



# Mobile Networking

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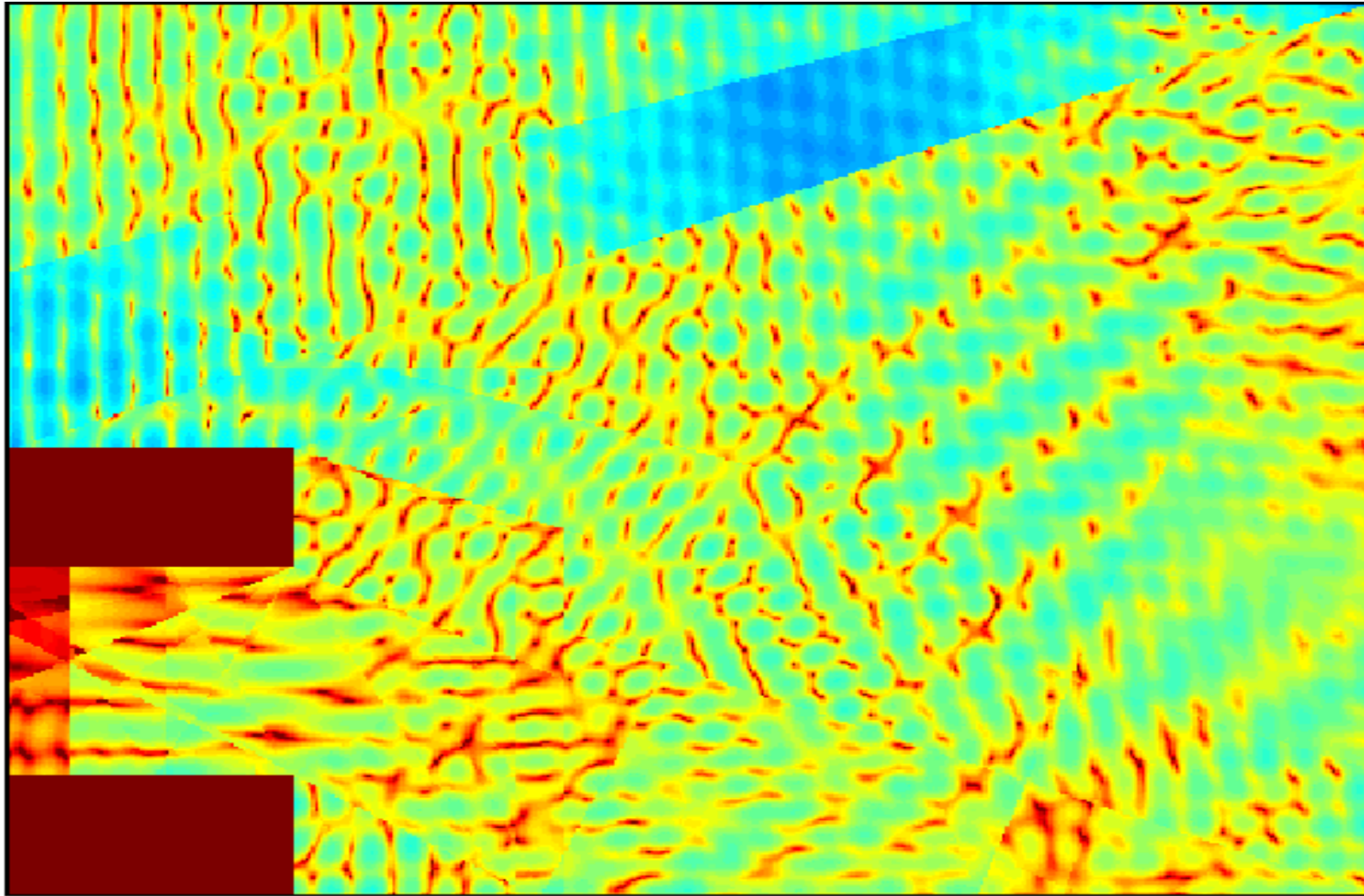
PLCP, Packet Format

# **802.11B PHYSICAL LAYER**

# Contents

- PHY Layer Characteristics and Data Rates
  - Area Concept
  - Layers and Functions (PLCP and PMD Sublayers)
  - Antennas
- DSSS in IEEE 802.11b PHY Layer
  - Barker Codes and Channel Allocation
- IEEE 802.11b Packet Format
  - PLCP Format

