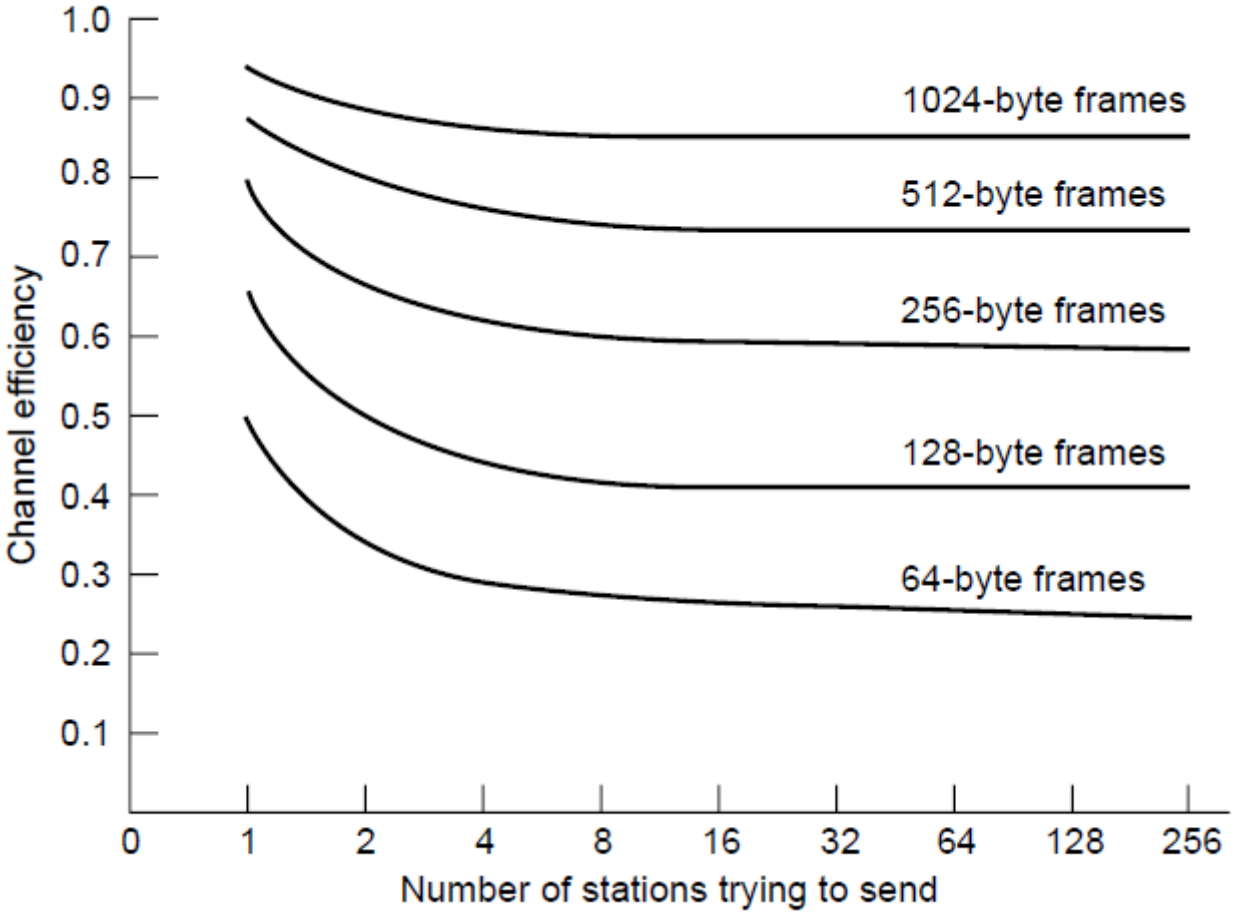
10th collision, slots selected from 0, 1, …,1023

随机时间的定义： 随机数 1，2，3，4，单位是时间槽。

低负载的时候**降低延时**，在高负载的时候**提高信道利用率**


待发帧
置碰撞次数计数器N=0
Y
媒体忙?
N
发送帧
N
碰撞?
N
发送完?
Y
发送成功
Y
发送Jam
碰撞次数N=N+1
N
N>=16?
Y
发送失败
延迟随机时间

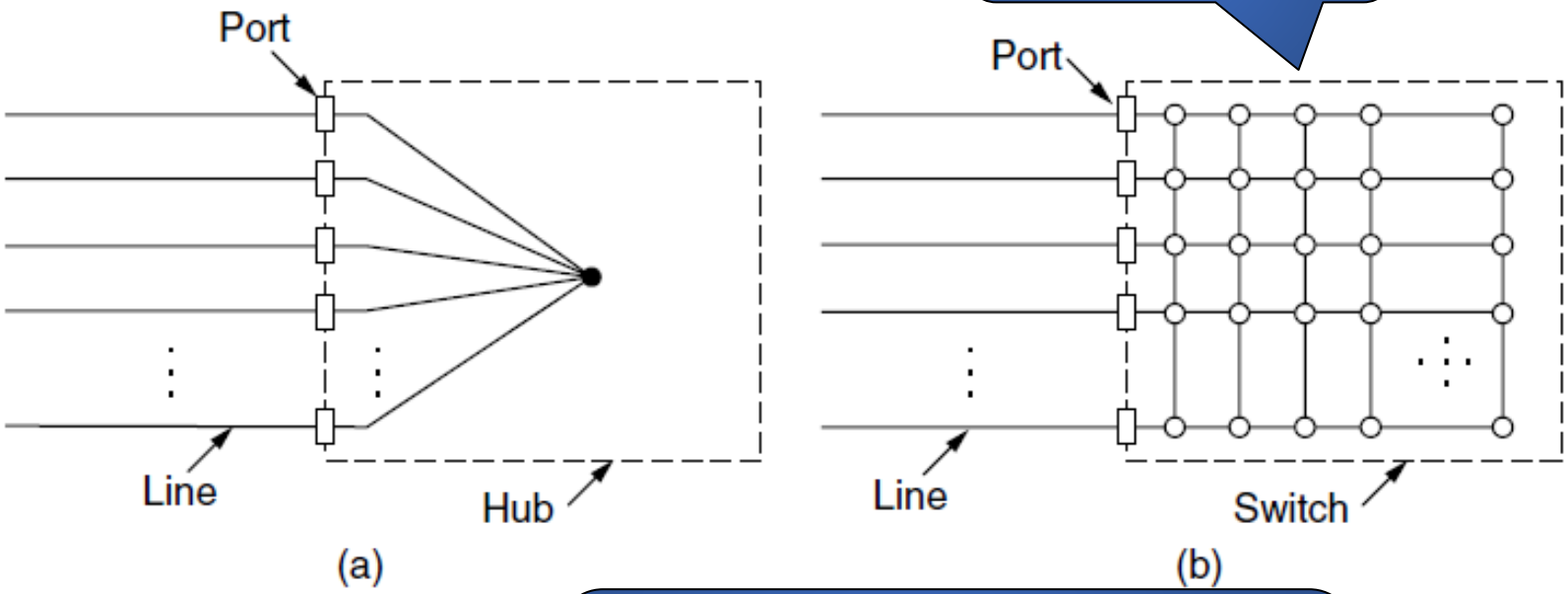
Ethernet Performance



Efficiency of Ethernet at 10 Mbps with 512-bit slot times.

Switched Ethernet (1)

只把帧输出到该帧想去的端口



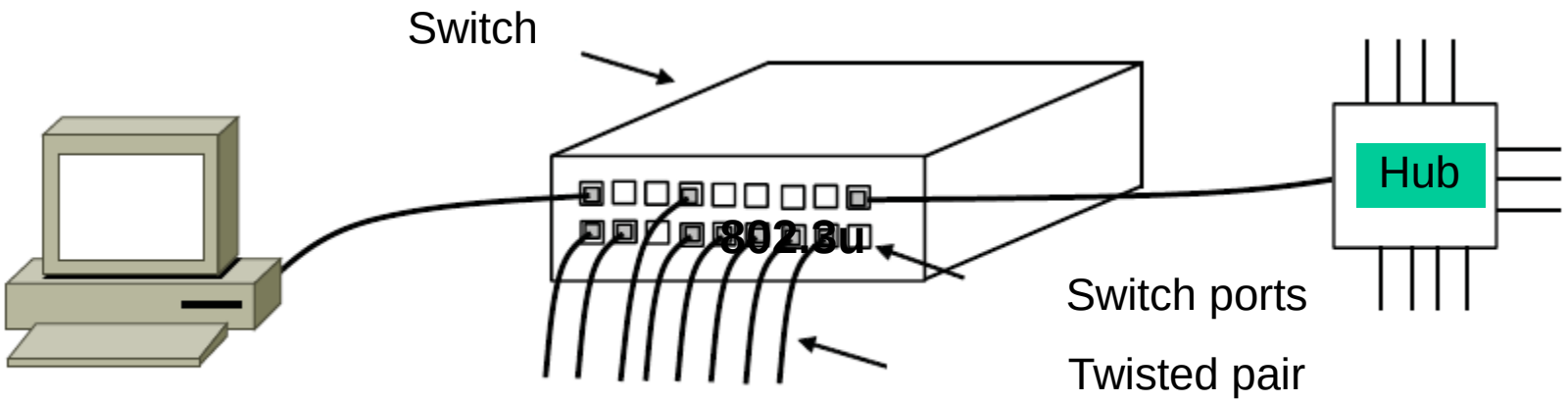
优点

1）没有冲突，同时发提高吞吐量。（冲突域）

2）有利于安全 （混杂模式）

(a) Hub. (b) Switch.

Switched Ethernet (2)



An Ethernet switch.

Fast Ethernet（802.3u）

快速以太网：210m

- Upgrade existing base of LANs (i.e. Ethernets) in such a way that the interfaces remain the same, but the capacity goes up, that is the 100 Mbps Ethernet.
- Data formats, interfaces, and protocols are all the same. That means that we can only drop the bit time from 100 nsec to 10 nsec. Just telling everyone to **shorten their wires**.

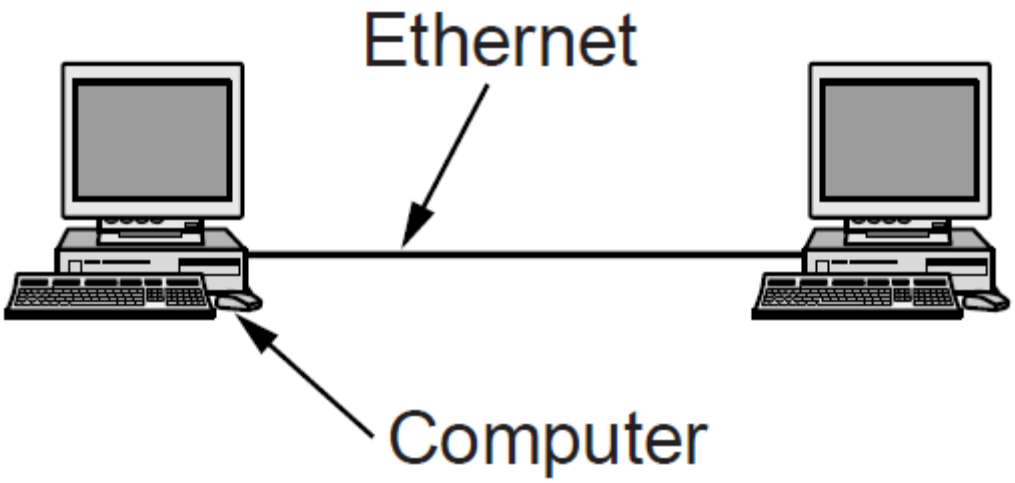
速度加快10倍

Fast Ethernet（ 802.3u ）

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

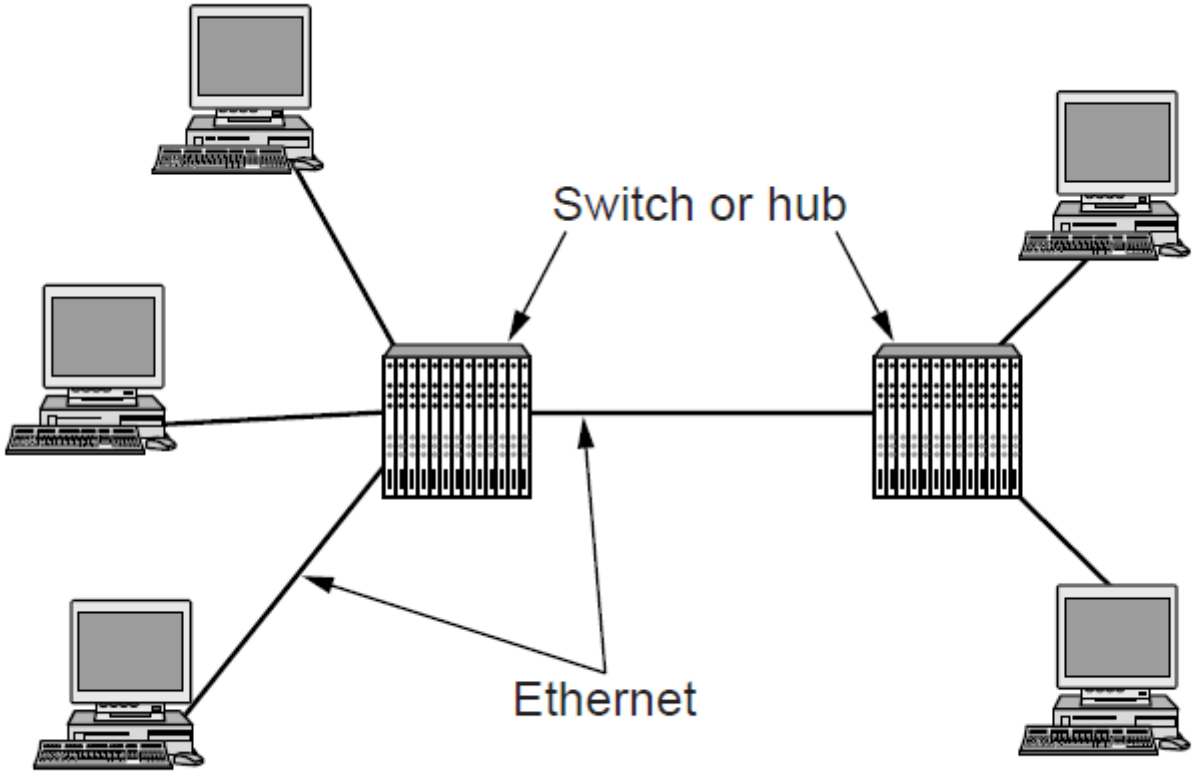
The original fast Ethernet cabling.

