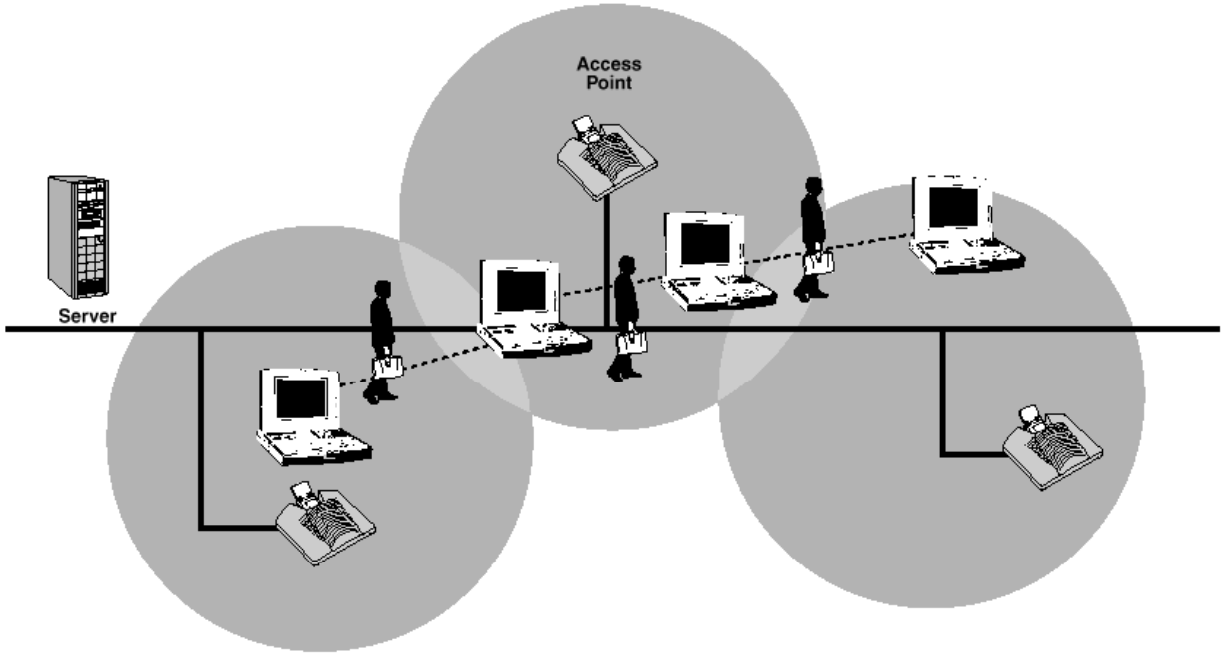
IEEE 802.11 Wireless LAN

Wireless LAN

Basic Service Set (BSS): single cell

Extended Service Set (ESS): multiple cells



What is Wireless LAN

A flexible data communication system

An extension to, or as an alternative for a wired LAN

WLANs transmit and receive data over the air using electromagnetic waves

WLANs are becoming more widely recognized as a general-purpose connectivity alternative for a broad range of business customers

