



Physical Layer Part 2

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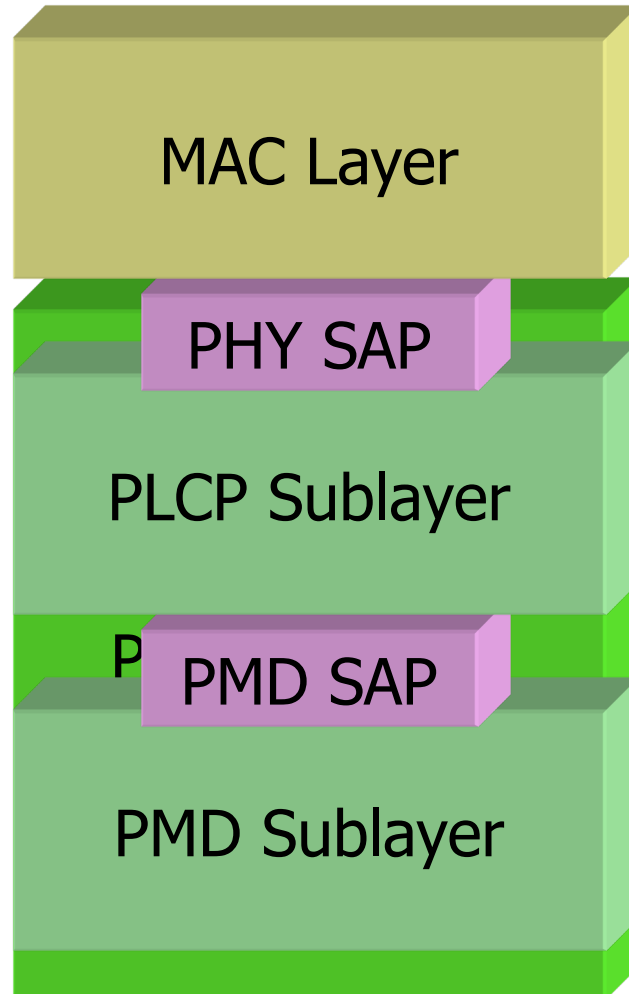


Outline

- Modulation Techniques
 - Basic knowledge
 - Narrow Band
 - Spread Spectrum
- Physical Layer Architecture
- Physical Layer Operation



Physical Layer Architecture





PLCP Sublayer

- Physical Layer Convergence Procedure
- Communicate to MAC via primitives through Physical Layer Service Access Point (SAP)
- Prepare PLCP protocol data unit (PPDU) (append fields to MPDU)
- PPDU provides for asynchronous transfer of MPDU between stations



PMD Sublayer

- Physical Medium Dependent
- Provide actual transmission and reception of Physical Layer entities via wireless medium
- Interface directly to the medium
- Provides modulation and demodulation of the transmission frame



Outline

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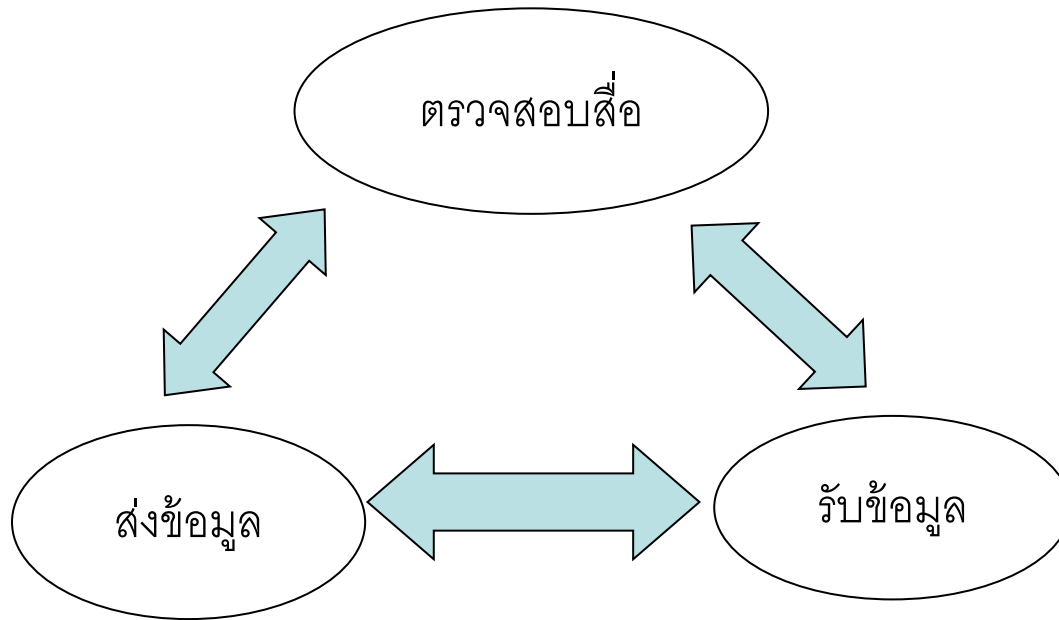


Physical Layer Operations

- 3 State machines
 - Carrier Senses: determine the state of the medium
 - Transmit: send the data frame
 - Receive: receive the data frame



