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802.11 Physical Layer Frame Format
Modulation Techniques
PLCP Protocol Data Unit

Pankaj Seervi

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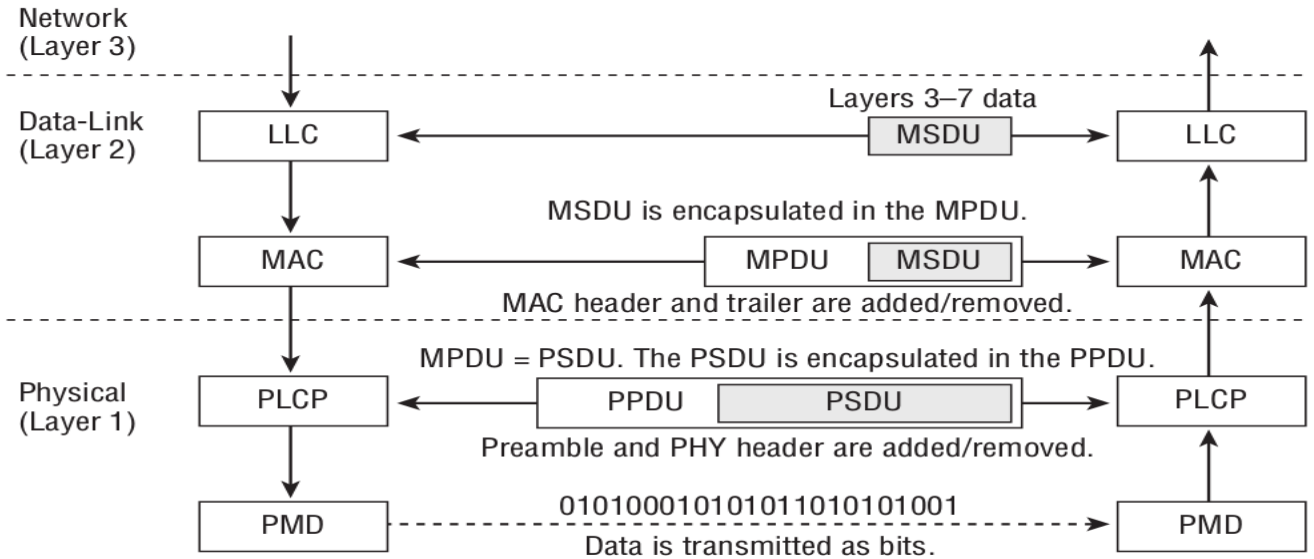
Physical layer