# Area Concept

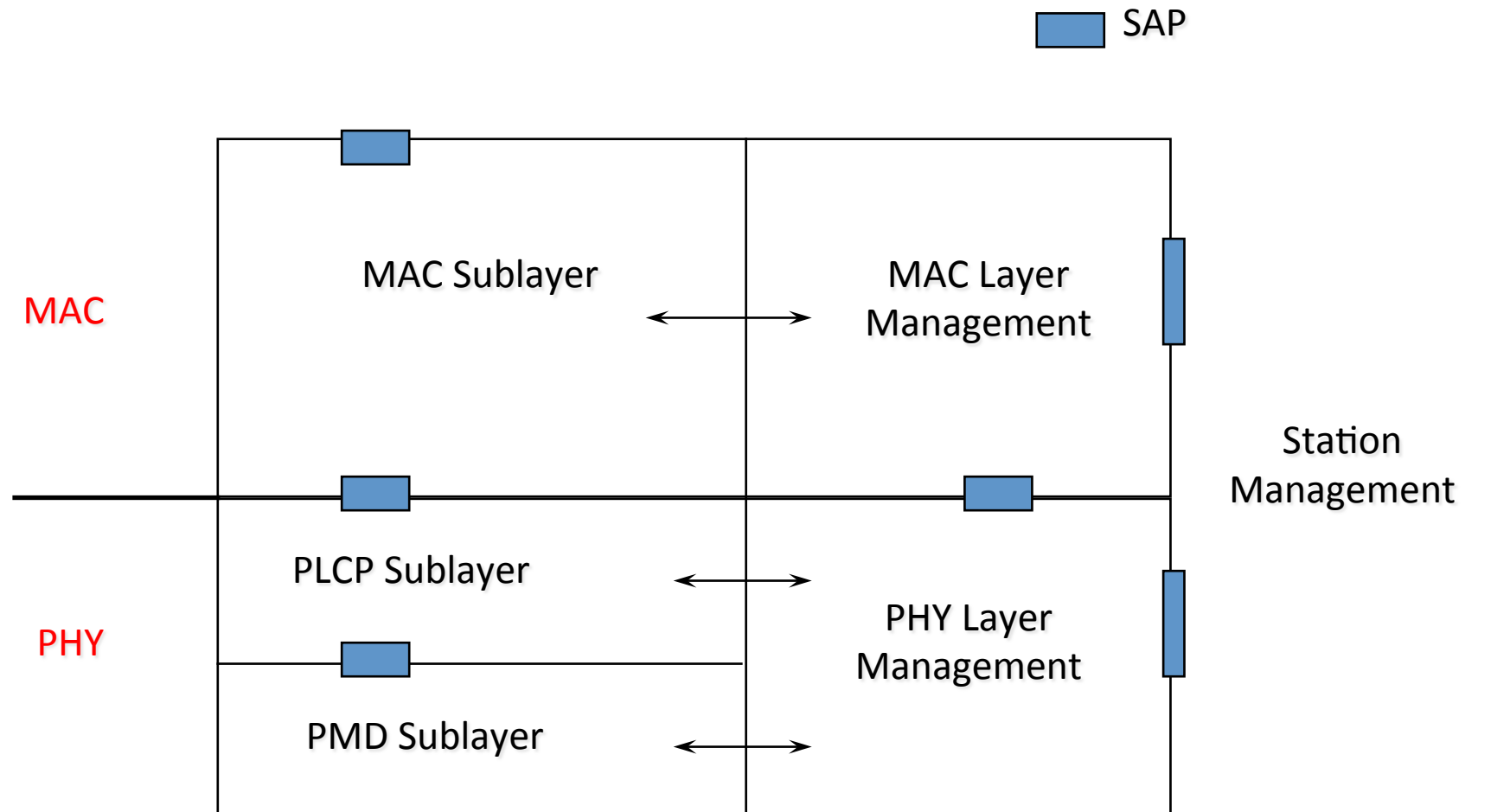


The difference between the **greatest signal strength** and the **least signal strength** is **50 dB**

# Requirements

- Single MAC to support multiple PHYs
  - Support single and multiple channel PHYs
  - PHYs with different medium sense characteristics.
- Should allow overlap of multiple networks in the same area and channel space
- Need to be Robust for Interference?
  - ISM band (Industry, Science and Medicine)
    - Microwave, other non-802.11 interferers
    - Co-channel interference

# 802.11 - Layers and Functions (Review)



# 802.11 - Layers and Functions (Review)

- **MAC Entity**
  - basic access mechanism
  - fragmentation/defragmentation
  - encryption/decryption
- **MAC Layer Management Entity**
  - synchronization
  - power management
  - roaming
  - MAC MIB (management information base)

# 802.11 - Layers and Functions (Review)

- **Physical Layer Convergence Protocol (PLCP)**
  - PHY-specific, supports common PHY SAP
  - Provides Clear Channel Assessment signal (carrier sense)
- **Physical Medium Dependent Sublayer (PMD)**
  - modulation and encoding
- **PHY Layer Management**
  - Channel tuning (channel switching delay : **224μs** in 802.11b)
  - PHY MIB
- **Station Management**
  - Interacts with both MAC Management and PHY Management



# Outdoor Application - Antenna

## Antennas



Pasadena Networks, LLC <http://www.pasadena.net>

# PHY Layer Services

- **PHY\_DATA transfers**
  - multiple rates (1, 2, 5.5, 11Mbps)
  - extended rates (22, 33 or 6, 12, 24, 36, 48, 54Mbps)
  - The algorithm for performing rate switching is beyond the scope of the standard – “*more in advanced features*”
- **Clear Channel Assessment (CCA)**
  - carrier sense
  - detect start frame delimiter
- **PHY Management**
  - channel tuning

# PHY Layers in 802.11b

- **Frequency Hop Spread Spectrum (FHSS)**
  - 2.4 GHz band, 1 and 2 Mbps transmission
    - 2GFSK, 4GFSK
    - 2.5 hops/sec over 79 1MHz channels (North America)
- **Direct Sequence Spread Spectrum (DSSS)**
  - 2.4 GHz band, 1 and 2 Mbps transmission
    - 11 chip Barker sequence
    - DBPSK, DQPSK (Differential Binary/Quadrature Phase Shift Keying)
  - 2.4 GHz band, 5.5 and 11 Mbps transmission
    - CCK (Complementary Code Keying), PBCC (Packet Binary Convolutional Code)
    - CCK : QPSK(5.5Mbps), DQPSK(11Mbps)
    - PBCC : BPSK(5.5Mbps), QPSK(11Mbps) (optional)
    - Sep. 1999 (802.11b)
  - 2.4 GHz band, 22 and 33 Mbps transmission
    - PBCC-22, PBCC-33
    - Jan. 2002 (802.11g D2.1 - optional)
- **Baseband IR (Infrared)**
  - Diffuse infrared
  - 1 and 2 Mbps transmission, 16-PPM and 4-PPM
    - PPM : Pulse Position Modulation

# **IEEE 802.11b PHY**

## **Terminology in Specification**

- 1 Mbps : Basic Rate (BR)
- 2 Mbps : Extended Rate (ER)
- 5.5/11 Mbps : High Rate (HR)
- 22~33/6~54 Mbps : Extended Rate PHY (ERP)

# Unlicensed Operation RF Bands

- **902MHz**
  - 26MHz BW (902-928MHz)
  - Crowded and Worldwide limited
  - *IEEE 802.11 WLAN, coreless phone, etc.,*
- **2.4GHz**
  - 83.5MHz BW (2400-2483.5MHz)
  - Available worldwide
  - *IEEE 802.11(b/g) WLAN, Bluetooth and HomeRF, etc.,*
- **5.1GHz**
  - 300MHz (three 100MHz segments)
  - Unlicensed NII
  - *802.11a WLAN*
    - OFDM / 6,12,18,24,36,48,54Mbps / BPSK,QPSK,16-QAM, 64-QAM
  - *HiperLAN I and HiperLAN II*
    - 23.5Mbps/GMSK and 6-54Mbps/BPSK,QPSK,16-QAM, 64-QAM
  - Wireless ATM (QoS) - Japan ...

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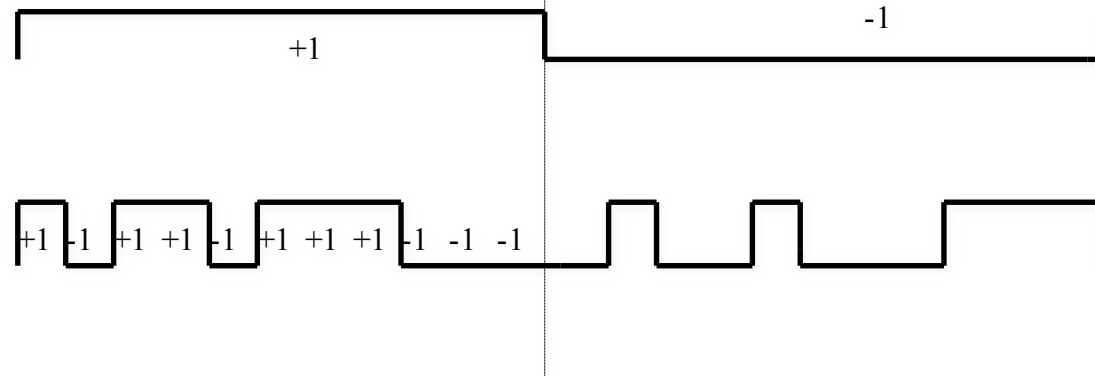
802.11b DSSS