Physical Layer state

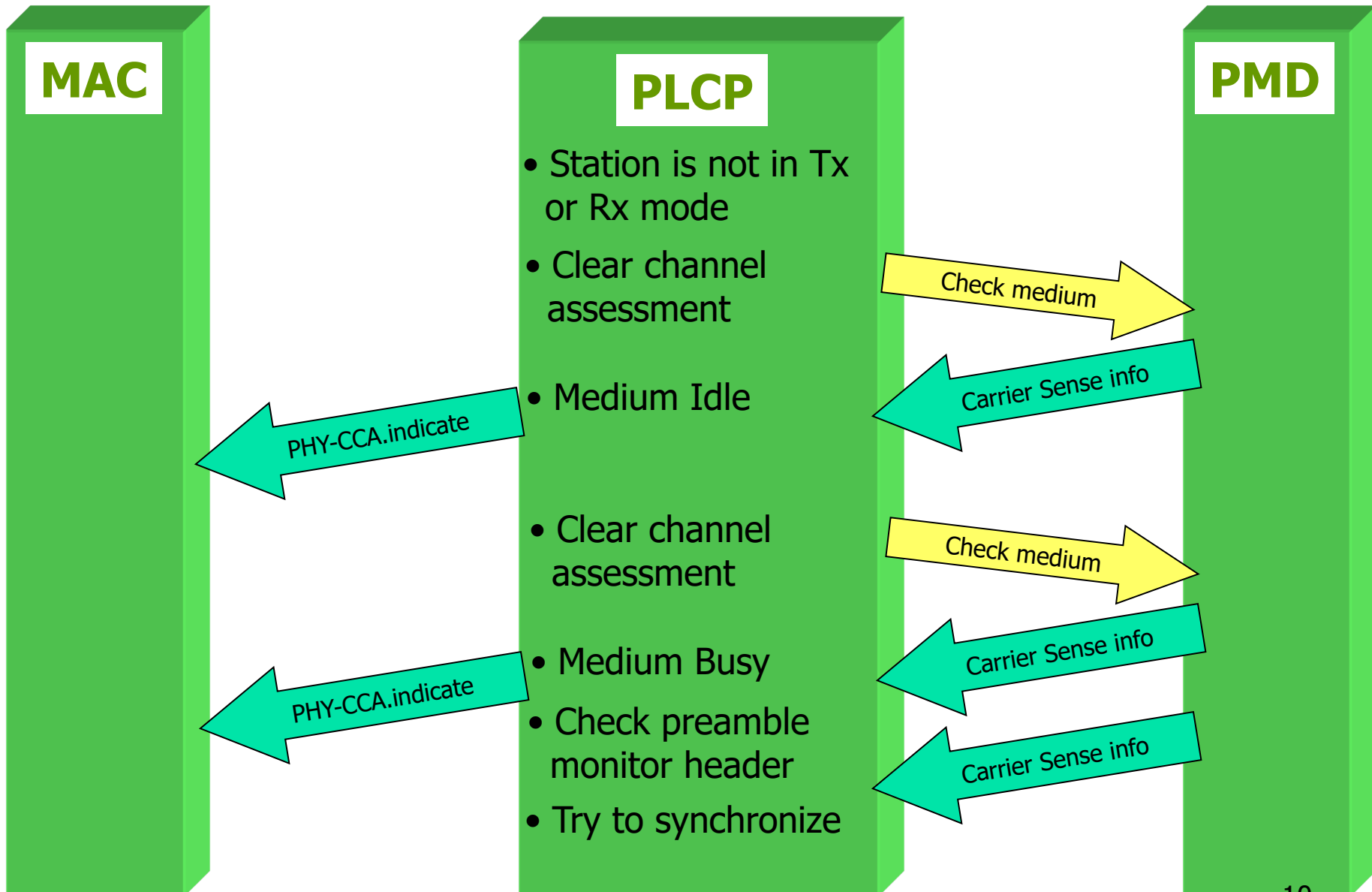




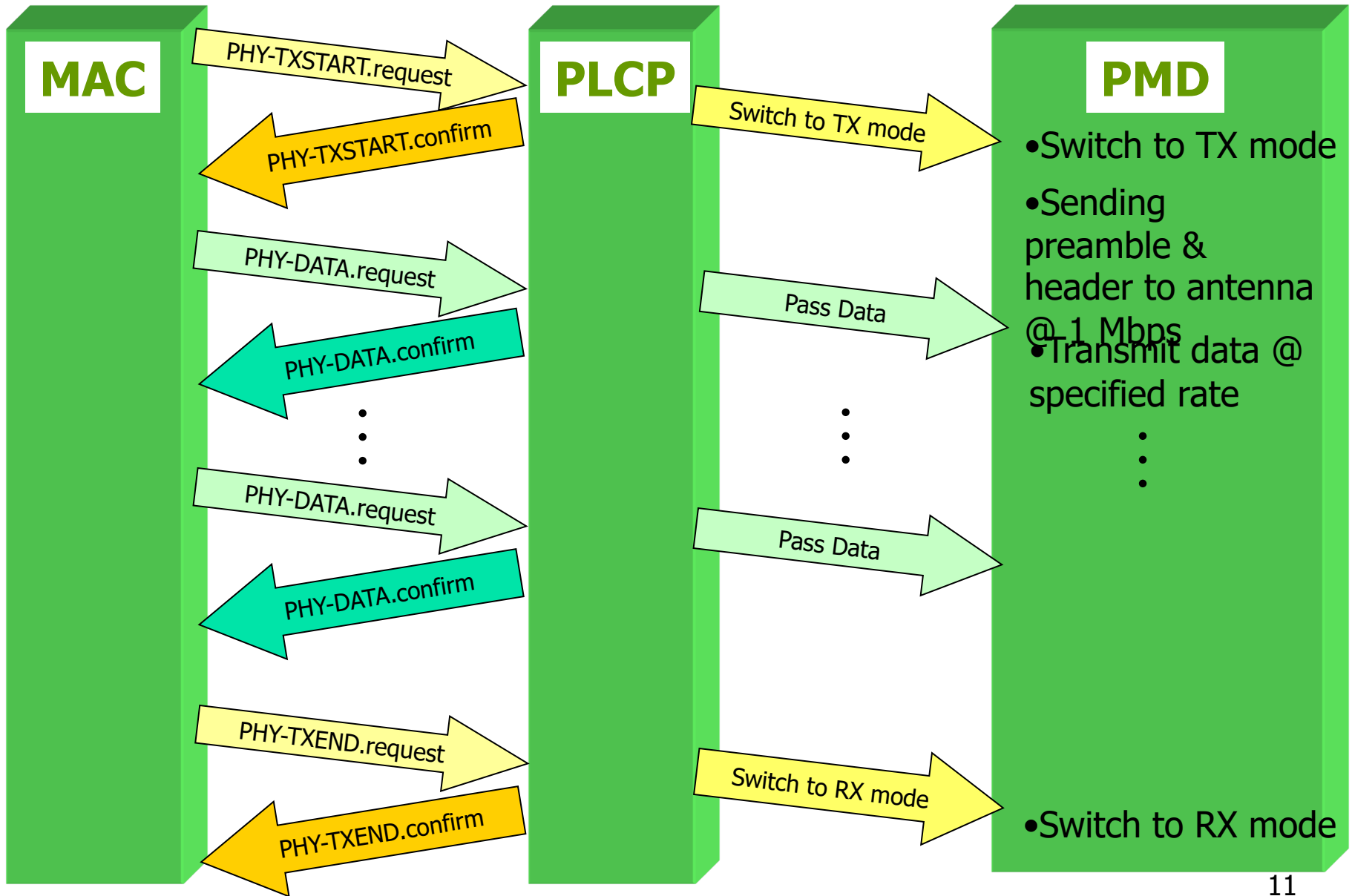
Physical Layer Service Primitives

MAC → PLCP	PLCP → MAC	Description
	PHY-CCA.indication	(busy/idle : send every channel changes state)
PHY-TXSTART.request	PHY-TXSTART.confirm	Start TX
PHY-DATA.request	PHY-DATA.confirm	Transfer Data
PHY-TXEND.request	PHY-TXEND.confirm	End TX
PHY-CCARESET.request	PHY-CCARESET.confirm	Reset Clear Channel Assessment state machine
	PHY-DATA.indication	Transfer Data
	PHY-RXSTART.indication PHY-RXEND.indication	Received a valid start frame/PLCP header