Gigabit Ethernet (1)



A two-station Ethernet

Gigabit Ethernet (2)



A two-station Ethernet

Gigabit Ethernet (

千兆以太网：200m

- **载波扩展**
  - 根本目的在于扩展网络的物理覆盖范围，由物理层控制，而帧填充是由链路层控制
  - 共享式千兆时间槽增加到512B，10M和100M Ethernet都是64B
  - 最小帧长度保持在64B
  - 发送的数据帧超过512B，则无需载波扩展，若处于64B－512B之间，需要载波扩展

- **帧突发**
  - 数据包捆绑：在一个时间槽内捆绑多个网络帧，提高带宽使用效率，但需要彻底改变MAC接口

10 Gigabit Ethernet

Name	Cable	Max. segment	Advantages
10GBase-SR	Fiber optics	Up to 300 m	Multimode fiber (0.85μ)
10GBase-LR	Fiber optics	10 km	Single-mode fiber (1.3μ)
10GBase-ER	Fiber optics	40 km	Single-mode fiber (1.5μ)
10GBase-CX4	4 Pairs of twinax	15 m	Twinaxial copper
10GBase-T	4 Pairs of UTP	100 m	Category 6a UTP

Gigabit Ethernet cabling

4.4 Wireless Lans

802.11 architecture and protocol stack

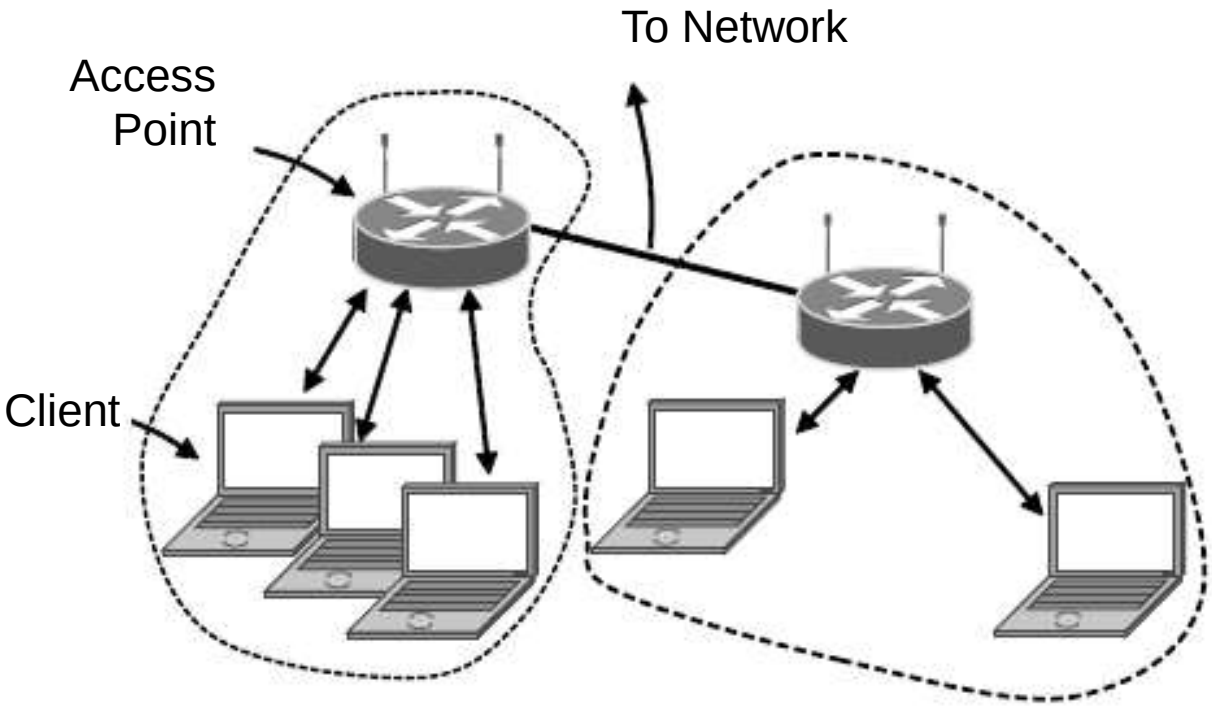
802.11 physical layer

802.11 MAC sublayer protocol

802.11 frame structure

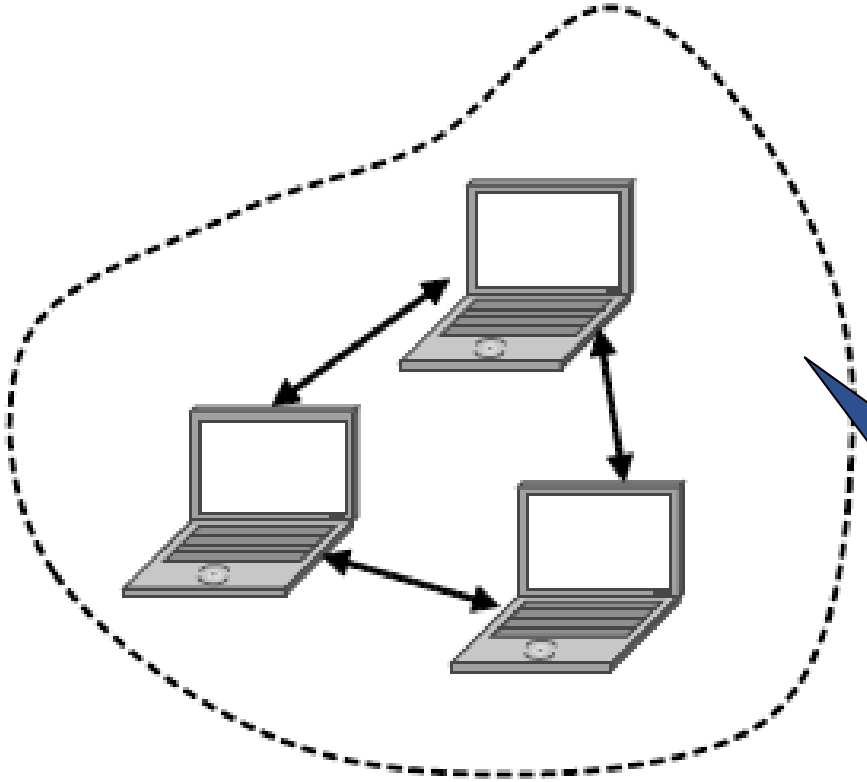
Services

802.11 Architecture and Protocol Stack (1)



802.11 architecture – infrastructure mode

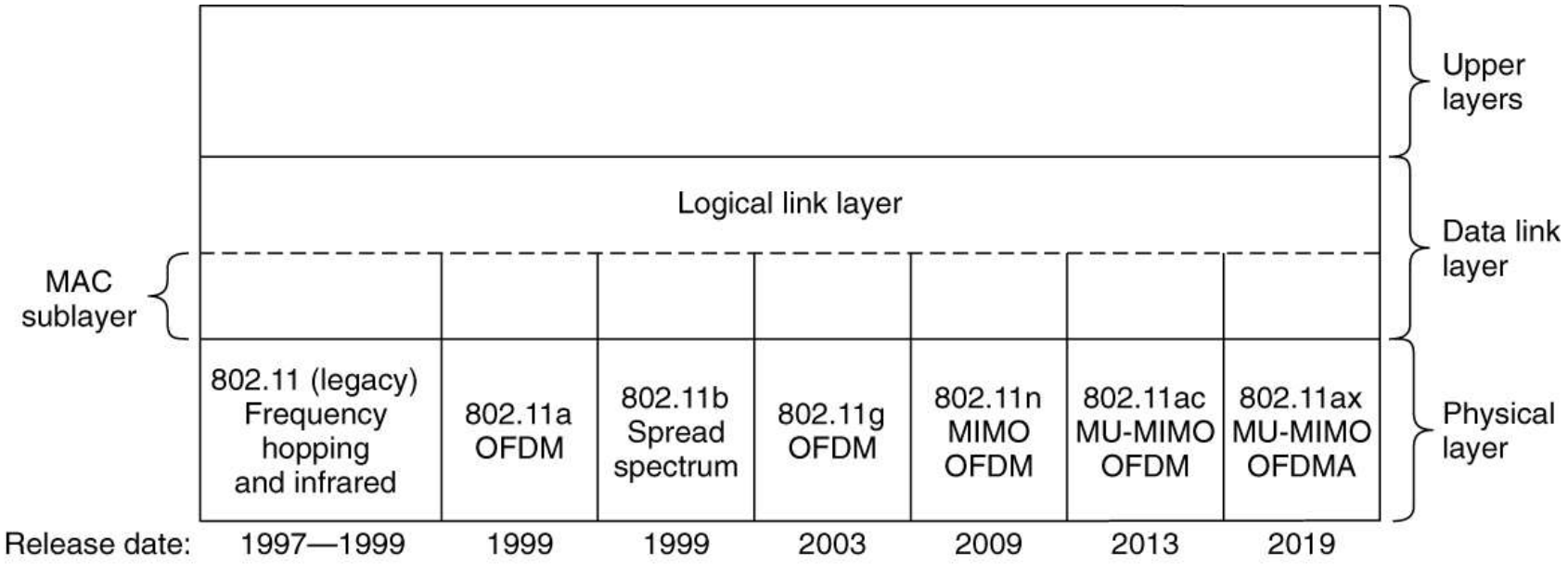
802.11 Architecture and Protocol Stack (2)



自组织对等式多跳移动通信网络。Ad Hoc源于拉丁语，意思是“for this”引申为“for this purpose only”

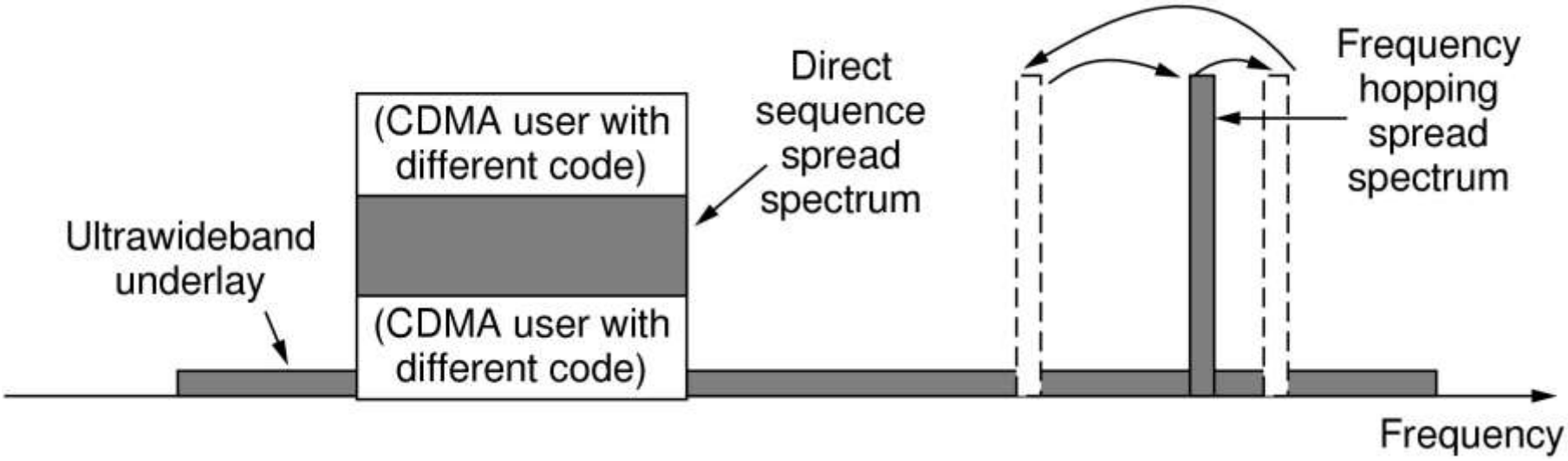
802.11 architecture – ad-hoc mode

802.11 Architecture and Protocol Stack (3)



Part of the 802.11 protocol stack.