Why Wireless LAN

Mobility

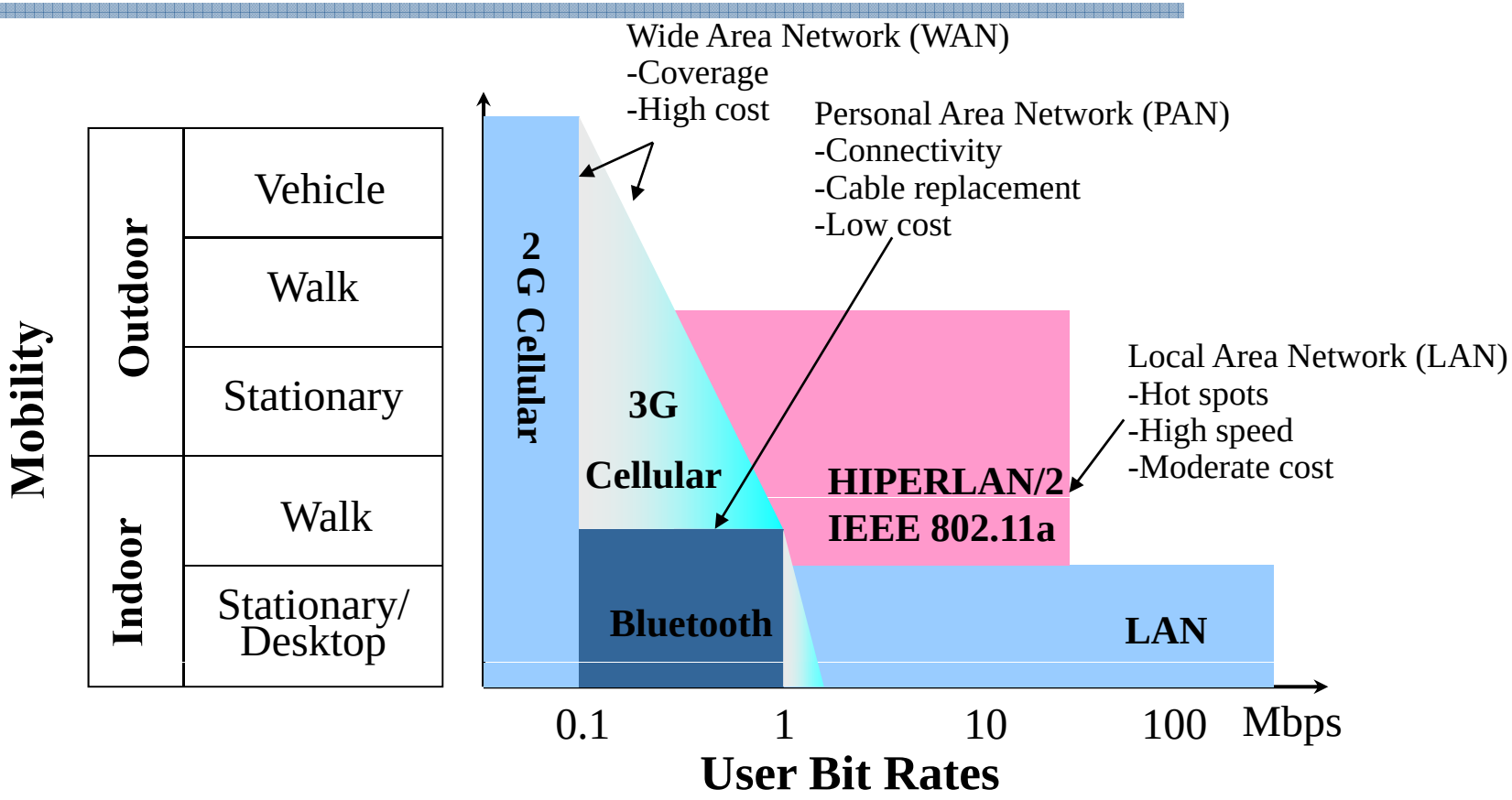
Installation Speed and Simplicity

Installation Flexibility

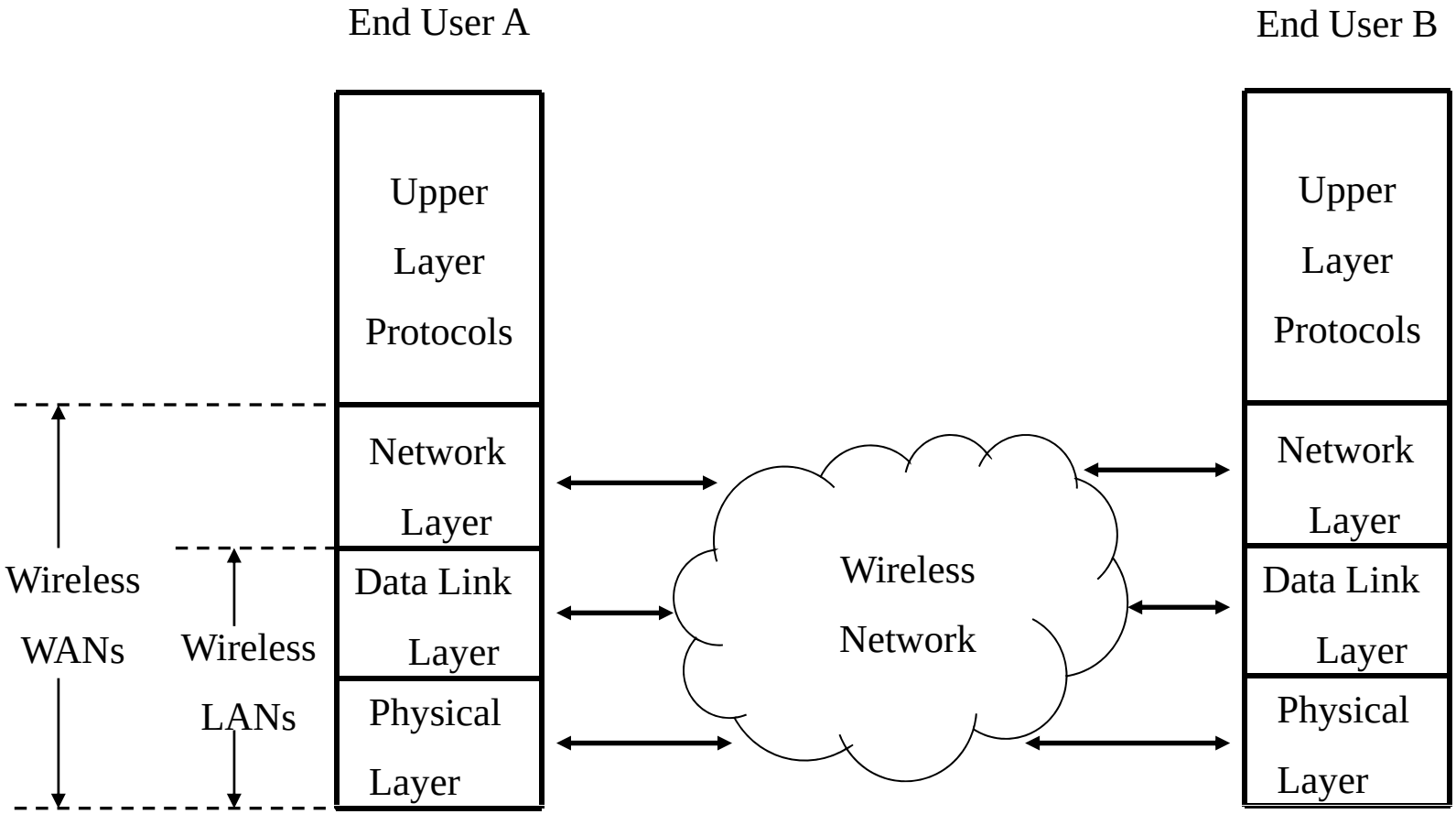
Reduced Cost-of-Ownership

Scalability

Wireless Data Solution



Wireless LAN in the OSI reference model



(Source: J. Geier, Wireless LANs: Implementing Interoperable Networks)

Wireless LAN Standards

IEEE 802.11 Series

- A common MAC layer has been specified for IEEE 802.11 series
- The main differences lie in physical layer
  - IEEE 802.11 standard (1997. 6.)
  - IEEE 802.11b standard (1998. 7.)
  - IEEE 802.11a standard (1999. 9.)
  - IEEE 802.11g standard
- Enhanced MAC
  - IEEE 802.11e standard

Wireless LAN Standards

- Physical layer
  - 802.11b - 2.4GHz ISM band/ 11Mbps using DSSS
  - 802.11a - Unlicensed 5GHz/ 54Mbps using OFDM
- MAC for WLAN
  - DCF (Distributed Coordination Function)
    - Based on CSMA/CA (contention based) with different IFSs & Backoff procedure
  - PCF (Point Coordination Function)
    - Centralized contention-free access method, Optional
  - EDCF and HCF in the 802.11e

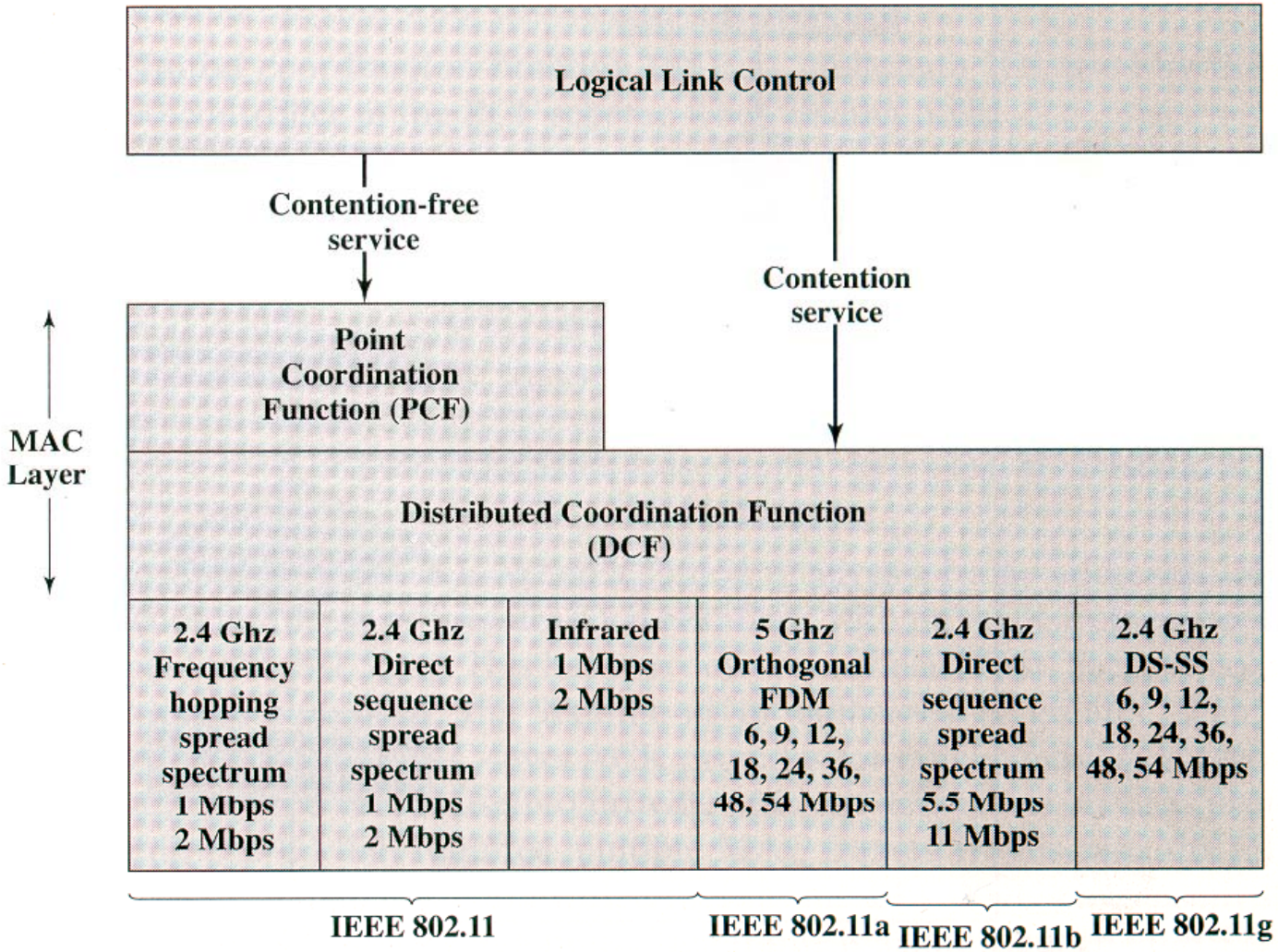
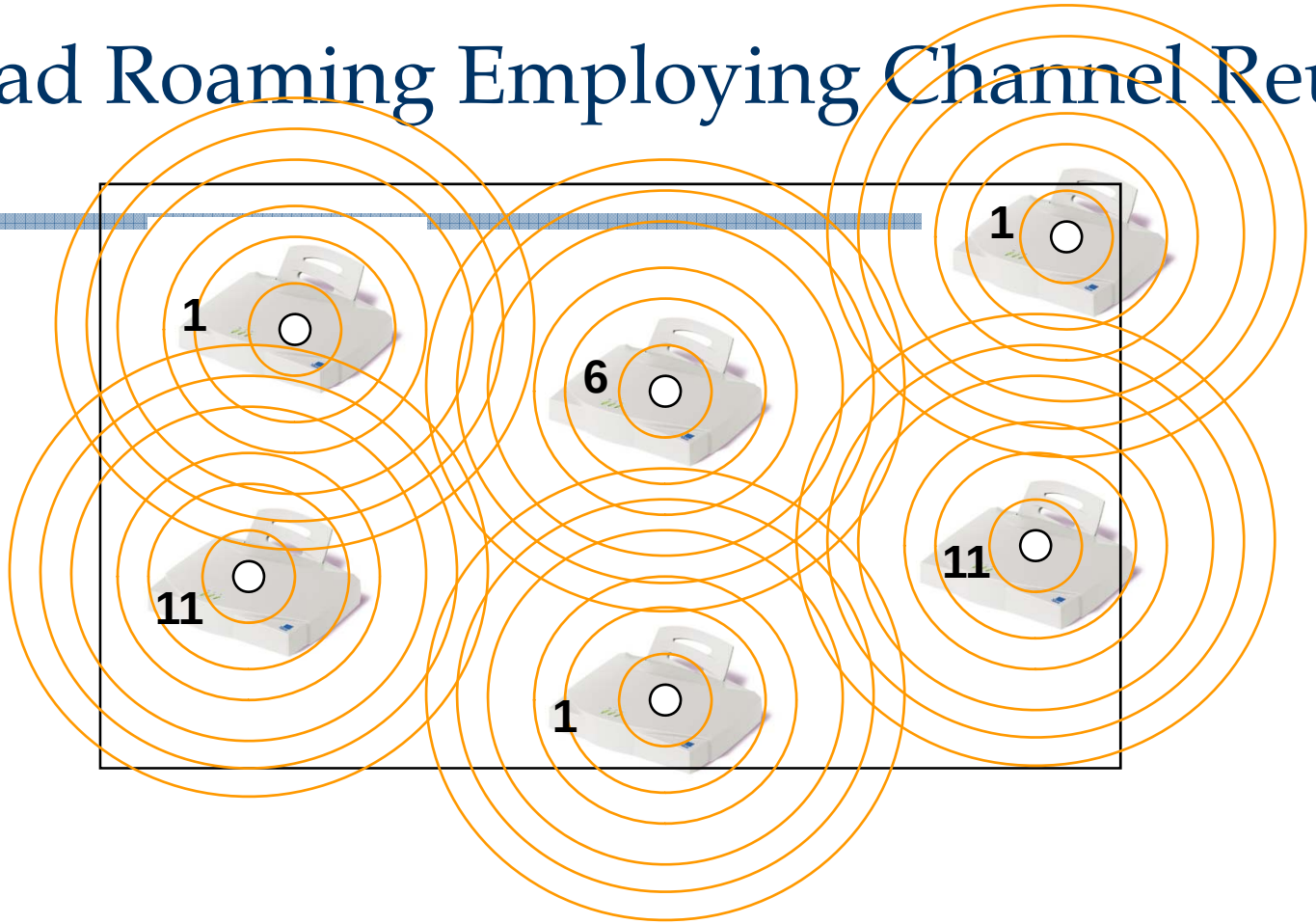