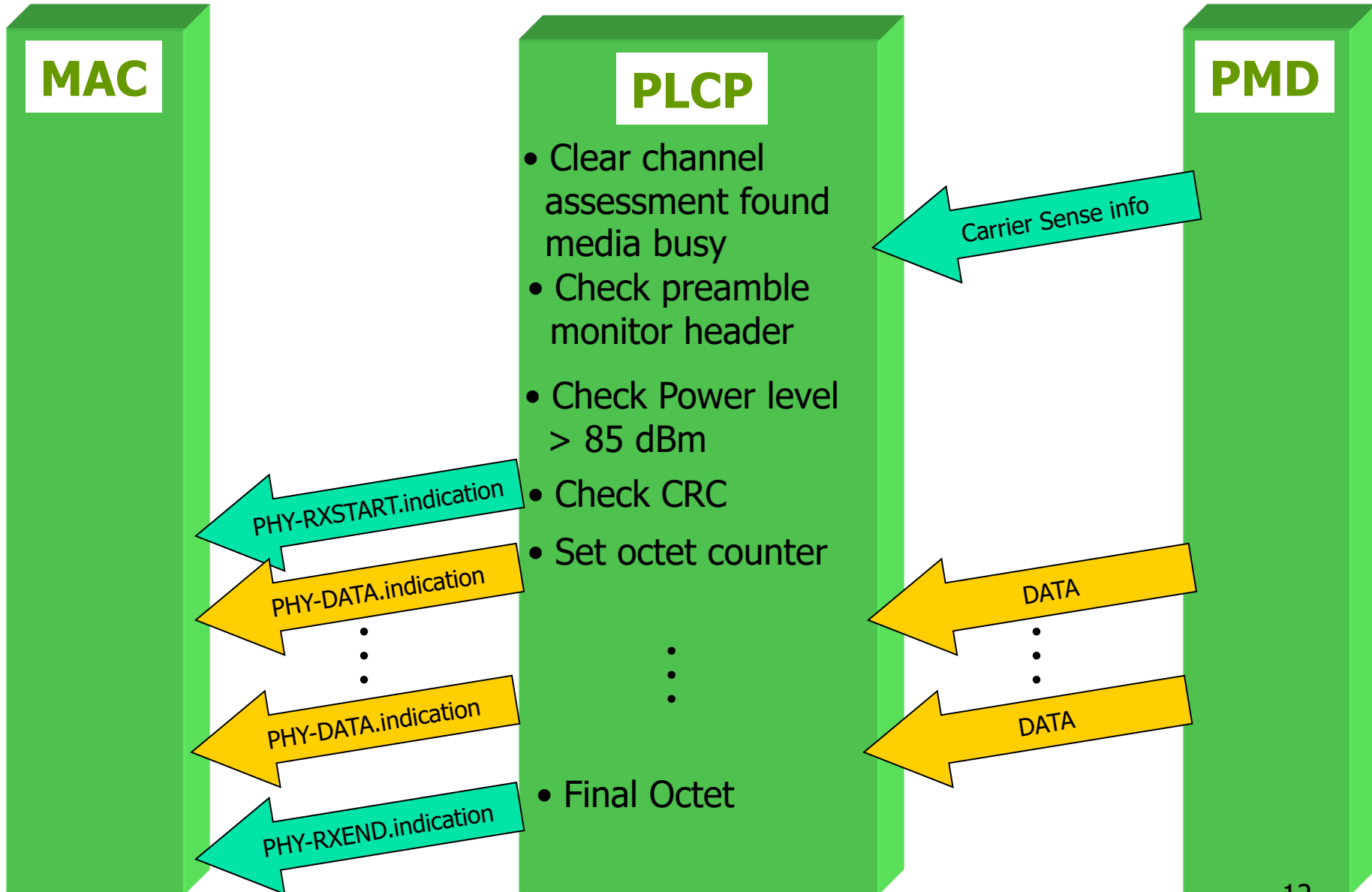
Carrier Sense Function



Transmit Function



Receive Function



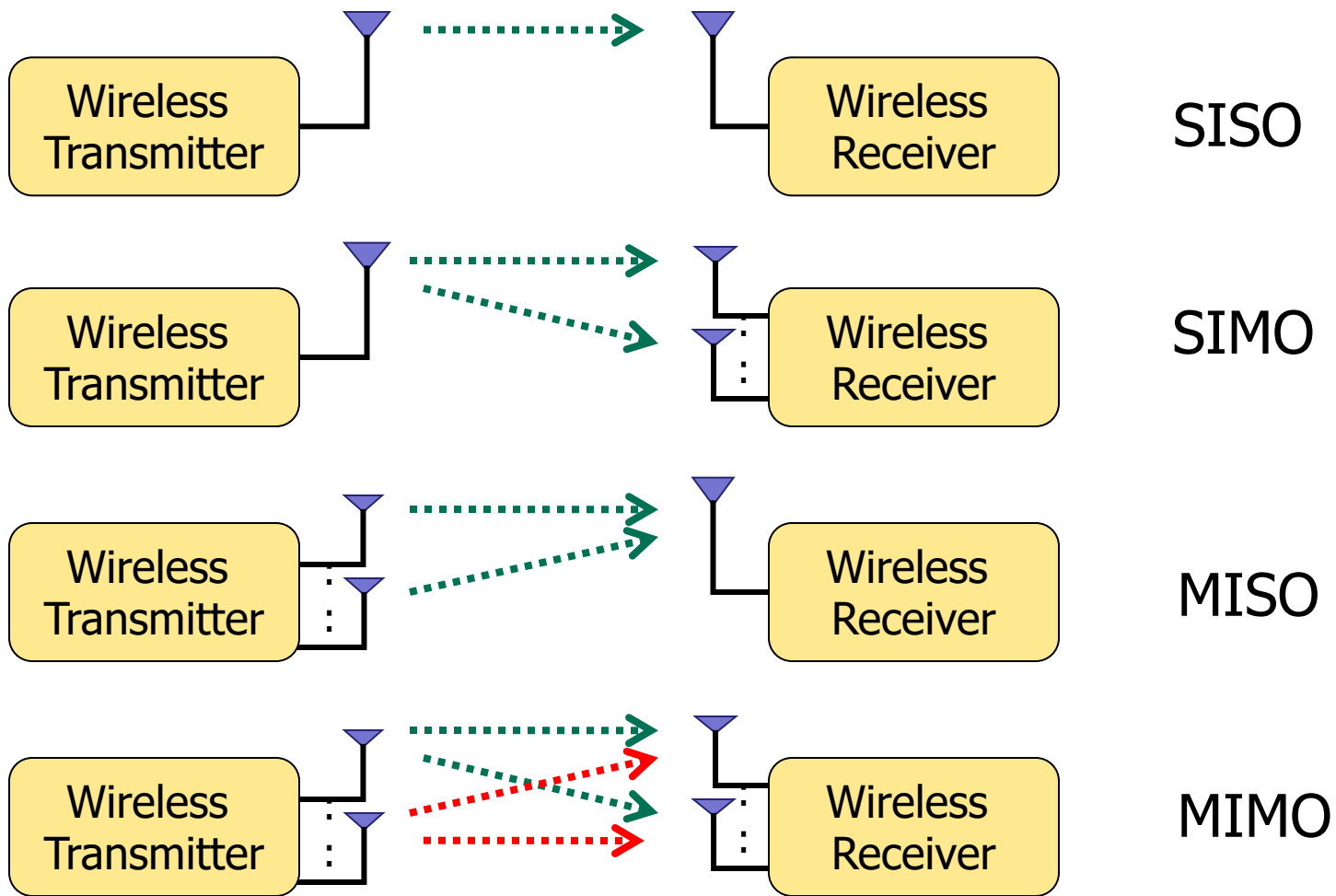


Multiple Antenna Diversities

- Receive function will operate with
 - Single Antenna
 - Multiple Antennas
- Signal Degradation Factors
 - Distance
 - Atmosphere
 - Barrier
- Multiple-path propagation
 - Decrease the signal strength
 - Use multiple antennas (diversity) to improve the received signal

