Chapter 12

Multiple Access
多路访问

Figure 12.1 *Data link layer divided into two functionality-oriented sublayers*

数据链路层分为两个功能子层:

数据链路控制子层和多路访问控制子层

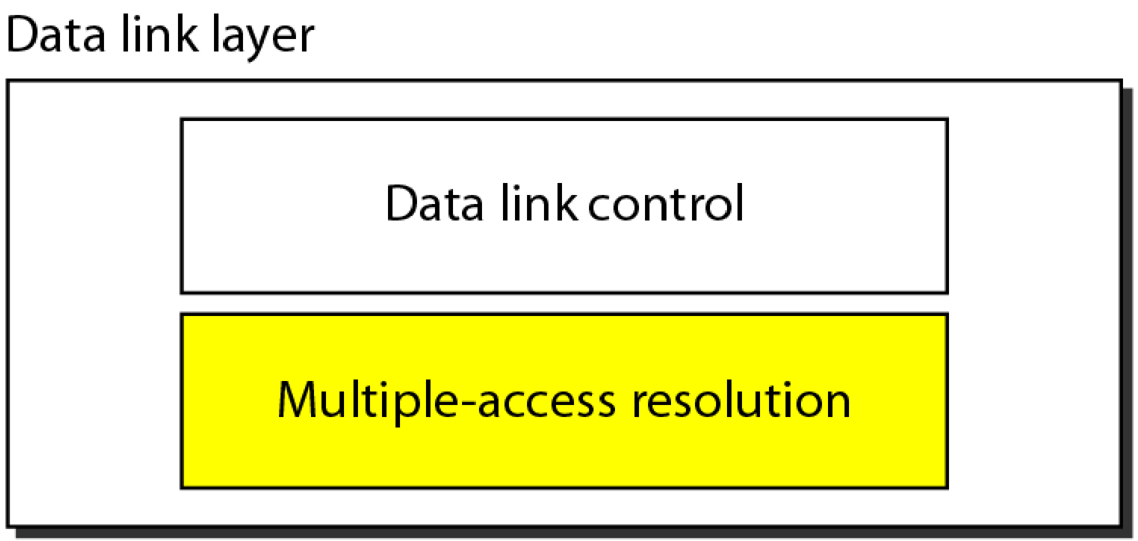
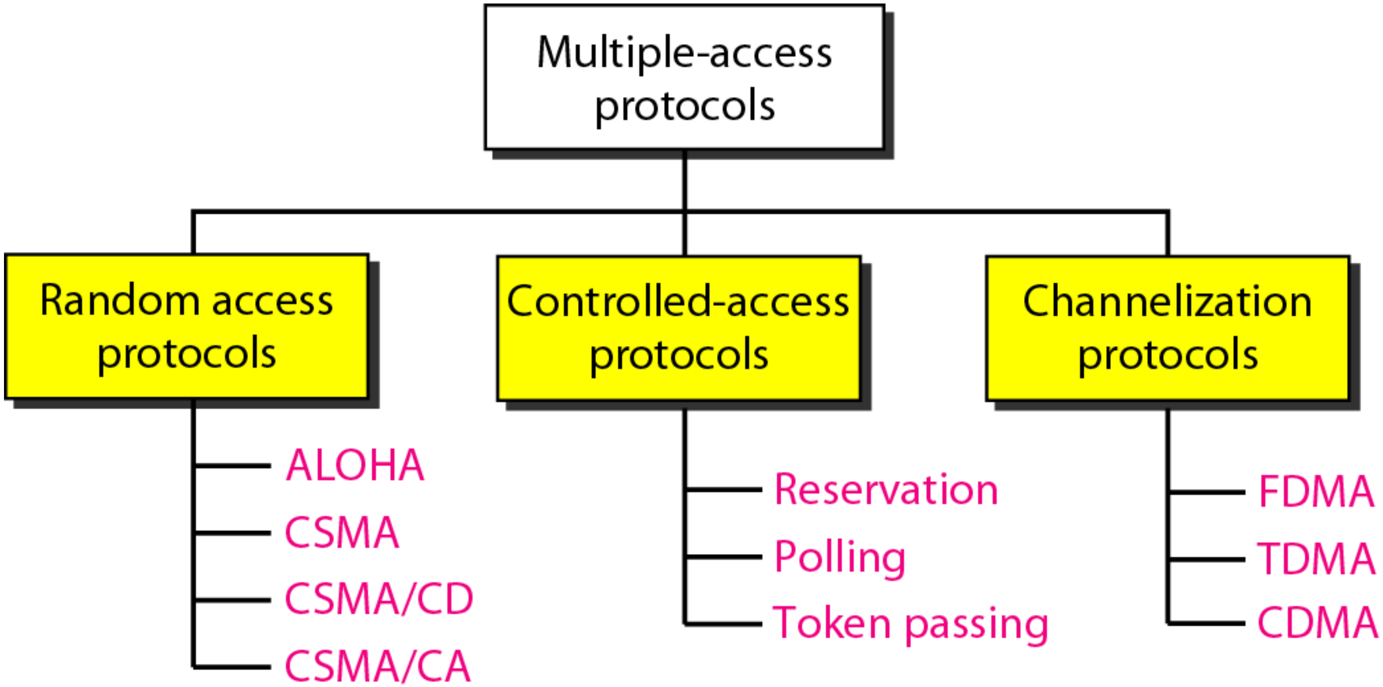


Figure 12.2 *Taxonomy of multiple-access protocols discussed in this chapter*

多路访问控制协议的分类：

随机访问协议　　受控访问控制 协议　　通道化协议



12-1 RANDOM ACCESS 随机访问协议

In random access or contention methods, no station is superior to another station and none is assigned the control over another. No station permits, or does not permit, another station to send. At each instance, a station that has data to send uses a procedure defined by the protocol to make a decision on whether or not to send.

在随机访问或竞争访问方式中，没有一个站点是优于其它站点的，也不能控制其它站点。没有站点有权力允许或不允许其它站点发送或不发送数据。有数据要发送的站通过自身的协议决定发送还是不发送数据。

Topics discussed in this section:

ALOHA — **ALOHA协议**
Carrier Sense Multiple Access — **载波侦听多路访问协议 CSMA**
Carrier Sense Multiple Access with Collision Detection 带有冲突检测能力CSMA
Carrier Sense Multiple Access with Collision Avoidance 带冲突避免CSMA

Figure 12.3 *Frames in a pure ALOHA network* 纯ALOHA的帧

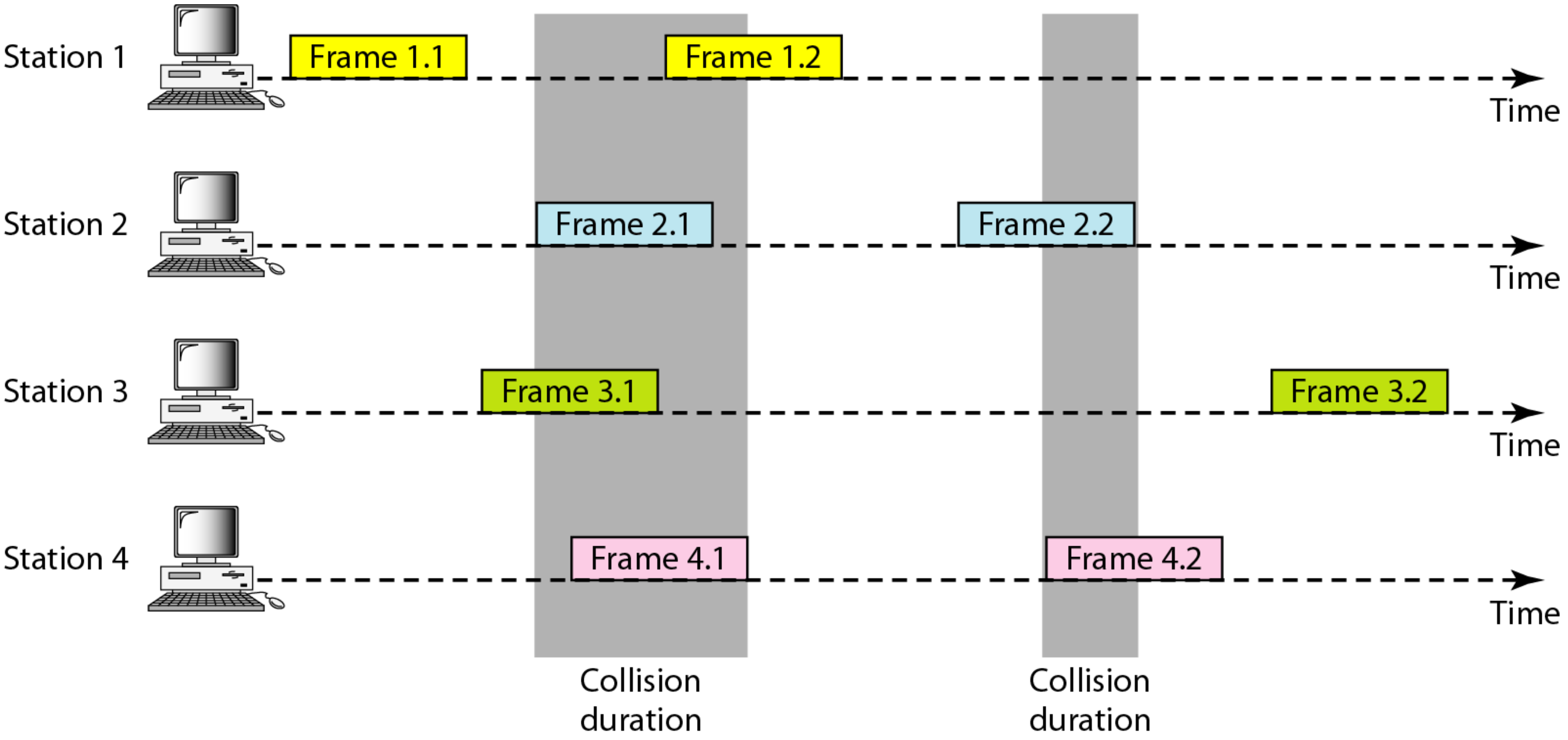
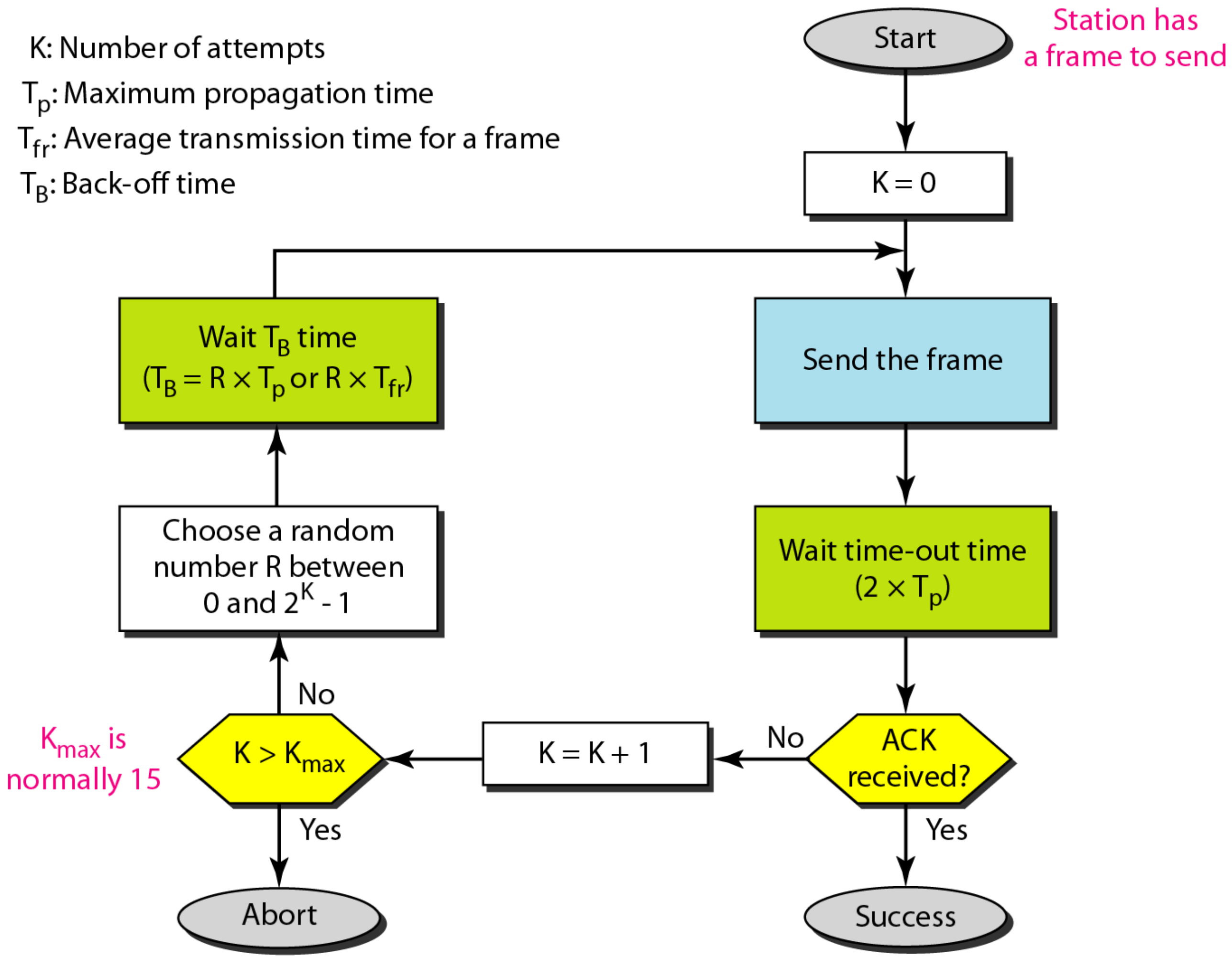