Flashback…



Spread spectrum and ultra-wideband (UWB) communication

802.11 Architecture and Protocol Stack (3)

商品介绍 规格参数 包装清单 商品评价(196057) 售后保障 新人188礼包移动专享

商品名称：TP-LINKTL-WDR5600 商品编号：1361933 品牌：普联（TP-LINK） 商品毛重：0.74kg

商品产地：中国大陆 类别：无线路由，智能路由器，安全.. 协议：802.11n，802.11ac 适用范围：家庭路由

更

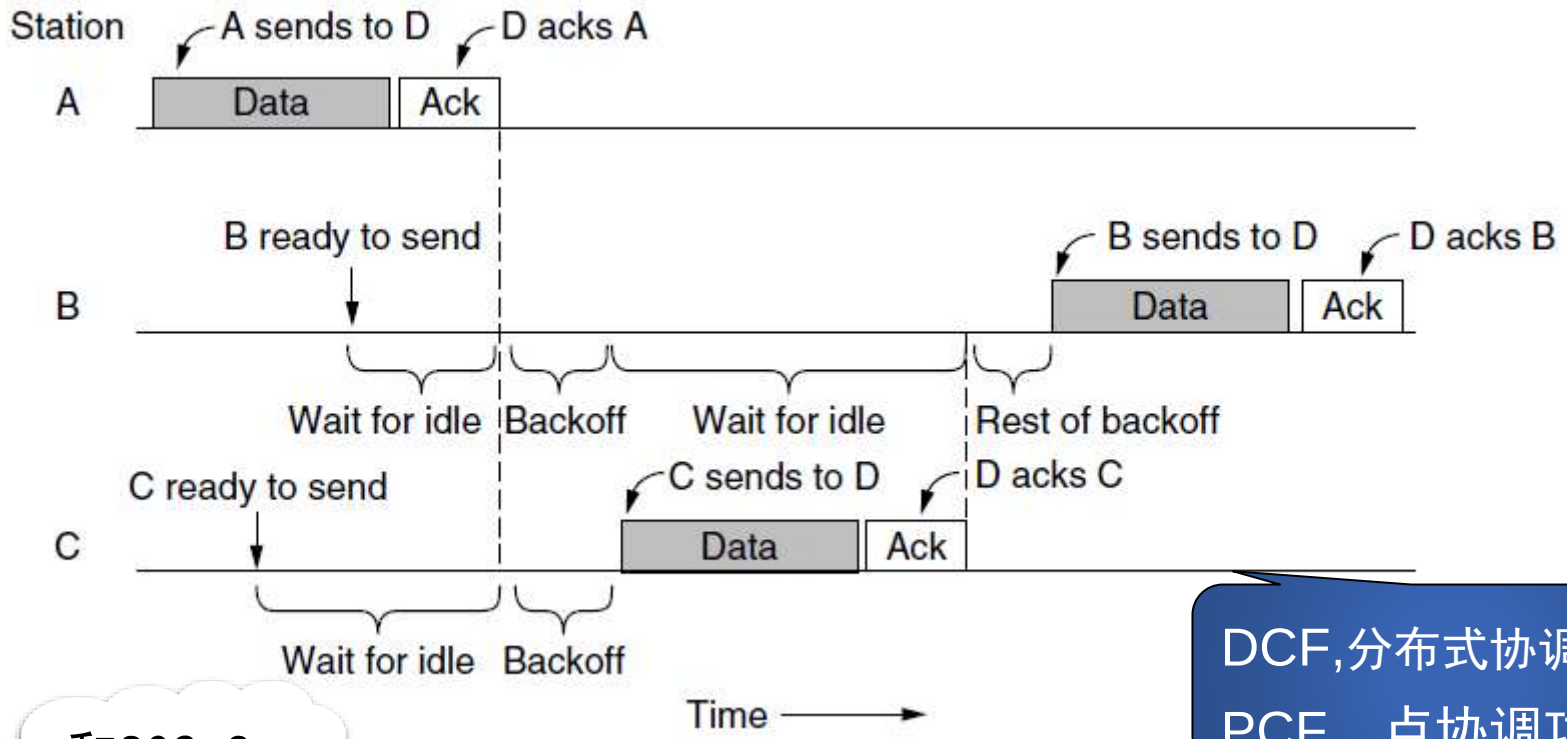
¥149.00

TP-LINK TL-WDR5600 900M 11AC大户型智能双频无线路由器 家用穿墙王【京

已有196058人评价

对比 关注 加入购物车

The 802.11 MAC Sublayer Protocol (1)



Sending a frame with CSMA/CA.

DCF,分布式协调功能

PCF，点协调功能

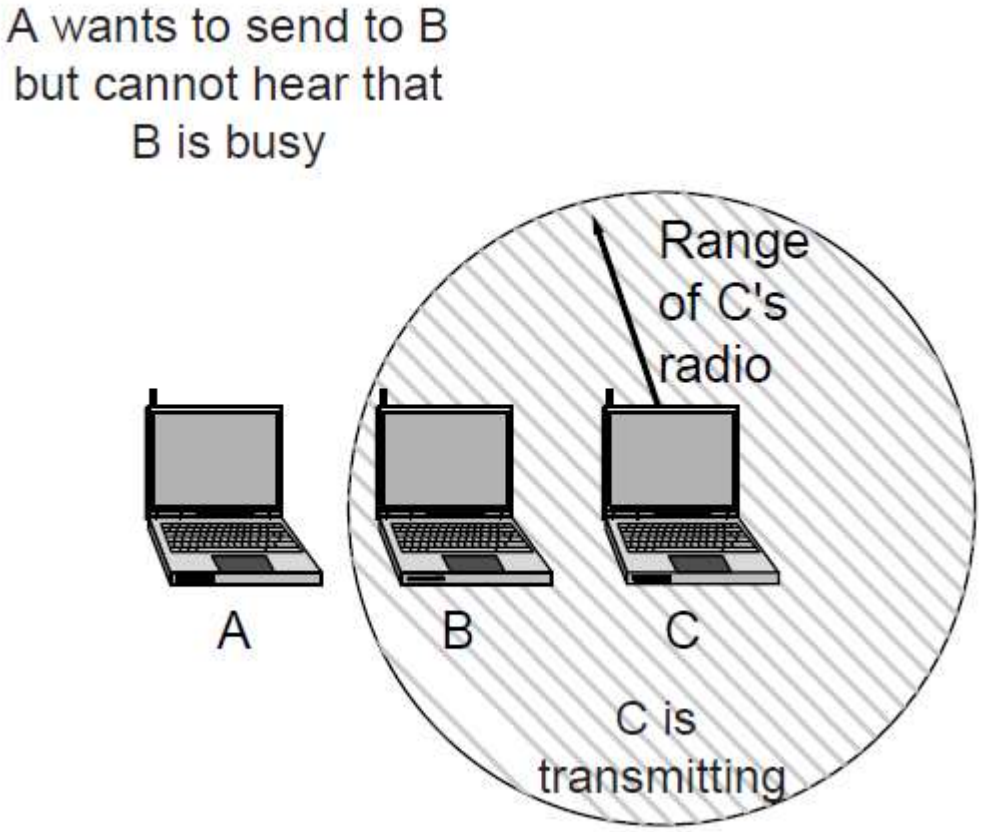
和802. 3的不同

因为冲突无法被检测：

1） 早期的后退避免冲突。

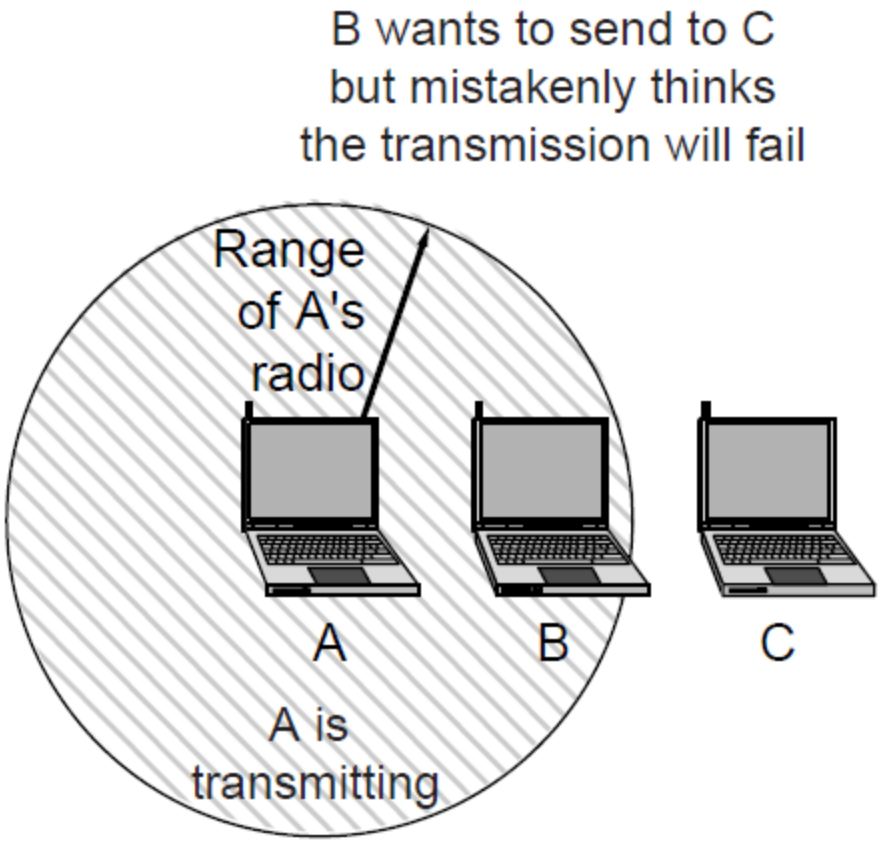
2）用ACK确认来推断是否发生冲突。

The 802.11 MAC Sublayer Protocol (2)



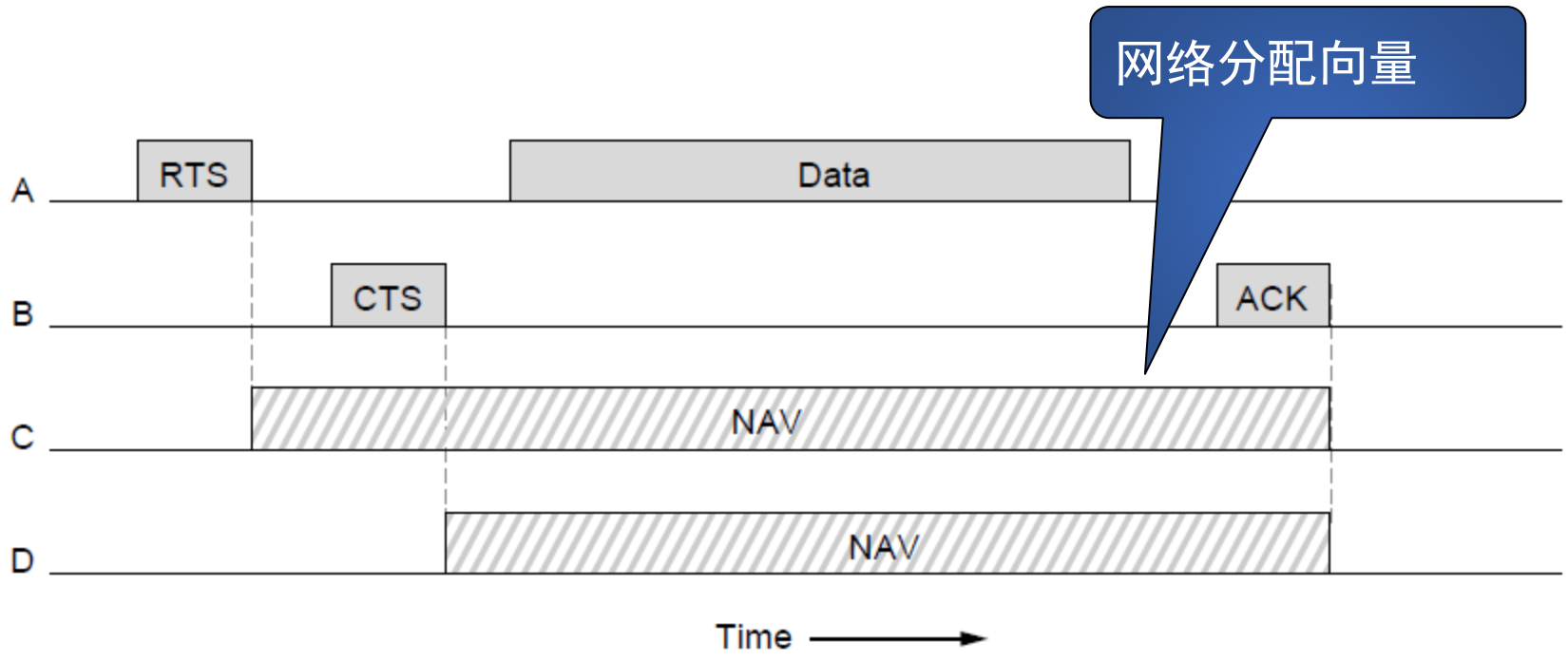
The hidden terminal problem.

The 802.11 MAC Sublayer Protocol (3)



The exposed terminal problem.