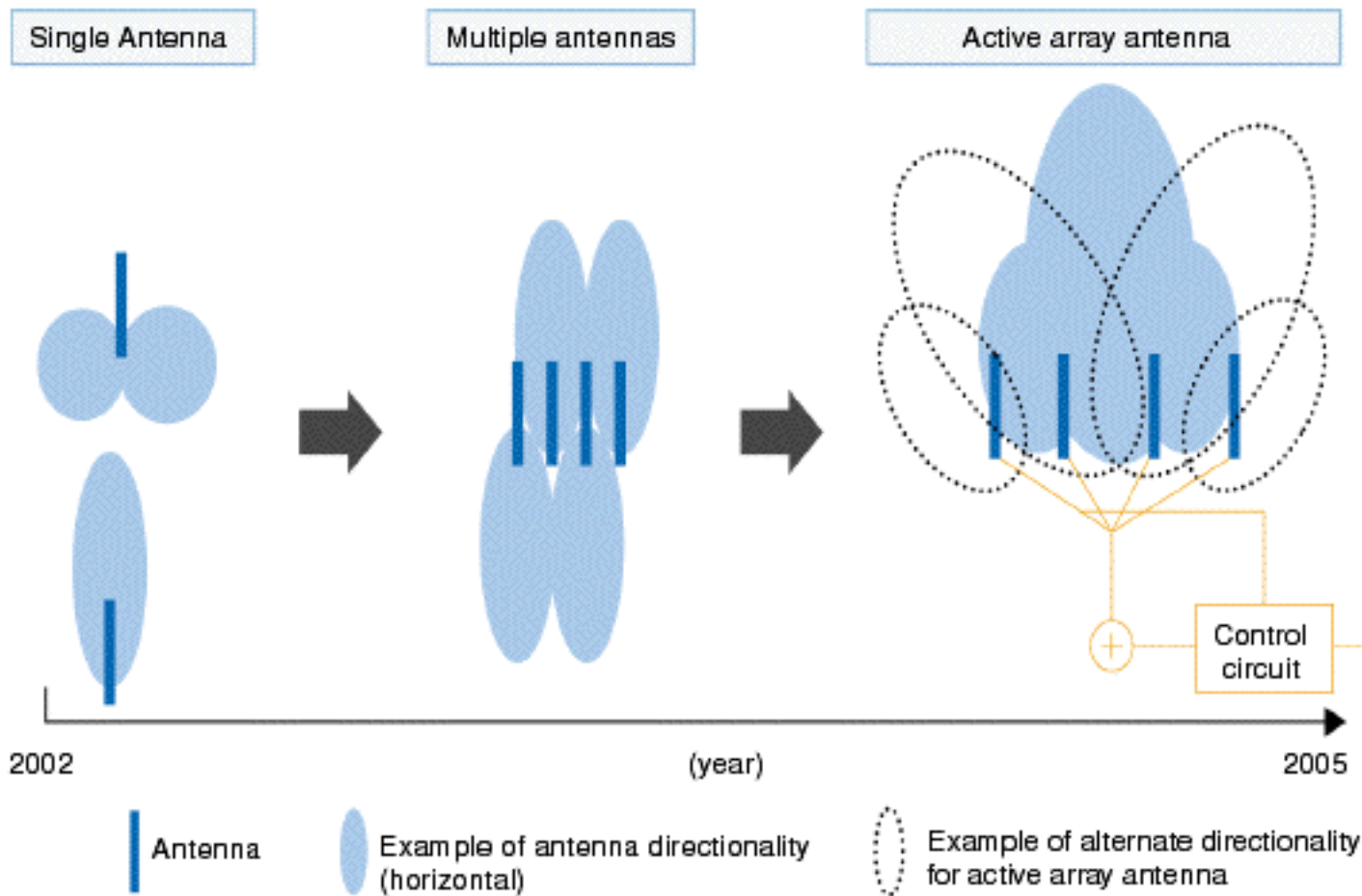


Multiple Antennas





Multiple Antennas



http://techon.nikkeibp.co.jp/english/img2/nea_0211comnet-1fig1.gif



IEEE 802.11 PHY Layer

- FHSS Physical Layer
- DSSS Physical Layer
- Infrared (IR) Physical Layer



FHSS Physical Layer

- Low cost
- Low power consumption
- Most tolerant to noise
- Low potential data rate
- Medium range ($<$ DSSS)