Figure 12.4 *Procedure for pure ALOHA protocol 纯ALOHA协议的流程图*



Example 12.1

The stations on a wireless ALOHA network are a maximum of 600 km apart. If we assume that signals propagate at 3×10^8 m/s, we find $T_p = (600 \times 10^5) / (3 \times 10^8) = 2$ ms. Now we can find the value of T_B for different values of K.

一个纯ALOHA协议的站点之间最大距离为600公里，信号的传播速度为30万公里/秒，那么$T_p = (600 \times 10^5) / (3 \times 10^8) = 2$ ms。对于不同的K值，得到不同的T_B值。

a. For $K = 1$, the range is {0, 1}. The station needs to generate a random number with a value of 0 or 1. This means that T_B is either 0 ms (0×2) or 2 ms (1×2), based on the outcome of the random variable.

若K=1，则取值范围{0, 1}。即站内的随机数位0或1。这意味着T_B 是 0 ms (0×2)或是2 ms (1×2)。

Example 12.1 (continued)

b. ***For K = 2, the range is {0, 1, 2, 3}. This means that T_B can be 0, 2, 4, or 6 ms, based on the outcome of the random variable.***

若K=2，则取值范围{0,1,2,3}。这意味着T_B 是 0ms, 2ms, 4ms, 6ms。

c. ***For K = 3, the range is {0, 1, 2, 3, 4, 5, 6, 7}. This means that T_B can be 0, 2, 4, . . . , 14 ms, based on the outcome of the random variable.***

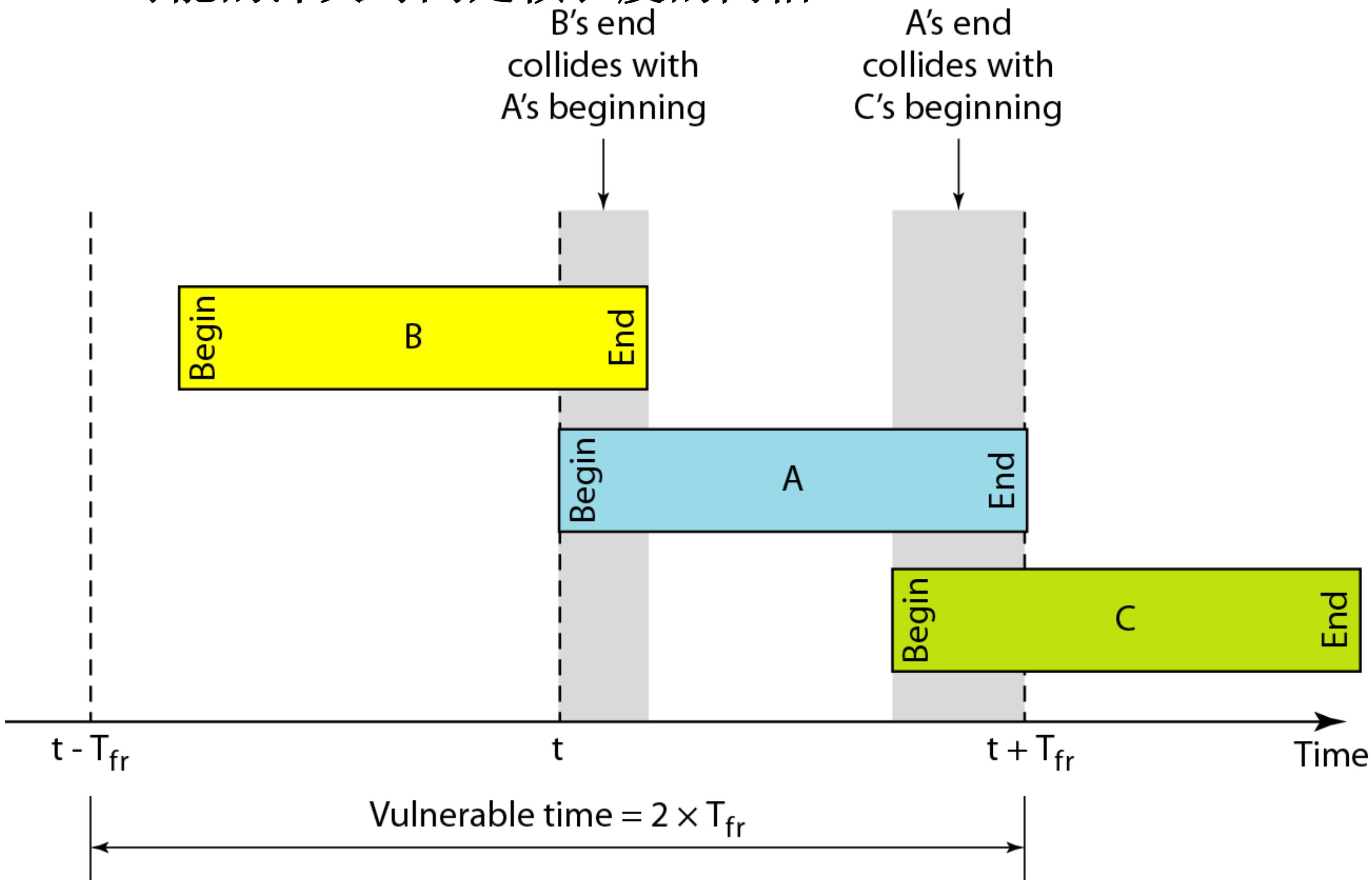
若K=3，则取值范围{0,1,2,3,4,5,6,7}。这意味着T_B 是 0ms, 2ms, 4ms, 6ms,……, 14ms。

d. ***We need to mention that if K > 10, it is normally set to 10.***

但是，若K值大于10时，随机数取值范围通常设定为10。

Figure 12.5 *Vulnerable time for pure ALOHA protocol*

纯ALOHA可能的冲突时间是帧长度的两倍



Example 12.2

A pure ALOHA network transmits 200-bit frames on a shared channel of 200 kbps. What is the requirement to make this frame collision-free?

一个纯ALOHA帧长200比特，带宽200kbps, 这个帧在传输过程中无冲突的条件是什么？

Solution

Average frame transmission time T_{fr} is 200 bits/200 kbps or 1 ms. The vulnerable time is 2 × 1 ms = 2 ms. This means no station should send later than 1 ms before this station starts transmission and no station should start sending during the one 1-ms period that this station is sending.

帧的传输时间为T_{fr} = 200 bits/200 kbps = 1 ms. 则可能的冲突时间为2ms。意味着前1ms和后1ms都没有其它站发送数据帧。

Note

G是帧传输时间内系统产生的帧的平均数量

The throughput for pure ALOHA is $S = G \times e^{-2G}$.

The maximum throughput $S_{max} = 0.184$ when G= (1/2).