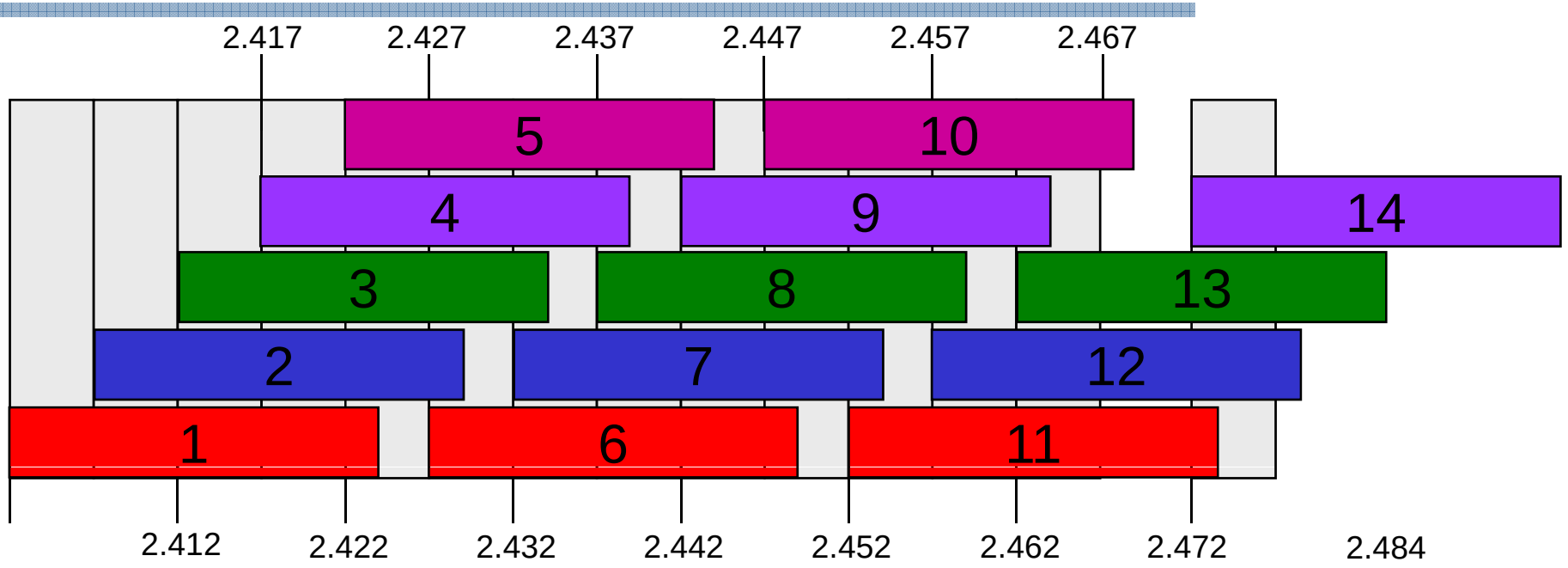
Figure 17.5 IEEE 802.11 Protocol Architecture

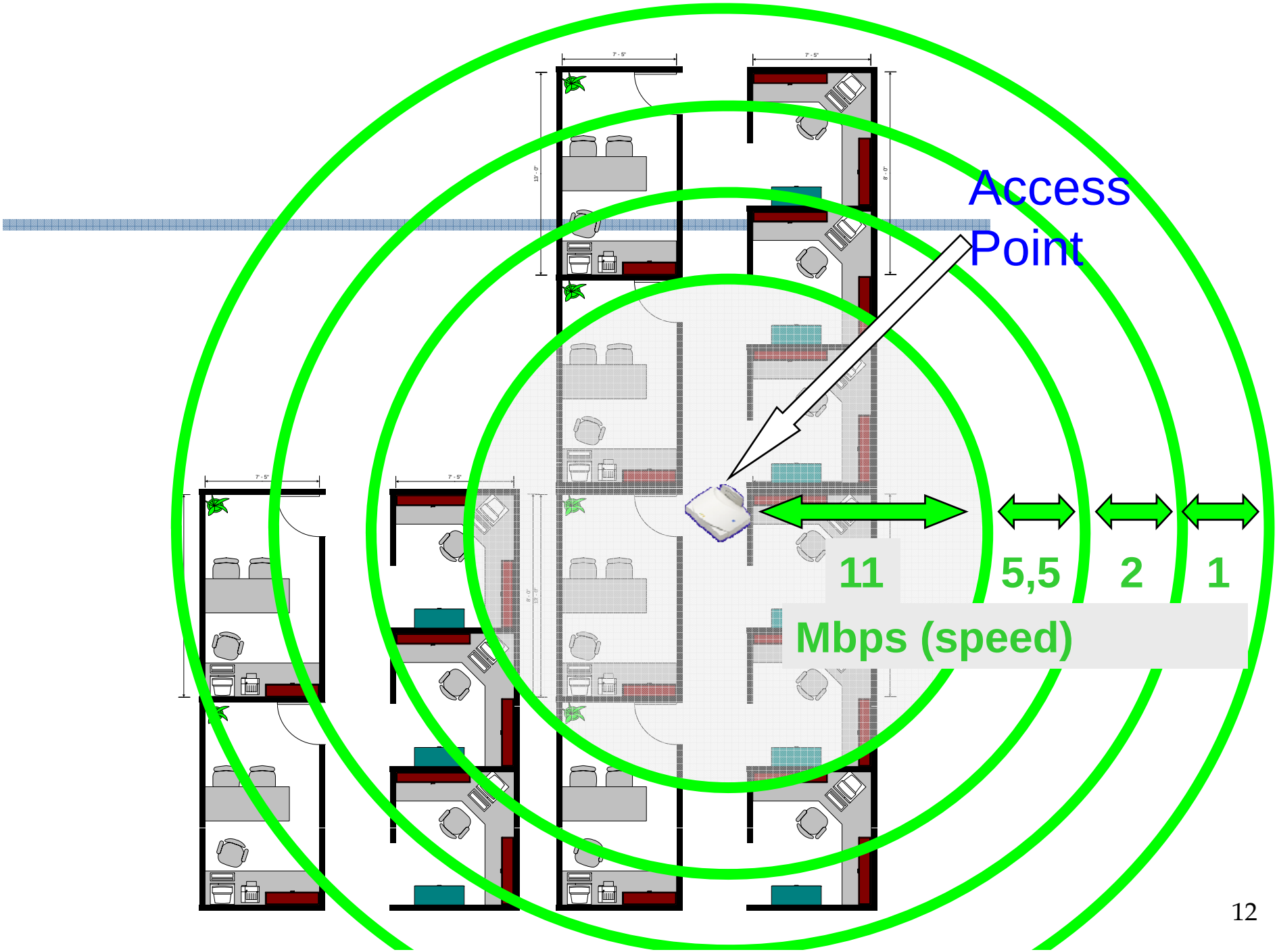
Broad Roaming Employing Channel Reuse



Access Points can be programmed to 3 different channels and these can be re-used to provide *potentially unlimited coverage.*

