Introduction to Industrial IEEE 802.11 Wireless

Industry has already accepted wireless networking as an excellent solution for many different applications. The main advantages are the convenience of connecting devices without relying on wired networks, and avoiding the cost of installing wire conduits at sites where doing so would be prohibitive.

IEEE 802.11 Specifications

The IEEE 802.11 standard specifies a way to use radio frequency (RF) technology to send Ethernet packets over the air. Today’s WLANs are based on the IEEE 802.11 standard and referred to as Wi-Fi networks. By common agreement between regulatory agencies around the world (FCC, ETSI, etc.), a WLAN transmits over unlicensed spectrums, with only minor variations from country to country. The 802.11b standard, which operates in the 2.4 GHz frequency band at 11 Mbps, was the first commercially successful WLAN technology.

As wireless technology matured, a higher transmission rate of 54 Mbps was achieved with 802.11g, which operates in the 2.4 GHz band, and 802.11a, which operates in the 5 GHz frequency band. It is common for dual-band Wi-Fi access points and client network adapters to support various combinations of 802.11a, 802.11b, and 802.11g. Choosing the right WLAN technology is an important factor in determining the performance of your wireless network and overall return on investment.

<table>
<thead>
<tr>
<th>Standard</th>
<th>IEEE 802.11b</th>
<th>IEEE 802.11a</th>
<th>IEEE 802.11g</th>
<th>IEEE 802.11n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year Approved</td>
<td>1999</td>
<td>1999</td>
<td>2003</td>
<td>2009</td>
</tr>
<tr>
<td>Compatibility</td>
<td>IEEE 802.11b compliant</td>
<td>IEEE 802.11a compliant</td>
<td>IEEE 802.11b/g compliant</td>
<td>IEEE 802.11a/b/g/n compliant</td>
</tr>
<tr>
<td>Frequency Band</td>
<td>2.4 GHz</td>
<td>5 GHz</td>
<td>2.4 GHz</td>
<td>2.4/5 GHz</td>
</tr>
<tr>
<td>Channel Bandwidth</td>
<td>20 MHz</td>
<td>20 MHz</td>
<td>20 MHz</td>
<td>20 or 40 MHz</td>
</tr>
<tr>
<td>Number of Spatial Streams</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1 to 4</td>
</tr>
<tr>
<td>Max. Data Rates</td>
<td>11 Mbps</td>
<td>54 Mbps</td>
<td>54 Mbps</td>
<td>600 Mbps²</td>
</tr>
<tr>
<td>Data Rate Configurations</td>
<td>4</td>
<td>8</td>
<td>12³</td>
<td>576</td>
</tr>
<tr>
<td>Spread Spectrum</td>
<td>DSSS</td>
<td>OFDM</td>
<td>OFDM, DSSS</td>
<td>OFDM</td>
</tr>
<tr>
<td>Typical Indoor Range²</td>
<td>100 to 150 feet</td>
<td>30 to 50 feet</td>
<td>100 to 150 feet</td>
<td>150 to 200 feet</td>
</tr>
<tr>
<td>Typical Indoor Range³</td>
<td>200 to 300 feet</td>
<td>50 to 100 feet</td>
<td>200 to 300 feet</td>
<td>450 to 600 feet</td>
</tr>
</tbody>
</table>

- a. IEEE 802.11b includes backwards compatibility.
- b. This is a general rule of thumb that can be applied when planning a wireless network.
- c. Theoretical data rate with 4-stream MIMO

Next Generation High Bandwidth 802.11n Solutions

The next generation IEEE 802.11n standard allows wireless communication speeds to theoretically reach 300 Mbps. In order to achieve 300 Mbps, the physical layer needs to support a higher transmission speed that is at least 50 times faster than IEEE 802.11b and 10 times faster than IEEE 802.11g. To extend the wireless communication distance, IEEE 802.11n has added more specifications to the MIMO standard, which uses multiple antennas to increase transmission speed. MIMO (Multiple Input Multiple Output) is a key technology in the 802.11n standard, and offers greater transmit power and signal strength on the transmitter side and receiver side, respectively. By simultaneously transmitting several signals on the same transmission frequency but over two special streams, MIMO delivers greater range and data throughput. With improved OFDM (Orthogonal Frequency Division Multiplexing) modulation, MIMO can use multiple carriers to transmit multiple signals that are then combined into a single signal. This overcomes multipath fading effects that would otherwise severely degrade received signal quality. As an enhancement to existing 802.11 technologies, 802.11n offers a suite of advanced new features that increase effective data throughput, extend wireless coverage, and create more reliable networks.