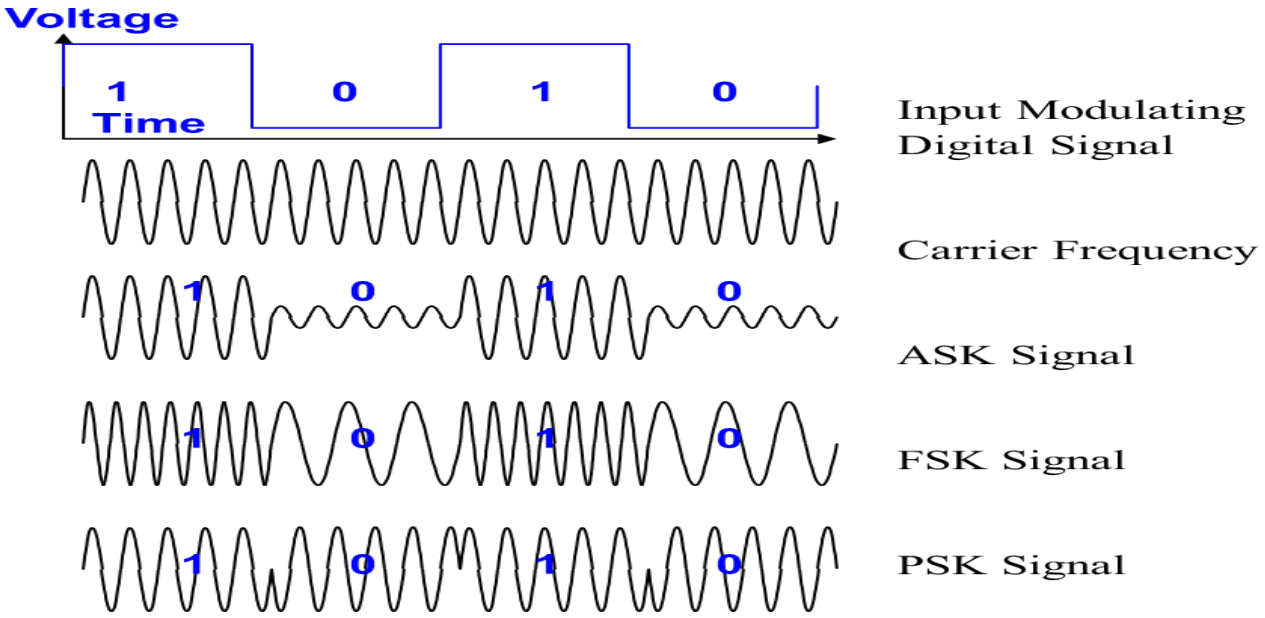
MODULATION

- **Modulation** is the process of varying one or more properties of a periodic waveform, called the **carrier signal**, with a modulating signal that typically contains information to be transmitted.
- Need for Modulation:
  - To reduce the antenna height
  - For multiplexing of signals
  - To reduce noise and interference
- Types of Modulation:
  - Analog modulation
  - Digital Modulation

Digital Modulation Techniques

- ASK
- FSK(BFSK)
- PSK(BPSK)
- QPSK

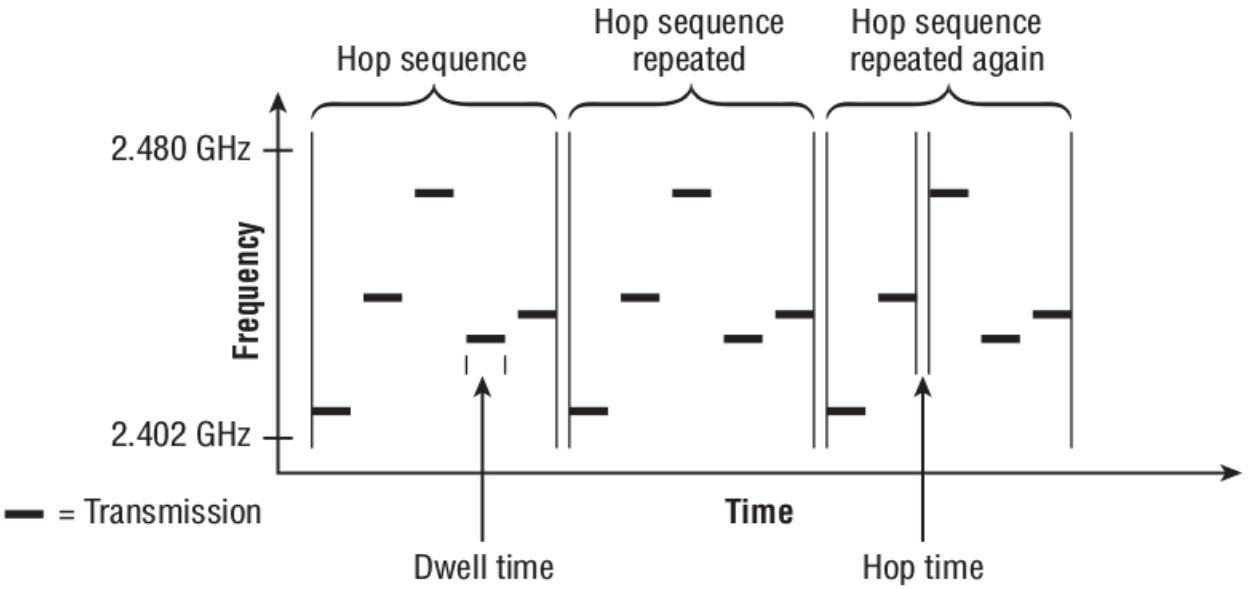
Digital Modulation Techniques



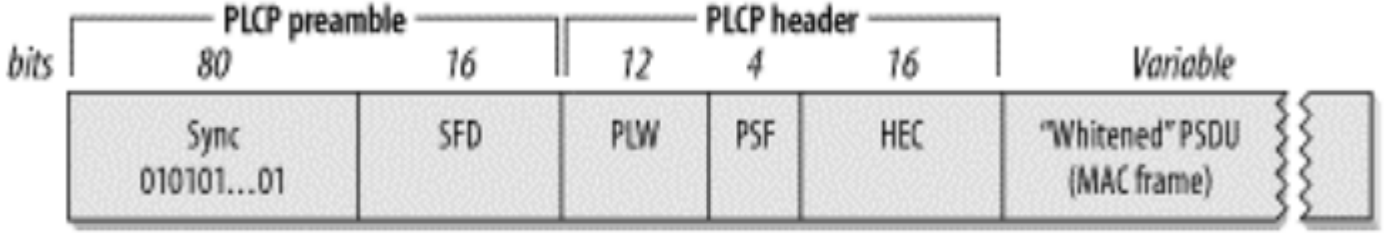
802.11 FHSS(Frequency hopping spread spectrum) PHY

- Frequency hopping spread spectrum (FHSS) was used in the original 802.11 (Legacy) standard.
- FHSS provides 1 and 2 Mbps RF communications using the 2.4 GHz ISM band for legacy radios.
- Frequency hopping depends on rapidly changing the transmission frequency in a predetermined, pseudo random pattern.
- 802.11 FHSS would use 79 MHz of frequencies, from 2.402 GHz to 2.480 GHz.
- The original IEEE 802.11 standard mandates that each hop is 1 MHz in size.
- The hopping sequences contain at least 75 hops, but no greater than 79 hops.
- FHSS uses Gaussian Frequency Shift Keying (GFSK) to encode the data.