纯ALOHA的吞吐量是$S = G \times e^{-2G}$，当G=(1/2)时，最大吞吐量为$S_{max} = 0.184$。

Figure 12.6 *Frames in a slotted ALOHA network*

时隙ALOHA网络中的帧

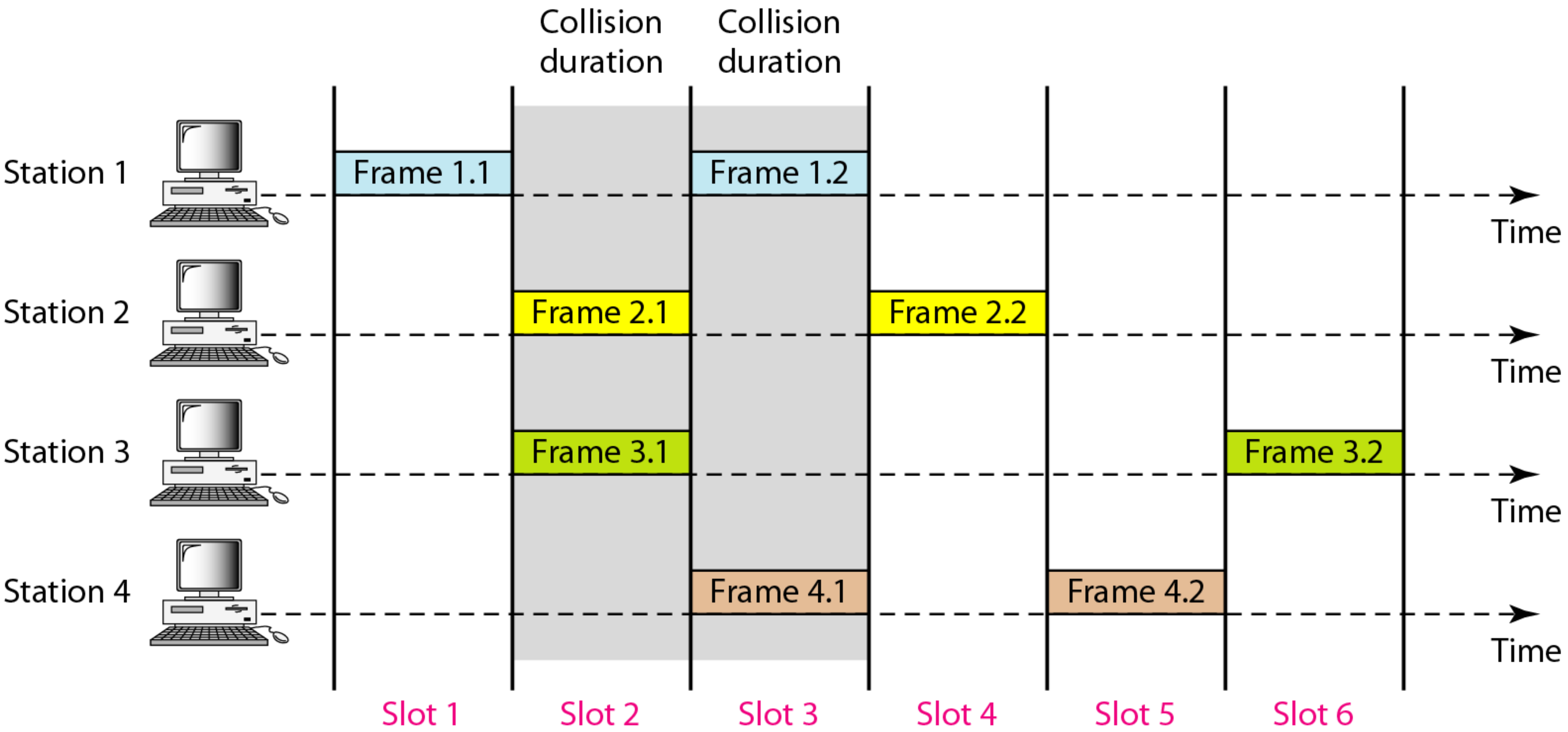
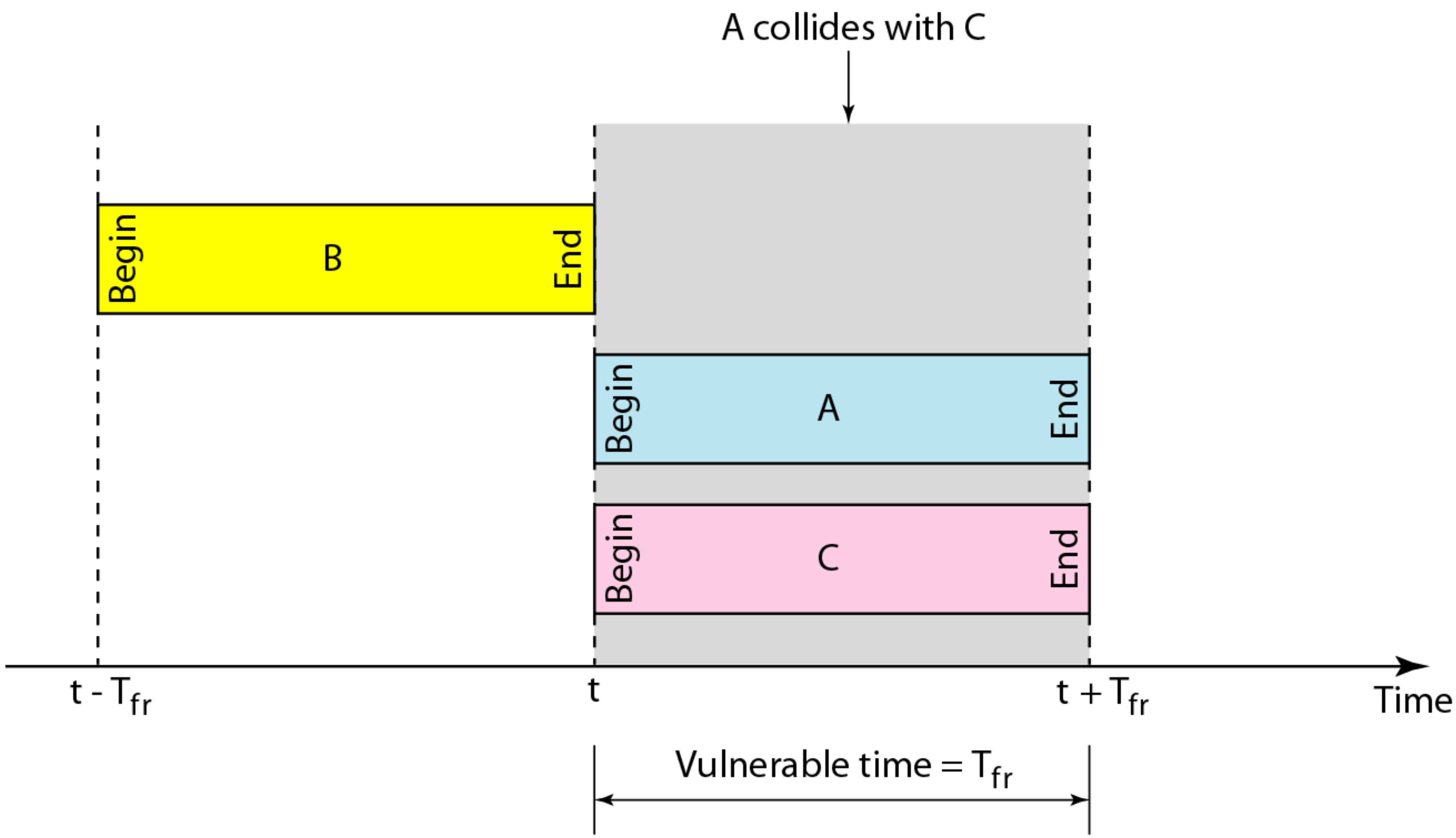


Figure 12.7 *Vulnerable time for slotted ALOHA protocol*

时隙ALOHA网络中的帧，其可能的冲突时间是帧长度的1倍。



Note

The throughput for slotted ALOHA is $S = G \times e^{-G}$.

The maximum throughput $S_{max} = 0.368$ when G = 1.