802.11b DS Channels




Access
Point
11
5,5
2
1
Mbps (speed)

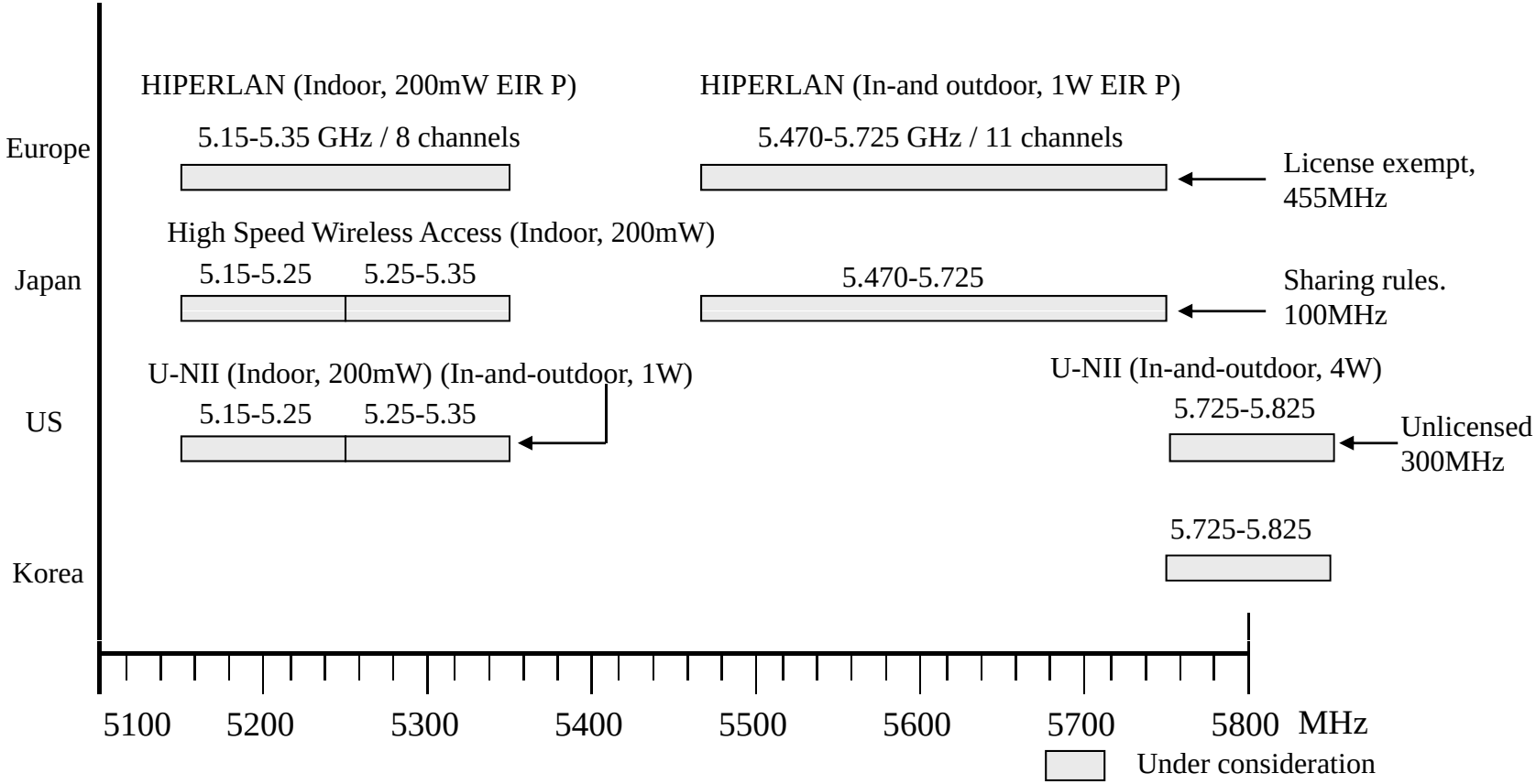
802.11b and 802.11a

	802.11b	802.11a
Modulation	DSSS	OFDM
Carrier frequency	2.4GHz	5GHz
Max physical rate	11Mbps	54Mbps
Max data rate, layer3	5Mbps	32Mbps
MAC/Media sharing	CSMA/CA	

IEEE 802.11a

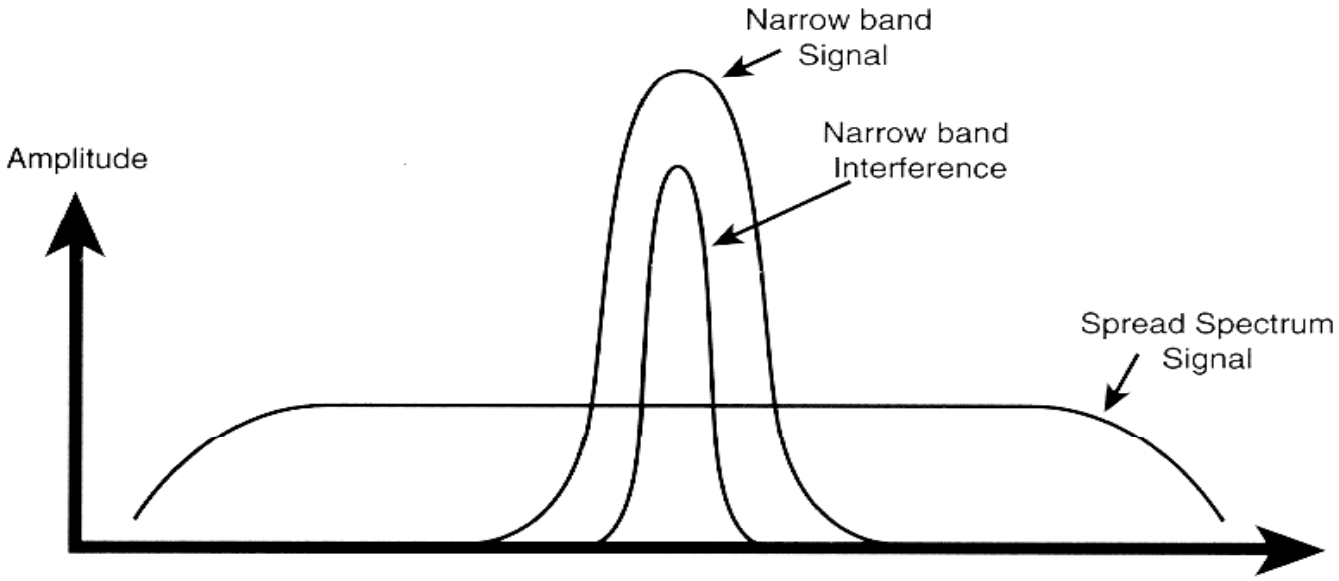
Accepted the new modulation scheme, OFDM for higher data rate