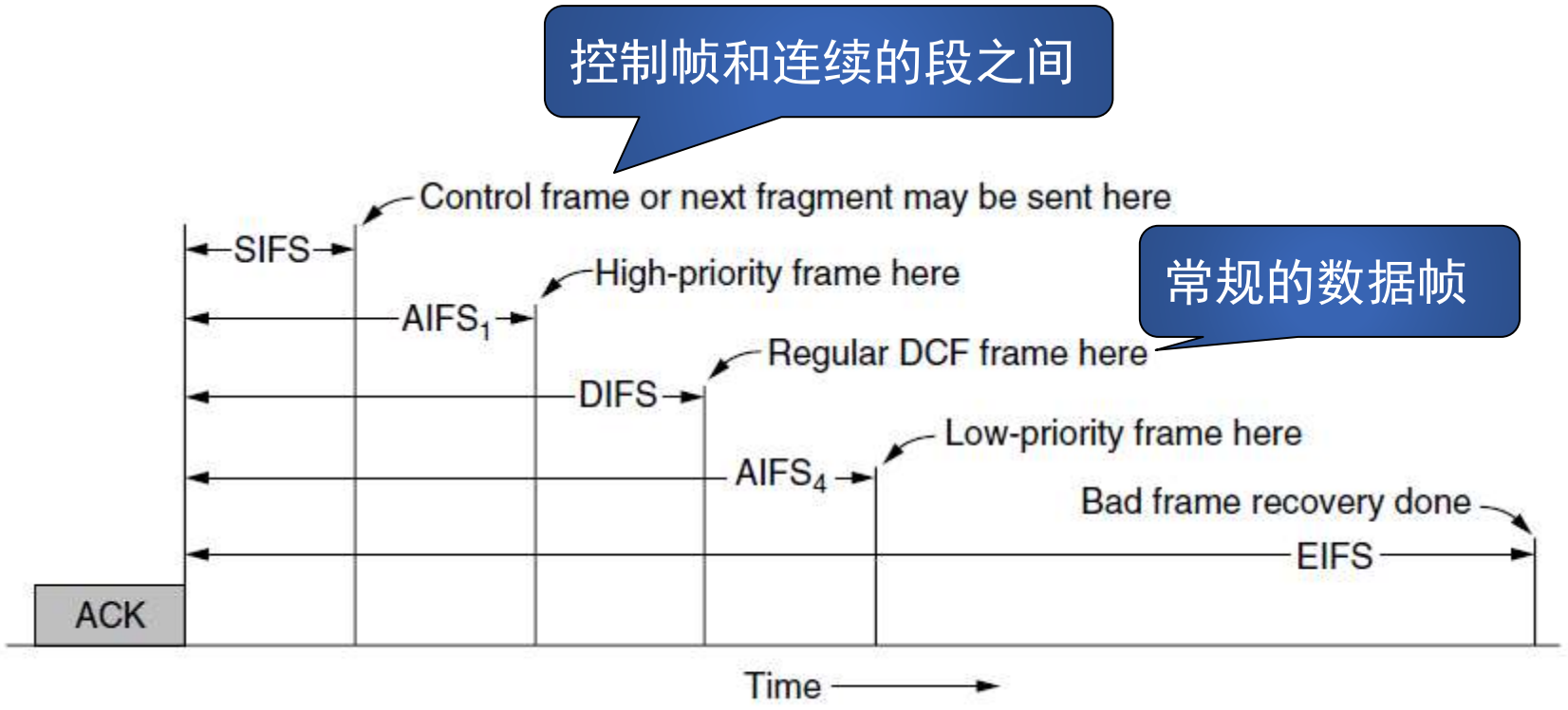
The 802.11 MAC Sublayer Protocol (4)



The use of virtual channel sensing using CSMA/CA.

C-A-B-D

The 802.11 MAC Sublayer Protocol (5)



Interframe spacing in 802.11

The 802.11 MAC Sublayer Protocol (5)

① 一个工作站希望在无线网络中传送数据，如果没有检测到网络中正在传送数据，则附加等待一段时间间隔DIFS;

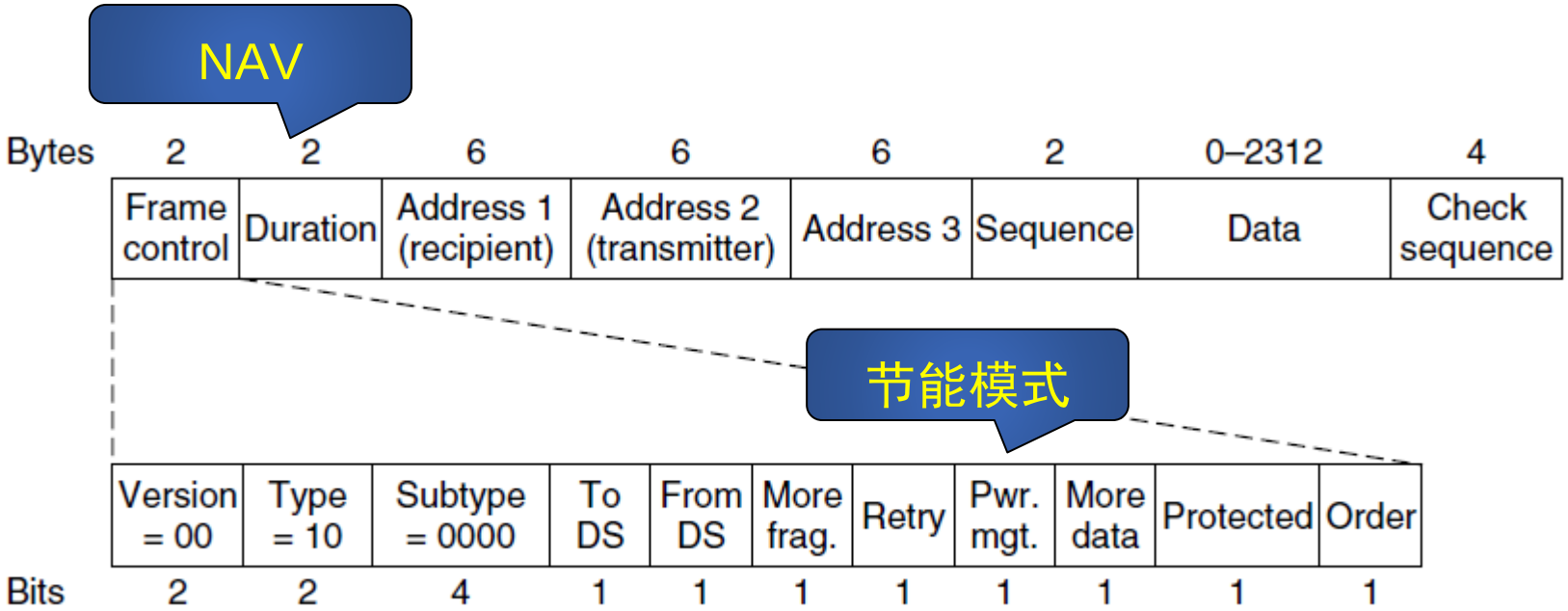
② 再随机选择一个时间片继续探测，如果无线网路中仍旧没有活动的话，则发送一个请求发送帧RTS;

③ 接收工作站收到RTS帧后，等待短暂时间间隔SIFS后发一个清除发送控制帧CTS，用于指明准备接收数据。

④ 在再次等待一个SIFS间隔后，发送端开始发送数据；

⑤ 接收端收到数据后也等待SIFS时间后发送ACK帧指示数据已经到达。

802.11 Frame Structure



发往AP：AP 源 目的

来自AP：接收 AP 原始的源

Format of the 802.11 data frame

WIFI

Wi-Fi联盟（全称：国际Wi-Fi联盟组织），英语：*Wi-Fi Alliance*，简称WFA），是一个商业联盟，拥有 Wi-Fi的商标。它负责Wi-Fi 认证与商标授权的工作，总部位於美国德州奥斯汀（Austin）。 成立于1999年，主要目的是在全球范围内推行Wi—Fi产品的兼容认证，发展IEEE802.11标准的无线局域网技术。目前，该联盟成员单位超过200家，其中42%的成员单位来自亚太地区，中国区会员也有5个。

Services

- Association and data delivery
- Security and privacy
- Prioritization and power control

4.5 Bluetooth

Bluetooth architecture

Bluetooth applications

Bluetooth protocol stack

Bluetooth radio layer

Bluetooth link layers

Bluetooth frame structure

Bluetooth 5

海盗王，harald blaatand

Bluetooth

短距离、低功耗、低成本的无线电连接

- **Essence:** Bluetooth is to allow very different (portable and fixed) devices located in each other's proximity to exchange information:

  - Let very different portable devices (PDA, cellular phone, notebook) set up connections
  - Replace many of the existing cables (headset, keyboard, mouse, printer)
  - Provide better wireless connection (handsfree solutions)
  - Provide wireless access to Internet entry points
  - Relatively high bandwidth: 1Mbit/second

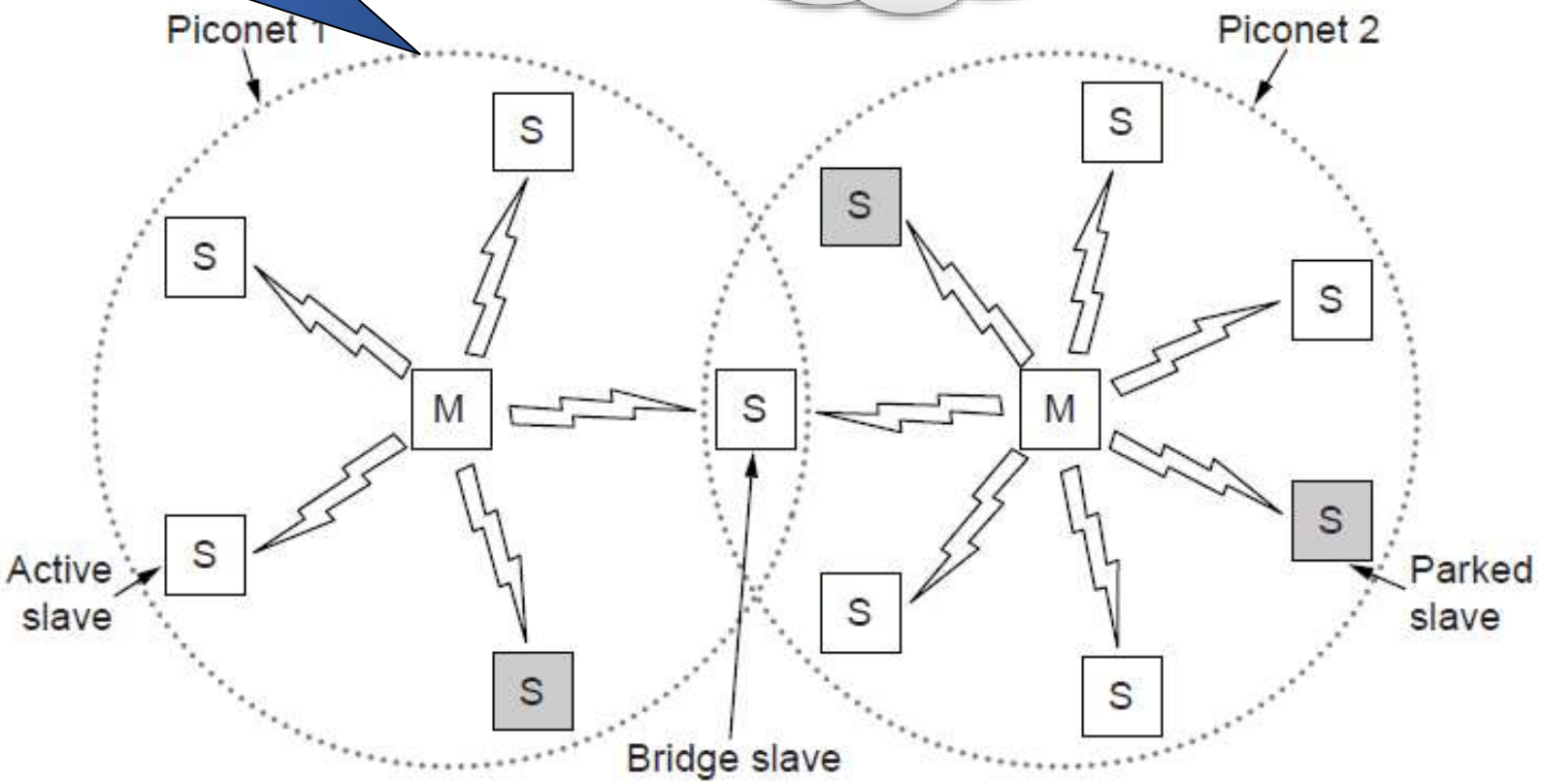
Bluetooth Architecture

- **piconet**:
  - A collection of devices that communicate. The collection is set up by a single **master device**, probing for other devices to join as **slaves**
  - Up to seven slaves can be active in the same piconet; more slaves may be in a (low power) "parked" state
- **Important:**
  - Overlapping piconets form a **scatternet**
  - A device can participate in multiple (overlapping) piconets