802.11 FHSS PHY



802.11 FHSS PHY

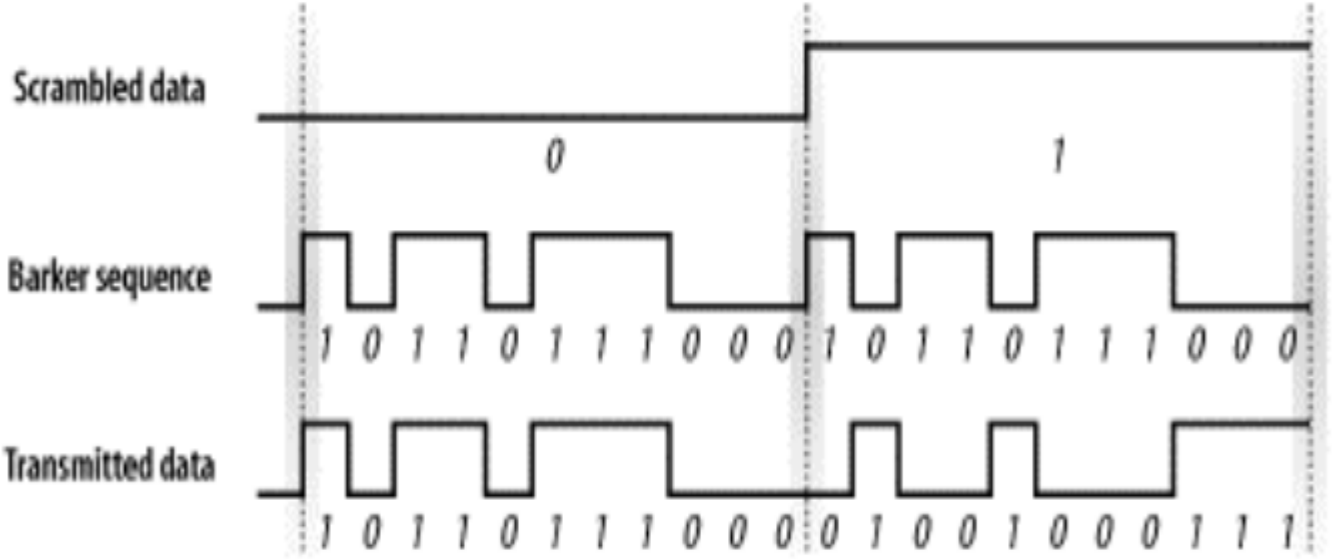


- Sync: To alert the receiver that the potentially receivable signal is present.
- Start Frame Delimiter: Consists of 16 bit as 0000 1100 1011 1101
- PSDU Length Word(PLW): The 12-bit length field informs the receiver of the length of the MAC frame that follows the PLCP header
- PLCP signaling(PSF): bit 0 is reserved, bit 1-3 encode the speed at which the payload MAC frame is trasmitted.
- Header Error Check(HEC)

802.11 DSSS(Direct sequence spread spectrum) PHY

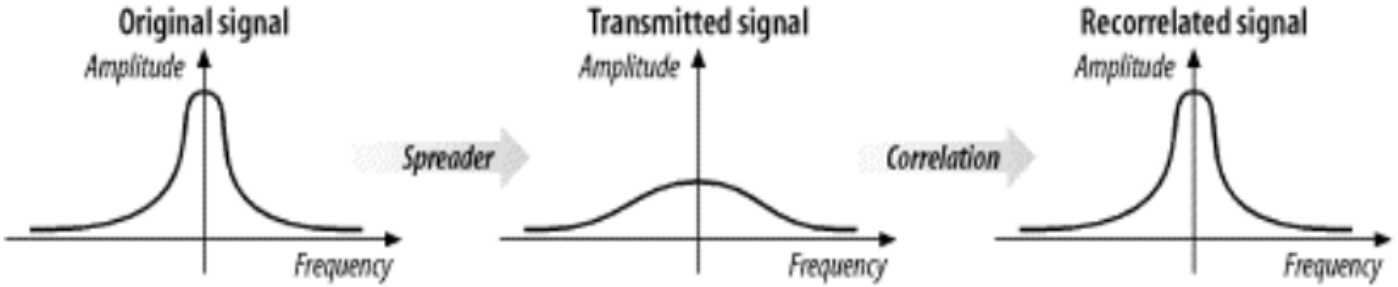
- DSSS provides 1 and 2 Mbps RF communications using the 2.4 GHz ISM band.
- The data that is being transmitted is spread across the range of frequencies that make up the channel. The process of spreading the data across the channel is known as **data encoding**.
- The system converts the 1 bit of data into a series of bits that are referred to as chips.
- To create the chips, a Boolean XOR is performed on the data bit and a fixed-length bit sequence pseudo random number (PN) code. Using a PN code known as the **Barker code.**
- Binary data 1 = 1 0 1 1 0 1 1 1 0 0 0
- Binary data 0 = 0 1 0 0 1 0 0 0 1 1 1

