**12. How is the data rate calculated?**

The data rate in Wi-Fi basically tells us how fast data is transmitted over the wireless channel. It depends on multiple factors related to the physical layer and modulation technique.

**Key Factors That Affect Data Rate:**

* **Modulation Scheme**: Higher-order modulations like 64-QAM, 256-QAM, or 1024-QAM can transmit more bits per symbol.
* **Coding Rate**: Forward Error Correction (FEC) is used. A coding rate like 3/4 means 3 bits of useful data out of every 4 bits sent.
* **Channel Bandwidth**: Wider channels (20, 40, 80, 160 MHz) allow more data to be sent in parallel.
* **Number of Spatial Streams (MIMO)**: More streams = more parallel data = higher throughput.
* **Guard Interval**: A shorter Guard Interval (e.g., 400 ns instead of 800 ns) reduces overhead and slightly increases the rate.
* **Symbol Rate (depends on channel width)**: Determines how many symbols are sent per second.

**Data Rate = (Number of Subcarriers) × (Bits per Symbol) × (Coding Rate) × (Number of Spatial Streams) × (Symbol Rate)**

**Example: Data Rate Calculation for 802.11n (Wi-Fi 4)**

* **Modulation**: 64-QAM (6 bits per subcarrier)
* **Coding Rate**: 5/6
* **Channel Bandwidth**: 40 MHz
* **Guard Interval**: Short (400 ns)
* **Number of Spatial Streams**: 2

**Determine the number of data subcarriers**: For 802.11n with a 40 MHz channel → 108 data subcarriers

**Bits per subcarrier** (based on modulation): 64-QAM → 6 bits per subcarrier

**Coding rate**: 5/6 → only 5 bits out of every 6 are actual data bits

**Symbol duration**: With 400 ns guard interval, total symbol duration is  
3.6 μs (3.2 μs + 0.4 μs)

**Symbols per second** = 1 / 3.6 μs = **277,778 symbols/sec**

**Data rate per spatial stream**  
= subcarriers × bits per subcarrier × coding rate × symbols/sec  
= 108 × 6 × (5/6) × 277,778  
= 108 × 5 × 277,778  
= **150 Mbps**

**Total data rate** (for 2 spatial streams)  
= 150 Mbps × 2 = **300 Mbps**