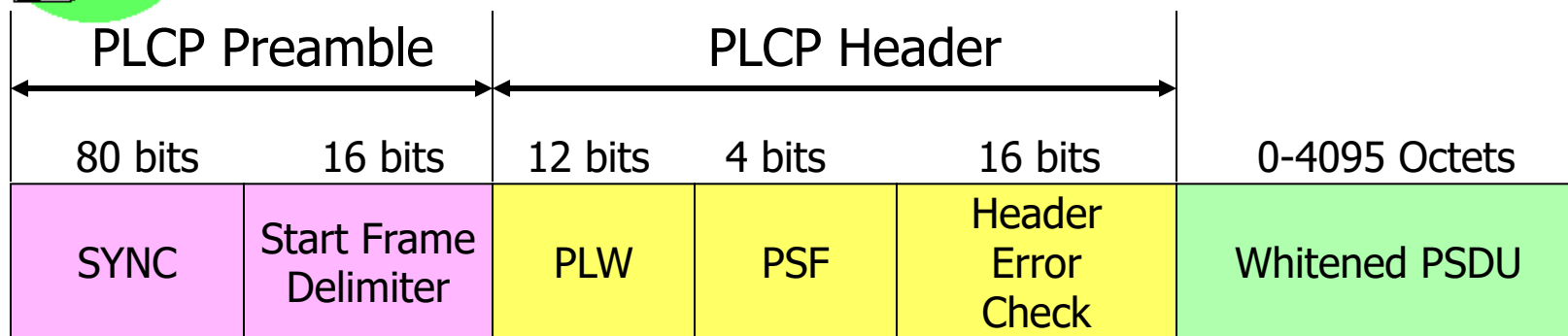


FHSS Architecture

- FHSS PLCP Sublayer
- FHSS PMD Sublayer
- Primitives



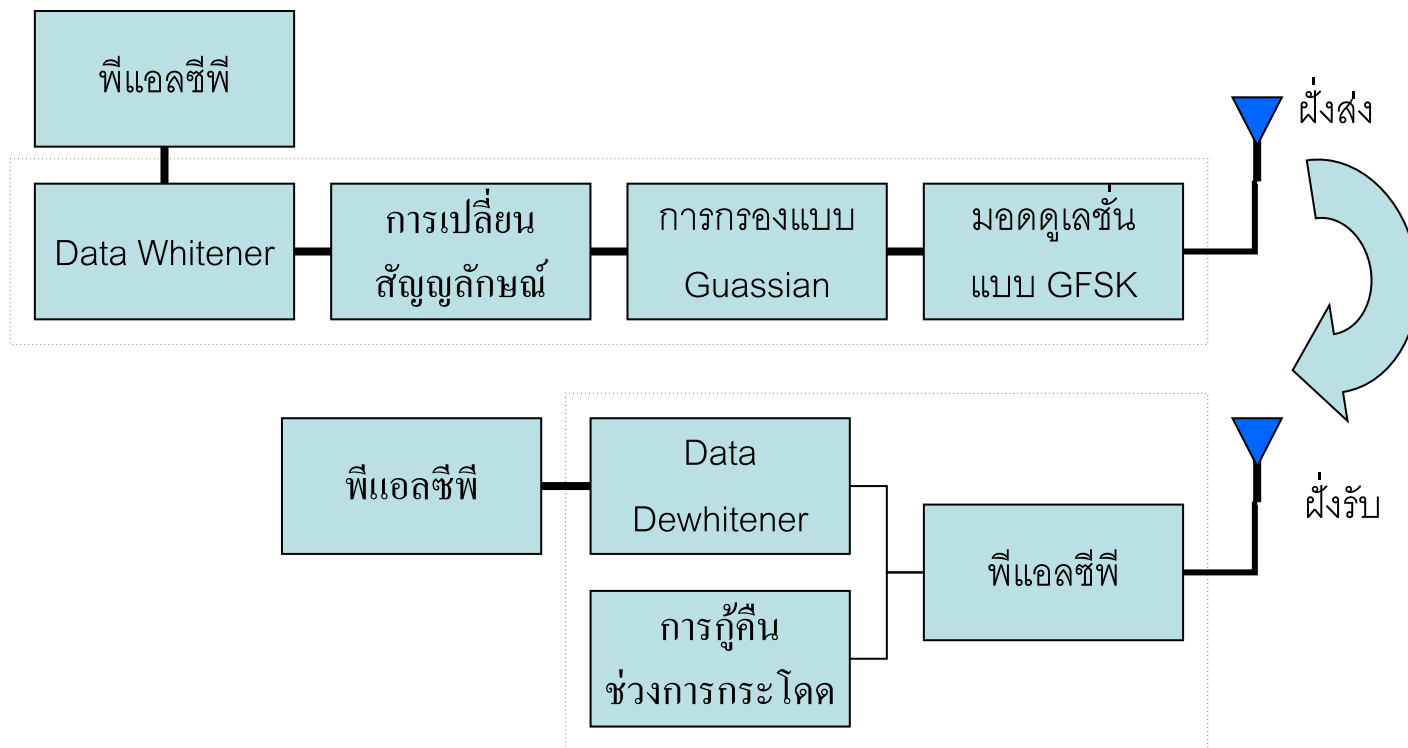
FHSS PLCP frame



↑ PSDU=PLCP Service Data Unit
 ↑ Payload (MPDU)
 ↑ Reduce DC bias, scramble
 ↑ 16-bit CRC
 ↑ PLCP Signaling Field: data rate (1- 4.5 Mbps)
 ↑ PSDU Length word
 ↑ 0000110010111101: define the beginning of a frame
 ↑ 0 & 1 alternating : synchronization purpose



FHSS HW



ปรับปรุงจาก 802.11 Wireless Networks, Gast, O'reilly



FHSS PMD

- Perform actual Tx/Rx of PPDU by hopping between channel (hopping sequence)
- Provides FHSS modulation/demodulation



FHSS PMD Service Primitives

PLCP → PMD	PMD → PLCP	Description
PMD_DATA.request	PMD_DATA.indicate	Transfer Data
PMD_TXRX.request		Set Tx/Rx mode
PMD_PA_RAMP.request		Set Ramp up/down Tx power
PMD_ANTSEL.request		Select antenna (1..N)
PMD_PWRMGMT.request		Put radio in sleep mode
PMD_TXPWRLVL.request PMD_FREQ.request		Select power level Tx Freq (channel ID)
	PMD_RSSI.indication	Signal Strength (0-15)