802.11 DSSS PHY

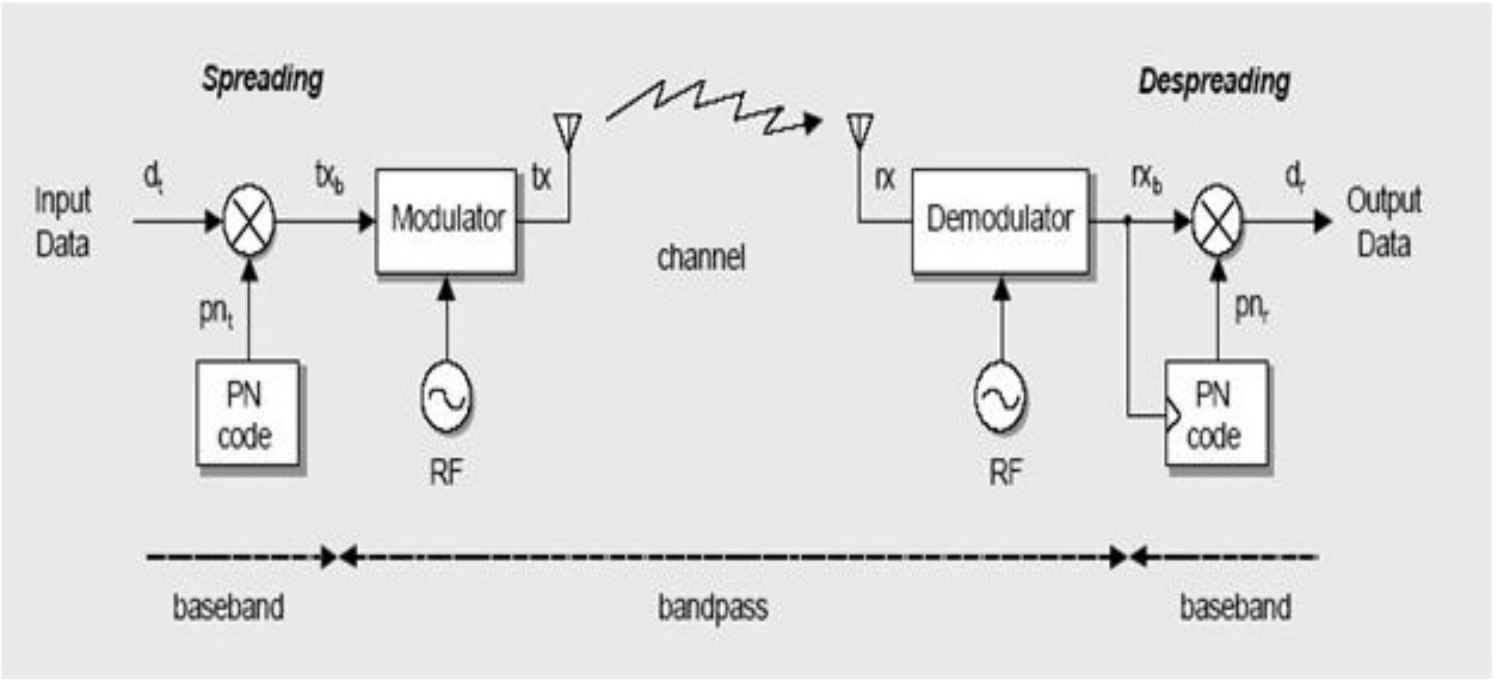


802.11 DSSS PHY

- Although 1 bit of data might need only 2 MHz of frequency space, the 11 chips will require 22 MHz of frequency carrier space.
- This process of converting a single data bit into a sequence is often called **spreading** or **chipping.**