Bluetooth Architecture

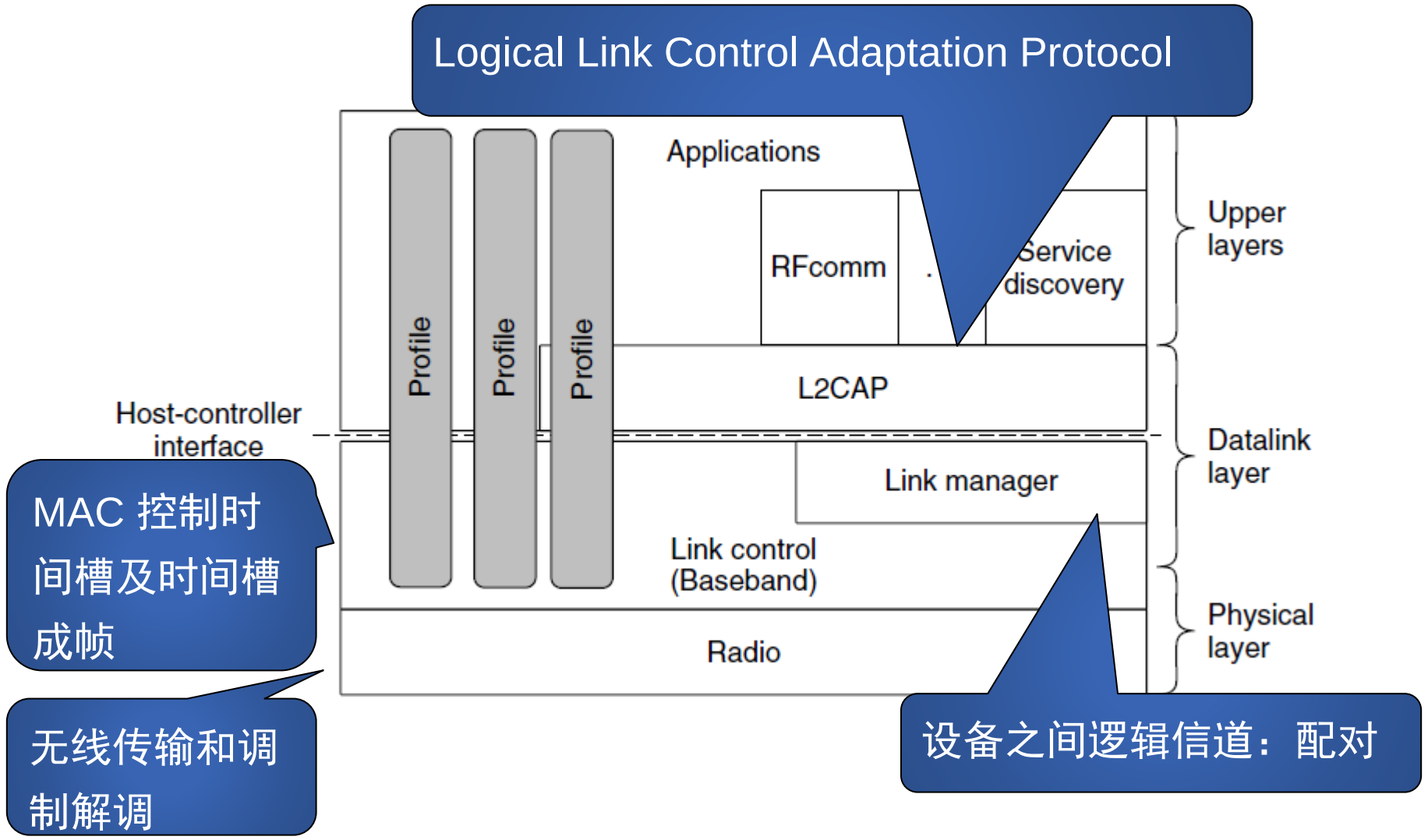
集中式的TDM系统

什么系统？



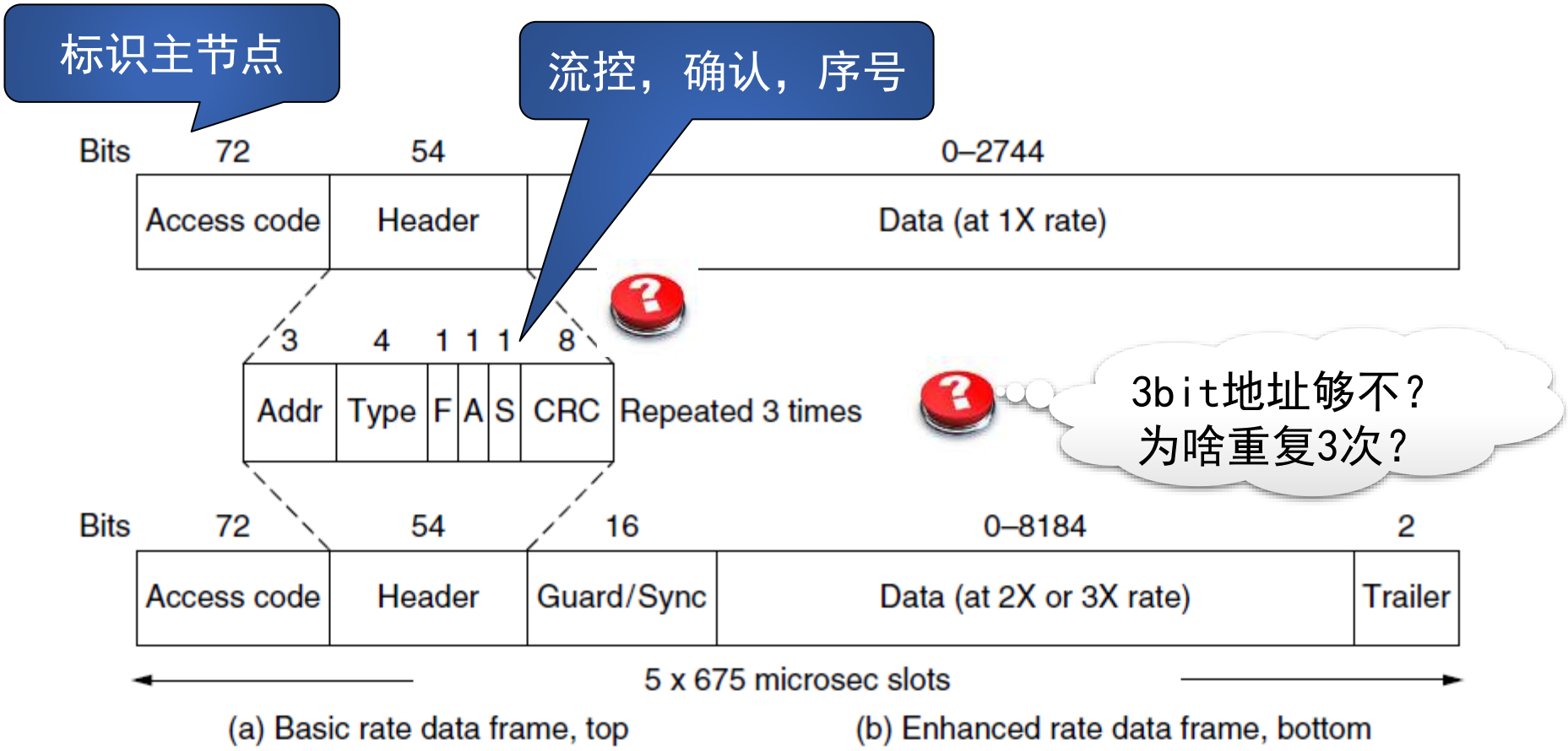
Two piconets can be connected to form a scatternet

Bluetooth Protocol Stack



The Bluetooth protocol architecture.

Bluetooth Frame Structure



Typical Bluetooth data frame at (a) basic, and (b) enhanced, data rates.

Bluetooth Future

- LAN access: let a bunch of Bluetooth devices set up a wireless LAN
- Electronic business cards
- File transfer
- Automatic synchronization between computers and other devices
- Car (in-vehicle) communication
- High-quality audio/video
- Geographical positioning

Bluetooth 5

- Support for Internet of Things devices
- Speed increased from 1 Mbps to 2 Mbps
- Message size has gone up from 31 bytes to 255 bytes
- Range indoors has gone up from 10 m to 40 m
- Power requirements have been reduced slightly
- Range of the beacons has gone up slightly
- Slightly better security

4.6 RFID

Electronic Product Code
电子产品码

Radio Frequency
Identification 无线射频识别

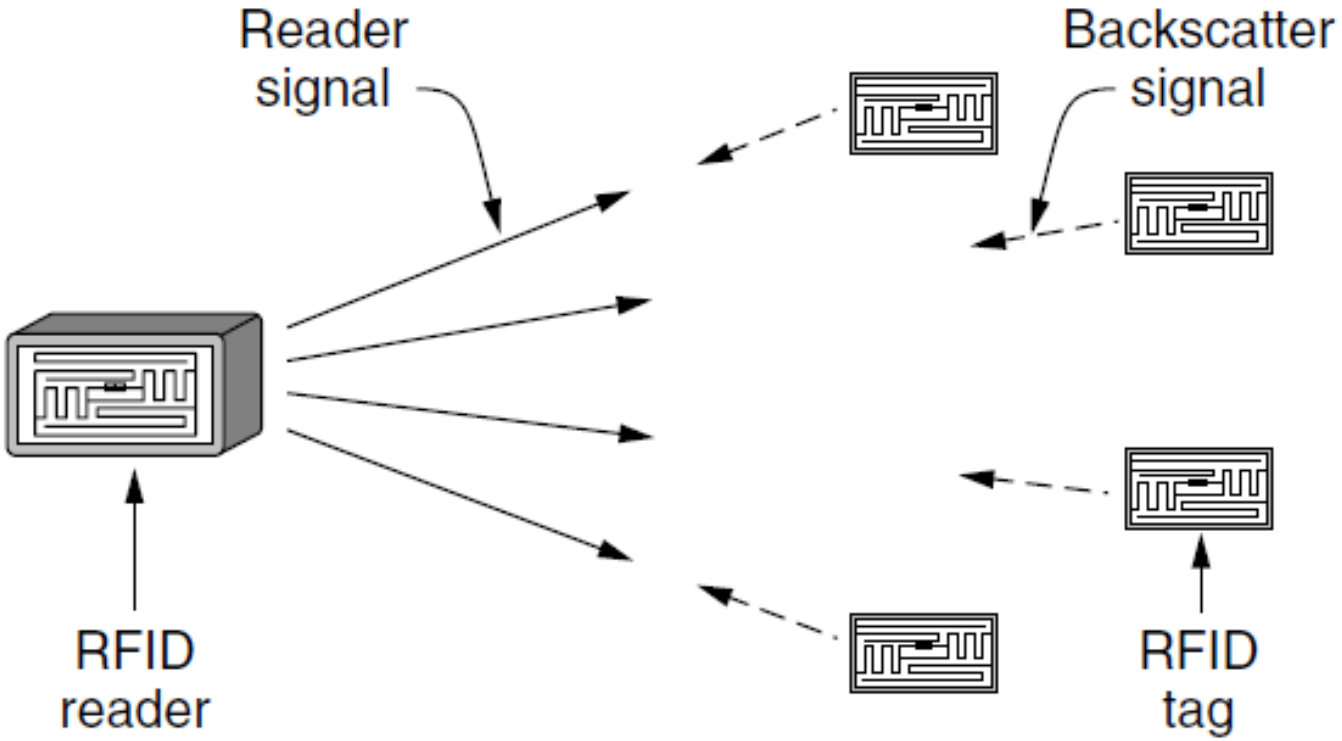
- EPC Gen 2 architecture
- EPC Gen 2 physical layer
- EPC Gen 2 tag identification layer
- Tag identification message formats