# **DIRECT SEQUENCE SPREAD SPECTRUM (DSSS)**

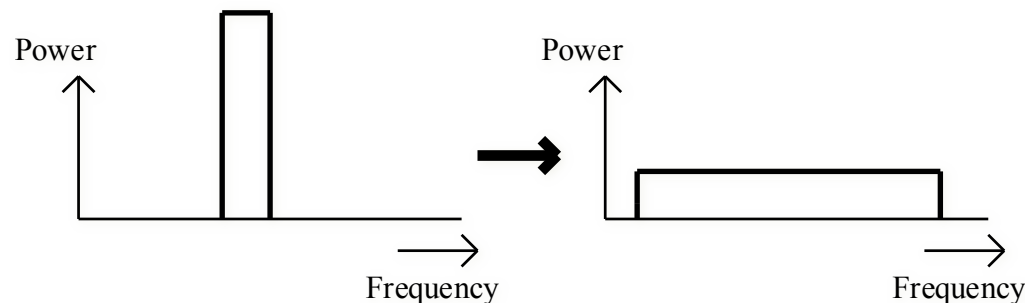
# What is DSSS?

## (Review)

- We spread the signal symbol with a sequence



- Wider Bandwidth
- Less power density

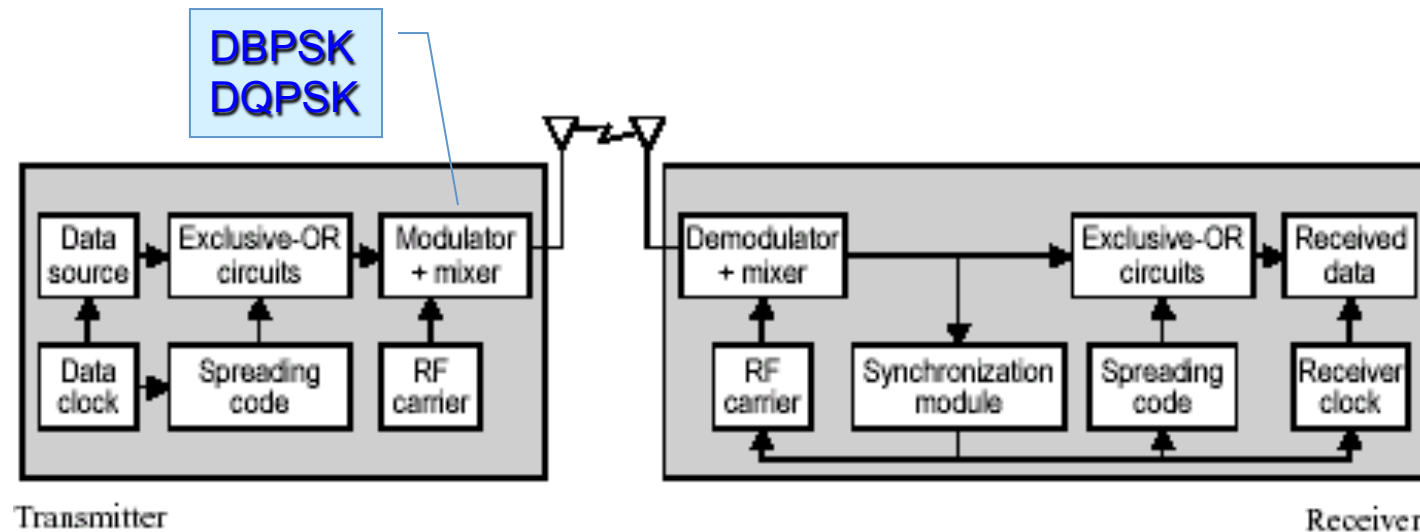




# 11 chip BARKER Sequence

- Good autocorrelation properties
- Minimal sequence allowed by FCC
- Coding gain 10.4 dB
  - Robust against interferers and noise (10 dB suppression)
- Robust against time delay spread
  - Resolution of echoes

# DSSS Hardware Block Diagram



Transmitter and receiver schematic

# IEEE 802.11 DSSS PHY Characteristics

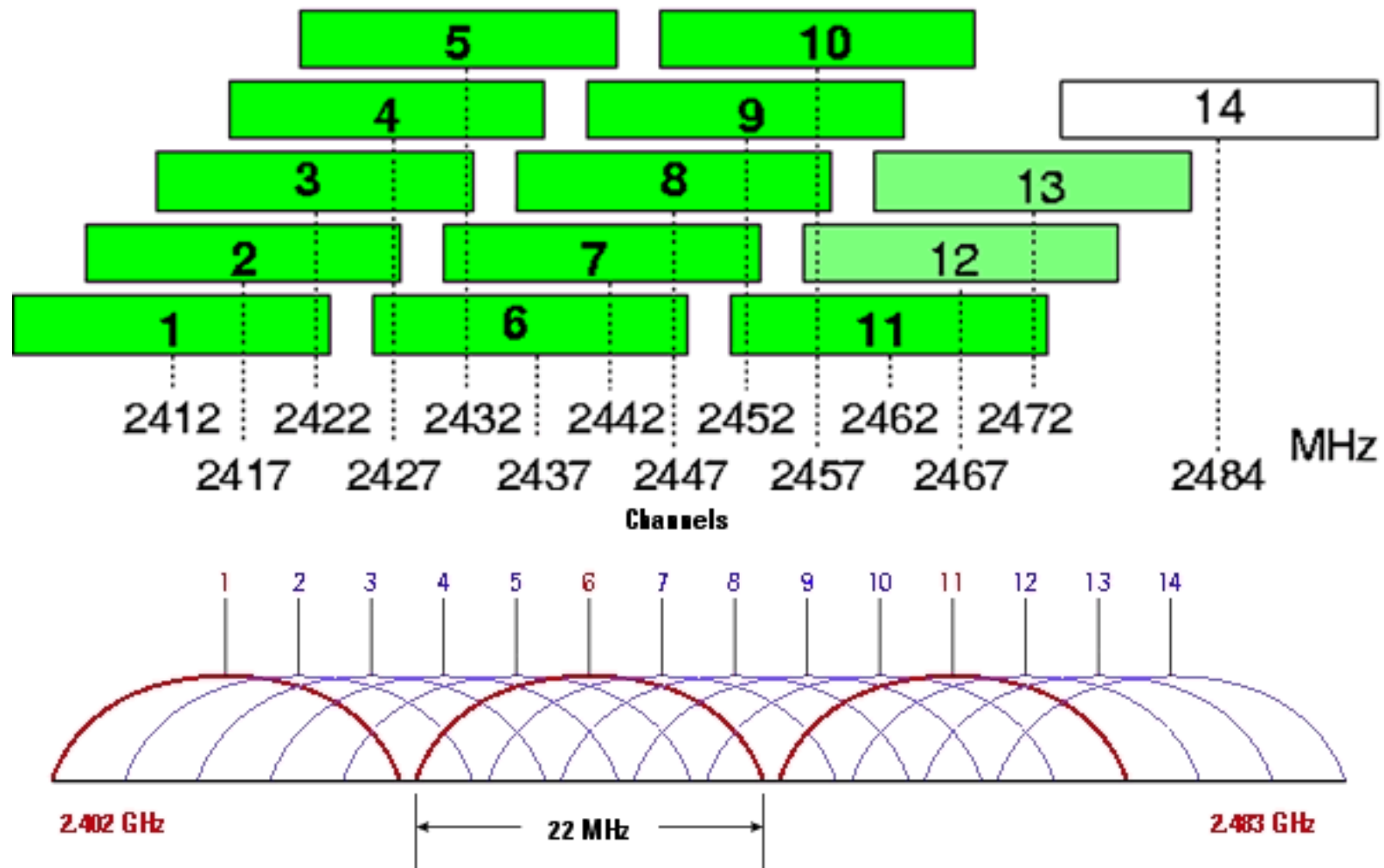
- **2.4 GHz ISM band**
- **1 and 2 Mb/s data rate**
  - DBPSK and DQPSK modulation
  - Chipping rate 11 MHz with 11 chip Barker sequence
- **5.5 and 11 Mbps (802.11b)**
  - CCK (QPSK, DQPSK modulations – mandatory)
  - PBCC (BPSK, QPSK modulations – optional)
- **22 and 33 Mbps (802.11g)**
  - PBCC-22, PBCC-33 modulation (TI proposal – optional)
- **Multiple channels in 2.4 to 2.4835 GHz band**