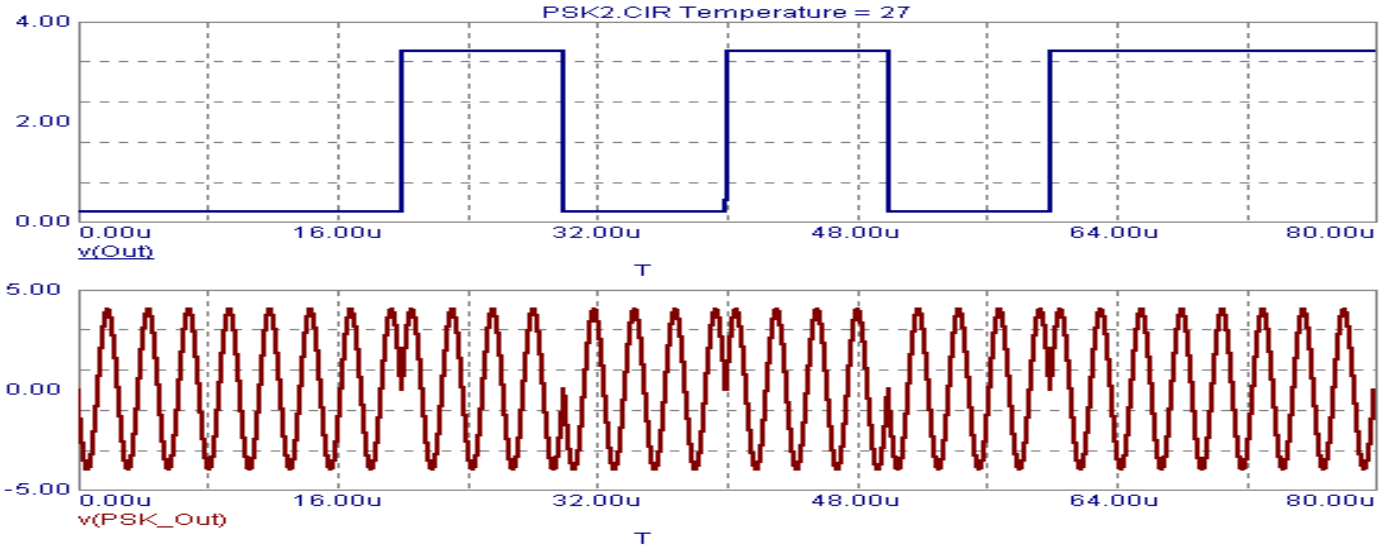


802.11 DSSS PHY



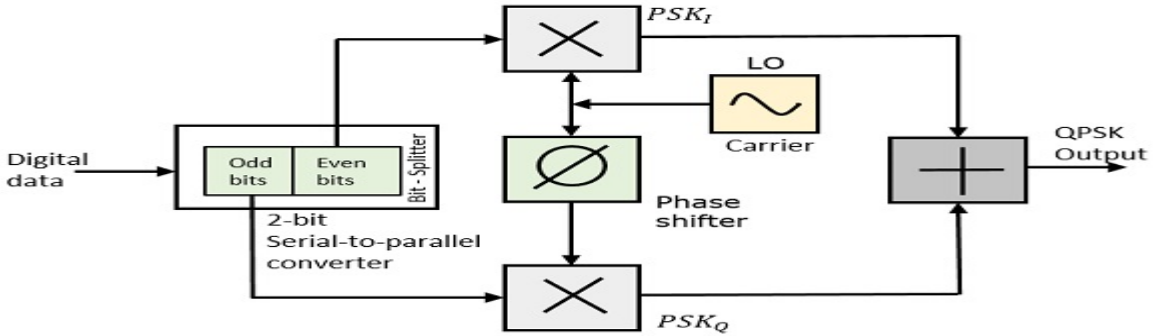
BPSK

- The bit rate is equal to the baud rate (symbol rate).

