Standard-related patent landscape: Wifi 4

Patent Mapping to the Wifi 4 standard in LexisNexis® IPlytics®

General Scope

WiFi 4, also known as 802.11n, represents a widely adopted wireless networking standard designed to enhance the speed, range, and overall performance of wireless networks. With a focus on improving data transfer rates and reliability, WiFi 4 is instrumental in providing faster and more stable wireless connectivity for a variety of devices, including laptops, smartphones, and IoT (Internet of Things) devices. The standard operates in both the 2.4 GHz and 5 GHz frequency bands, offering increased bandwidth and reduced interference, making it a key technology for residential, business, and public WiFi deployments.

References

- As outlined by the Institute of Electrical and Electronics Engineers (IEEE), WiFi 4 (802.11n) is described as a significant advancement in wireless networking technology. The IEEE emphasizes its role in improving data rates and range, stating that it "provides enhanced reliability and performance for wireless communication, making it suitable for a wide range of applications in diverse environments."
  Source: *ieee.org*

- Industry reports from the WiFi Alliance, the organization responsible for promoting and certifying WiFi technologies, highlight the widespread adoption of WiFi 4 in consumer electronics and networking equipment. The WiFi Alliance emphasizes WiFi 4's contribution to delivering improved wireless experiences, stating that it "enables higher data rates, extended coverage, and better overall wireless performance, addressing the growing demands of connected devices."
  Source: *wifi.org*

Wi-Fi generations

Generation/IEEE Standard	Maximum link rate	Standards development	Adopted	Frequency
Wi-Fi 7 (802.11be)	N.A.	2019-today	N.A.	2.4/5 and 6 GHz
Wi-Fi 6E (802.11ax)	600 to 9608 Mbit/s	2014-today	2019	6 GHz
Wi-Fi 6 (802.11ax)	600 to 9608 Mbit/s	2014-today	2019	2.4/5 GHz
Wi-Fi 5 (802.11ac)	433 to 6933 Mbit/s	2008-2013	2014	5 GHz
Wi-Fi 4 (802.11n)	72 to 600 Mbit/s	2003-2013	2008	2.4/5 GHz

Wifi 4 standard	Topics (positive concepts)
Relevant concepts	▪ 802.11n is an IEEE (Institute of Electrical and Electronics Engineers) industry standard for local Wi-Fi network communications, ratified in 2009. It replaced older 802.11a, 802.11b, and 802.11g Wi-Fi technologies but was superseded by the 802.11ac in 2013 and 802.11ax (Wi-Fi 6) in 2019. ▪ 802.11n features: MIMO (Multiple Input Multiple Output): ▪ Utilizes multiple antennas at both the transmitter and receiver to improve communication performance and increase data rates. Channel Bonding: ▪ Supports the use of wider channel bandwidths, up to 40 MHz, to increase data throughput. Spatial Multiplexing: ▪ Enables the transmission of multiple data streams simultaneously over the same frequency band, improving overall throughput. Modulation Schemes: ▪ Introduces higher-order modulation schemes, such as 64-QAM (Quadrature Amplitude Modulation), to increase data rates. Frame Aggregation: ▪ Aggregates multiple frames into a single transmission, reducing overhead and improving efficiency. Dynamic Frequency Selection (DFS): ▪ Allows devices to dynamically switch between channels to avoid interference and optimize performance. Space-Time Block Coding (STBC): ▪ Improves reliability in MIMO systems by transmitting multiple copies of the same data over multiple antennas with different phases. Short Guard Interval: ▪ Reduces the guard interval between symbols, improving spectral efficiency and reducing latency. QoS (Quality of Service): ▪ Enhances the prioritization and management of data traffic to ensure better performance for different types of applications. Backward Compatibility: ▪ Designed to be compatible with older Wi-Fi standards (802.11a/b/g), allowing 802.11n devices to communicate with devices using these older standards. Greenfield Mode: ▪ Introduces a "greenfield" mode that excludes backward-compatible support for legacy devices, optimizing performance in environments with only 802.11n devices. HT (High Throughput) Mode: ▪ Encompasses various enhancements, including the use of wider channels and improved modulation schemes, to achieve higher data rates.