Wireless Architectures At-a-Glance

WDS

A Wireless Distribution System (WDS) provides an easy way for APs to communicate wirelessly with each other. As shown in the figure to the right, one AP acts as a wireless access point and forwards packets to the other AP through the WDS before the packets are sent to the Ethernet LAN.
In addition, two or more LAN segments can be connected wirelessly. As illustrated in the figure to the right, a pair of wireless LAN-to-LAN bridges is used to connect two LAN segments. Since the AP is WDS-enabled, it can operate in bridge mode.

**STP/RSTP**

Spanning Tree Protocol (STP) was designed to help reduce link failures in a network and provide protection from loops. STP can effectively increase system reliability to allow your network to run non-stop. Networks that have a complicated architecture are prone to broadcast storms caused by unintended loops in the network. STP is part of the IEEE 802.1D standard (1998 Edition) bridge specification.

Rapid Spanning Tree Protocol (RSTP) implements the Spanning Tree algorithm and protocol defined by the IEEE 802.1w-2001 standard. RSTP is not only backwards compatible with STP, but is able to determine the topology of a bridged network much more quickly than STP.

**Wireless Security**

Wireless networks use radio waves, which mean that your data can be intercepted by other parties. A proper protection mechanism for radio transmissions on any network is always a concern for protocol designers. The right balance between security, transparency, and cost effectiveness is important when determining the type of security to use for your WLAN. You should take into account your target environment, the security levels that your WLAN can support, and the effect that stronger security methods could have on performance. The following table summarizes implementation considerations and client requirements when using different WLAN security strategies.

<table>
<thead>
<tr>
<th>Method</th>
<th>Client Support</th>
<th>Considerations</th>
</tr>
</thead>
</table>
| WEP      | Built-in support on all 802.11a, basic 802.11b, and 802.11g devices | -Provides basic security  
-Requires manual key management                                                              |
| WPA      | Requires WPA-enabled system and network card driver | -Provides dynamically generated keys that are periodically refreshed  
-Provides similar shared key user authentication  
-Provides robust security for small networks                                                       |
| WPA2     | Requires WPA-enabled system and network card driver | -Provides robust security for small networks  
-Wireless stations may require hardware to upgrade to support WPA2                                |
| 802.11X  | Requires WPA-enabled system and network card driver | -Provides dynamically generated keys that are backwards compatible with the original WPA technology |

**Industrial-grade Wireless LANs**

Industrial environments are filled with hazards such as dust, EMI/noise, and temperature extremes. To overcome these challenges, Moxa’s industrial-grade wireless solutions are ruggedized with IP68-rated housing that resists water, oil, and even corrosion damage. In addition, Moxa’s AWK series meets or exceeds a number of industry standards, such as EN50155 certification for rolling stock and UL1D2/ATEC or Class 1 Zone II for oil and gas.

**100 ms Turbo Roaming for Seamless Connections**

IEEE 802.11 technology gives networks an effective range of only a few hundred meters. When wireless clients are on moving objects they need to “roam” between many wireless access points. However, in many applications users need an uninterrupted network data connection when the client moves from one access point to another. Without fast roaming time, constant roaming could create frequent handoffs and poor performance. Moxa’s proprietary Turbo Roaming has a fast handover time of less than 100 ms. Turbo Roaming increases the roaming speed by unifying AP channels and avoiding wasted channel-hopping time while roaming. Moxa’s APs support Turbo Roaming technology to provide fast seamless roaming on wireless networks.
**Long-distance Communication**

IEEE 802.11 standards are not designed for outdoor use, and generally speaking, the range of a standard 802.11 wireless network is only 100 to 300 meters. When the distance between two wireless devices is increased, packets sent over such a long distance can become unstable and create a drop in network performance. The AWK's support for long distance communication makes it easier to configure a long-distance solution. A proprietary algorithm developed by Moxa can be used to determine which parameters should be used to optimize performance. Practical uses of the algorithm include the deployment of long-range point-to-point and point-to-multipoint wireless networks at a reduced cost, and address issues related to security, reliability, and speed.

**DI/DO**

Moxa’s AWK devices provide a more modern way for system operators to monitor remote APs with real-time alarm messages that trigger almost instantaneously when exceptions occur. In other words, warning messages are actively triggered in response to events such as network and power interruptions. When integrated with other important sensors via digital inputs (DI), the AWK can also provide an automatic alarm mechanism. This is done by redirecting warning messages to an IP network by email or log record.