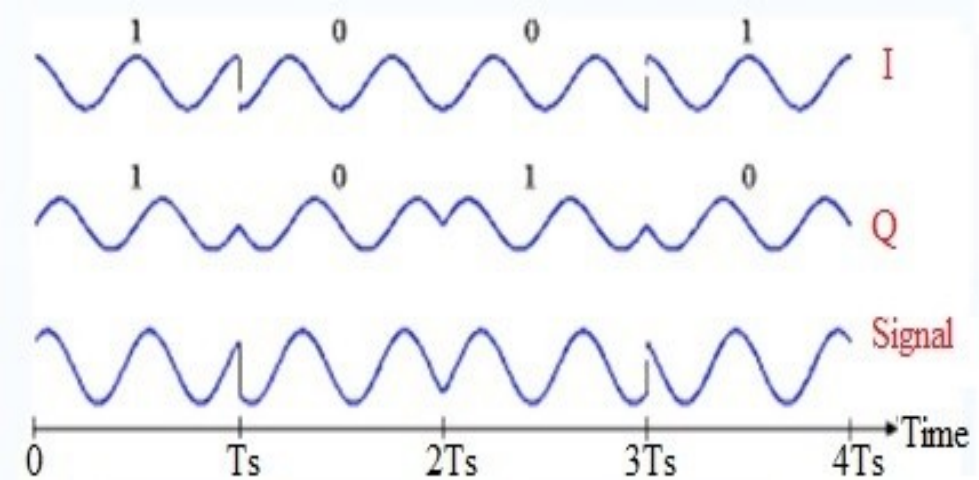


QPSK

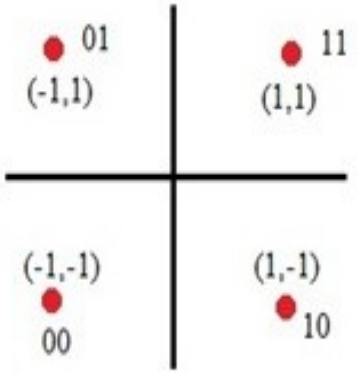
- QPSK is a form of Phase Shift Keying in which two bits are modulated at once, selecting one of four possible carrier phase shifts (0, 90, 180, or 270 degrees) .
- QPSK allows the signal to carry twice as much information as ordinary PSK using the same bandwidth.
- The bit rate is two times the baud rate (symbol rate).