条形码？

RFID技术具有条形码所不具备的防水、防磁、耐高温、使用寿命长、读取距离大、标签上数据可以加密、存储数据容量更大、存储信息更改自如等优点

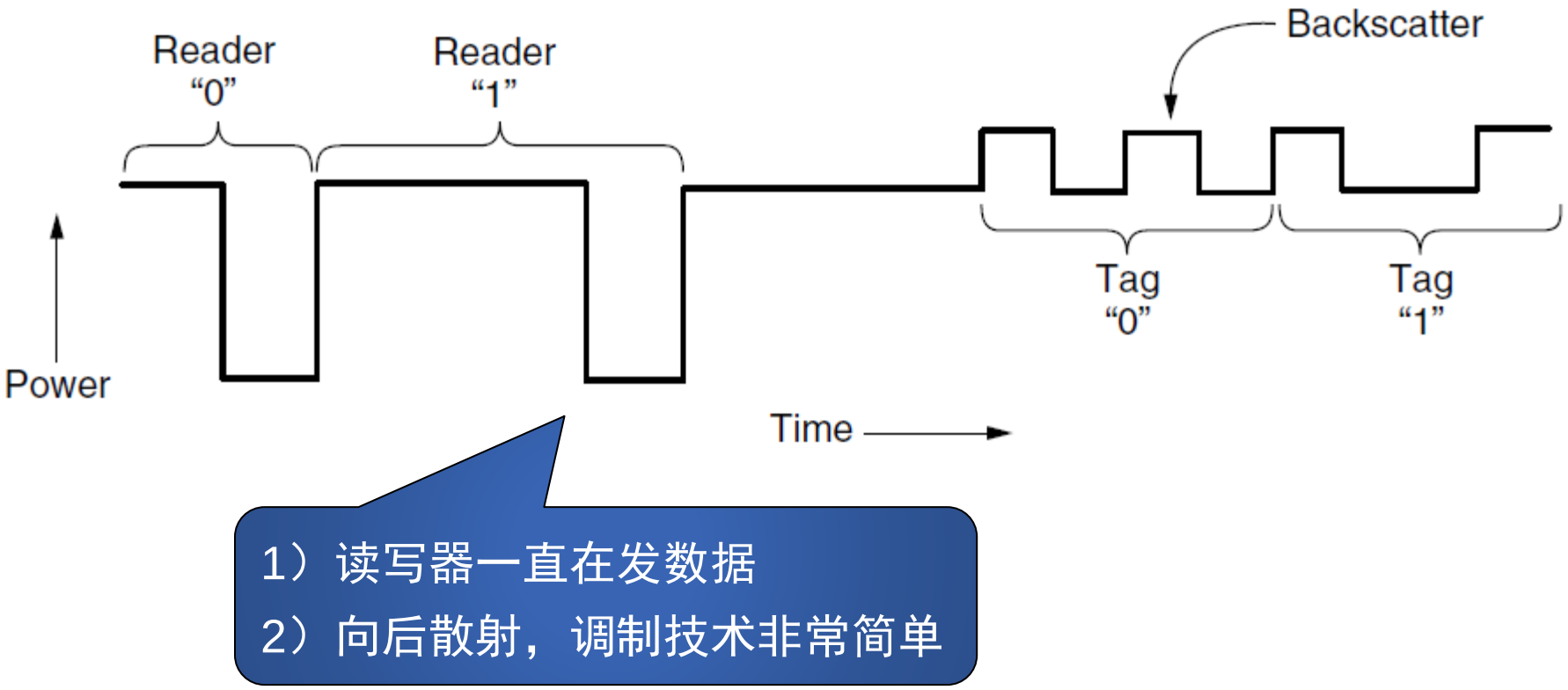
EPC Gen 2 Architecture

1） 读写器的多路访问，多个标签的竞争
2） 多个读写器的竞争



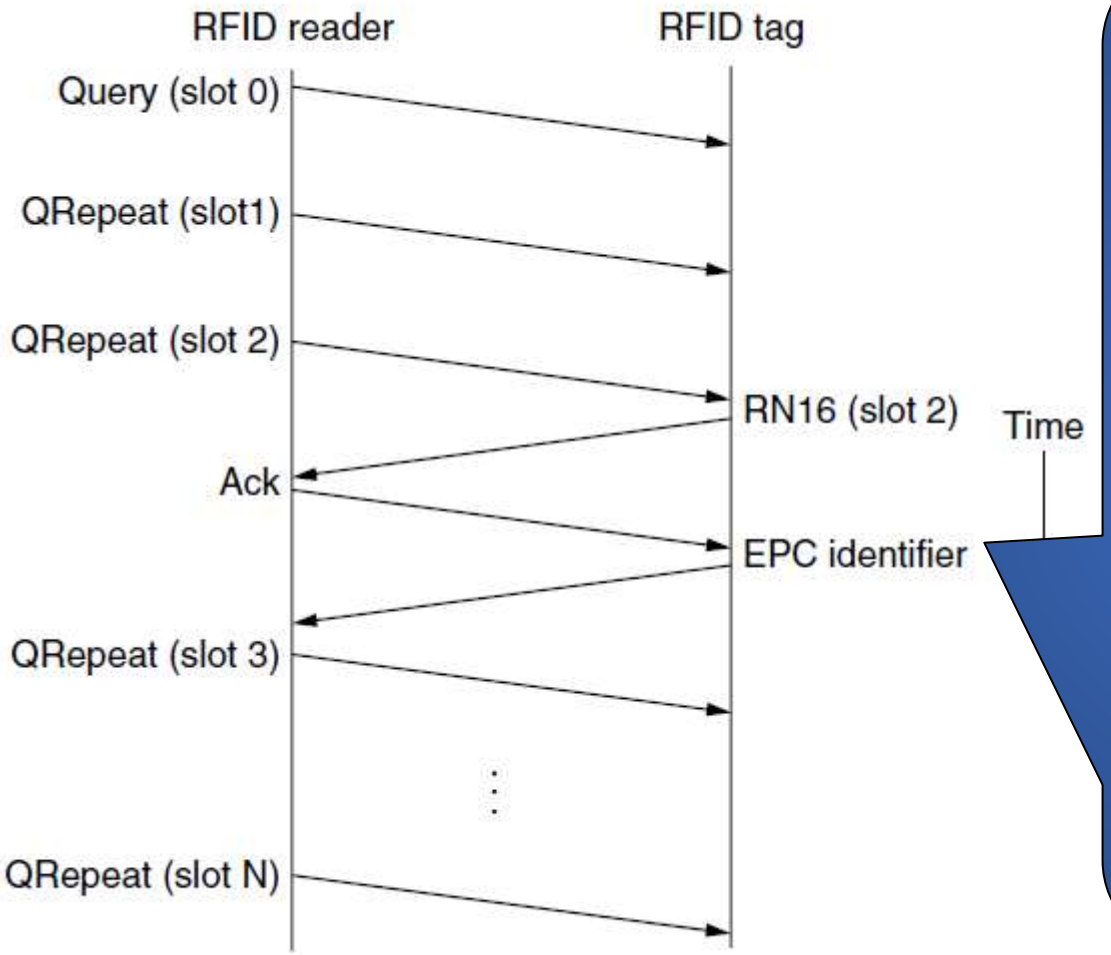
RFID architecture.

EPC Gen 2 Physical Layer



Reader and tag backscatter signals.

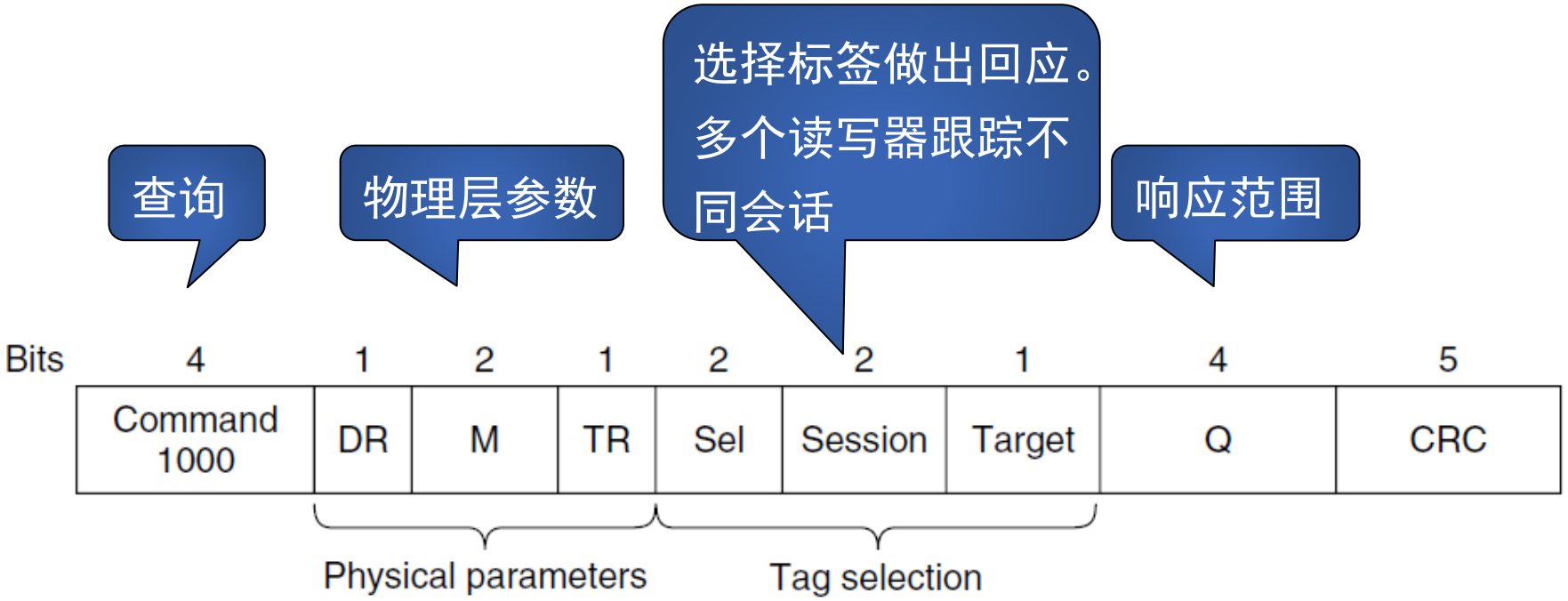
EPC Gen 2 Tag Identification Layer



- 最接近的是分槽ALOHA
- 读写器告诉标签的时间槽范围，标签在此范围内响应
- 标签选择一个时间槽，先发RN16
- 收到读写器ACK后，再发EPC

Example message exchange to identify a tag.

Tag Identification Message Formats



返回的消息就是标签：标签不止是识别符，一些新的研究标签有传感器，可以运行小程序。。

Format of the Query message.

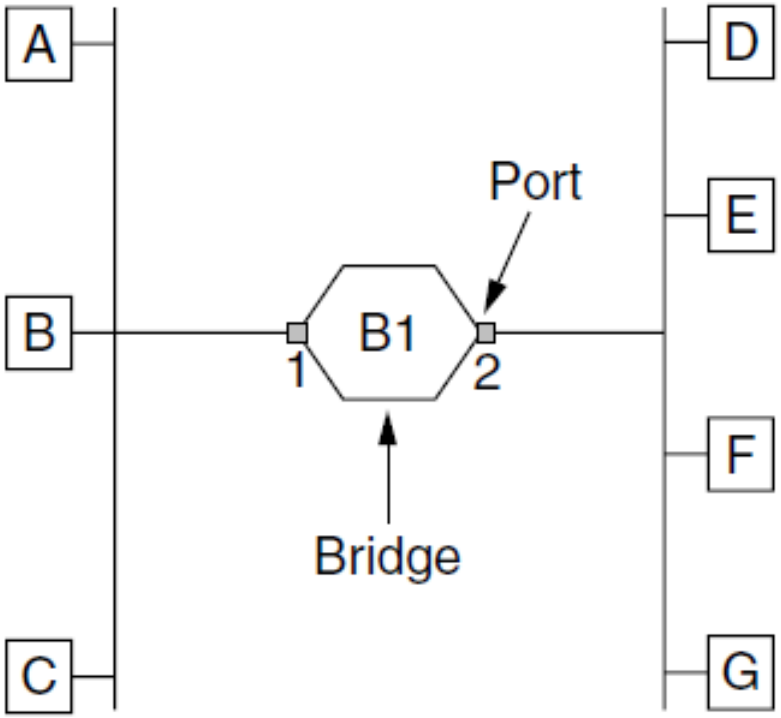
4.7 Data Link Layer Switching

物理上，多LAN连起来或者划分

- Uses of bridges
- Learning bridges
- Spanning tree bridges
- Repeaters, hubs, bridges, switches, routers, and gateways
- Virtual LANs

  -The IEEE 802.1Q standard

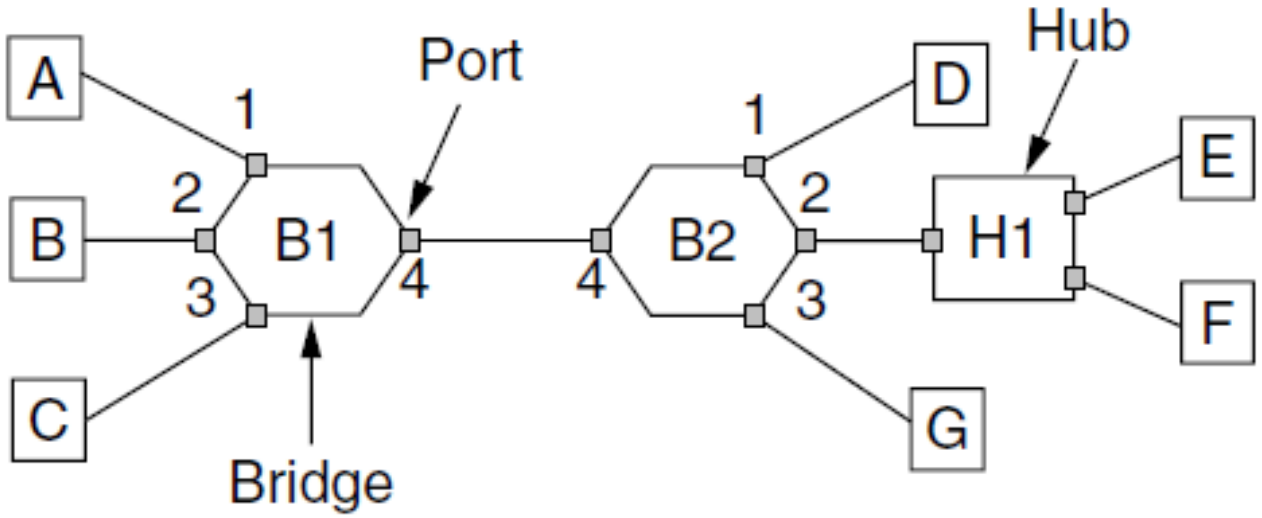
Learning Bridges (1)



Bridge connecting two multidrop LANs

Learning Bridges (2)

A—B, A---D, A--E



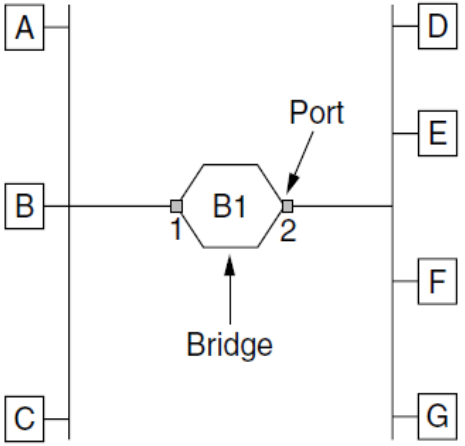
Bridges (and a hub) connecting seven point-to-point stations.