Spectrum Allocation in 5GHz



Direct Sequence Spread Spectrum

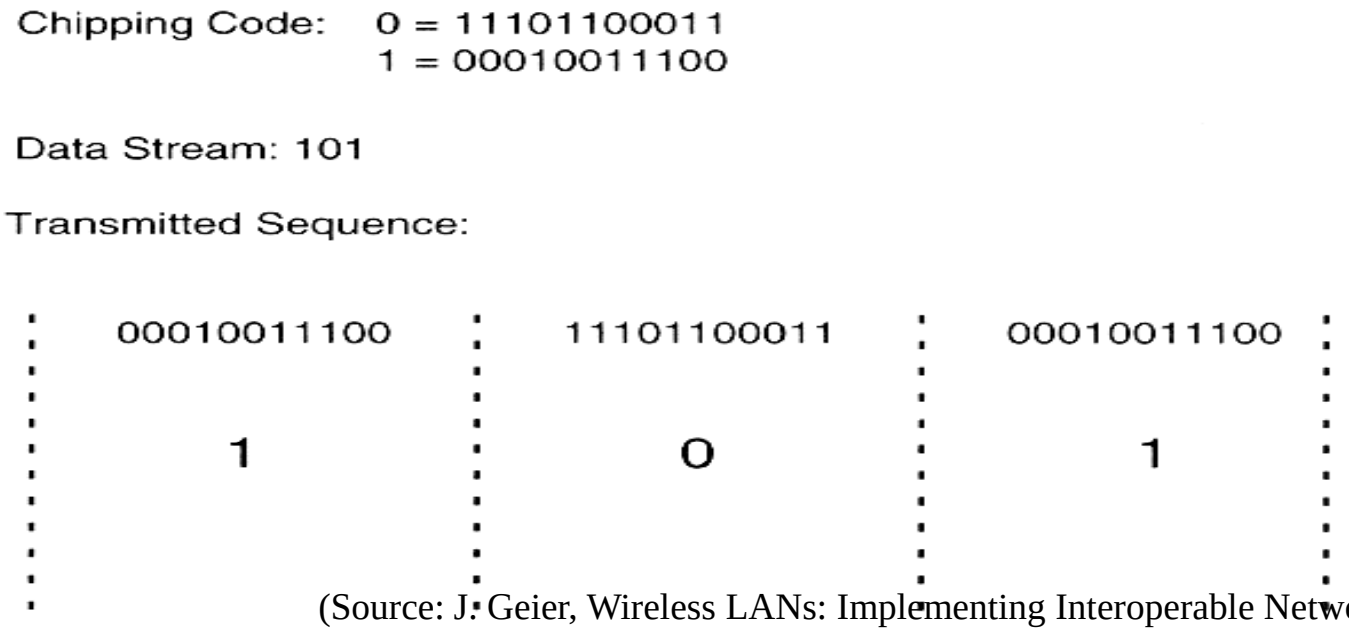
Spread spectrum "spreads" a signal's power to gain signal-to-noise performance



(Source: J. Geier, Wireless LANs: Implementing Interoperable Networks)

Direct Sequence Spread Spectrum

Direct sequence spread spectrum sends a specific string of bits for each data bit sent

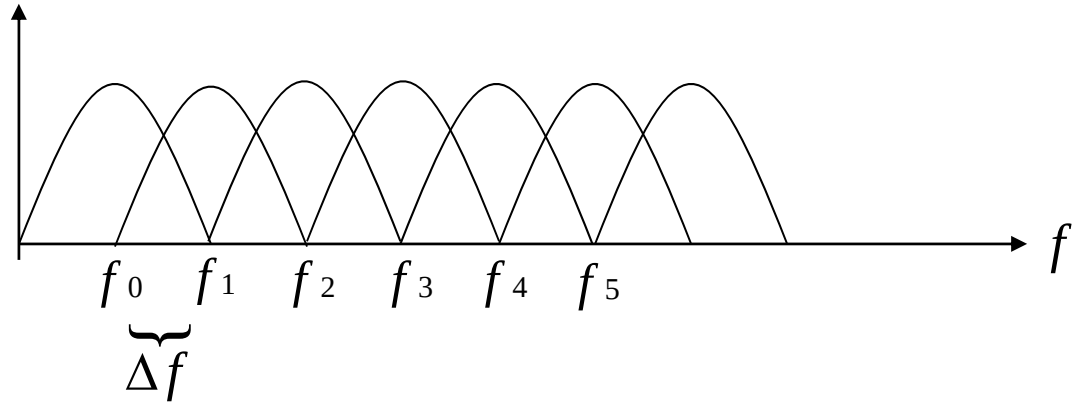


(Source: J. Geier, Wireless LANs: Implementing Interoperable Networks)

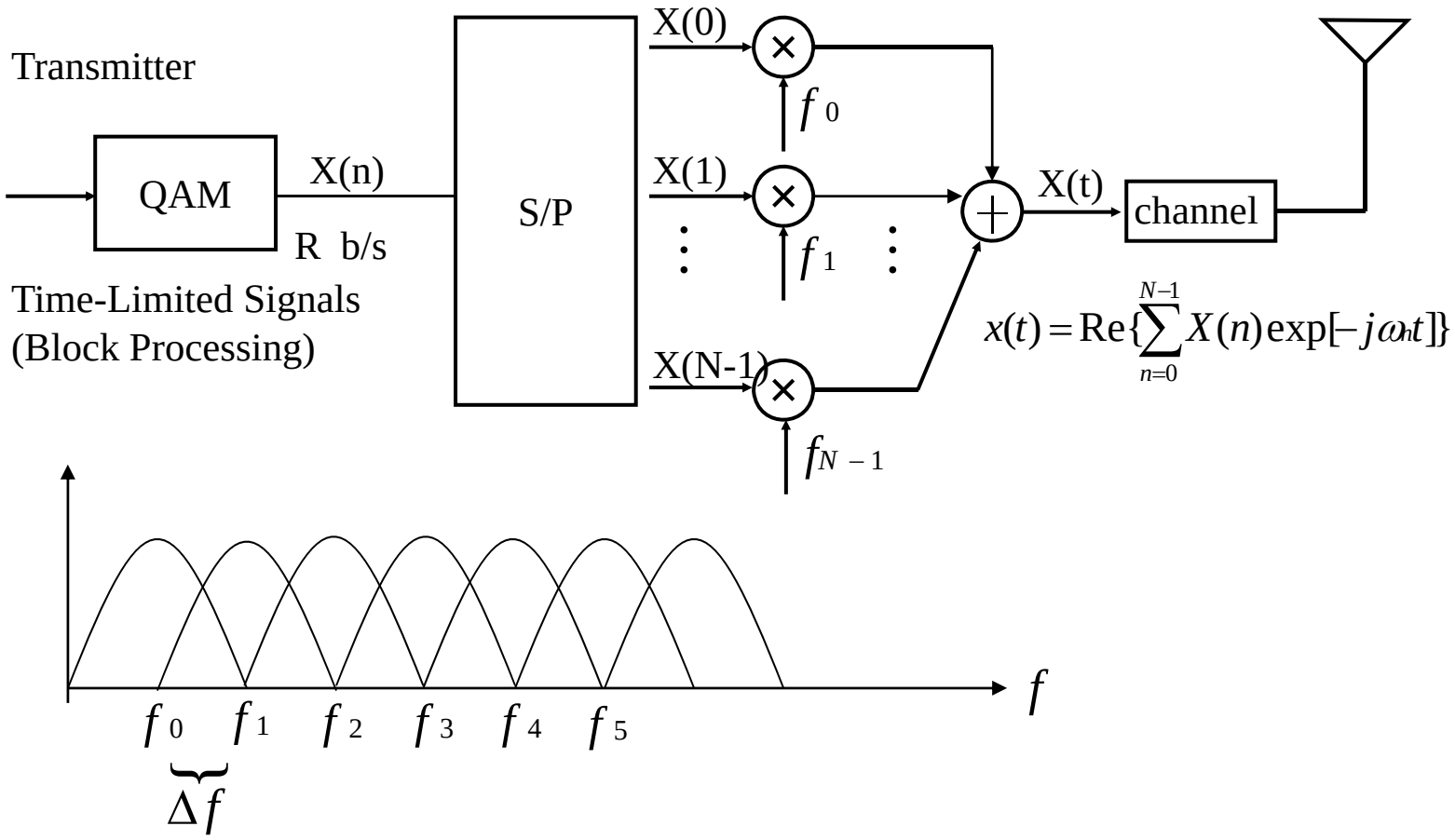
OFDM (Orthogonal Frequency Division Multiplexing) in IEEE 802.11a