# DSSS PHY Frequency Channel Plan

| CHNL_ID | Frequencies | FCC Channel Frequencies | ETSI Channel Frequencies | Japan Frequency (MKK) | Japan Frequency (New MKK) |
|---------|-------------|-------------------------|--------------------------|-----------------------|---------------------------|
| 1       | 2412 MHz    | X                       | X                        | -                     | X                         |
| 2       | 2417 MHz    | X                       | X                        | -                     | X                         |
| 3       | 2422 MHz    | X                       | X                        | -                     | X                         |
| 4       | 2427 MHz    | X                       | X                        | -                     | X                         |
| 5       | 2432 MHz    | X                       | X                        | -                     | X                         |
| 6       | 2437 MHz    | X                       | X                        | -                     | X                         |
| 7       | 2442 MHz    | X                       | X                        | -                     | X                         |
| 8       | 2447 MHz    | X                       | X                        | -                     | X                         |
| 9       | 2452 MHz    | X                       | X                        | -                     | X                         |
| 10      | 2457 MHz    | X                       | X                        | -                     | X                         |
| 11      | 2462 MHz    | X                       | X                        | -                     | X                         |
| 12      | 2467 MHz    | -                       | X                        | -                     | X                         |
| 13      | 2472 MHz    | -                       | X                        | -                     | X                         |
| 14      | 2484 MHz    | -                       | -                        | X                     | X                         |

- **FCC** (US), **IC** (Canada) and **ETSI** (Europe) : 2.4GHz - 2.4835GHz
- **Japan**: 2.471GHz - 2.497GHz (MKK : channel 14; new MKK : channels 1-14)
- **France**: 2.4465GHz - 2.4835GHz (channels 10, 11, 12, 13)
- **Spain**: 2.445GHz - 2.475GHz (channels 10, 11)
- FCC pushes the unused unlicensed TV broadcasting band 3.65GHz-3.70GHz as WLAN band.

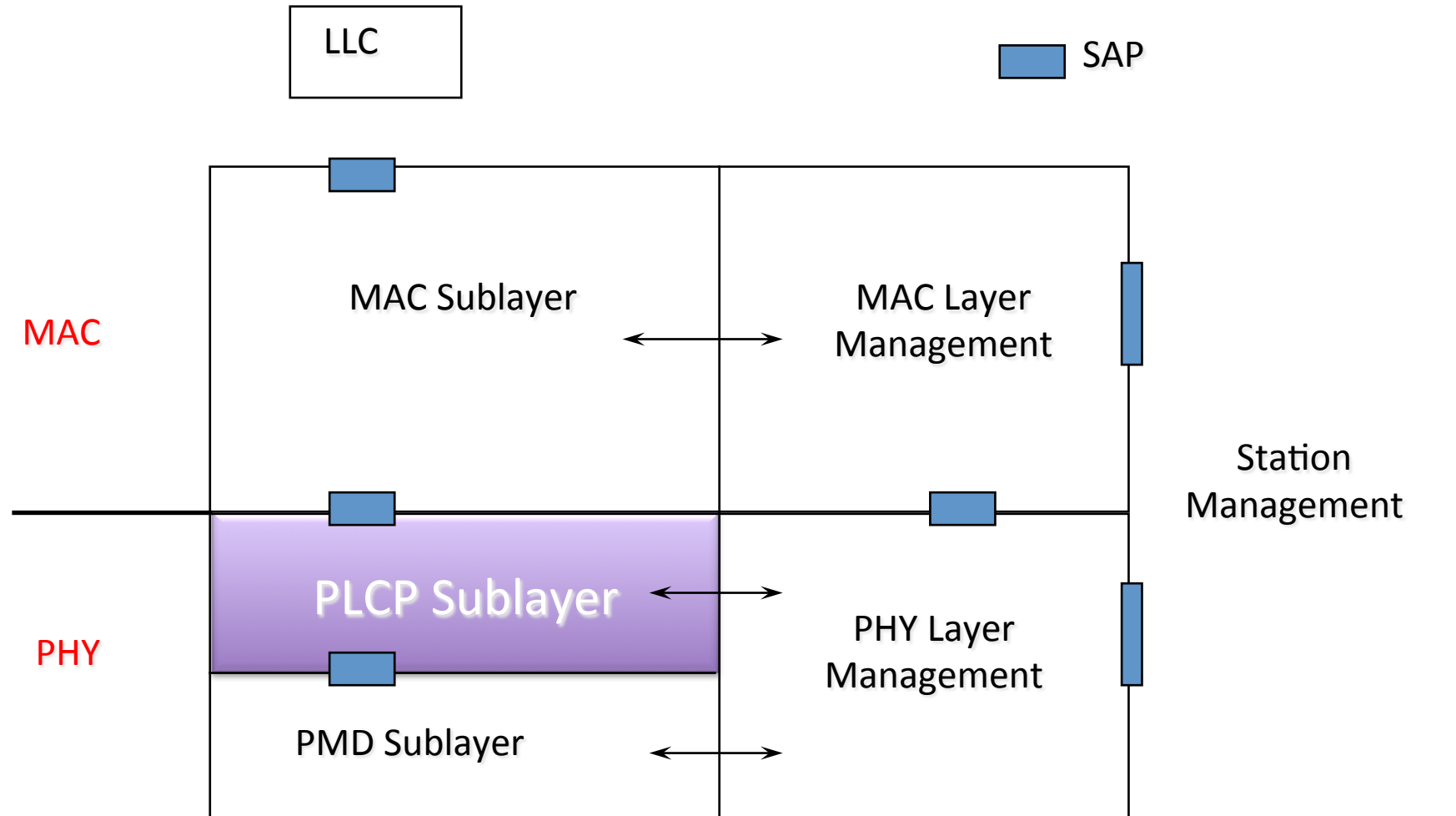
# Channels in 802.11b



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# PLCP (PHY Convergence) Sublayer