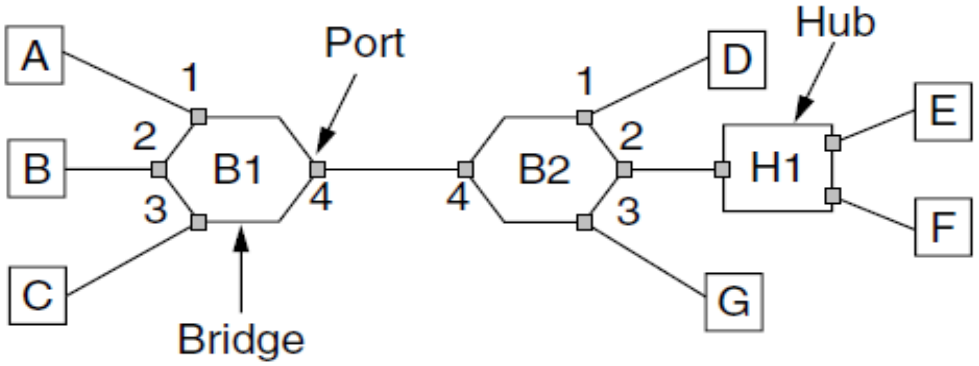
Learning Bridges (2)

- Flooding algorithm
  - Every incoming frame for a **unknown destination** is output on all the LANs to which the bridge is connected except the one it arrived on.
- Backward learning
  - The bridges operates in **promiscuous mode**, so they see every frame sent on any of their LANs. By looking at the source address, they can tell which machine is accessible on which LAN.

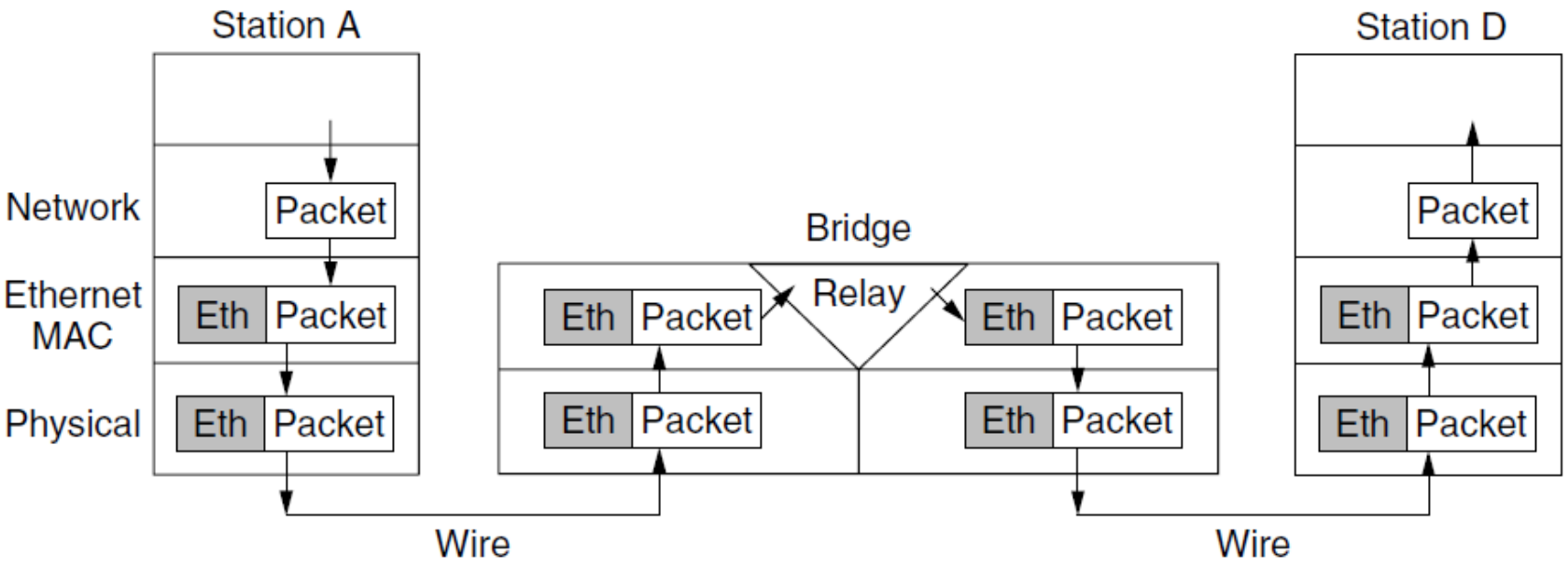
Learning Bridges (2)

- Routing strategies
  - If destination and source LANs are the same, discard the frame.
  - If the destination and source LANs are different, forward the frame.
  - If the destination LAN is unknown, using flooding.



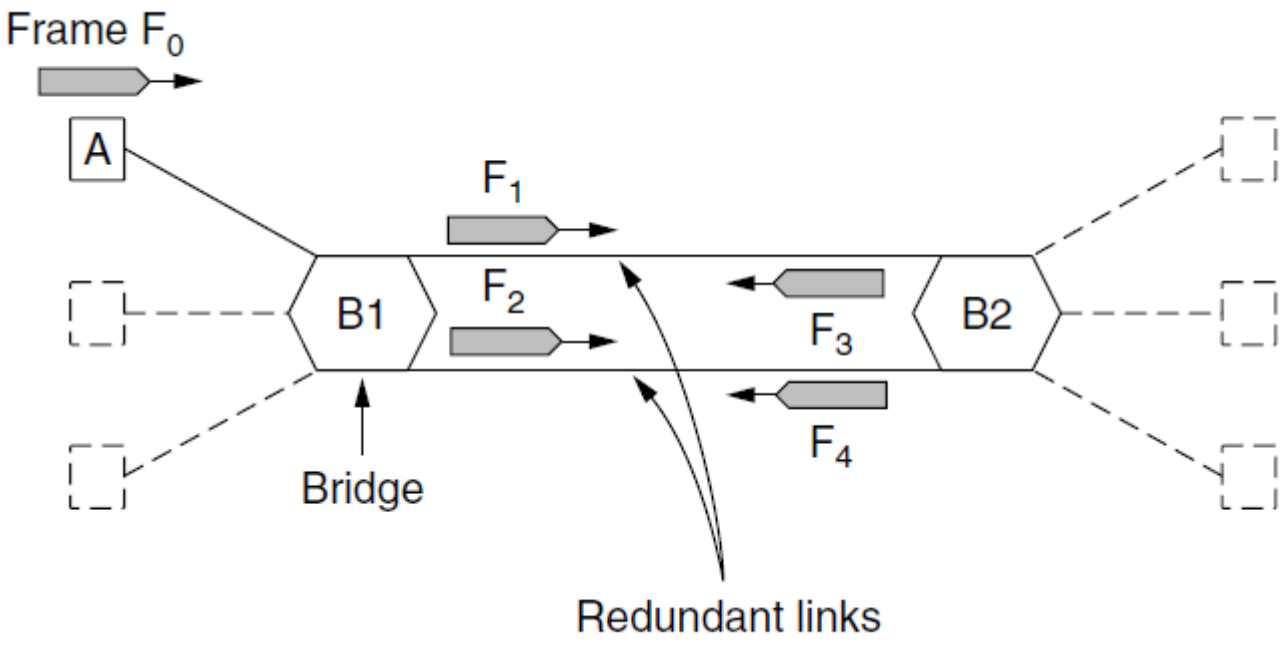


Learning Bridges (3)



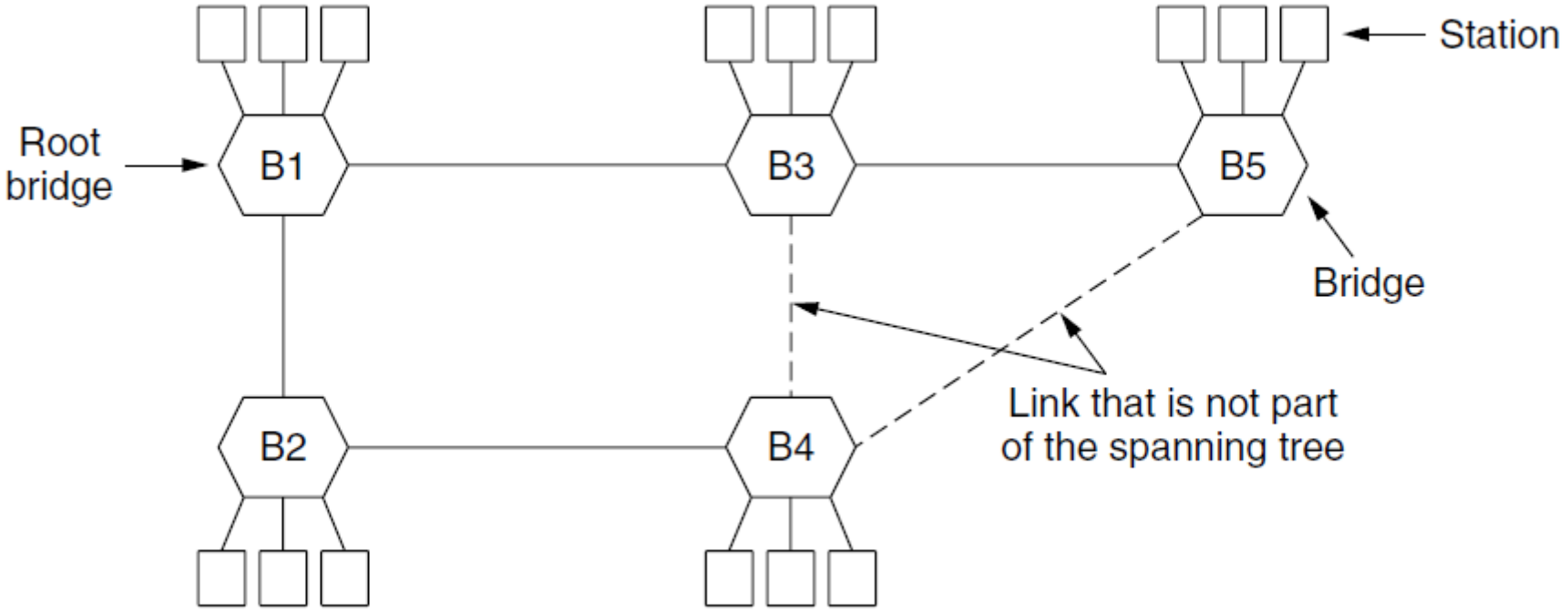
Protocol processing at a bridge.

Spanning Tree Bridges (1)



Bridges with two parallel links

Spanning Tree Bridges (2)



A spanning tree connecting five bridges. The dotted lines are links that are not part of the spanning tree.

Poem by Radia Perlman (1985) Algorithm for Spanning Tree (1)

I think that I shall never see

A graph more lovely than a tree.

A tree whose crucial property

Is loop-free connectivity.

A tree which must be sure to span.

So packets can reach every LAN.

. . .

Poem by Radia Perlman (1985) Algorithm for Spanning Tree (2)

. . .

First the Root must be selected

By ID it is elected.

Least cost paths from Root are traced

In the tree these paths are placed.

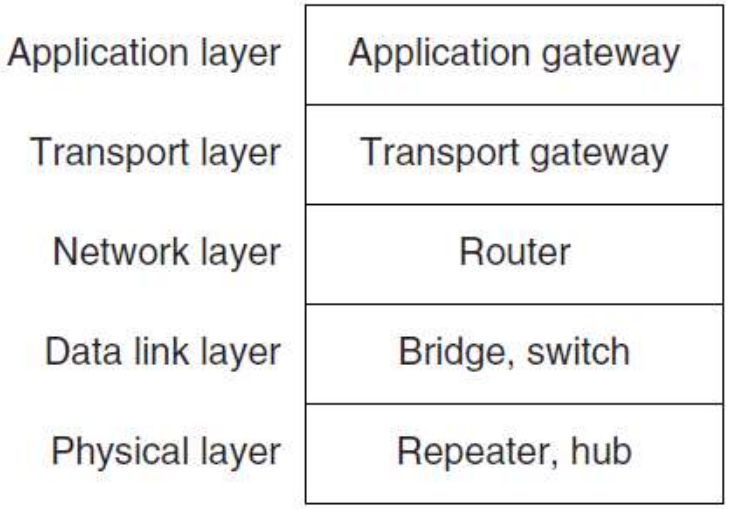
A mesh is made by folks like me

Then bridges find a spanning tree.

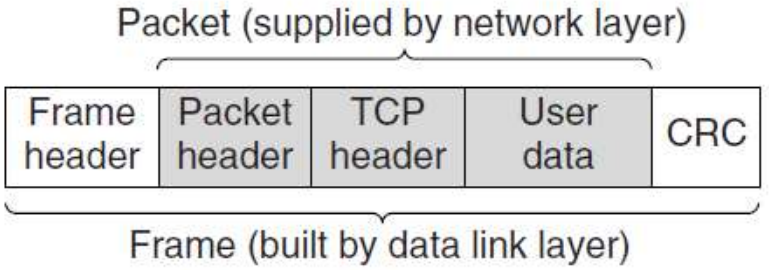
Poem by Radia Perlman (1985) Algorithm for Spanning Tree (3)

- Spanning tree: A tree with all nodes and lines but no loops.
  - Each bridge broadcasts its ID across the attached LAN segments. The lowest numbered bridge becomes root for that segment.
  - A root bridge for a segment knows it can never be the root for the tree, if it finds out there's a bridge with a lower number.
  - Bridges advertise their distance to the "real" root, that's how we build a spanning tree.