64 possible subcarriers in 20 MHz channel

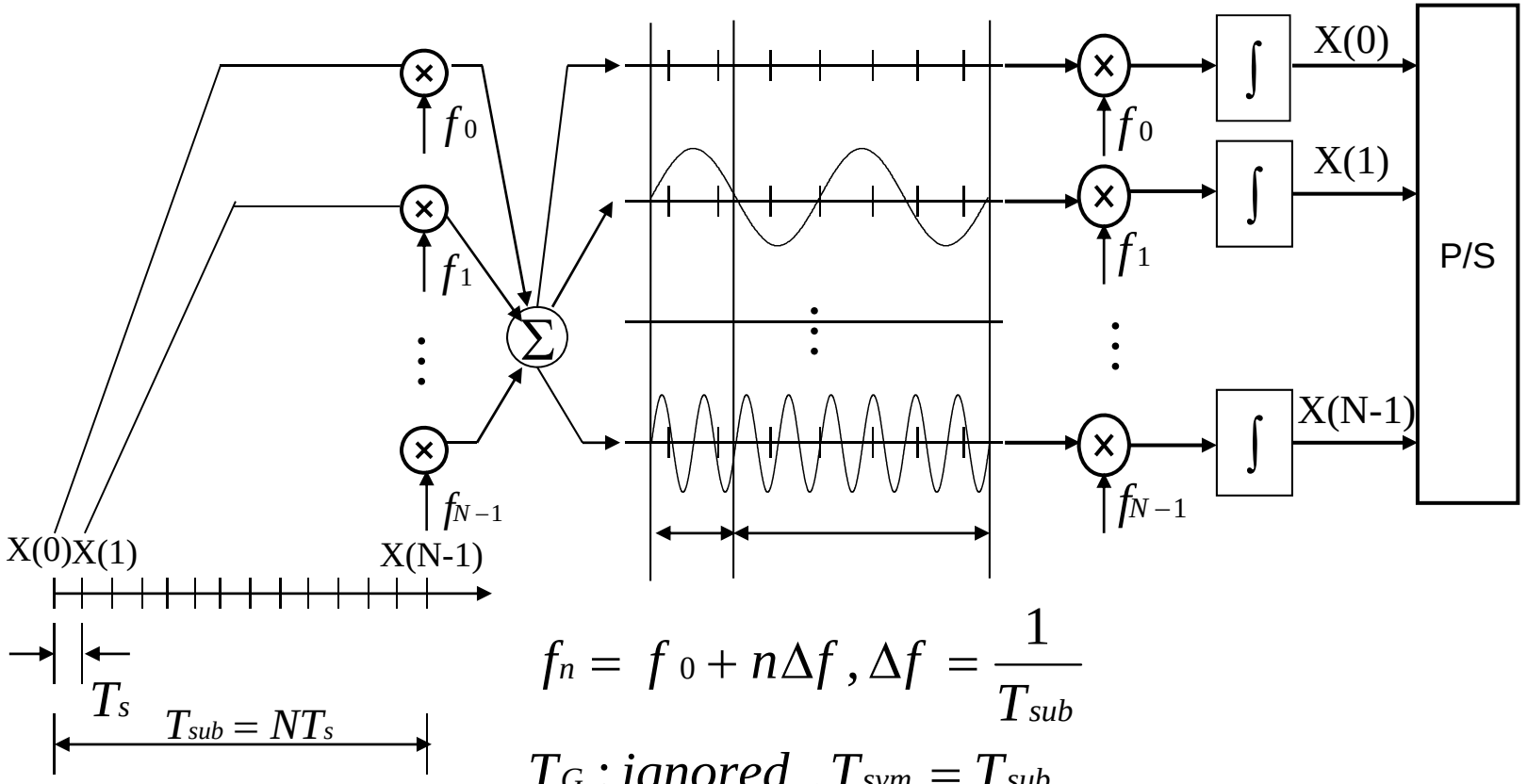
- 4 pilot subcarriers
- 48 subcarriers for sending information in parallel fashion
- Bits are loaded in each subcarrier for one OFDM symbol



OFDM (Orthogonal Frequency Division Multiplexing)



OFDM (Orthogonal Frequency Division Multiplexing)



$$f_n = f_0 + n\Delta f, \Delta f = \frac{1}{T_{sub}}$$

$$T_G : ignored, T_{sym} = T_{sub}$$

PHY modes supported in IEEE 802.11a and HIPERLAN/2 (48 subcarriers in 20 MHz)

Mode	Data rate (Mbps)	Modulation	Code rate	Coded bits per subcarrier	Coded bits per OFDM symbol	Data bits per OFDM symbol
1	**6**	BPSK	1/2	1	48	24
2	9	BPSK	3/4	1	48	36
3	**12**	QPSK	1/2	2	96	48
4	18	QPSK	3/4	2	96	72
5 (802.11a)	**24**	16QAM	1/2	4	192	96
5(H/2)	27	16QAM	9/16	4	192	108
6	36	16QAM	3/4	4	192	144
7 (802.11a)	48	64QAM	2/3	6	288	192
7 (H/2)	54	64QAM	3/4	6	288	216
8(802.11a)	54	64QAM	3/4	6	288	216

6, 12, 24Mbps are mandatory

MAC layer of the IEEE 802.11 Series

MAC layer provides

- Accessing the wireless medium
- Joining the network
- Providing authentication and privacy

MAC layer of the IEEE 802.11 Series

Two service types

- DCF (Distributed Coordination Function)
  - Supports asynchronous type services
  - Basic contention-based access method
- PCF (Point Coordination Function)
  - Supports synchronous type or time-bounded services
  - Optional centralized contention-free access method

MAC layer of the IEEE 802.3 and 802.11

IEEE 802.3 (Ethernet)

- CSMA/CD
- 1-persistent: Once the channel is sensed idle by a station, tx takes place with probability 1
- Backoff algorithm when collision detected

IEEE 802.11 (WLAN)

- CSMA/CA
- p-persistent: tx takes place with probability p or tx is deferred one unit of time with probability 1-p (to avoid collision)
- After a successful tx, the channel is released by Backoff time before contending for the channel again