时隙ALOHA的吞吐量是$S = G \times e^{-G}$，当G= (1)时，最大吞吐量为$S_{max} = 0.368$。

Figure 12.8 *Space/time model of the collision in CSMA*

CSMA中冲突的时空模型

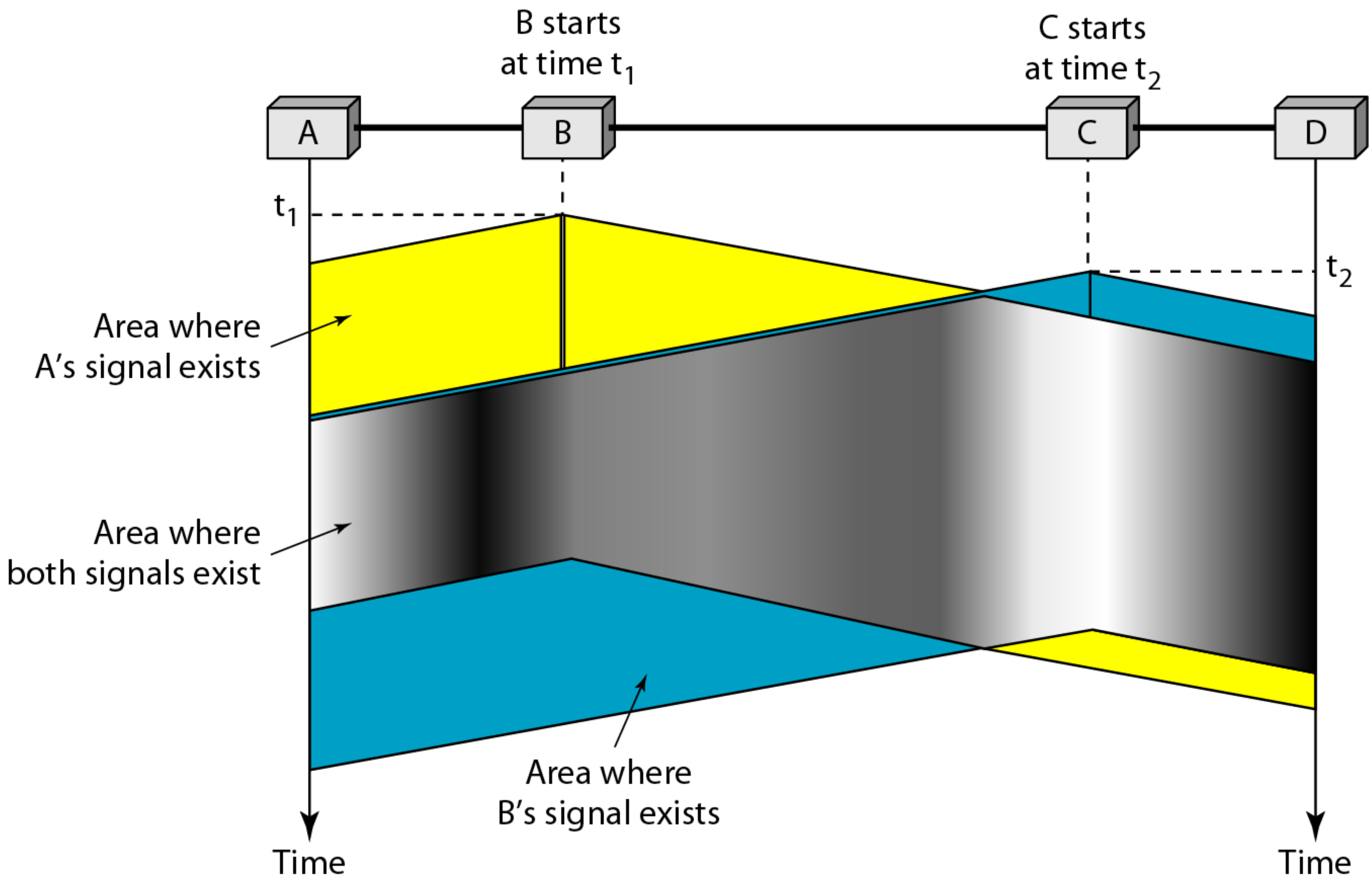


Figure 12.9 *Vulnerable time in CSMA*
CSMA碰撞冲突时间

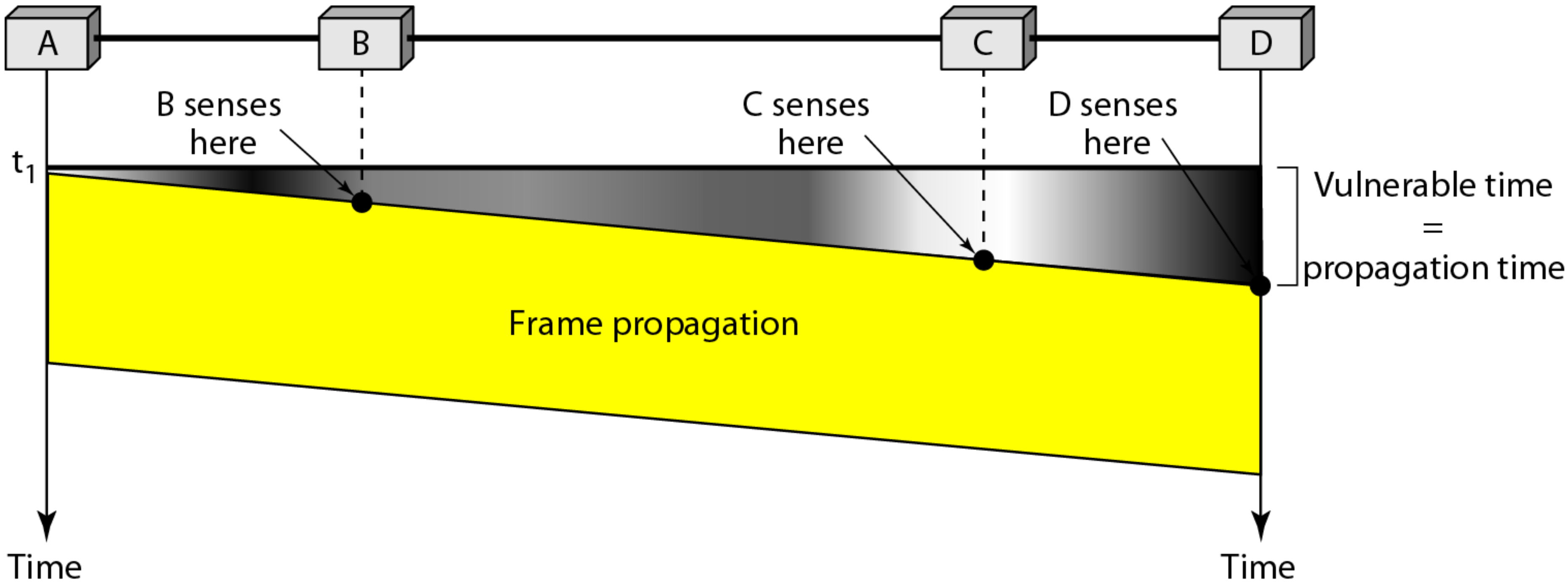
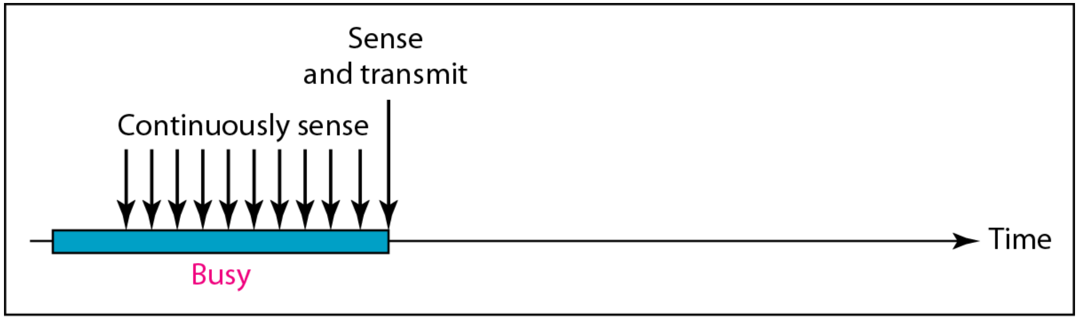
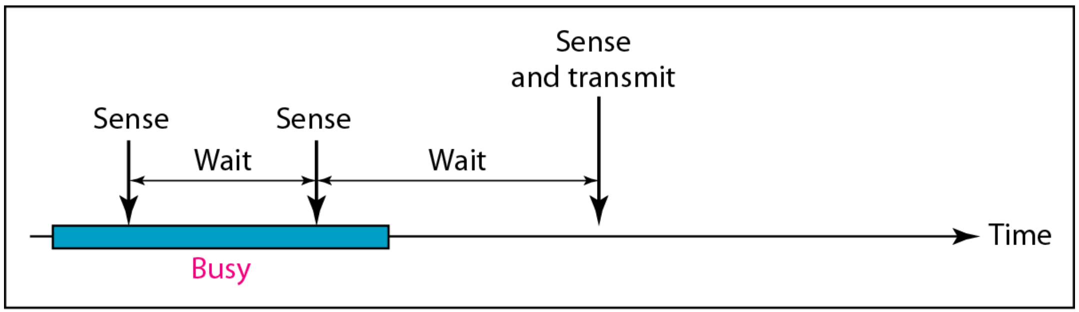


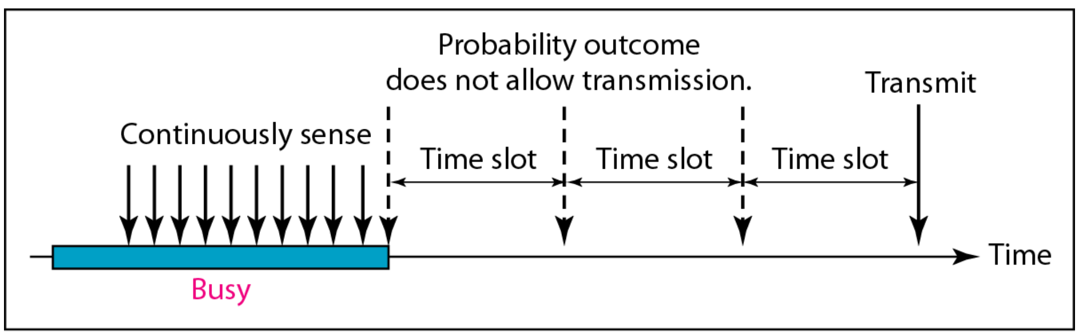
Figure 12.10 *Behavior of three persistence methods*
三种坚持型方法的行为



a. 1-persistent

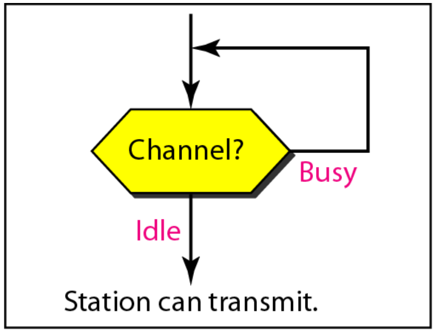


b. Nonpersistent

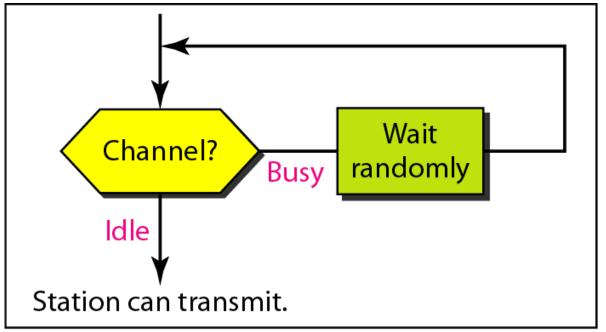


c. p-persistent

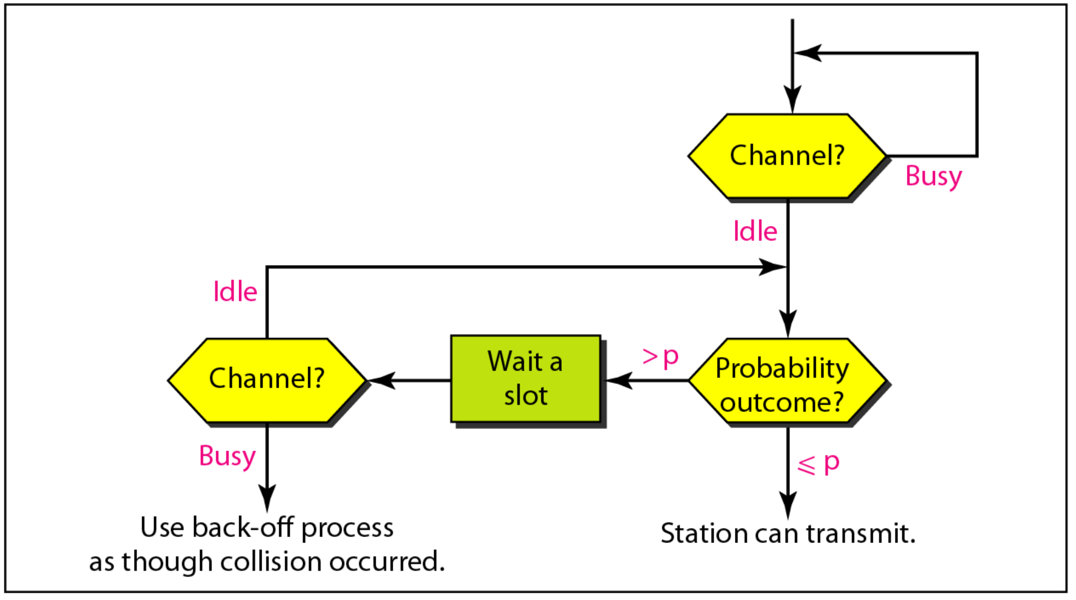
Figure 12.11 *Flow diagram for three persistence methods*
三种坚持型方法的流程框图