**Certified to Meet Industrial Reliability Standards**

Industrial environments often involve unknown, hazardous conditions that can influence the operation of Ethernet devices. Failure in an industrial system can cause serious disasters and even the loss of life and property. Moxa’s industrial products have received UL/cUL Class 1 Division 2 and ATEX C1Z2 certifications, which were developed to indicate which industrial control and information technology devices are suitable for hazardous locations such as maritime environments, mines, oil refineries, and other industrial settings. In addition, environmental compliance with the EN50155 and EN50121-3-2 standards is essential for determining which devices can be used safely and reliably in railway-related and on-train applications.

**Wireless VLAN (Multi-SSID)**

A Virtual LAN (VLAN) is a collection of clients or hosts grouped together as if they were attached to the broadcast domains in a Layer 2 network. Based on the SSID, two or more clients can be added to a VLAN and grouped into the same LAN segment regardless of geographical location. Without additional routers, you can easily use Layer 2 switches with AWK APs and set the broadcast domain boundaries. VLANs provide network administrators with leeway in addressing network security, management, and scalability issues.

**WMM for Communication Prioritization**

Quality of Service (QoS) is a network term for controlling and measuring data transmission rates, throughput, and error rates, and is becoming an essential part of wireless communications when transmitting multimedia data, such as audio and video. Some important data requires a high quality of flow and throughput control and low error rates. WMM (Wi-Fi Multimedia) is based on a subset of the IEEE 802.11e protocol, which was designed to provide QoS on a WLAN. WMM allows the prioritization of data transmissions to help control the quality of communications.
Advanced Industrial Wireless Solutions

**Moxa Makes Wireless Robust, Secure, and Reliable**

Today's wireless applications demand data integrity, secure transmissions, and high overall network reliability. As a leader in industrial device networking, Moxa provides you with more comprehensive industrial wireless solutions and is ready to help you upgrade to industry-leading WLAN solutions.

Moxa’s support of standards-based wireless products allows an winning combination of reliability, redundancy and throughput in secure wireless LANs. Moxa’s AWK series supports a high level of security, RF redundancy, and faster 50 ms Turbo Roaming for both indoor and outdoor environments. Successful proven deployments in highly demanding environments, such as mining, oil and gas, heavy industry and railway systems, demonstrate the AWK’s unparalleled reliability under extreme conditions.

**Redundant Wireless**

In most cases, radio interference occurs on a dedicated frequency or a narrow frequency band. Utilizing two or more frequencies to communicate at the same time can help maintain constant data transmission, even if there is interference at one of the frequencies. This strategy greatly increases the availability of wireless links and makes the entire wireless network more reliable.

Dual-RF solutions such as the AWK-5222 and AWK-6222 feature two independent wireless communication modules as well as multiple Ethernet ports. In addition to being ideal for wireless infrastructures, these products can also provide a more reliable connection and greater versatility for use on a variety of industrial networks.

**Wireless Bridging**

In addition to wireless redundancy mode, “Wireless Bridge” mode is also available with Moxa’s dual-RF solution, which can form a master-slave bridge mode to link other SSID and extend wireless coverage. This mode is designed to provide a more optimized WDS mode that overcomes WDS mode’s throughput problems, in which more nodes can cause a serious drop in throughput. With Wireless Bridge mode, the bandwidth of the wireless link will not be reduced (from using Dual RF and isolation of the overlap frequency channel), but instead will easily extend your wireless range.

**Redundant Roaming**

By combining the advantages of two key techniques, Moxa’s Turbo Roaming and dual RF redundancy, Moxa’s advanced redundant roaming enhances secure mobility for mission-critical or latency-sensitive applications, and can benefit from more rapid roaming with a reliable wireless connection. The AWK-5222 and AWK-6222’s redundant mode allows for super fast roaming ensuring quick handoff for roaming clients during the transition between access points. The two RFs of wireless client will transmit data simultaneously, and when they detect a weak or weakening AP signal, the dual RF client will instantaneously start roaming for the next AP.

**Faster Secure 50 ms Turbo Roaming with the WAC-1001 Wireless Controller (Centralized)**

Moxa’s cutting-edge Turbo Roaming technology together with the WAC-1001 wireless controller dramatically shrinks roaming time down to 50 ms, even when wireless security is active. It is perfect for highly mobile wireless communications scenarios such as rolling stock applications. The WAC-1001 is designed for the AWK-3121-RS and AWK-4121-RS series which supports a high level of proactive authentication and encryption to ensure your network stays securely connected. To realize smooth handoffs, the wireless client can be pre-authenticated by the wireless controller to allow seamless roaming without re-authentication. This mechanism significantly reduces authentication latency during re-association and thus greatly enhances the speed and reliability of roaming connectivity for delay-sensitive real-time applications. Exclusive Moxa’s 50 ms Turbo Roaming technology includes a higher data transmission rate, dependable remote equipment monitoring and alerts, and resilience in extreme mobile environments.