Operation of the CSMA/CA

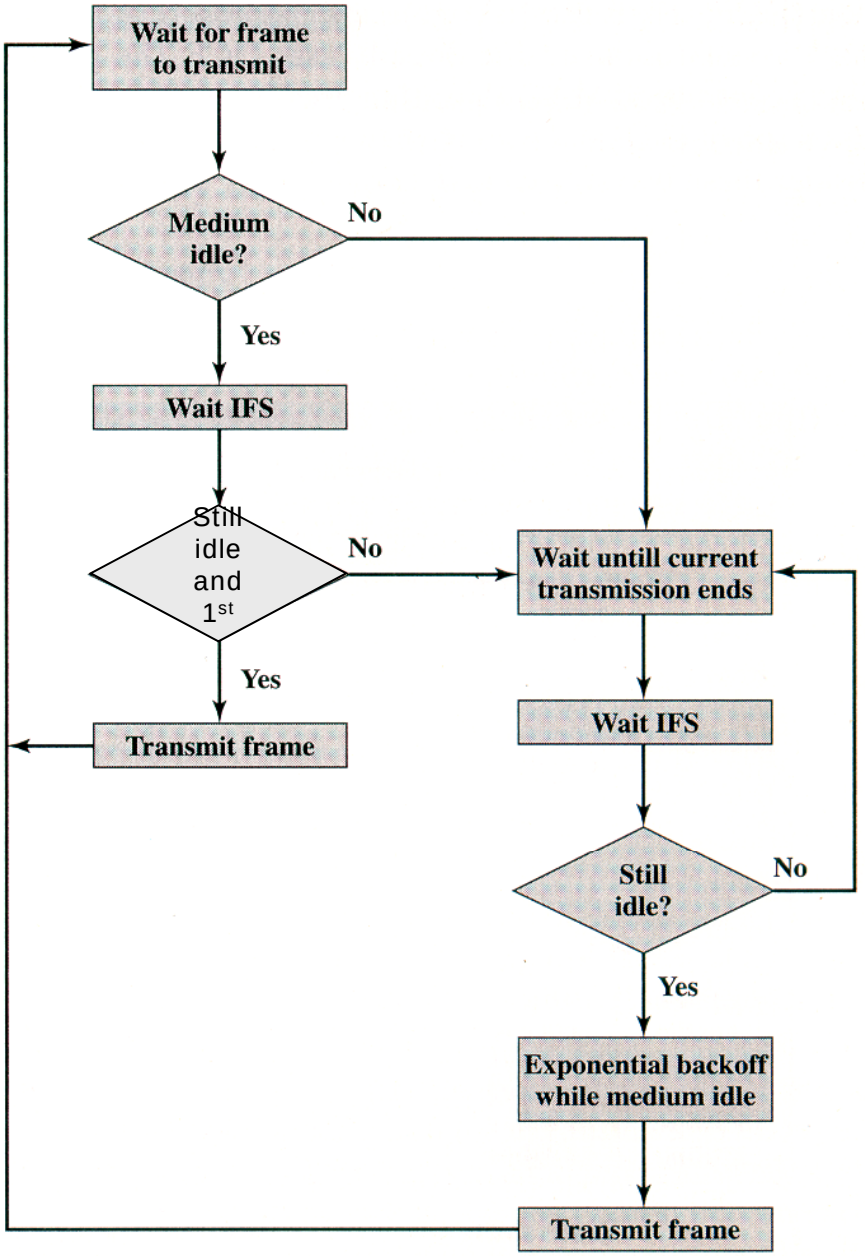
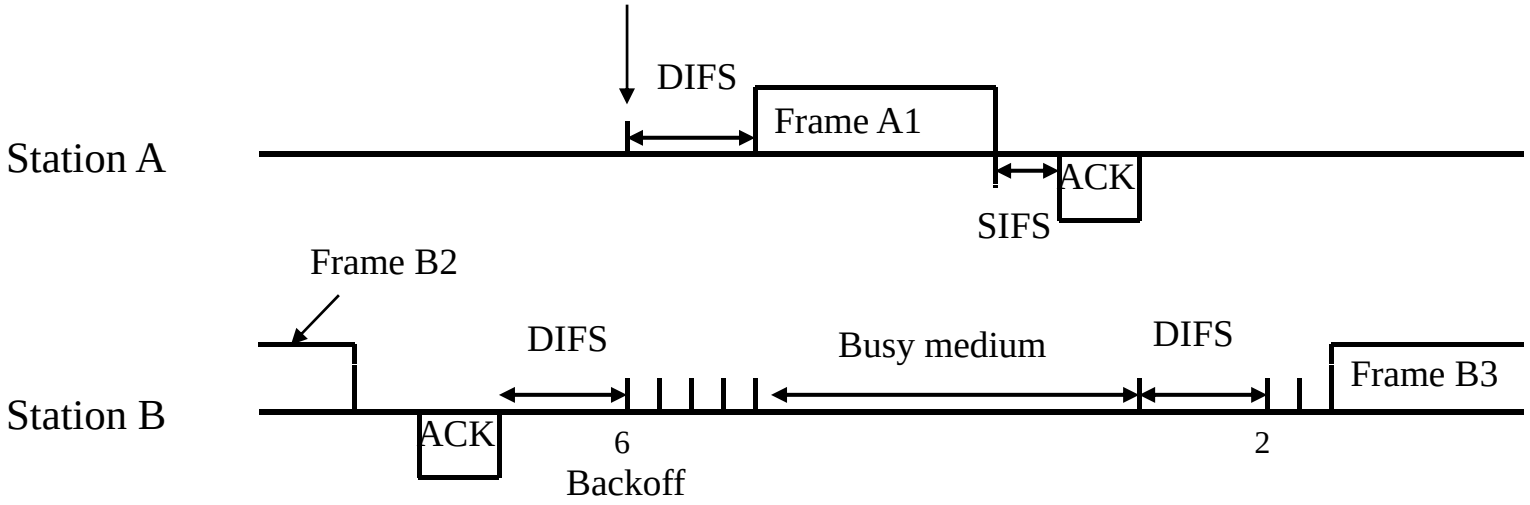


Figure 17.6 IEEE 802.11 Medium Access Control Logic

MAC layer of the IEEE 802.11/DCF

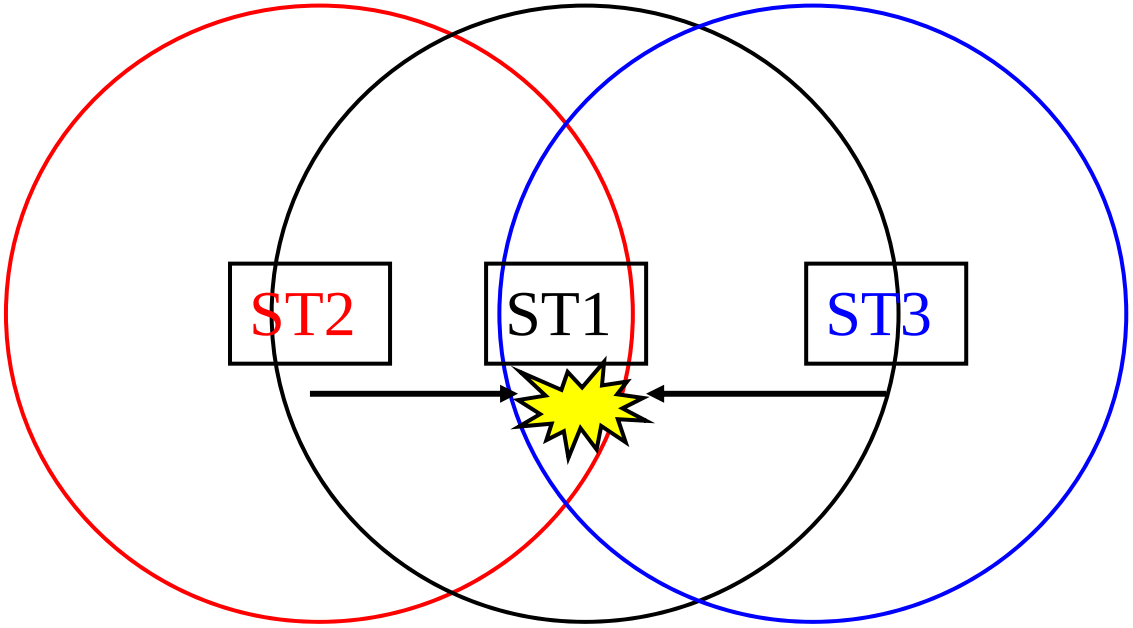
CSMA/CA: Contention-based method

- No collision detection
- Stop-and-wait ARQ



(Source: H. Li et al., Performance Comparison of the Radio Link Protocols of IEEE 802.11a and HIPERLAN/2)