DSSS Physical Layer

- High cost
- High power consumption
- High potential data rate
- More range

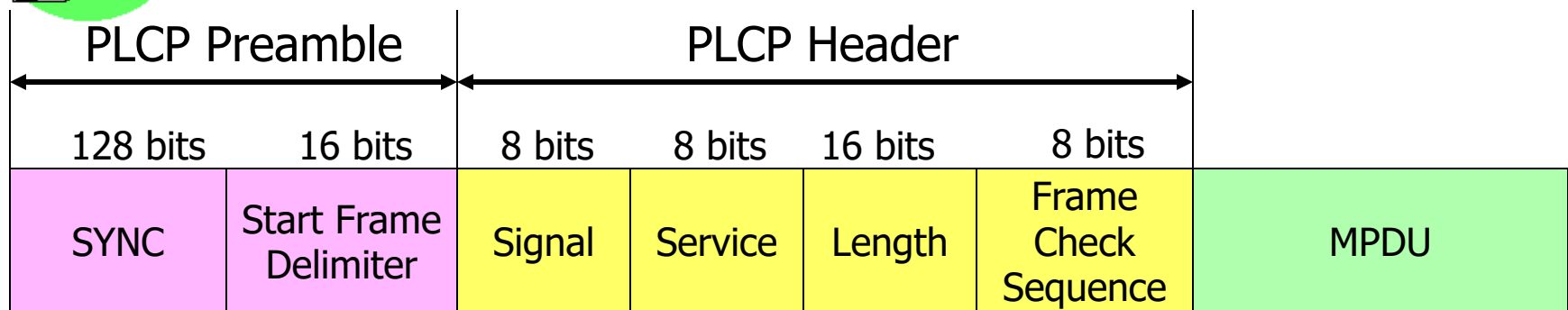


DSSS Architecture

- DSSS PLCP Sublayer
- DSSS PMD Sublayer
- Primitives



DSSS PLCP frame



↑
 0 & 1 alternating : synchronization purpose

↑
 1111001110100000: define the beginning of a frame

↑
 Modulation type: data rate

↑
 Reserved

↑
 #microsec. To transmit the MPDU

↑
 16-bit CRC

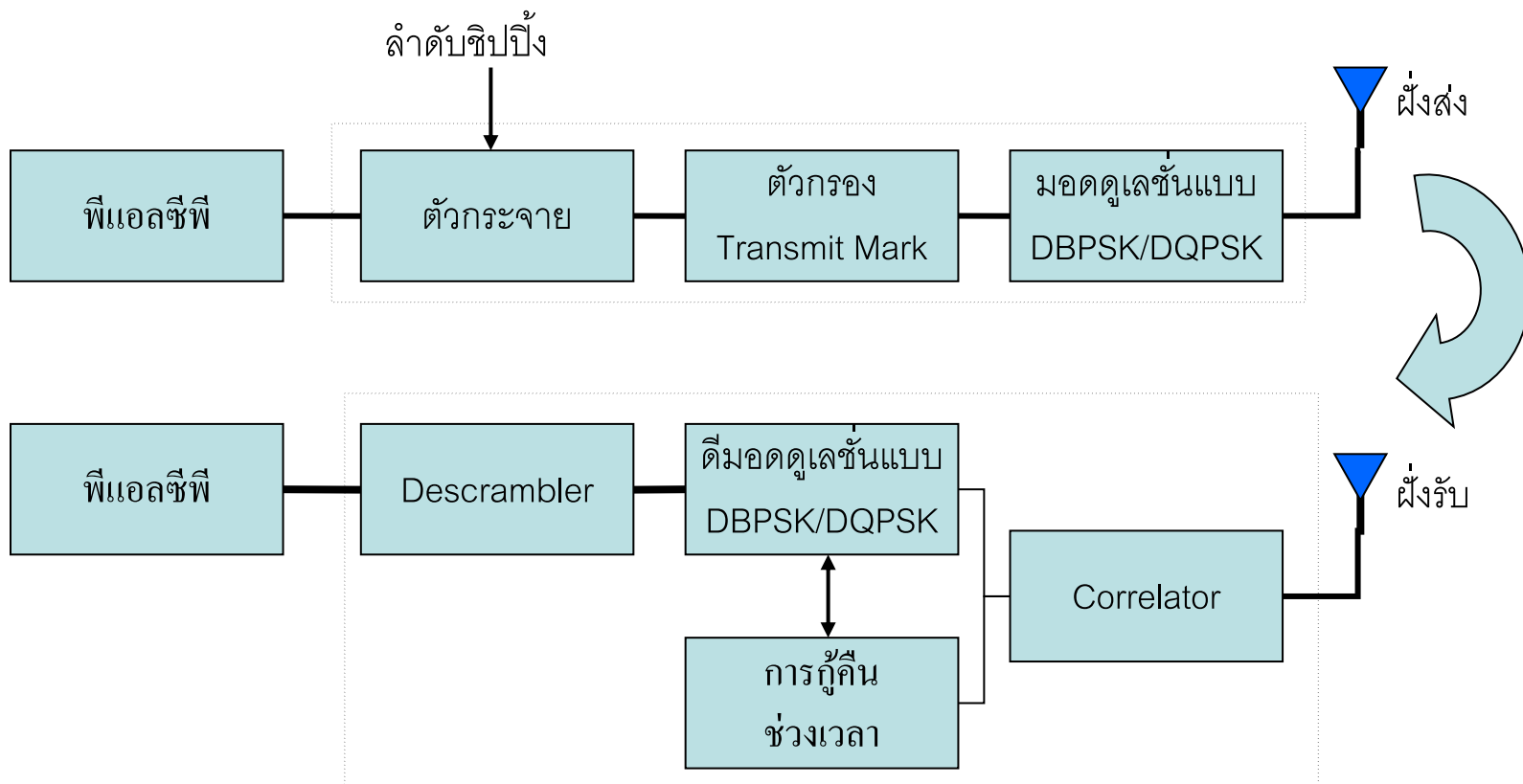


DSSS

- Preamble and PLCP header are transmitted at 1Mbps
- Regardless of data transmission speed
- Payload prepared by the MAC layer is sent at the rate specified in the services field
- The transmitter uses DBPSK (1Mbps) and DQPSK (2Mbps) modulation



DSSS HW



Complementary Code Keying (CCK)



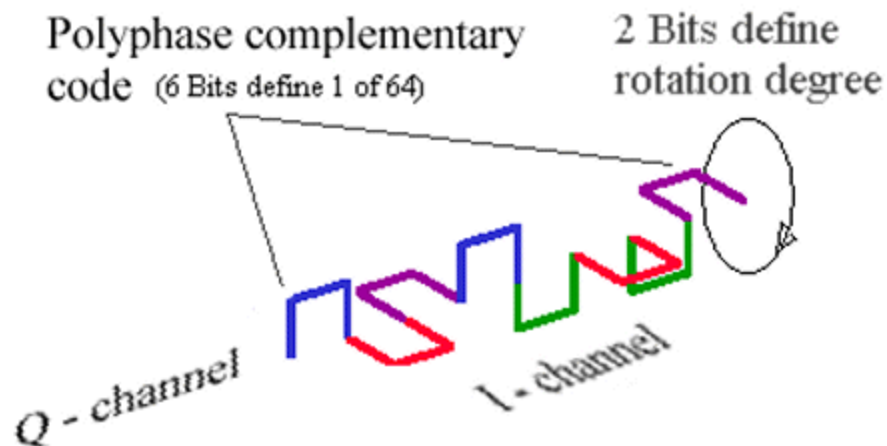
- 1998
- Proposed by Lucent Technologies and Harris Semiconductor (later owned by Intersil)
- Achieve 5.5Mbps and 11Mbps Tx rates

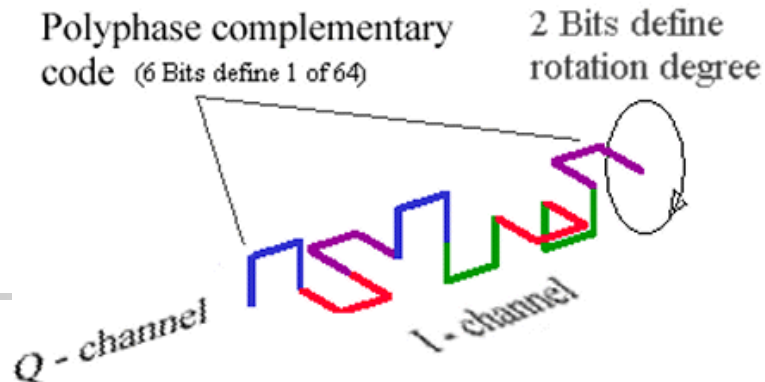


- IEEE adopted the CCK and released the 802.11b in 1999
 - new option to transmit PLCP header with a **short (56 bits) preamble**
 - only the Synchronization and Start Frame Delimiter fields are transmitted at 1Mbps
 - The rest of the PLCP header is transmitted at 2Mbps (using DSSS **DQPSK**)
 - data payload at either the same 2Mbps, or using CCK at 5.5Mbps or 11Mbps.



- based on polyphase complementary codes
 - not binary \rightarrow complex codes
 - real component placed in the vertical plane
 - complex component in the horizontal plane