QPSK



QPSK Time Diagram



QPSK Constellation

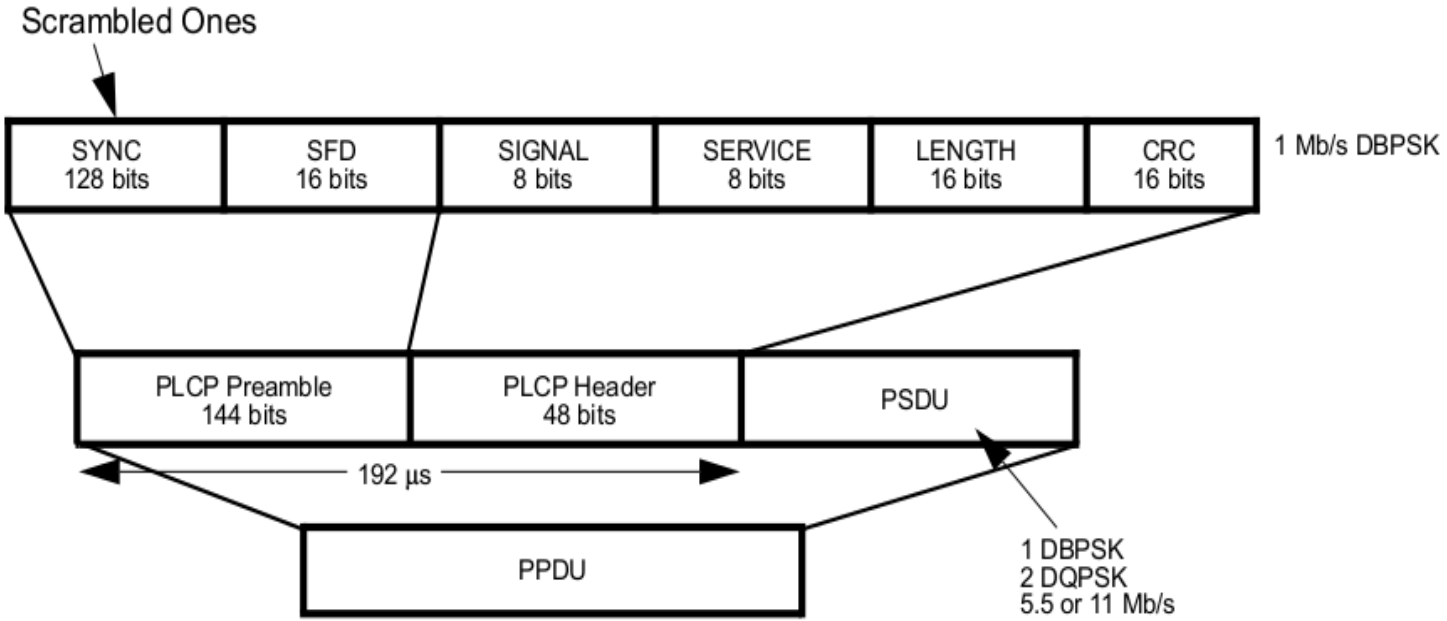
QAM

- QAM 16
- QAM 64

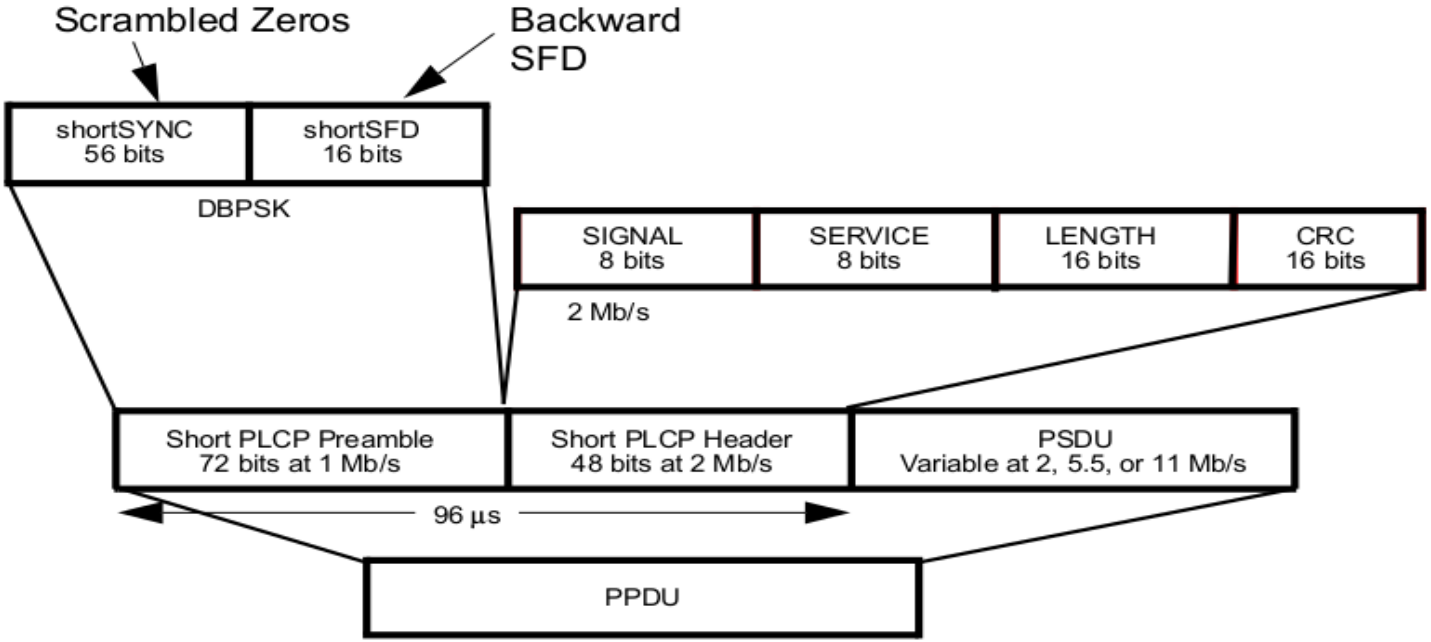
802.11b HR - DSSS PHY

- HR DSSS provides 1 Mbps, 2Mbps, 5.5Mbps and 11 Mbps RF communications using the 2.4 GHz ISM band.
- The 802.11b 5.5 and 11 Mbps speeds are known as High-Rate DSSS (HR-DSSS).
- To help provide the faster speeds of HR-DSSS, a more complex code, Complementary Code Keying (CCK) is used.
- CCK uses an eight-chip pseudorandom number (PN), along with using different PNs for different bit sequences.

Long PPDU format



Short PPDU format



PPDU Format

- Sync Field

  → TO alert receiver that the potentially receivable single is present. Rx(STA) will synchronize with the incoming

  single after detecting the sync field.

  - For Long PLCP preamble → 128 bits (1111.....1)
  - For short PLCP preamble → 56 bits (0000.....0)

- SFD (Start Of Frame Delimiter)

  → It is a dictator that information PLCP header is coming next. Syn with Tx and Rx must occur before SFD filed.

  - For Long PLCP preamble → 16 bits (1111 0011 1010 0000)
  - For short PLCP preamble → 16 bits (0000 0101 1100 1111)

PLCP HEADER

- Signal (8 bits)

  → Indicate with modulation method will be used to transmit the PSDU portion of PPDU.

  - For Long PLCP preamble → 0x0A - 1 Mbps; 0x14 - 2 Mbps; 0x37 - 5.5 Mbps; 0x6E - 11 Mbps
  - For short PLCP preamble → 2 Mbps, 5.5 Mbps, & 11 Mbps

- Service(8bits)

  - For Both PLCP Preamble → b2 - Clock lock, b3– Modulation(0=CCK, 1=PBCC), b7– Length Extension bit.