Repeaters, Hubs, Bridges, Switches, Routers, and Gateways



(a)



(b)

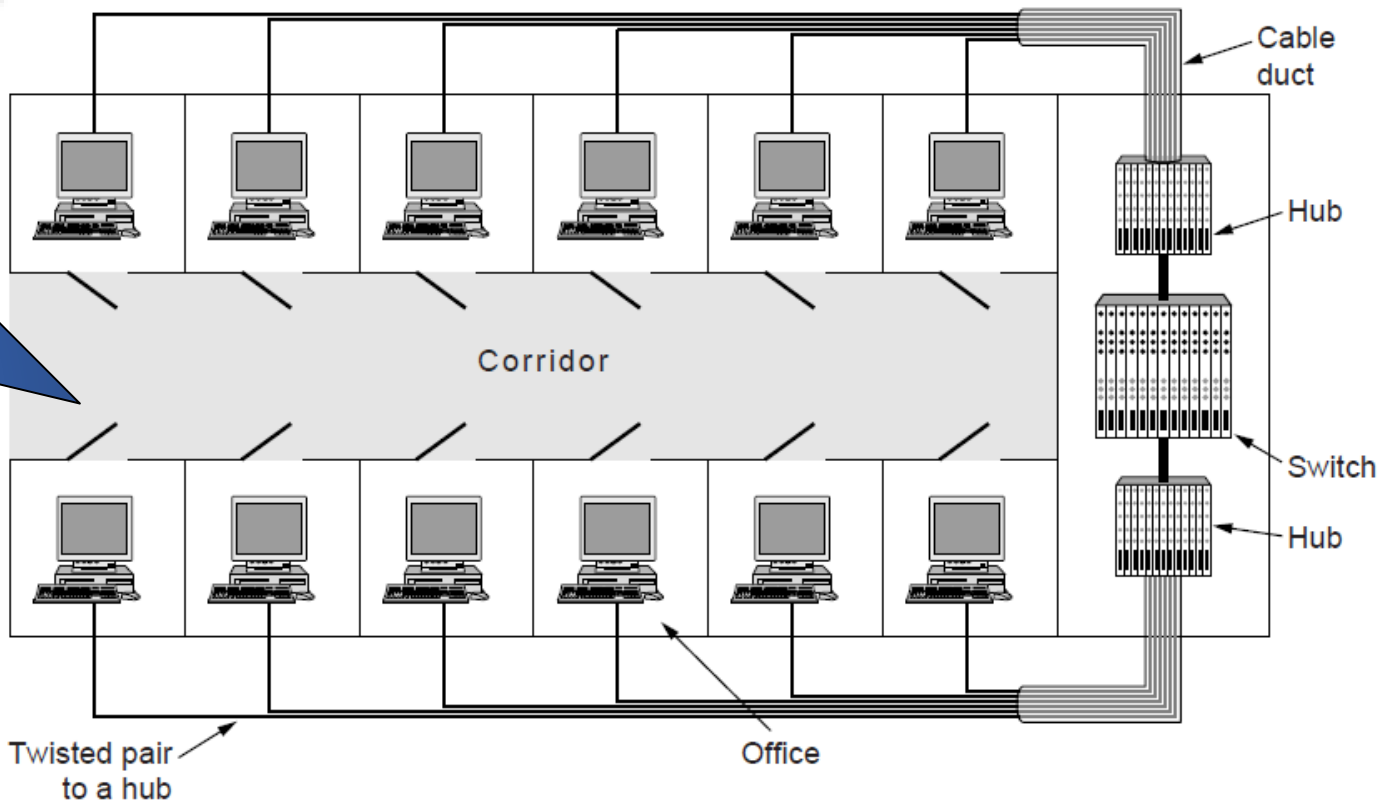
(a) Which device is in which layer.
(b) Frames, packets, and headers.

Virtual LANs (1)

为什么划分？

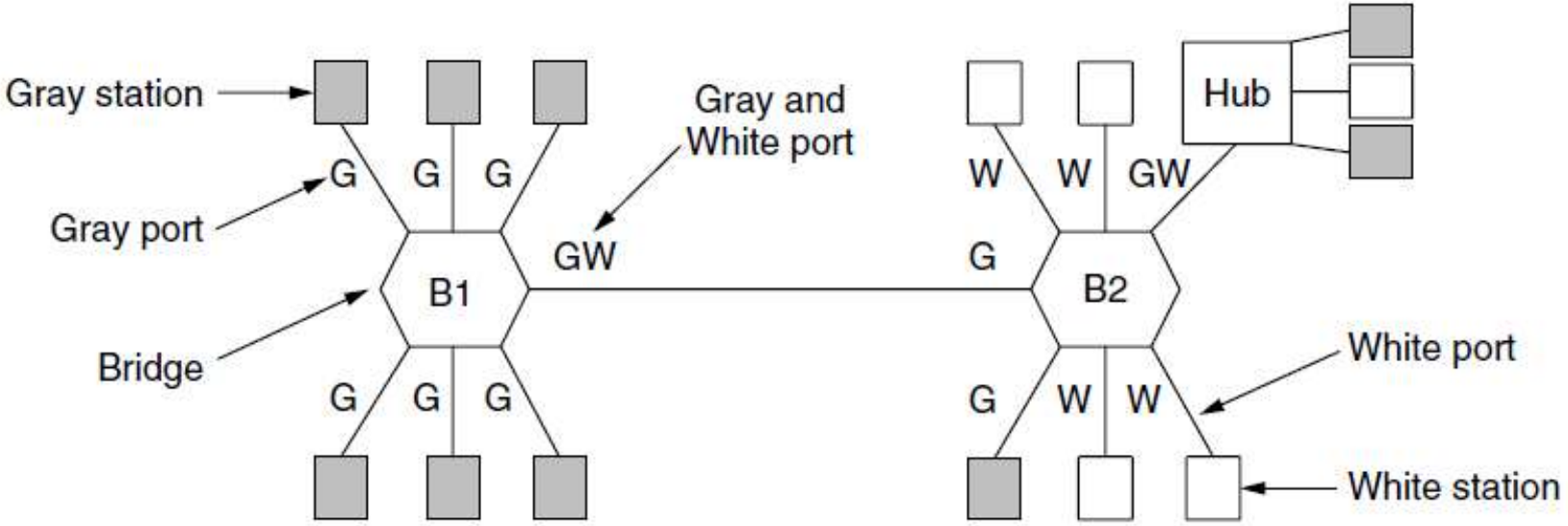
逻辑拓扑和物理拓扑相脱离

1） 安全性
2）负载不同
3）广播流量
e.g.网桥，ARP



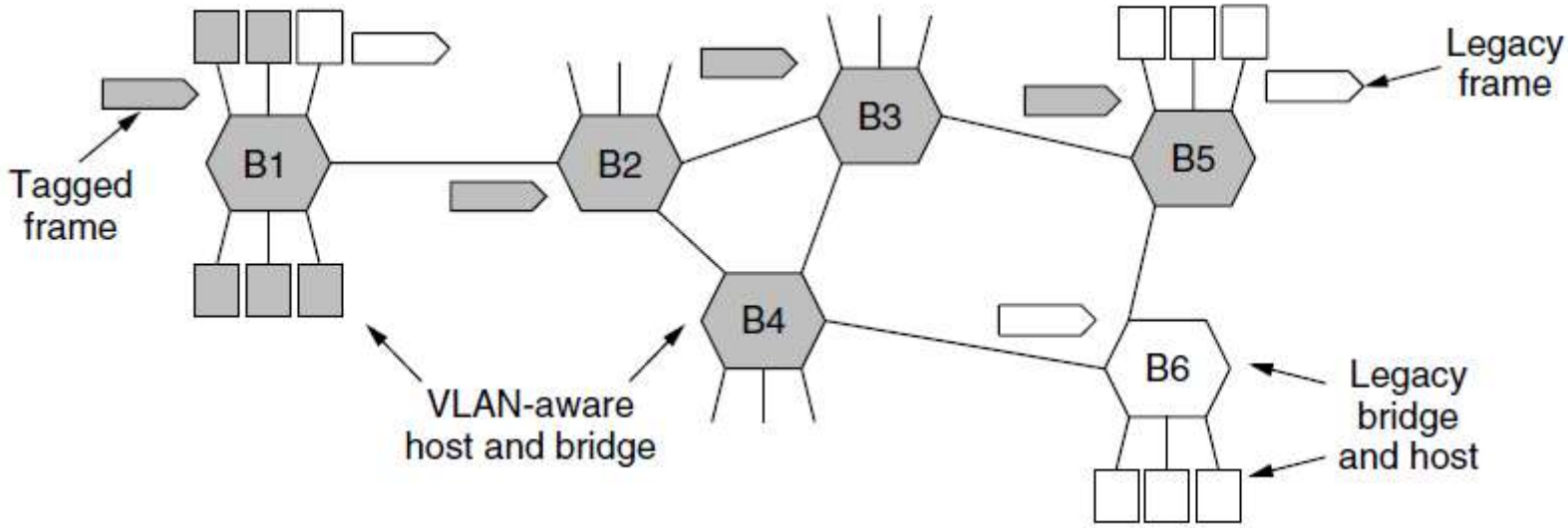
A building with centralized wiring using hubs and a switch.

Virtual LANs (2)



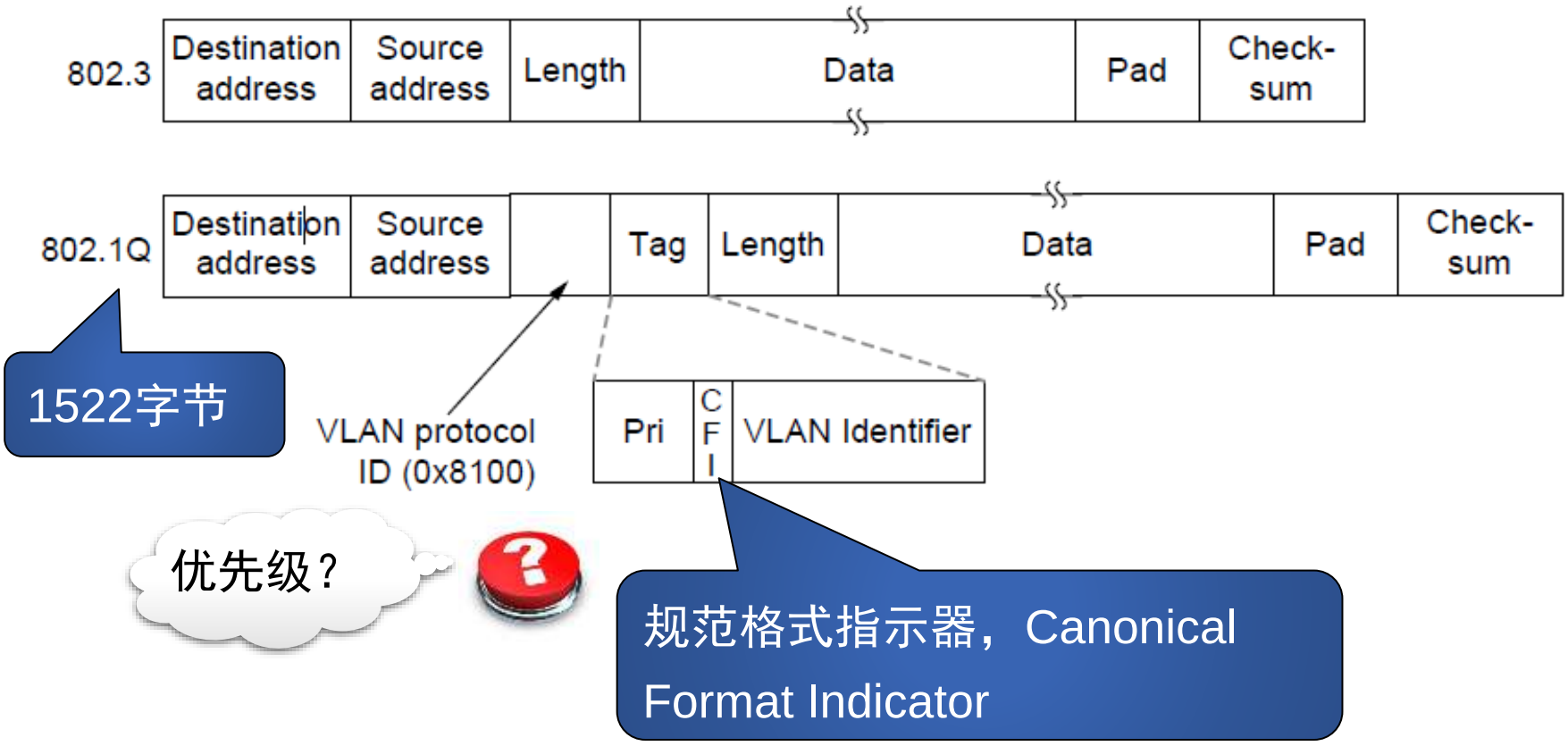
Two VLANs, gray and white, on a bridged LAN.

The IEEE 802.1Q Standard (1)



Bridged LAN that is only partly VLAN-aware. The shaded symbols are VLAN aware. The empty ones are not.

The IEEE 802.1Q Standard (2)



The 802.3 (legacy) and 802.1Q Ethernet frame formats.

End

Chapter 4