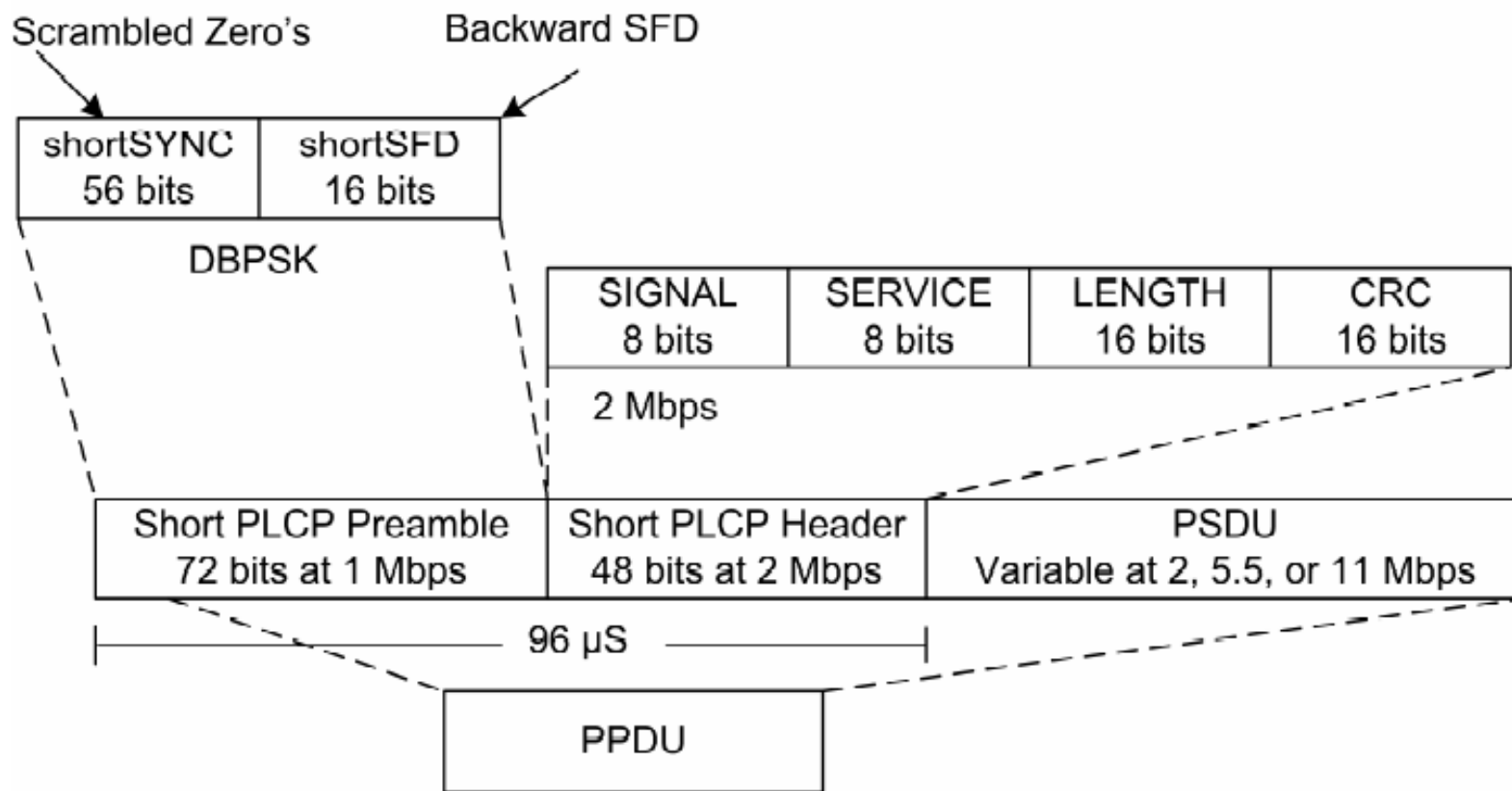




- The modulator uses
 - 6 bits of each byte to pick one of 64 unique orthogonal eight chips long polyphase complementary codes
 - two bits of the byte are used to rotate the whole code word (0, 90, 180 or 270 degrees)
- real and complex parts of the resulted code go to the I(in-phase) and Q(quadrature) channels of the IQ modulator



More on Preamble Frame





Signal Field (802.11b)

Data Rate (Mbps)	Signal Field Value
1	00001010
2	00010100
5.5	00110111
11	01101110



DSSS PMD

- Perform actual Tx/Rx of PPDU
- Provides DSSS modulation/demodulation



DSSS PMD Service Primitives

PLCP → PMD	PMD → PLCP	Description
PMD_DATA.request	PMD_DATA.indicate	Transfer Data
PMD_TXSTART.request PMD_TXEND.request PMD_TXPWRLVL.request		Start Tx End Tx Select power level
PMD_ANTSEL.request	PMD_ANTSEL.indicate	Select antenna (1..N)
PMD_RATE.request	PMD_RATE.indicate	Select data rate
PMD_ED.request	PMD_ED.indicate	Energy > Threshold
	PMD_RSSI.indication PMD_SQ.indicate PMD_CS.indicate PMD_CAA.indicate	Signal Strength (0-15) Signal Quality (PN code) Valid 802.11 DS Detect RF as CCA algo.



IR Physical Layer

- Lowest cost
- Highest tolerant to RF noise
- Lowest range
- Need ceiling
- More secure
- No frequency regulating
- No product ?
- IrDA: Infrared Data Association Standard

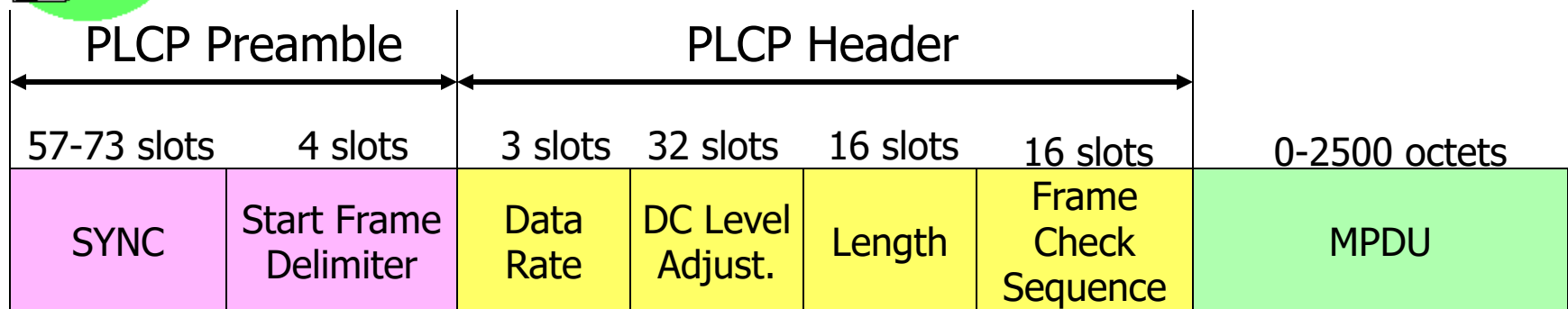


IR Architecture

- IR PLCP Sublayer
- IR PMD Sublayer



IR PLCP frame



↑ Pulse alternating : synchronization purpose

↑ 1001: define the beginning of a frame

↑ Data rate

↑ #microsec. To transmit the MPDU
Specified for 1 and 2 Mbps

↑ 16-bit CRC



IR PMD

- Mostly use diffused infrared
- Perform actual Tx/Rx of PPDU, translate binary to infrared light
- Provides IR modulation/demodulation



IR PMD

- Noise affects amplitude (not phase)
→ Pulse position reduces interference
- Pulse position modulation :PPM
 - Vary position of pulse
- For 1 Mbps → 16 PPM
- For 2 Mbps → 4 PPM



Pulse Position Modulation

Data bits	16-PPM signal
0000	0000 0000 0000 0001
0001	0000 0000 0000 0010
...	...
1000	1000 0000 0000 0000