- Length

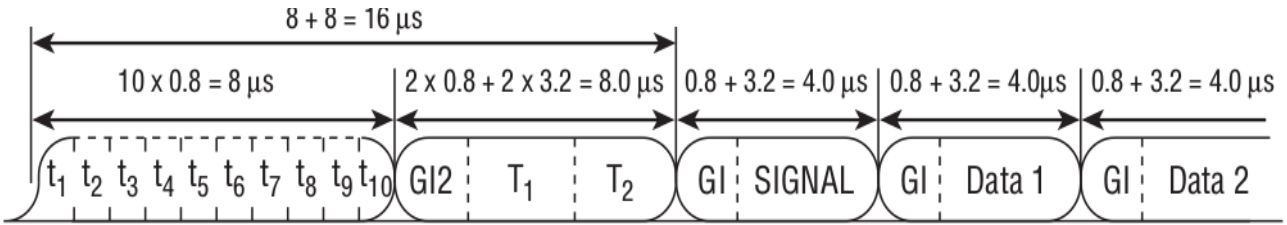
  → Number of microseconds that are required to transmit the PSDU.

- CRC(16 bit) :→ Provides protection for the other three filed in PPDU signal.

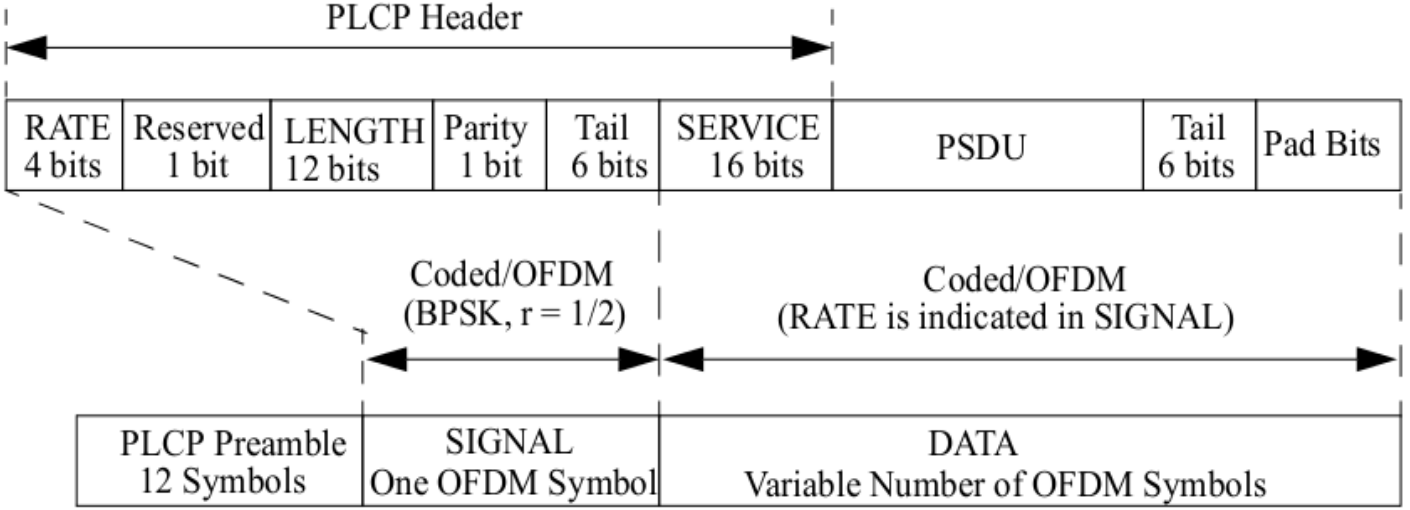
OFDM PLCP Preamble

- OFDM training structure, consists of 10 short symbols and 2 long symbols.
- t1 to t10 identify the short training symbols, GI2 is a long guard interval, and T1 and T2 identify the long training symbols.
- Following the PLCP preamble is the SIGNAL field and the DATA fields, each with a guard interval preceding them.
- The total training length is 16 μs. A short OFDM training symbol consists of 12 subcarriers and a long OFDM training symbol consists of 53 subcarriers.

OFDM – PLCP sublayer



OFDM – PLCP sublayer



802.11n HT PHY

PPDU Format

- Non-HT format (NON HT)
- HT-mixed format (HT MF)
- HT-greenfield format (HT GF)

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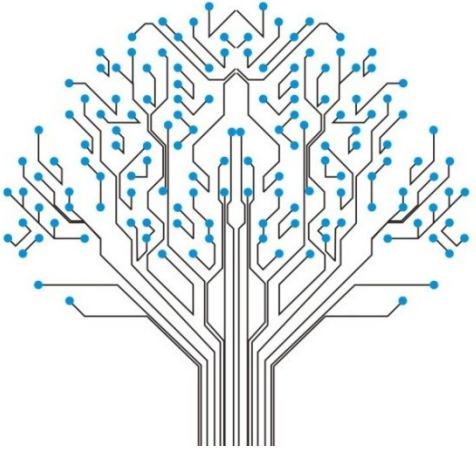
Thank you



Fairness

Learning

Responsibility

Innovation

Respect