Wifi 4 standard	Topics (negative concepts)
No relevant concepts	▪ 802.11n is an IEEE (Institute of Electrical and Electronics Engineers) industry standard for local Wi-Fi network communications, ratified in 2009. It replaced older 802.11a, 802.11b, and 802.11g Wi-Fi technologies but was superseded by the 802.11ac in 2013 and 802.11ax (Wi-Fi 6) in 2019. Cellular Integration: ▪ Some cellular technologies, such as LTE (Long-Term Evolution) and 5G, have tighter integration with cellular networks, allowing seamless handovers between Wi-Fi and cellular connections. Wide-Area Coverage: ▪ LPWAN (Low Power Wide Area Network) technologies, such as LoRaWAN and Sigfox, are designed for low-power, wide-area coverage, making them suitable for IoT applications in areas where Wi-Fi coverage may be limited. Ultra-Low Power Consumption: ▪ Some IoT-focused protocols, like Zigbee and Z-Wave, prioritize ultra-low power consumption for devices with extended battery life. Mesh Networking: ▪ Mesh networking is supported by standards like Zigbee, Thread, and Bluetooth Mesh, enabling devices to relay data through a network of interconnected nodes. This can enhance coverage in areas where a direct connection to the central access point may be challenging. Deterministic Communication: ▪ Time-Sensitive Networking (TSN) is a set of standards designed to provide deterministic communication over Ethernet networks. It is often used in industrial applications where precise timing is critical. Satellite Communication: ▪ Satellite communication standards, such as DVB-S2 for satellite broadband, are used for long-distance, global communication. Wi-Fi standards, including 802.11ac, are designed for local wireless networking and are not intended for global-scale communication. Dynamic Spectrum Access: ▪ Cognitive Radio technologies, found in some versions of IEEE 802.22, enable devices to dynamically adapt and use available spectrum in real-time based on environmental conditions. This is different from traditional Wi-Fi, which operates in designated frequency bands. Licensed Spectrum Usage: ▪ Cellular standards like LTE and 5G operate in licensed spectrum bands, providing a level of control and quality of service that unlicensed spectrum technologies like Wi-Fi may not have. Regulatory Domain Considerations: ▪ Standards like IEEE 802.15.4 and Zigbee operate in the 2.4 GHz and sub-GHz frequency bands and may have specific regulatory considerations.

Wifi 4 standard	Topics (negative concepts)
No relevant concepts	▪ **802.11 Features (Not in 802.11n):** MU-MIMO (Multi-User Multiple Input Multiple Output): ▪ Introduced in 802.11ac and further enhanced in 802.11ax, MU-MIMO allows multiple devices to simultaneously communicate with the access point, improving network efficiency in high-density environments. OFDMA (Orthogonal Frequency Division Multiple Access): ▪ Introduced in 802.11ax, OFDMA allows more efficient use of available spectrum by dividing channels into smaller resource units, enabling simultaneous communication with multiple devices. Target Wake Time (TWT): ▪ Introduced in 802.11ax, TWT allows devices to schedule when they wake up and communicate with the access point, reducing power consumption and improving efficiency in IoT and battery-powered devices. BSS Coloring: ▪ Introduced in 802.11ax, BSS Coloring helps differentiate between transmissions from different Basic Service Sets (BSSs), improving spatial reuse and reducing interference. Higher Modulation Schemes: ▪ 802.11ax supports more advanced modulation schemes, including 1024-QAM (Quadrature Amplitude Modulation), allowing for higher data rates. Improved Uplink Performance: ▪ 802.11ax enhances uplink performance through features like uplink MU-MIMO and improved resource allocation, addressing the asymmetrical nature of many applications. Enhanced Security (WPA3): ▪ While security improvements were made in 802.11n with WPA2, subsequent standards like 802.11ax have introduced WPA3, providing enhanced security features and protocols. Basic Service Set (BSS) Coloring: ▪ Introduced in 802.11ax, BSS Coloring helps differentiate transmissions from different BSSs, improving spatial reuse and reducing interference.