The Why and How of Wi-Fi®

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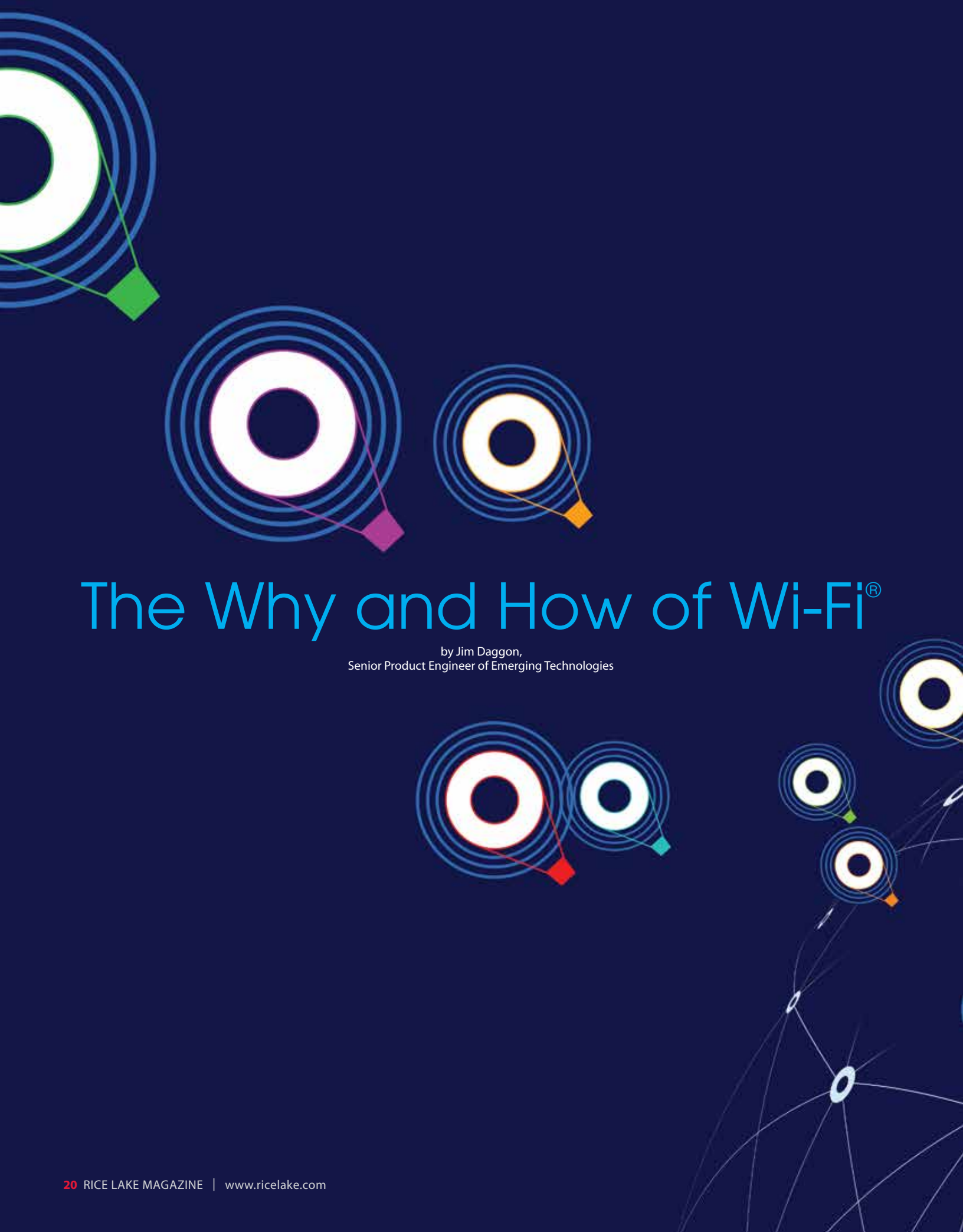

FROM THE GROUNDS OF A COFFEE SHOP TO THE HIGH FLYING SKIES IN AIRPLANES, WIRELESS ETHERNET CAN BE FOUND ALMOST EVERYWHERE. Wireless Ethernet, also known as Wi-Fi, is being used more often to replace wired LANs typically used in industrial settings. Scale communications may find themselves wanting to not only access the Internet but also the network itself. In this two part article, we will look at what Wi-Fi is, connectivity details, and how to design, set up, and troubleshoot the system.