a. 1-persistent



b. Nonpersistent



c. p-persistent

Figure 12.12 *Collision of the first bit in CSMA/CD*

CSMA/CD中第一个比特位碰撞冲突的情况

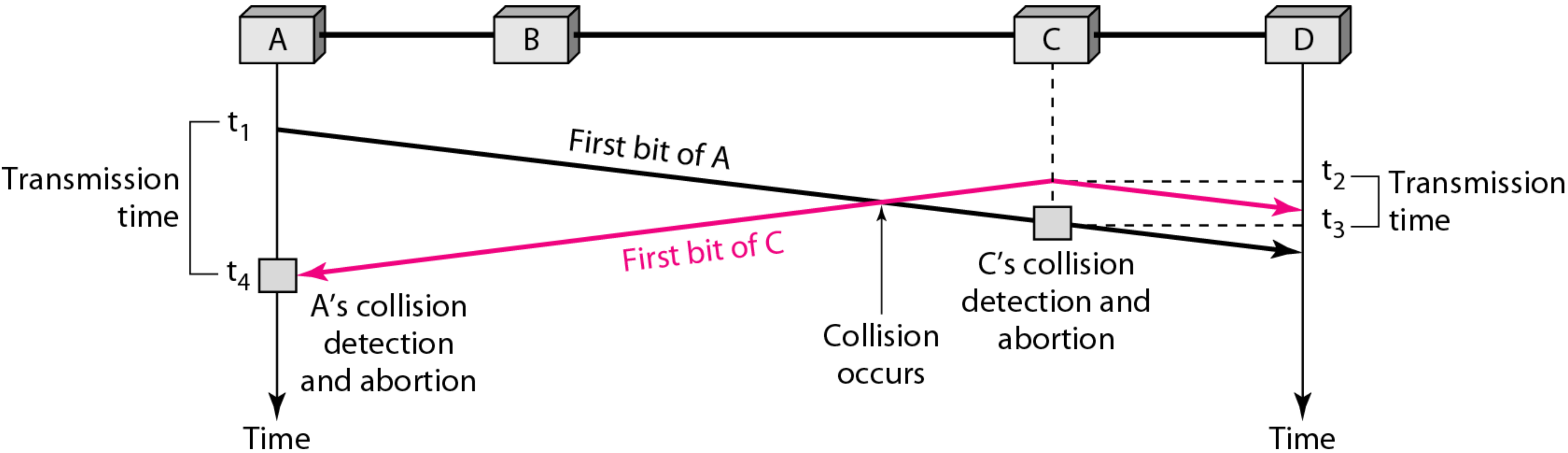
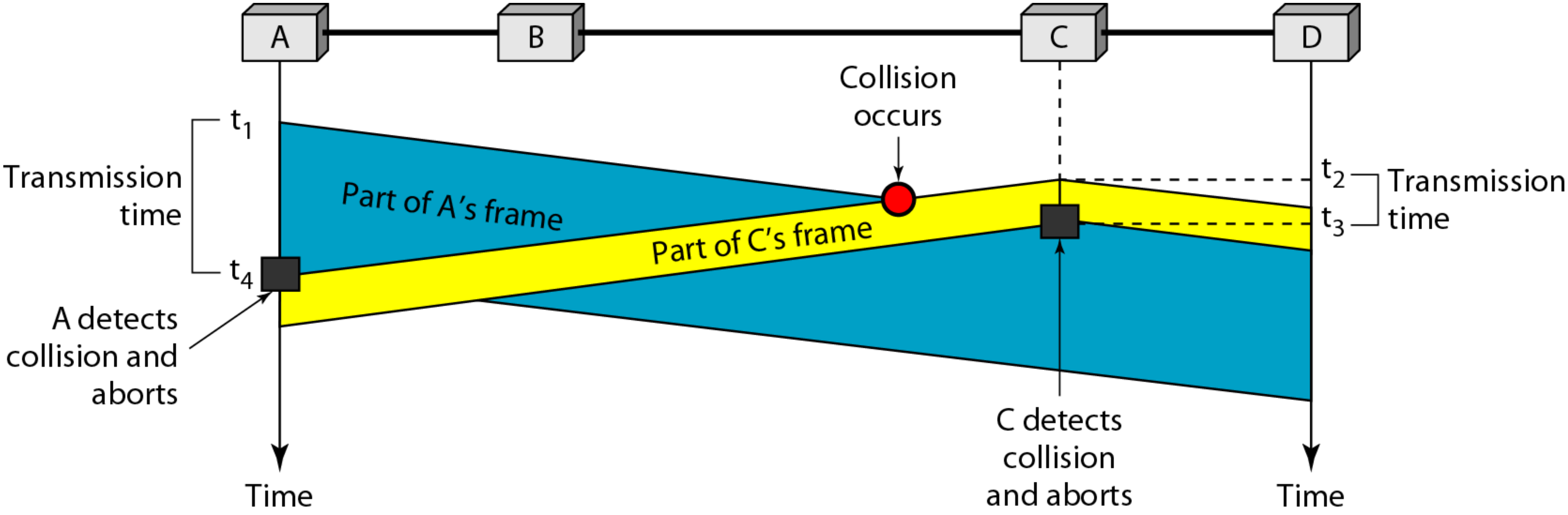


Figure 12.13 *Collision and abortion in CSMA/CD*

CSMA/CD中冲突和放弃传输的示意图



Example 12.5

A network using CSMA/CD has a bandwidth of 10 Mbps. If the maximum propagation time (including the delays in the devices and ignoring the time needed to send a jamming signal, as we see later) is 25.6 μs, what is the minimum size of the frame?

CSMA网络中，带宽10Mbps，最大传播时间为25.6us，那么最小帧长度是多少？

Solution

The frame transmission time is $T_{fr} = 2 \times T_p = 51.2$ μs. This means, in the worst case, a station needs to transmit for a period of 51.2 μs to detect the collision. The minimum size of the frame is 10 Mbps × 51.2 μs = 512 bits or 64 bytes. This is actually the minimum size of the frame for Standard Ethernet.

解：帧传播时间必须最少为最大传播时间的两倍以上，即$T_{fr} = 2 \times T_p = 51.2$ μs. 或者说，一个站点需要51.2us后才能检测到冲突。帧的最小长度是：