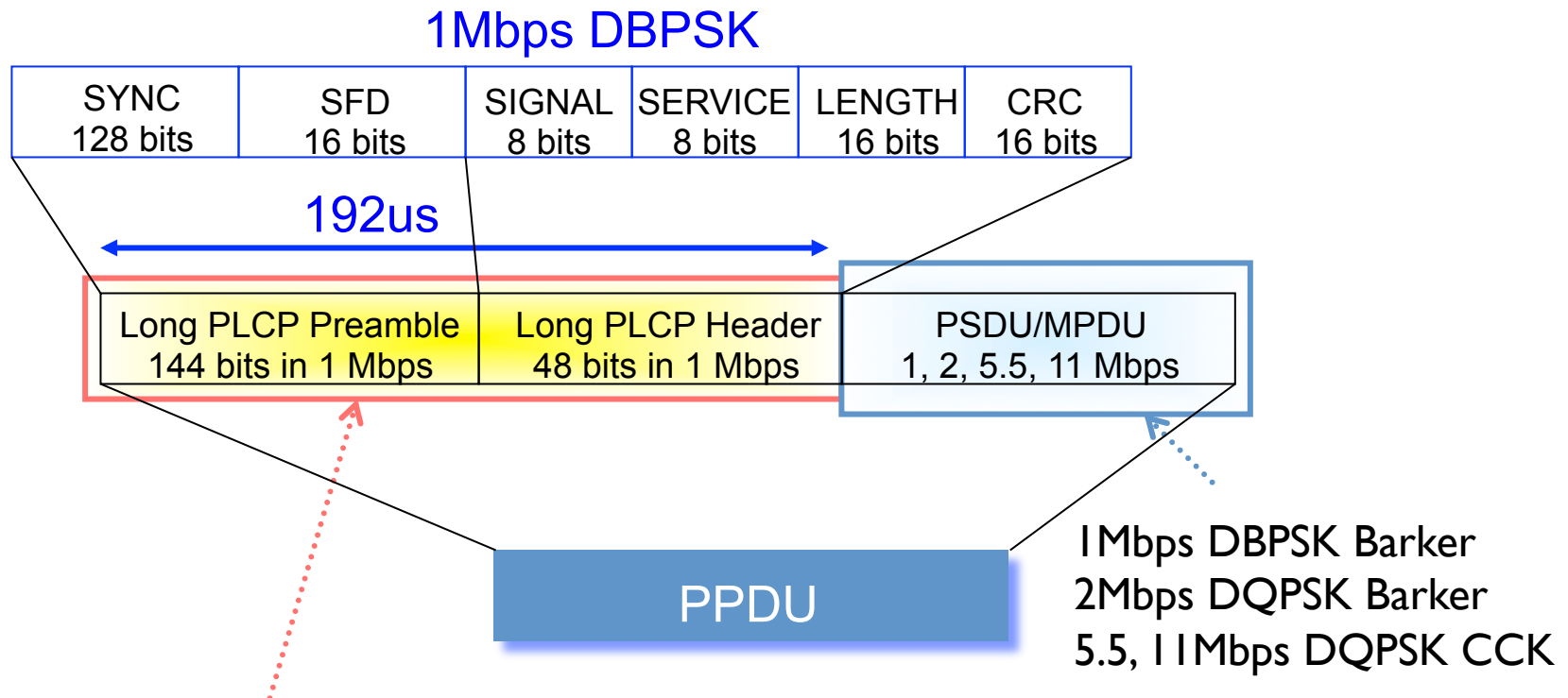
# PLCP Frame Formats in 802.11b

- Two different preamble and header formats
  - **Long PLCP PPDU format** (**Mandatory** in 802.11b)
    - 144-bit preamble : 1Mbps DBPSK
    - 48-bit header : 1Mbps DBPSK
    - Spend 192us
    - PSDU : 1, 2, 5.5, 11Mbps
    - Compatible with 1 and 2 Mbps
  - **Short PLCP PPDU format** (**Optional** in 802.11b)
    - Minimize overhead, maximize data throughput
    - 72-bit preamble : 1Mbps DBPSK
    - 48-bit header : 2Mbps DQPSK
    - Spend 96us
    - PSDU : 2, 5.5, 11 Mbps



