Module 3 — Assignment

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1.What are the different 802.11 PHY layer standards? Compare their characteristics.?

Solution:

Standard	Frequency Band	Max Data Rate	Modulation	Year Introduced	Key Features
802.11b	2.4 GHz	11 Mbps	DSSS/CCK	1999	First widely adopted WLAN
802.11a	5 GHz	54 Mbps	OFDM	1999	High-speed, short-range
802.11g	2.4 GHz	54 Mbps	OFDM (backward comp)	2003	Backward compatible with 802.11b
802.11n	2.4/5 GHz	600 Mbps	OFDM, MIMO	2009	MIMO, channel bonding (20/40 MHz)
802.11ac	5 GHz	6.9 Gbps	OFDM, MU-MIMO	2013	80/160 MHz, beamforming
802.11ax	2.4/5/6 GHz	~10 Gbps	OFDMA, MU-MIMO	2019	OFDMA, Target Wake Time
802.11be	2.4/5/6 GHz	>30 Gbps	OFDMA, MLO, 4096-QAM	2024 (expected)	Multi-Link Operation, low latency

2. What are DSSS and FHSS? How do they work?

Solution:

DSSS (Direct Sequence Spread Spectrum) spreads data over a wider frequency using a pseudorandom noise code to improve resistance to interference and jamming.

FHSS (Frequency Hopping Spread Spectrum) rapidly changes the carrier frequency across a range of frequencies in a pseudo-random pattern to reduce interference and enhance security.

3. How do modulation schemes work in the PHY layer? Compare different modulation schemes and their performance across various Wi-Fi standards.?

Solution:

Modulation	Bits/Symbol	Used In	Characteristics
BPSK	1	802.11a/b/g/n	Simple, robust, low data rate
QPSK	2	802.11a/g/n	Moderate data rate, balanced
16-QAM	4	802.11a/n/ac	Higher data rate, less robust
64-QAM	6	802.11n/ac	High throughput, noise-sensitive
256-QAM	8	802.11ac	Very high throughput
1024-QAM	10	802.11ax	Ultra-high, sensitive to noise
4096-QAM	12	802.11be	Extremely high throughput

4. What is the significance of OFDM in WLAN? How does it improve performance?

Solution:

OFDM (Orthogonal Frequency Division Multiplexing) divides the wireless channel into multiple orthogonal subcarriers. It allows parallel transmission of data, increases spectral efficiency, reduces interference, and combats multipath fading.

5. How are frequency bands divided for Wi-Fi? Explain different bands and their channels.?

Solution:

Wi-Fi uses several frequency bands:

- 2.4 GHz: Channels 1–14 (most are overlapping)

- 5 GHz: Channels 36–165 (mostly non-overlapping)

- 6 GHz: Used in Wi-Fi 6E and Wi-Fi 7 (channels 1–233)

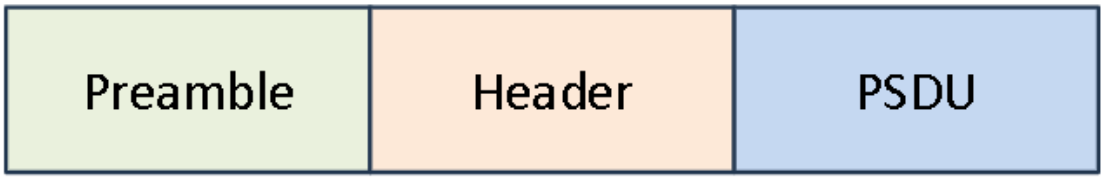
6. What is the role of Guard Intervals in WLAN transmission? How does a short Guard Interval improve efficiency?

Solution:

Guard Intervals are used to avoid inter-symbol interference caused by multipath. A short Guard Interval (400 ns) increases the data rate by reducing overhead, though it may increase error probability in noisy environments.

7. Describe the structure of an 802.11 PHY layer frame. What are its key components?

Solution:



The PHY frame includes:

- Preamble: Includes STF (Short Training Field) and LTF (Long Training Field) for synchronization and channel estimation.

- Header: Contains SIGNAL fields that describe the frame's characteristics.

- Payload: Carries the MAC frame and FCS (Frame Check Sequence).

8. What is the difference between OFDM and OFDMA?

Solution:

Feature	OFDM	OFDMA
Subcarriers	All used by one user (Multiplexing)	Divided among users (Multiple Access)
Efficiency	Good for single-user	High for multi-user

Used In	802.11a/g/n/ac	802.11ax/be

9. What is the difference between MIMO and MU-MIMO?

Solution:

Feature	MIMO	MU-MIMO
Users	Single-user	Multiple users
Spatial Streams	Sent to one device	Divided among devices
Used In	802.11n/ac	802.11ac/ax/be

10. What are PPDU, PLCP, and PMD in the PHY layer?

Solution:

PPDU (PHY Protocol Data Unit) is the complete frame sent over the air. PLCP (Physical Layer Convergence Protocol) prepares MAC frames for transmission. PMD (Physical Medium Dependent) handles modulation, coding, and actual transmission.

11. What are the types of PPDU? Explain the PPDU frame format across different Wi-Fi generations.?

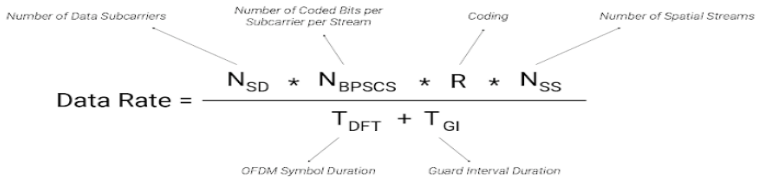
Solution:

Standard	PPDU Type	Key Features
802.11a/g	Legacy OFDM	STF, LTF, SIGNAL, Data
802.11b	DSSS	Preamble, Header, PSDU
802.11n	HT	Legacy + HT fields (HT-SIG, HT-LTF)
802.11ac	VHT	Legacy + VHT-SIG-A/B, VHT-STF/LTF
802.11ax	HE SU/MU/ER/TB	HE-SIG-A/B, LTFs for OFDMA & MU-MIMO

802.11be	EHT	Multi-Link, EHT-SIG, 4096-QAM, UL/DL MIMO

12. How is the data rate calculated?

Solution:



It depends on modulation scheme, coding rate, channel width, guard interval, and the number of spatial streams.