10 Mbps × 51.2 μs = 512 bits = 64 bytes. 这也是10兆以太网的最小帧长度。

Figure 12.14 *Flow diagram for the CSMA/CD*

CSMA/CD流程框图

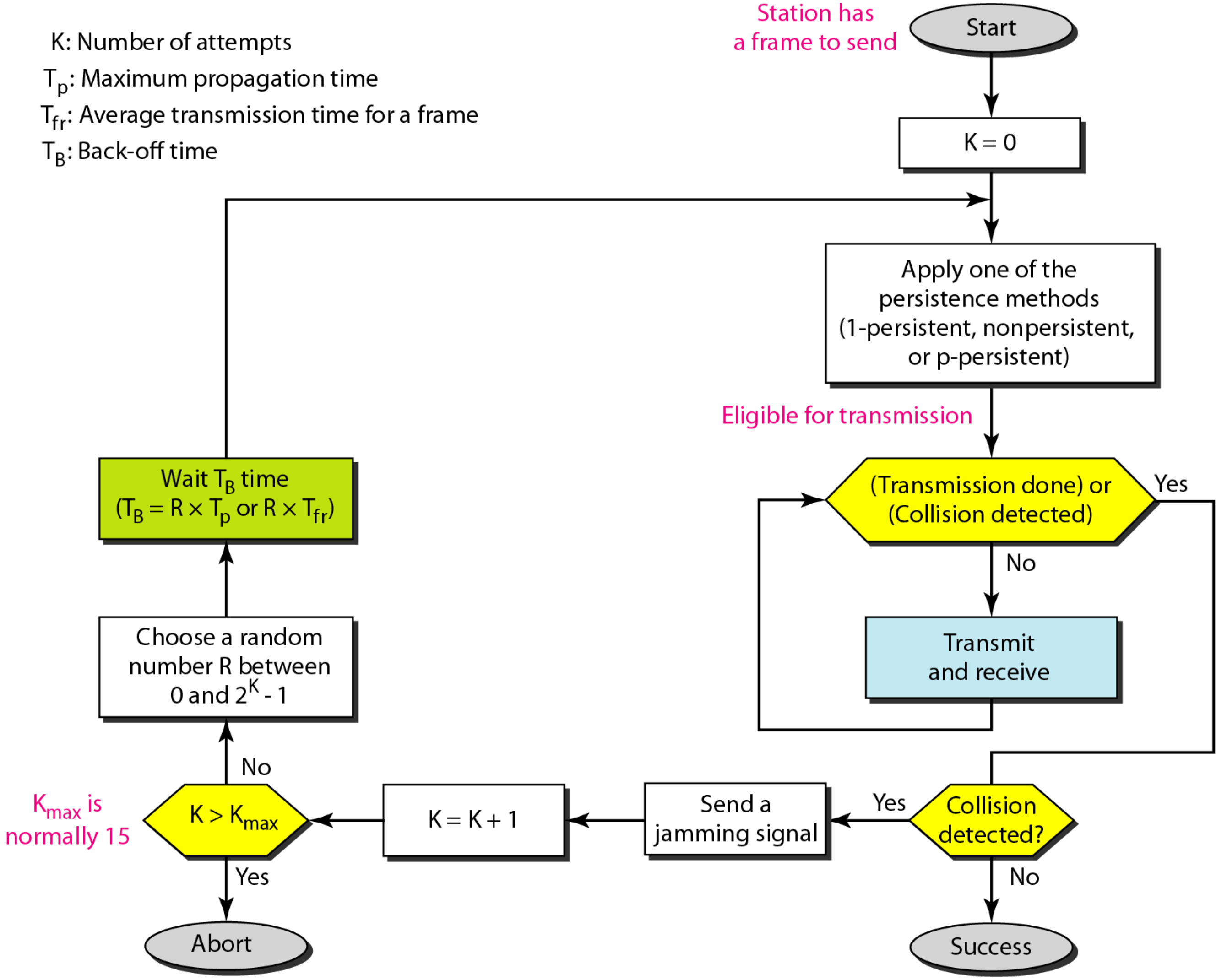


Figure 12.15 *Energy level during transmission, idleness, or collision*

信道在传输，空闲，冲突状态下电磁波能量级别大小（依此可以判别 CD）

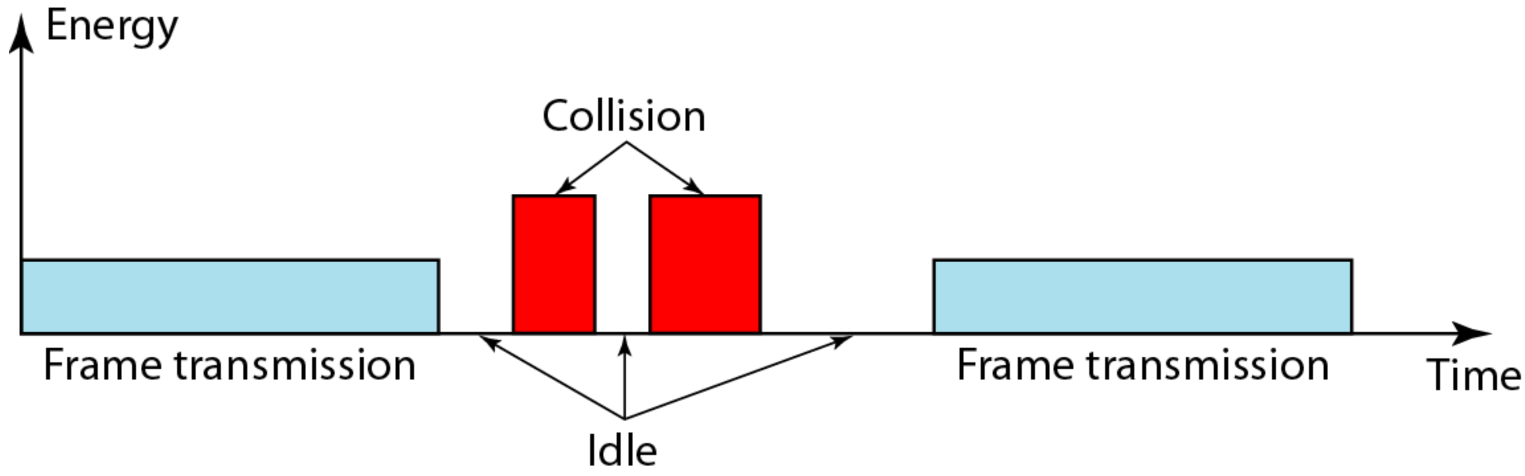
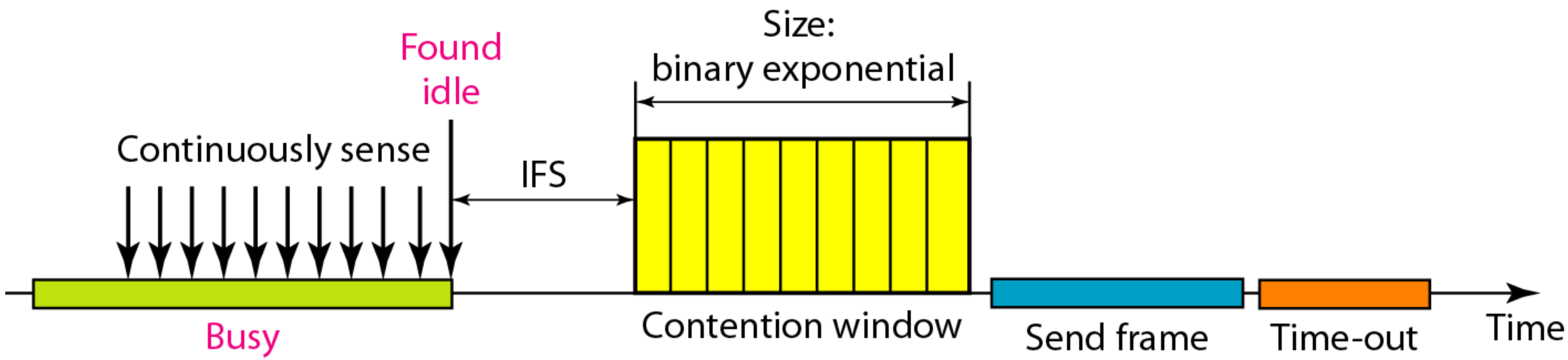


Figure 12.16 *Timing in CSMA/CA*

CSMA/CD中的时间的安排，主要包括帧间间隔，竞争窗口，和确认。



Note

In CSMA/CA, the IFS can also be used to define the priority of a station or a frame.

CSMA/CA中，IFS也能用来定义一个站或一个帧的优先权。

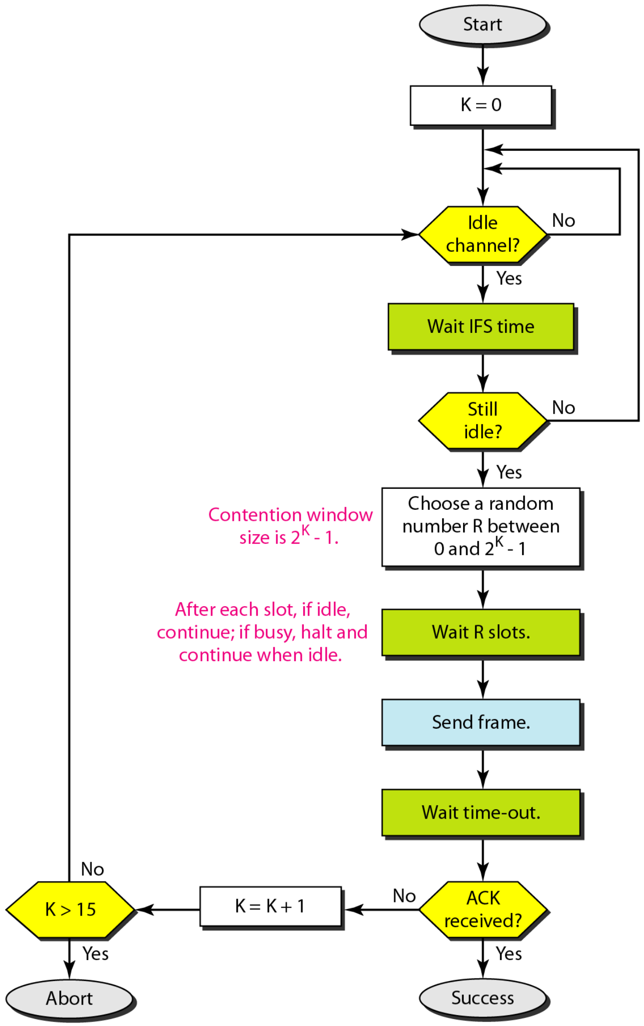
Note

In CSMA/CA, if the station finds the channel busy, it does not restart the timer of the contention window;
it stops the timer and restarts it when the channel becomes idle.

CSMA/CA中，若站发现信道忙，就不重启竞争窗口的定时器；而是停止定时器，直到信道空闲时再重启定时器。

Figure 12.17 *Flow diagram for CSMA/CA*

CSMA/CA流程框图



12-2 CONTROLLED ACCESS
受控访问协议

In controlled access, the stations consult one another to find which station has the right to send. A station cannot send unless it has been authorized by other stations. We discuss three popular controlled-access methods.

在受控访问协议中，站点之间相互协商以确定那一个站有权发送。没有得到授权的站点无权发送数据。主要有以下三类受控访问协议。

Topics discussed in this section:

