EION ByTES

Ten Factors that affect Wireless Signal Range

The range is defined as the maximum distance where communication can exist between two antennas in a wireless network. But the range is not only about distance. Here are some important considerations:

- Obstacles, terrain, and radio physics all affect range.
- Another factor in antenna design, with considerations like frequency bands and impedance.
- Noise is another important factor. Just like it's hard to hear someone at a crowded party, it's tough to pick out a radio signal in environments with lots of radio noise.

The various considerations and factors that can impact how well the devices in your network communicate include 10 different factors.

1 Power

Radio signals require a lot of power because, unlike messages running through a wire, they decay in an accelerated fashion. As radio signals radiate away from their source, they rapidly spread out like ripples in a pool. Both sound and radio decay according to the inverse square law. Each time you double the distance, you require four times the amount of power, so traversing long distances uses vastly more energy compared to shorter ones.

2 Throughput

In IoT, you often need to communicate small amounts of data from remote locations. Data throughput has a significant impact on range. When the data rate increases, the range for effective communication between devices can shrink. This is because fast data rates require a higher signal-to-noise ratio for successful demodulation.

If someone in a noisy room is speaking very rapidly they are hard to understand. If they slow down, they are easier to understand. Radios work similarly. Many IoT devices send as little as a single sensor value once per day. When that data is sent at a low bit rate, it can be detected much farther away.

3 Noise

In an RF network, the signal is the information transmitted between devices. Noise is anything else. Signal-to-noise (S/N) ratio is a metric that compares signal power levels to noise power levels. It's an important factor in determining the radio system's range because the range is about reliably distinguishing signal from noise, not the distance that a given radio signal can travel (which is infinite). Radio noise is part of the natural environment, which includes:

- Cosmic background radiation and solar interference
- Atmospheric sources like lightning
- Human sources like power lines, motors, fluorescent lighting, switches, computers and unrelated radio communications

Frequency 4

Lower frequency radio signals can easily diffract around objects and be bounced back by the atmosphere, increasing effective range. However, lower frequencies have limited bandwidth so throughput is constrained. Higher frequencies offer much higher throughput, but have difficulty diffracting around obstacles and will not be reflected back by the atmosphere, limiting their range.

5 Free Space Loss

As a radio signal travels through space, even in a vacuum, its signal will be diminished as it spreads out its energy over an ever-wider area. This spreading follows the inverse square law, which describes the exponential loss of power over distance. We address free space loss at a given frequency by reducing the distance between transmitter and receiver.

6 Diffraction

When a radio signal meets an object in its path, it will scatter or diffract, with some of the energy bending around the object, but the remainder being directed away from the receiver and therefore lost. Sharp edges diffract better than rounded objects, which tend to absorb more of the signal. Diffraction is just one of many reasons for avoiding objects in the signal path.

7 Multipath

In ideal environments like outer space, signals sent by a transmitter always arrive directly, without reflecting off any surfaces or objects. Here on Earth, things are unavoidably more complicated. In cases where the line of sight is clear, some signals will arrive directly, but others will bounce off nearby objects and terrain, thereby distorting them. Radio protocols and systems are typically designed to address some multipath interference. Placing antennas high up and clear of obstructions also helps.

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Absorption

Radio signals can travel an infinite distance across empty space; however, when they encounter objects, some of their energy is absorbed. Radio signals can travel through walls but are attenuated in the process. Humidity in the air can absorb enough radio energy to disrupt high-frequency signals. Tree leaves and other vegetation in the signal path can dissipate enough of the signal to cause problems at lower frequencies.

Hills or mountains can absorb, diffract, reflect or entirely block signals from reaching their destination. The makeup of the ground itself can have an effect at low frequencies, with signals travelling better over lakes, oceans or swamps than dry areas like deserts. The Fresnel Zone, a roughly football-shaped area between the antennas, should be as clear of terrain and obstacles as possible to optimize communications performance.

9

Terrain

Antennas & Range

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Antennas transform electrical signals into radio waves to transmit information "over the air." For receivers, radio waves are transformed back into electrical variations that computers can understand. Using the right antennas correctly is critical. Poor choices can limit range, waste battery power and turn an otherwise well-conceived system into a support nightmare.

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