Ethernet – The Basics

Most computers today use Ethernet technology to connect to their respective networks. Wired or wireless, the characteristics are meant to function similarly.

Why Wireless?

In today's industrial (and even non-industrial) applications, running cables can be tedious and expensive. One too-tight staple in a run of cable can greatly diminish the speed or even render it virtually useless causing you to bring in specialized technical personnel. Cable also limits the placement of a device whereas wireless connectivity allows a device to be mobile and flexible in positioning as the needs demand. For example, if a truck scale has a driveway between it and the scale house, running an underground conduit can be expensive and time consuming. In this situation, placing one antenna on top of the scale house and another one on a pole, next to the scale, can solve the problem easily.

In another situation, a long length of cable that is vastly unprotected from harsh elements would typically be a connection requirement between the scale house and a remote scoreboard. A wireless connection is able to solve this problem as it is an excellent candidate for connectivity anywhere there is a possibility of damaging a scale cable. In addition, remember that a home run cable can be damaged by excessive force such as vehicular traffic, but if the excitation lines are shorted in that process, the instrument can also be damaged, incurring a significant repair bill. Using a junction box and converting the home run cable to a wireless connection can alleviate that possibility. Always consider the entire cost of ownership of a system including repairs that may come up, rather than just the simple initial cost.

Range can also be an issue. Some wireless connections can operate over a few miles under the right conditions. These connections can help with remote access to data as well as remote printing in another location for auditing and tracking transactions as they occur.

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Ethernet and Wireless Terminology

Wi-Fi	A trade name used to refer to a wireless Ethernet system. This can also be described as a WLAN – a Wireless Local Area Network.
IP address	A unique Internet Protocol address that is assigned to the device. It consists of four sets of numbers 0-255, separated by a decimal point. (Ex: 192.168.14.3).
Subnet Mask	A number in the same format as an IP address that is used to limit the IP addresses that the device has access to.
Default Gateway	The IP address of the device that provides Internet access or access to another network.
MAC Address	Media Access Control Address – this is the unique hardware address that is given to every Ethernet product.
MIMO	Multiple Input, Multiple Output - A system that allows for multiple antennas for multiple data streams from the same device at the same time.
MU-MIMO	Multi-User MIMO – As above but from multiple devices at the same time.
Fieldbus	A digital, two-way link between field devices and automation systems that adds communication functionality.
Mbps	Million bits per second data rate.
GHz	Gigahertz – 1 billion hertz frequency (1,000,000,000 cycles per second).
MHz	Megahertz – 1 million hertz frequency (1,000,000 cycles per second).

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Wi-Fi Standards

The wireless Ethernet standards were developed by the IEEE (Institute of Electrical and Electronic Engineers) and have the designation of 802.11x where x is one or two letters. These standards determine some of the communications protocols and the frequency used for transmission. The designations start with "a" and are currently up to 802.11ah, but here are the more common ones:

802.11a The original 802.11 release

802.11b The second release – uses the 2.4 GHz frequency for longer outdoor range

802.11g The next major release after b, with data rates up to 54Mbps

802.11n Uses either 2.4 or 5 GHz, higher bandwidth, higher speeds, up to four simultaneous data streams (MIMO)

802.11ac Uses only 5 GHz frequency but can use eight streams with 4X the bandwidth. This gives much higher speed and allows for multiple users simultaneously. Release 2 of this standard will support MU-MIMO.