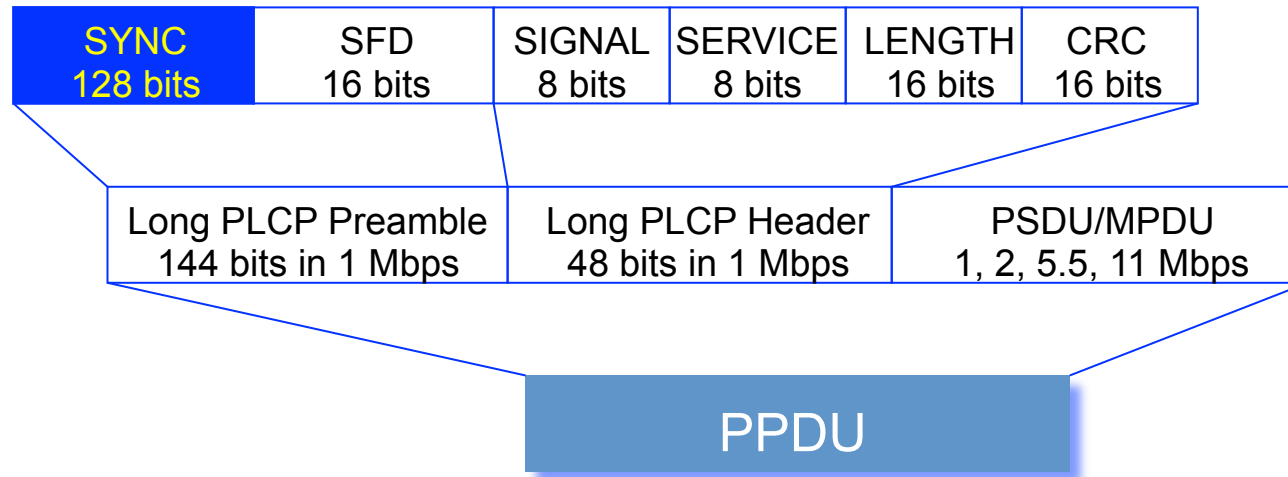
# Long PLCP Frame Format

- **Mandatory in 802.11b**



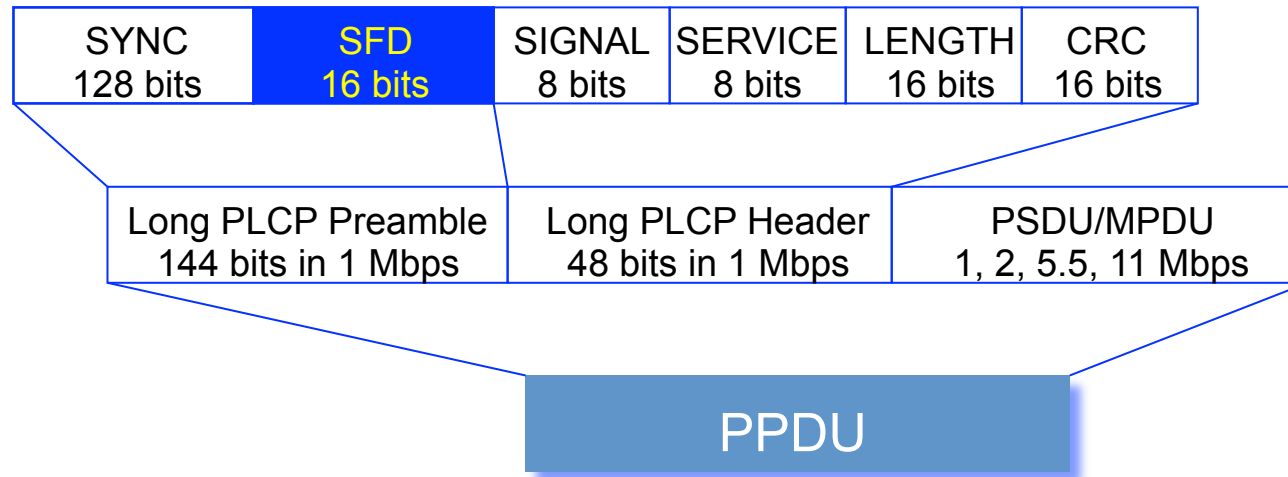
Preamble and Header always at 1Mb/s DBPSK Barker

# PLCP Synchronization



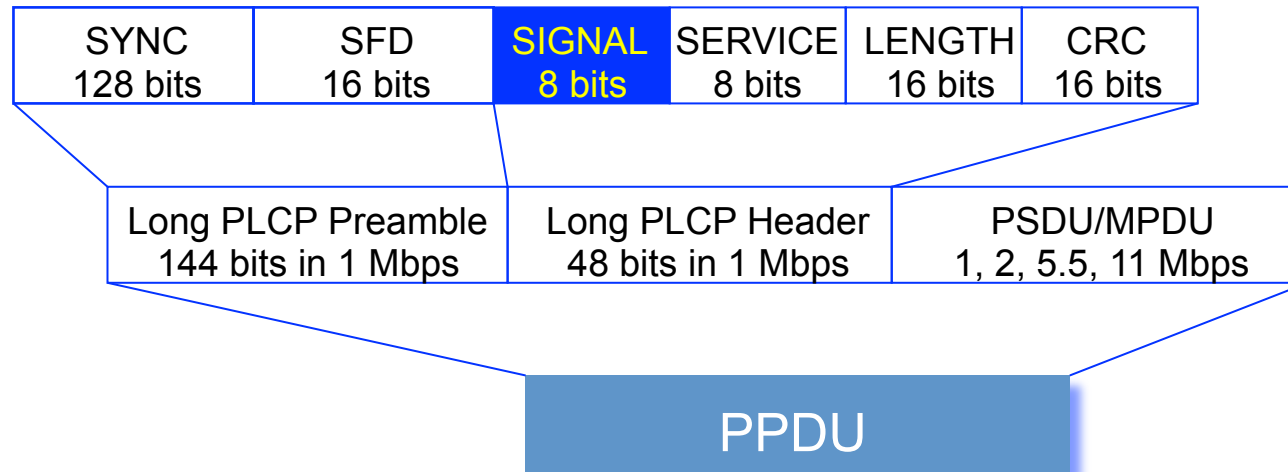
- 128 one bits ('1')
- Scrambled by scrambler
- Used for receiver to clock on to the signal and to correlate to the PN code

# Start Frame Delimiter



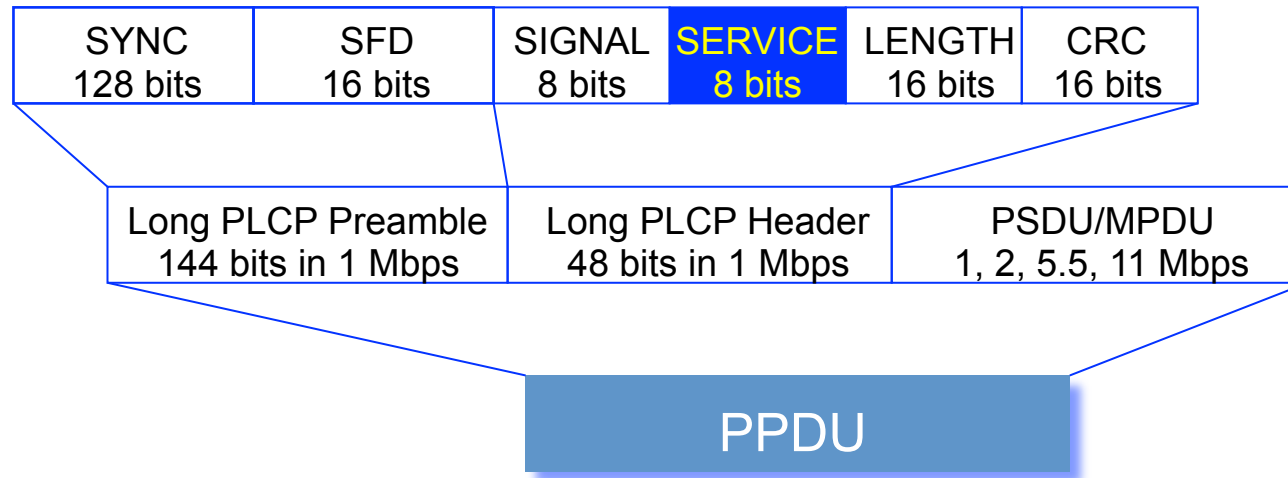
- 16-bit field (**hF3A0**)
- used for
  - bit synchronization