Data bits	4-PPM signal
00	0001
01	0010
10	0100
11	1000

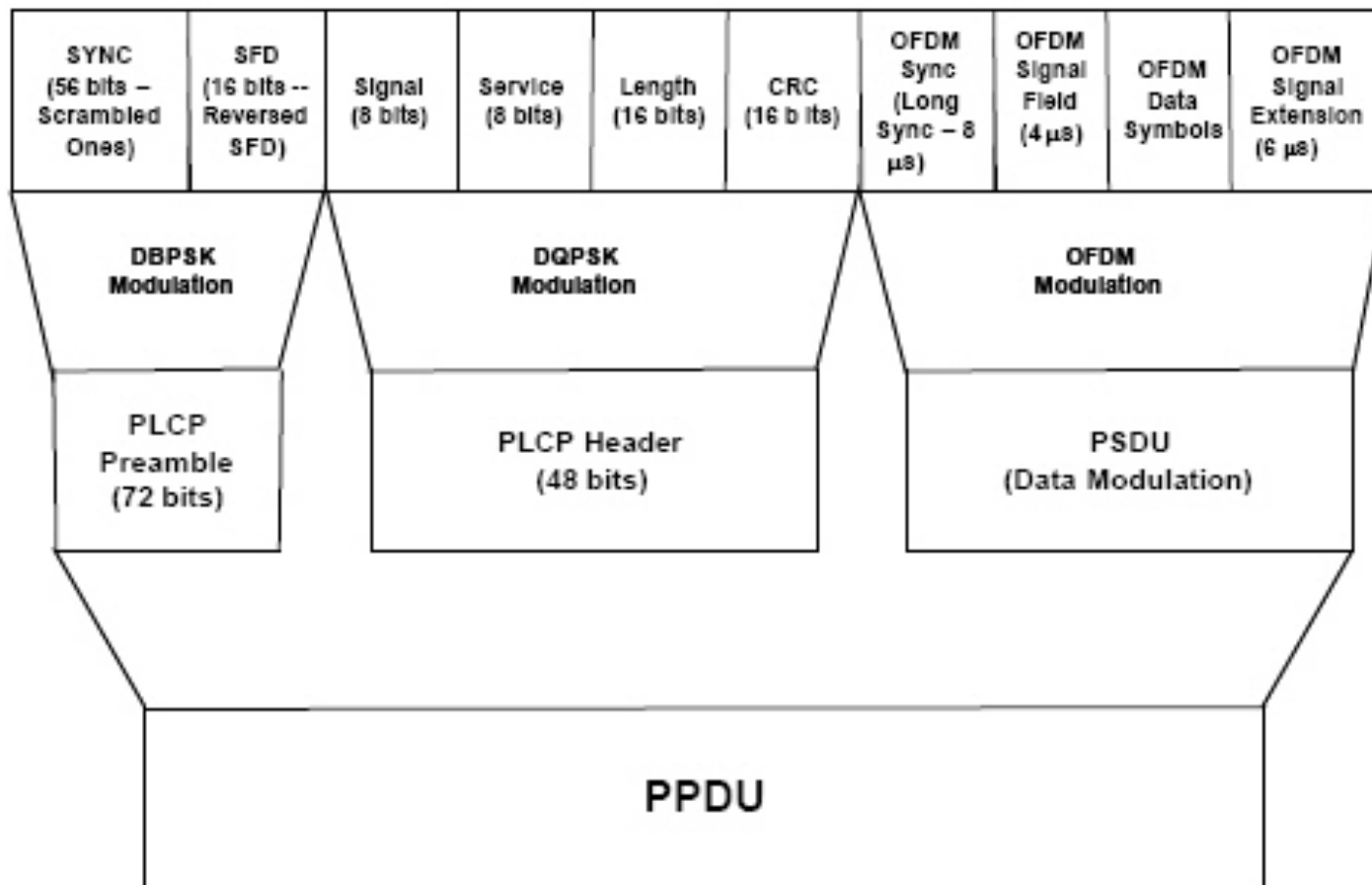


OFDM PLCP Frame





DSSS-OFDM PPDU





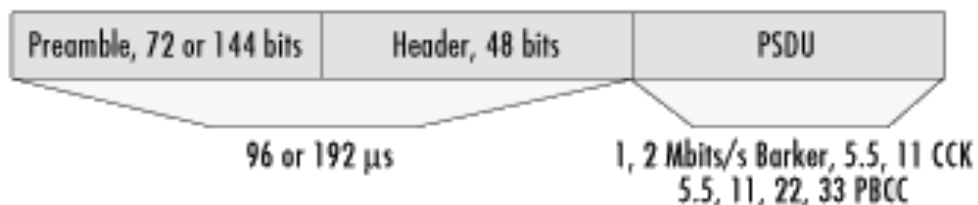
Transmission Rate

บิตข้อมูล	ความเร็วที่ได้ (Mbps)	ช่วงความเร็ว
1101	6	1 (BPSK)
1111	9	
0101	12	2 (QPSK)
0111	18	
1001	24	3 (16-QAM)
1011	36	
0001	48	4 (64-QAM)
0011	54	

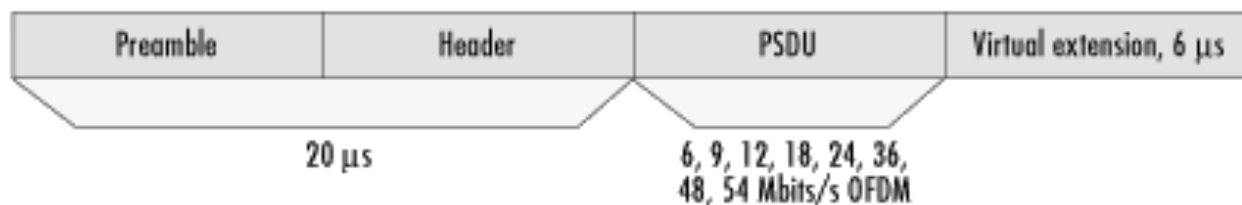


IEEE 802.11g OFDM

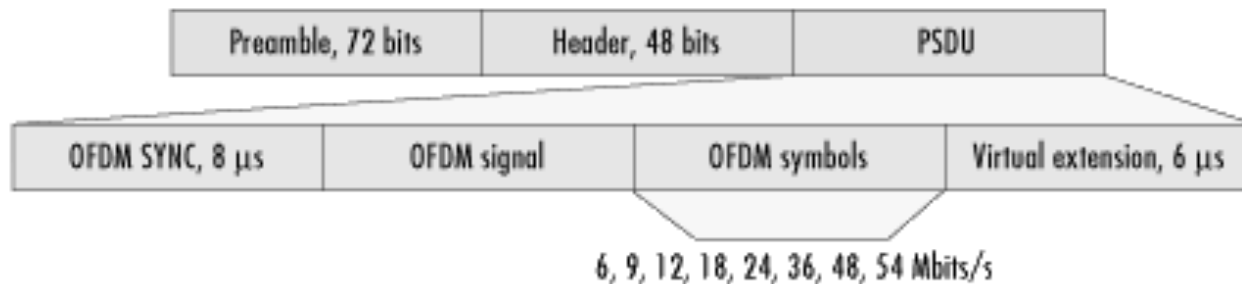
a) Barker, CCK and PBCC packet format



b) OFDM packet format



c) CCK-OFDM packet format



CCK and OFDM are mandatory in 802.11g; CCK-OFDM and PBCC are optional.

**Please see the latest
specification for new
standard update**