Range and Interference

The one thing everyone wants and needs to know is, how far can it go and will it work as well as wired at this distance and in this environment? A number of things can affect the range:

Frequency

Just as the radio in your car can only pick up one station at one frequency, the signal of your device can get lost or severely degraded if there are other devices emitting signals in the same frequency. The most popular frequency for wireless Ethernet is 2.4 GHz. This frequency is also used by:

- RC controlled devices
- Some cordless telephones
- Baby monitors
- Car alarms
- Bluetooth™
- Zigbee™
- Satellite TV
- Wireless phones

Noises in this frequency spectrum are generated by:

- Microwaves
- Some USB 3.0 wired devices such as external hard drives

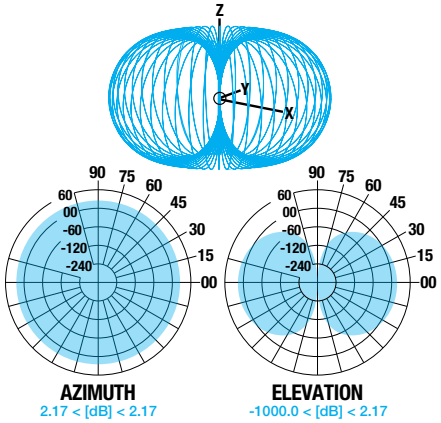
Some of the newer protocols such as 802.11n and 802.11ac can also run in the higher 5 GHz frequency and may need to be modified in implementation to not interfere with weather radar and military applications running nearby.

Environment

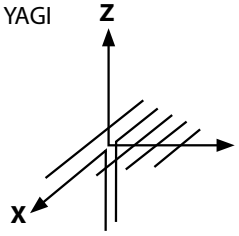
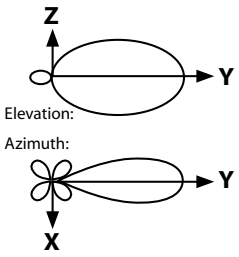
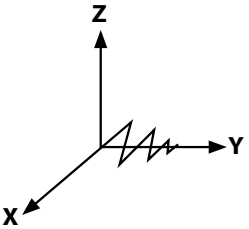
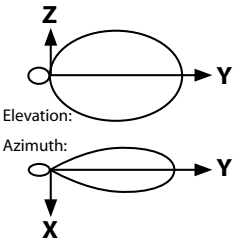
By obtaining a line of sight, meaning no obstructions between the transmitter and the receiver, you will gain optimum range and avoid possible interference. Obstructions can range from walls, buildings, trees, as well as other transmitters. To get the most range, look at the interference sources and select the frequency that has the least interference. Best results are achieved if you can arrange a system placing the antennas in a line of sight of each other. Keep in mind that even with an appropriate line of sight established, the published range can rapidly decrease due to environment and weather. In general, maximum range is approximately 150 feet indoors and 300 feet line of sight. In addition, multiple access points that are cabled to the switch or router can make a hotspot in a particular area that can be as much as 300 feet from the nearest wired switch.

Antenna Selection and Placement

In the event of a need to increase range through obstructions, a higher gain or beamforming antenna can be used. Some of these higher gain antennas simply provide a more focused beam in a particular direction instead of the circular antenna placement in a commonly used pole or omnidirectional one. See diagram below:



Radiation pattern for an omnidirectional antenna

Antenna Type	Radiation Pattern	Characteristics
YAGI 		**Polarization:** Linear horizontal as shown **Typical Half-Power Beamwidth** 50deg x 50deg **Typical Gain:** 5 to 15 dB **Bandwidth:** 5% or 1.05:1 **Frequency Limit:** **Lower:** 50 MHz **Upper:** 2 GHz
LOG PERIODIC 		**Polarization:** Linear **Typical Half-Power Beamwidth** 60deg x 80deg **Typical Gain:** 6 to 8 dB **Bandwidth:** 163% or 10:1 **Frequency Limit** **Lower:** 3 MHz **Upper:** 18 GHz **Remarks:** This array may be formed with many shapes including dipoles or toothed arrays.

Radiation Pattern for a "beam focused" antenna

In the next installment, we will discuss the practical design, installation and troubleshooting of a successful Wi-Fi installation. ■