Reservation 预约协议
Polling 轮询协议
Token Passing 令牌协议

Figure 12.18 *Reservation access method*

预约访问协议

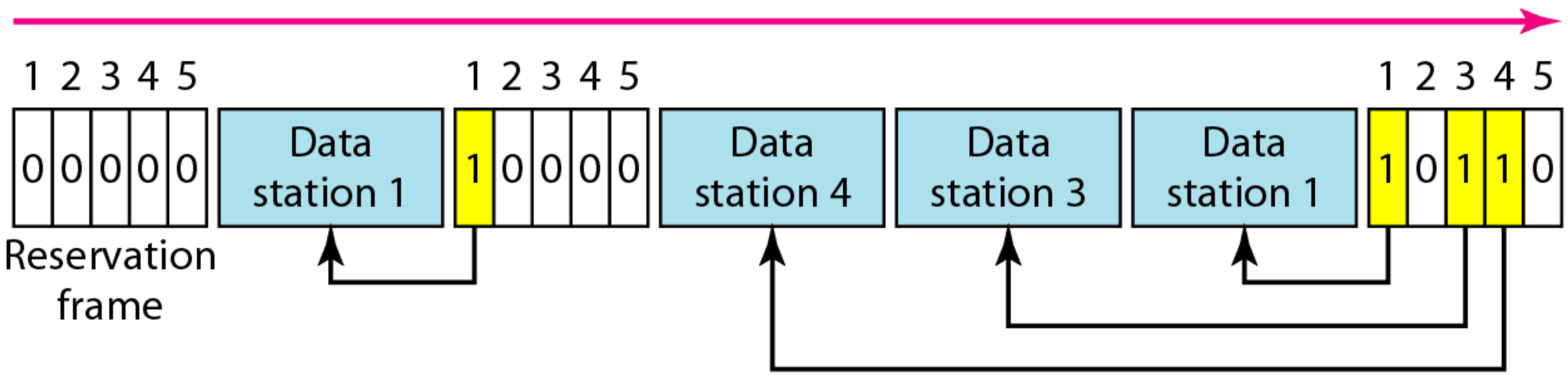


Figure 12.19 *Select and poll functions in polling access method*

轮询访问协议中选择和轮询

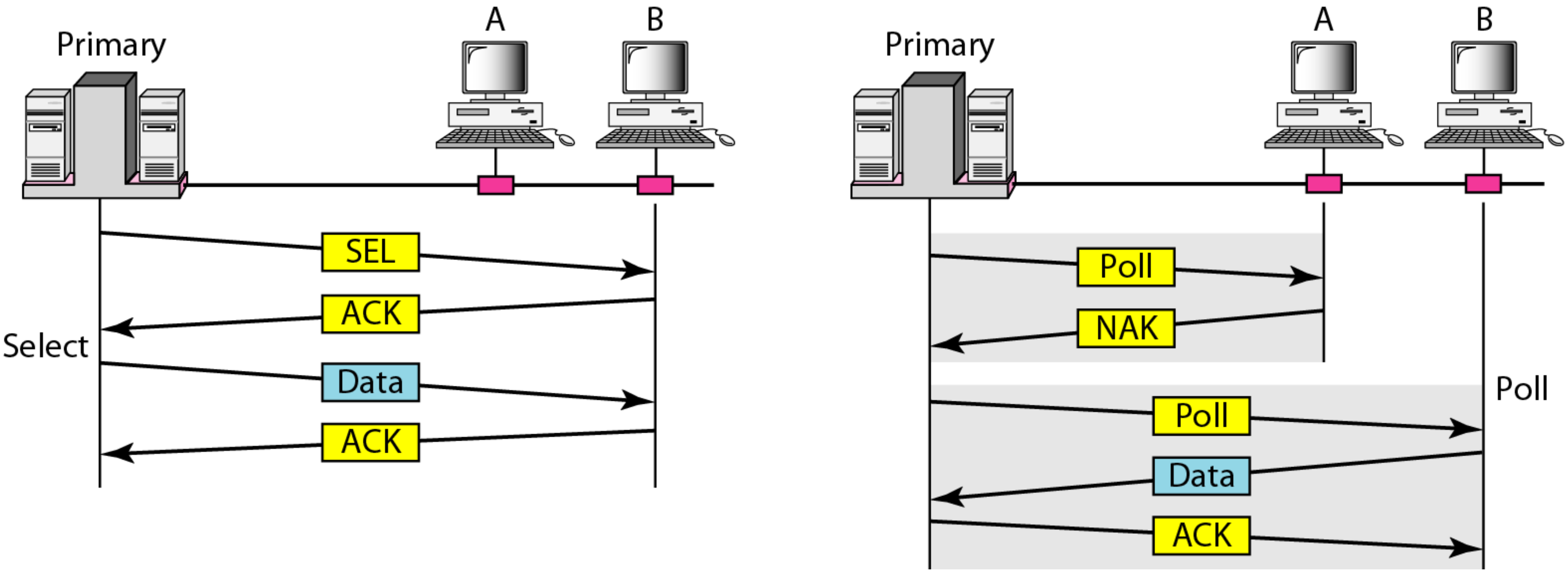
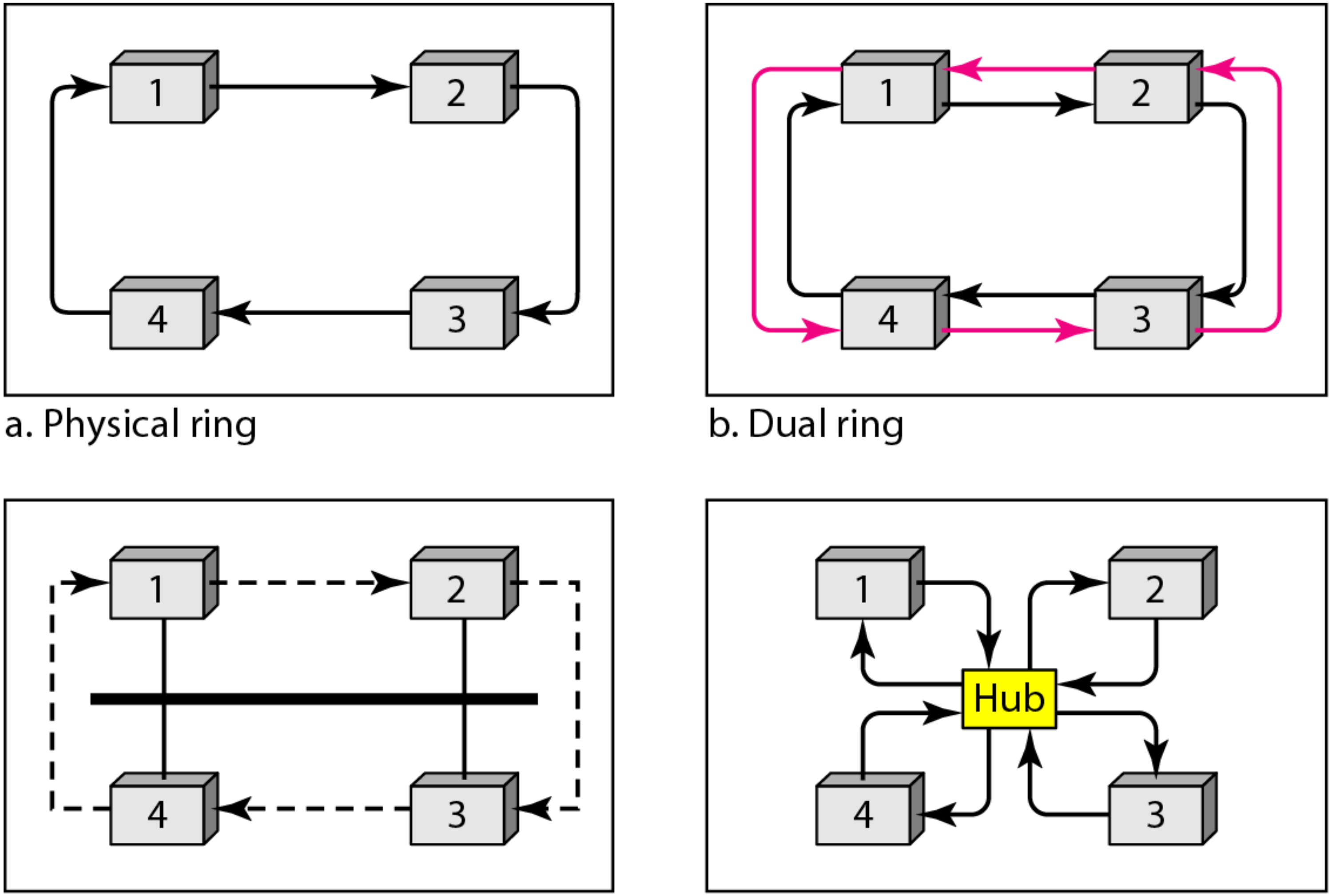


Figure 12.20 *Logical ring and physical topology in token-passing access method*

令牌环网协议中逻辑的环和实际的物理网络拓扑结构



a. Physical ring b. Dual ring c. Bus ring d. Star ring

12-3 CHANNELIZATION 通道化

***Channelization* is a multiple-access method in which the available bandwidth of a link is shared in time, frequency, or through code, between different stations. In this section, we discuss three channelization protocols.**

通道化也是一种多路访问方法。不同站点之间在时间域上、频率域上、或码域上正交化来共享信道。主要包括下面三种方式：

Topics discussed in this section:

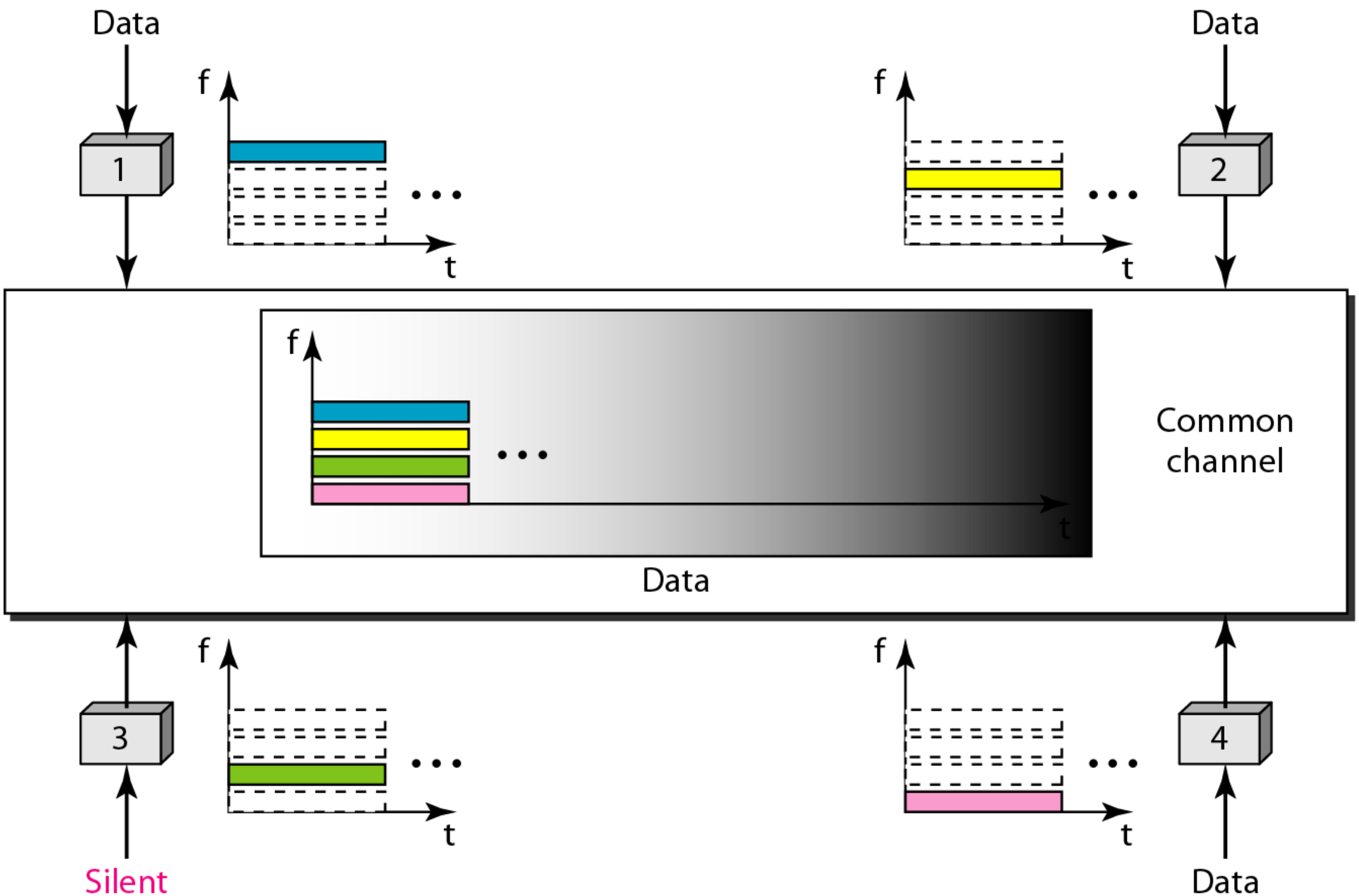
Frequency-Division Multiple Access (FDMA) 频分多址
Time-Division Multiple Access (TDMA) 时分多址
Code-Division Multiple Access (CDMA) 码分多址

Note

We see the application of all these methods in Chapter 16 when we discuss cellular phone systems.