# Signal Field



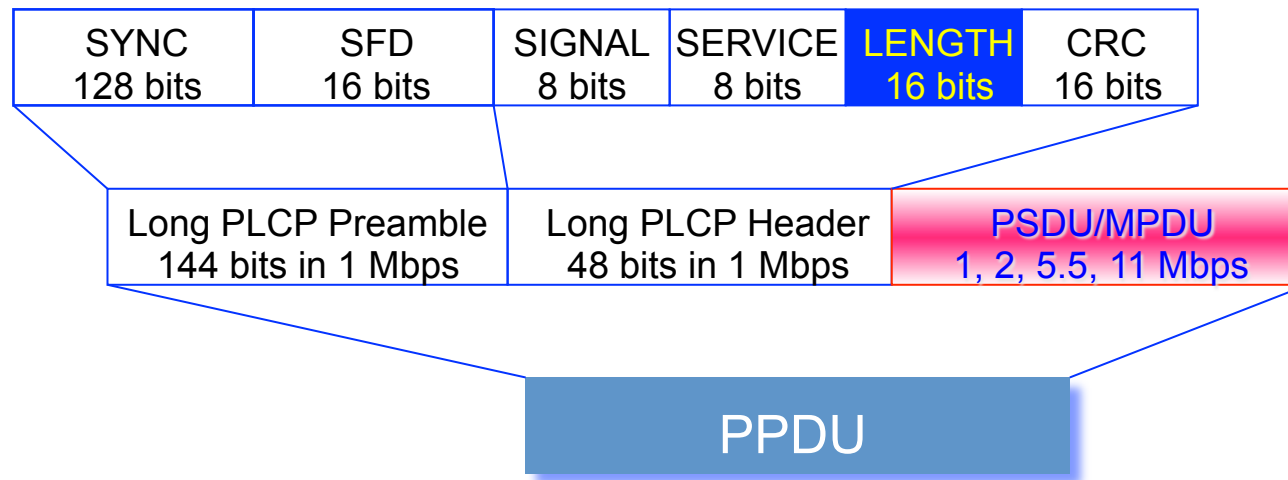
- 8 bits
- Rate indication
  - **h0A** 1Mb/s DBPSK
  - **h14** 2Mb/s DQPSK
  - **h37** 5.5Mb/s CCK or PBCC
  - **h6E** 11Mbps CCK or PBCC
- Other values reserved for future use

# Service Field



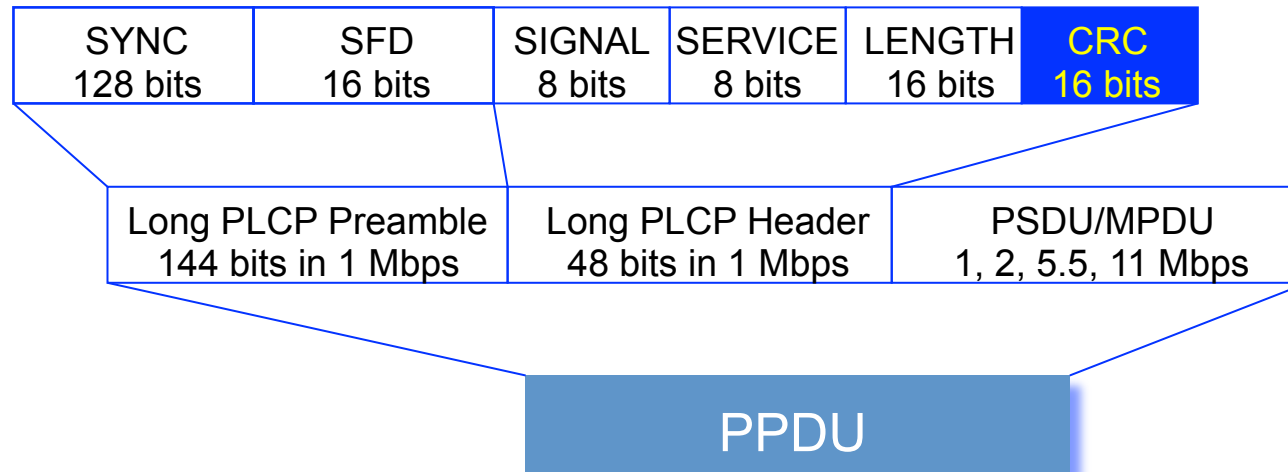
- Reserved for future use
  - Bit 2 : locked clock bit
    - Indicate transmit freq. (mixer) & symbol clocks (baseband) derived from same oscillator
    - optional in 802.11b and mandatory in 802.11g
  - Bit 3 : modulation selection
    - 0 : CCK / 1 : PBCC
  - Bit 7 : length extension bit (in the case data rate > 8Mbps)
- h00 signifies 802.11 compliant

# Length Field



- Indicates number of microseconds to be transmitted in PSDU/MPDU
  - Decided by Length and data rate (in TXvector)
- Used for
  - End of frame detection
  - Perform Virtual Carrier Sense (for those with lower data rate)
  - MPDU CRC sync