Hidden Terminal Problem

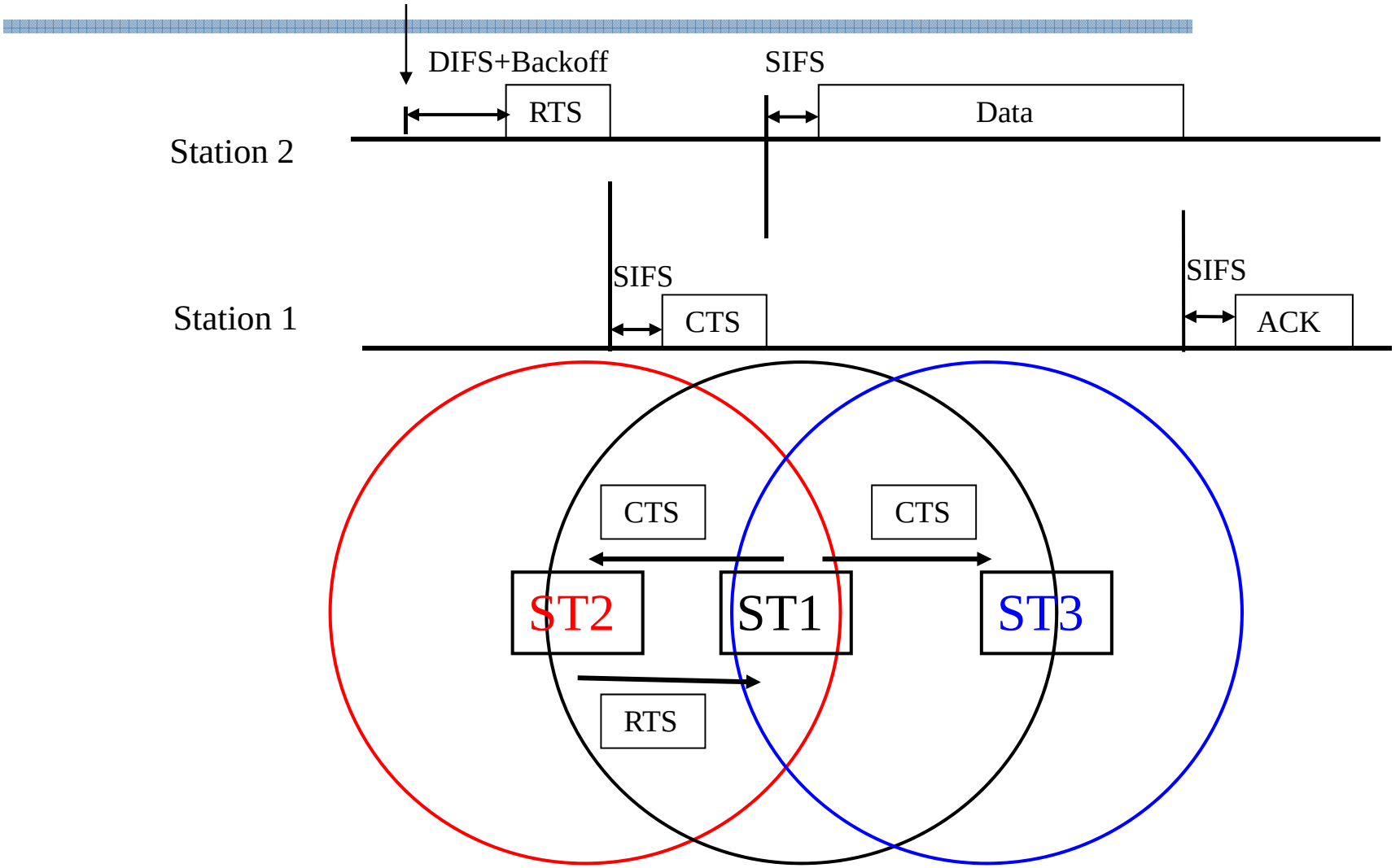


ST1 (AP) can hear both ST2 and ST3

ST2 and ST3 are hidden from each other due to the path loss

Collision can be occurred at ST1 (AP)

RTS/CTS to overcome the hidden terminal problem

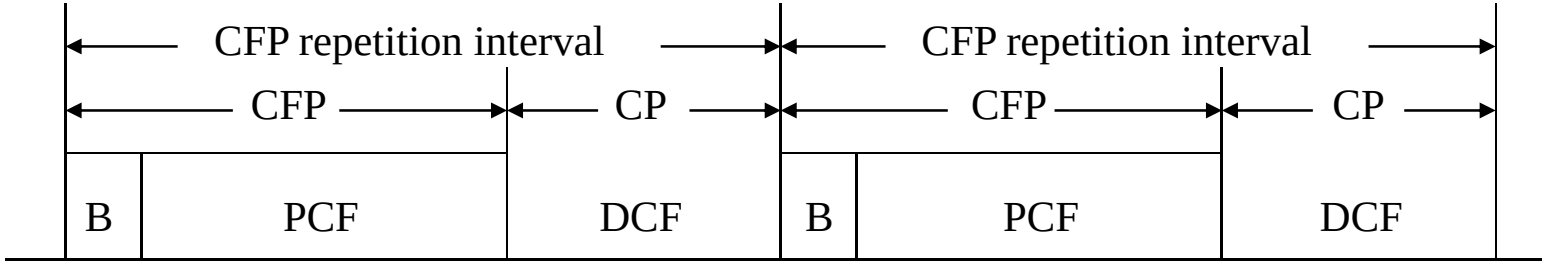


MAC layer of the IEEE 802.11/PCF

Contention-free access method

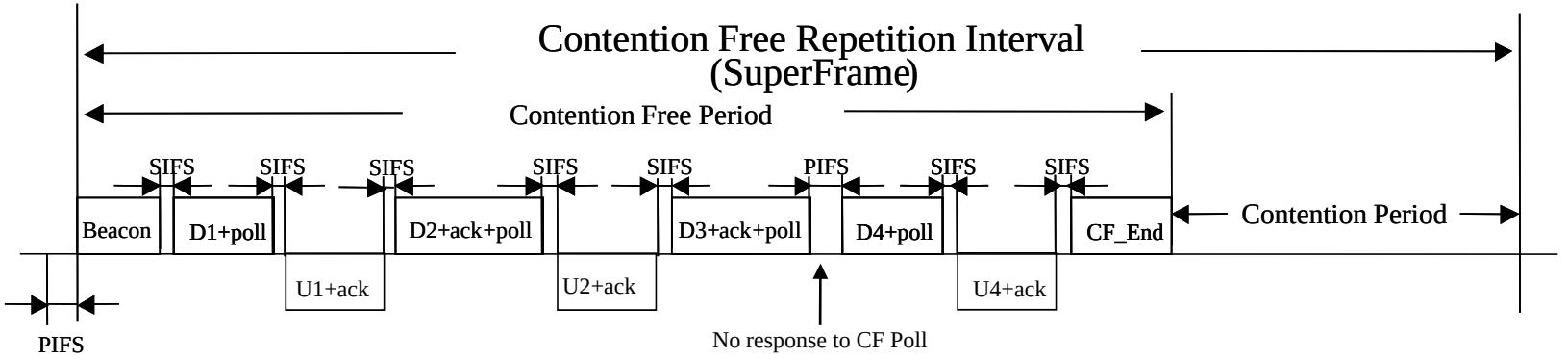
Polling by centralized control

Coexists with DCF



(Source: B. Crow et al., IEEE 802.11 Wireless Local Area Networks)

PCF

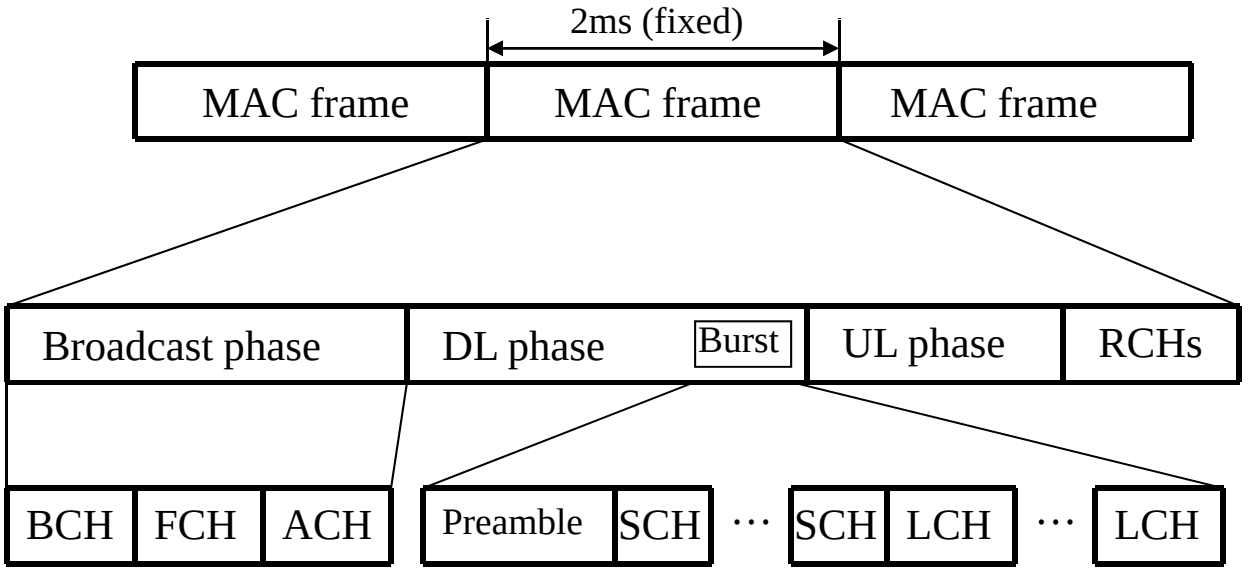

Contention Free Repetition Interval
(SuperFrame)
Contention Free Period
SIFS
SIFS
SIFS
SIFS
SIFS
PIFS
SIFS
SIFS
Beacon
D1+poll
D2+ack+poll
D3+ack+poll
D4+poll
CF_End
Contention Period
U1+ack
U2+ack
U4+ack
PIFS
No response to CF Poll

MAC layer of HIPER LAN/2

Centralized Multiple Access

Dynamic TDMA/TDD

Fixed LCH PDU payload size (48 octet)



(Source: H. Li et al., Performance Comparison of the Radio Link Protocols of IEEE 802.11a and HIPERLAN/2)

802.11 MAC Parameters

	802.11a	802.11b
SlotTime	9μ	20μ
SIFS	16μ	10μ
PIFS	25μ	30μ
DIFS	34μ	50μ
CWmin	15	31
CWmax	1023	1023

Common Rule

PIFS=SIFS+SlotTime

DIFS=SIFS+2SlotTime

802.11e

AIFSD[AC]
=SIFS+AIFS[AC]·SlotTime

(AIFS[AC] is an integer greater than zero)