第16章，讨论移动电话系统时，有这些方法的应用。

Figure 12.21 *Frequency-division multiple access (FDMA)*
频分多址

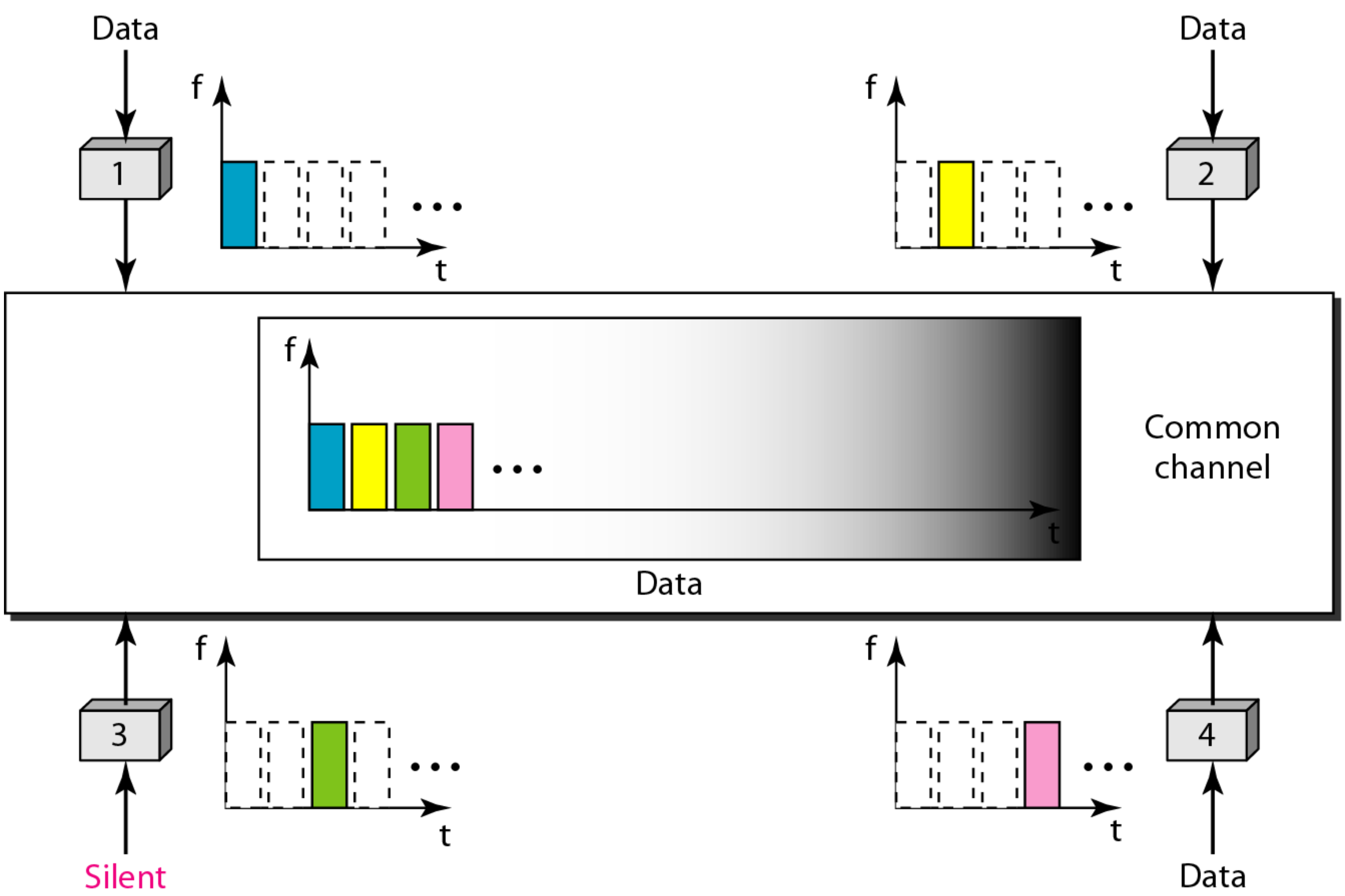


Note

In FDMA, the available bandwidth of the common channel is divided into bands that are separated by guard bands.

FDMA中，信道带宽被在频率域上被正交化，分割成若干子频带外加保护频带。

Figure 12.22 *Time-division multiple access (TDMA)*
时分多址



Note

In TDMA, the bandwidth is just one channel that is timeshared between different stations.

TDMA中，信道带宽被在时间域上被正交化，分割成若干时隙。

Note

In CDMA, one channel carries all transmissions simultaneously.

CDMA中，信道带宽被在码域上被正交化，各站用正交化的扩频码在共享信道中同时传输。

Figure 12.23 *Simple idea of communication with code*

用编码通信的简单思想示意图

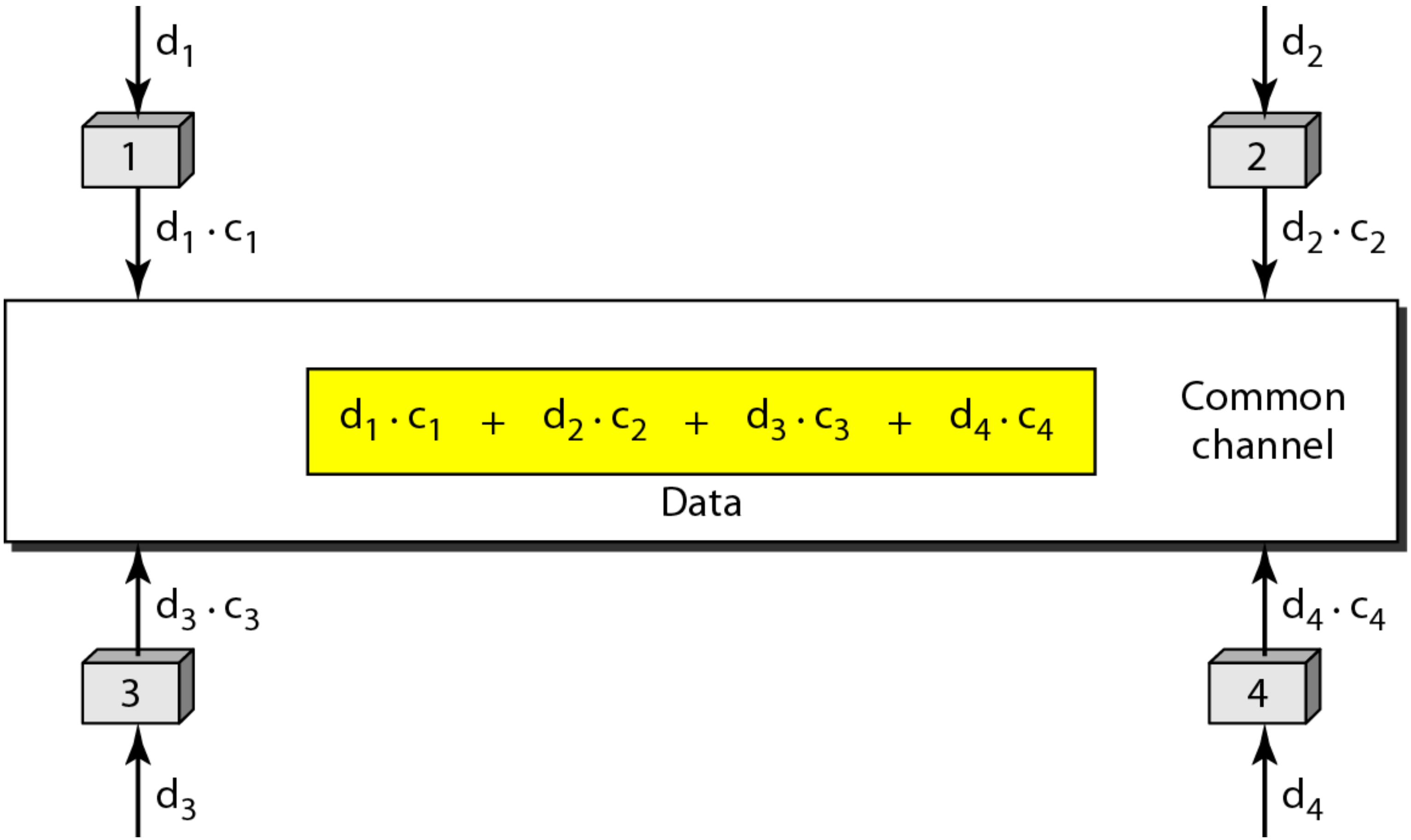


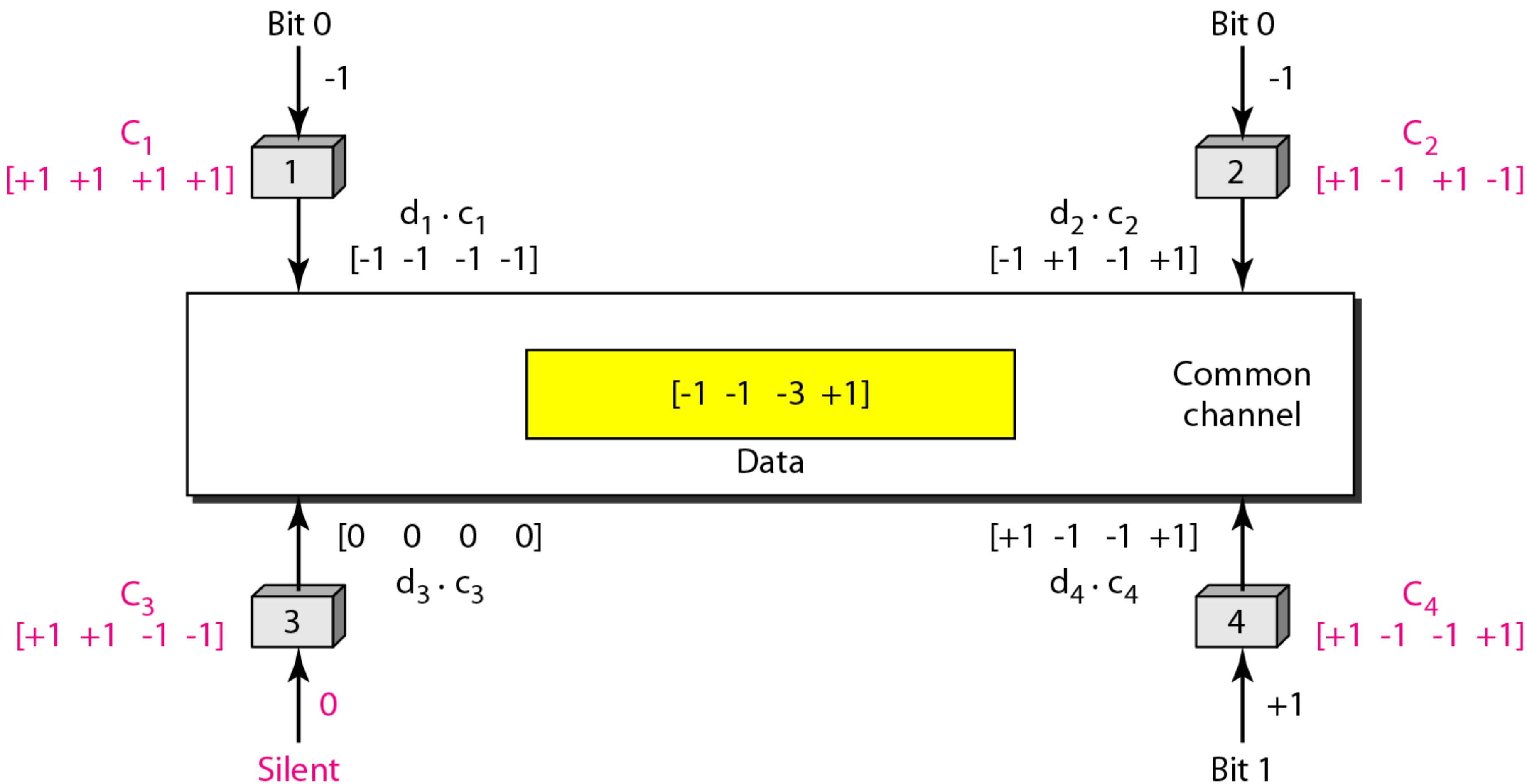
Figure 12.24 *Chip sequences* 正交化的码片序列

C_1	C_2	C_3	C_4
[+1 +1 +1 +1]	[+1 -1 +1 -1]	[+1 +1 -1 - 1]	[+1 -1 -1 +1]

Figure 12.25 *Data representation in CDMA*

数据表示

Figure 12.26 *Sharing channel in CDMA* 在共享信道中传输码片序列



作业：
11，14，（15，16，17合成同一题）