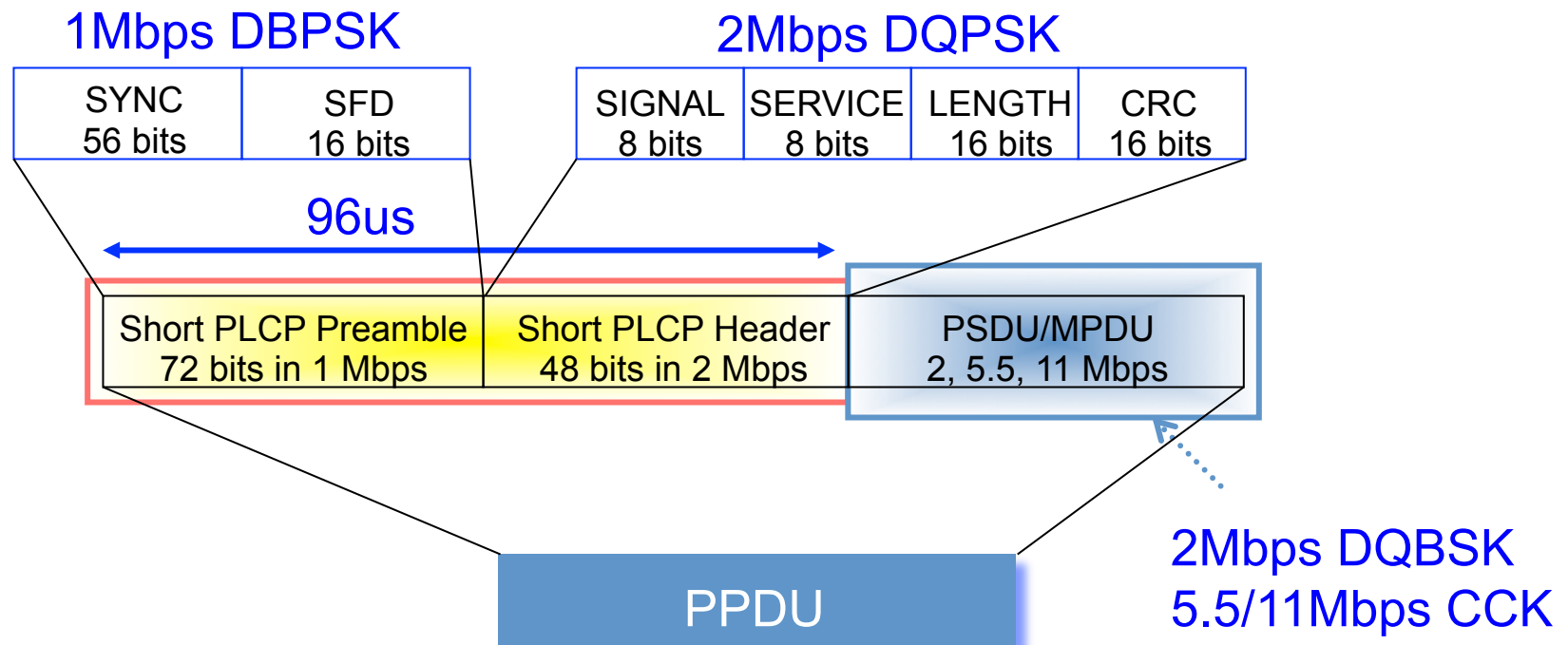
# CRC field



- CCITT CRC-16
- Protects Signal, Service and Length Field

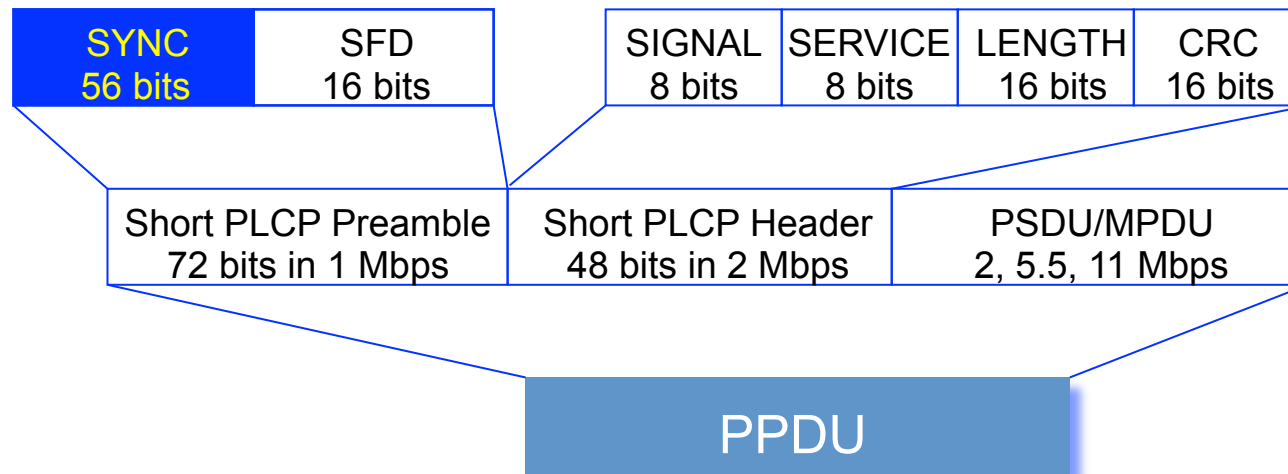
# Short PLCP Frame Format

- Optional in 802.11b



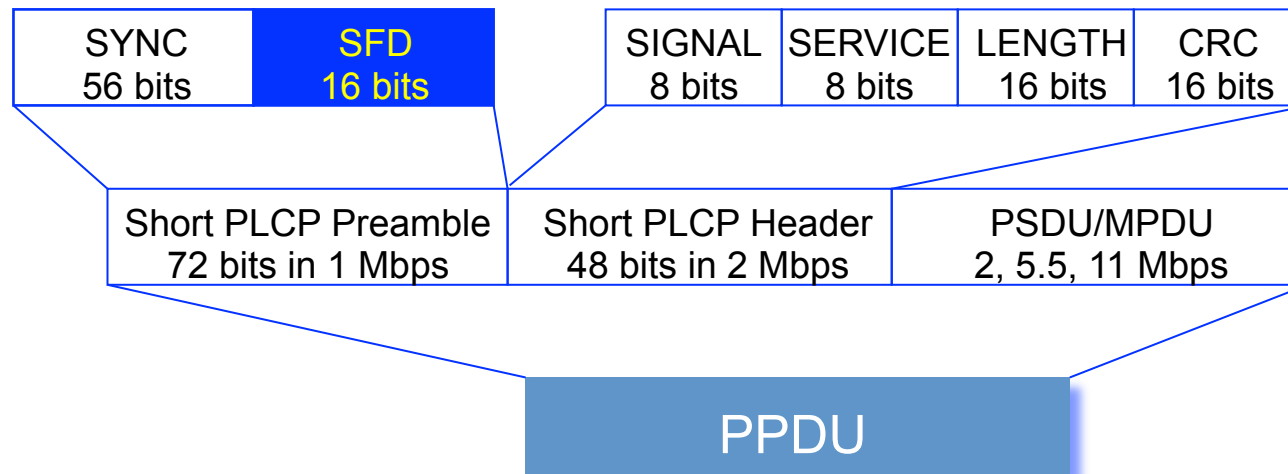


# PLCP Synchronization



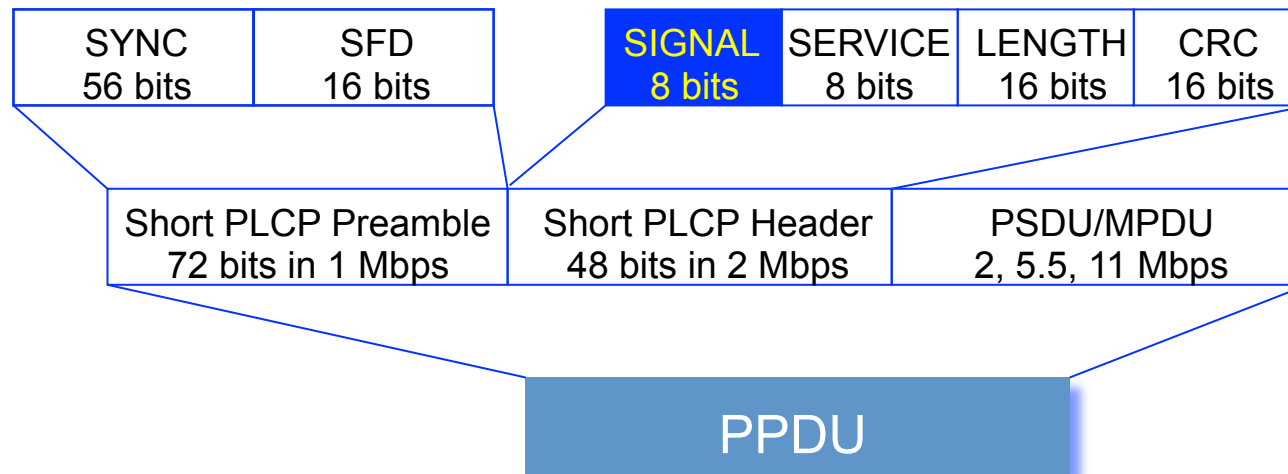
- 56 zero bits ('0')
- scrambled by scrambler with seed '0011011'
- Used for receiver to clock on to the signal and to correlate to the PN code

# Start Frame Delimiter



- 16 bit field (**h05CF**)
- used for
  - bit synchronization

# Signal Field



- Rate indication
  - **h14** 2Mb/s DQPSK
  - **h37** 5.5Mb/s CCK or PBCC
  - **h6E** 11Mbps CCK or PBCC
- Other values reserved for future use (100 kb/s quantities)