

A decorative graphic consisting of several overlapping, semi-transparent blue circles of varying sizes, creating a sense of depth and movement, positioned behind the title text.

Why Wireless Systems Operating in Unlicensed Spectrum Can Offer High Reliability

WHITE PAPER

Trilliant helps leading utilities and energy retailers achieve their smart grid visions through the Trilliant Communications Platform, the only communications platform purpose-built for the energy industry that integrates disparate systems of systems into a unified whole. The Trilliant Platform is deployed with more than 200 utilities worldwide to enhance energy efficiency, improve grid reliability, lower operating costs, integrate renewable energy resources and electric vehicles, and empower consumers to better manage their energy consumption.

1100 Island Drive
Redwood City, CA 94065
t 650-204-5050
f 650-508-8096
www.trilliantinc.com

Introduction

Some wireless broadband network operators feel that in order to offer highly reliable wireless services, a licensed band must be used. The use of unlicensed spectrum, for some operators, implies that services will be impaired by interference. It is true that a licensed band should be, in general, less noisy than an unlicensed band. The main source of noise in an unlicensed band is RF noise generated from other RF equipment (i.e. other users) operating within the same vicinity. However, numerous operators are operating their broadband wireless networks in unlicensed bands and offering high reliability services. This paper will illustrate why this is possible.

Unlicensed Frequencies

As compared to using licensed spectrum, the use of unlicensed spectrum does have some inherent challenges. Unlicensed spectrum is, by definition, available to all who wish to use it without a license. While government regulations try to ensure that unlicensed band users do not interfere with each other by placing limits on transmission power levels and the amount of time a transmitter can be on the air, interference is still a reality. However, by being aware of these challenges within unlicensed bands, i.e. by choosing your unlicensed RF technology carefully and by designing / planning your network with reliability in mind, such interference can be avoided resulting in high reliability services similar to those offered in licensed bands. The bottom line is that with the right choice of technology and with careful network design and planning, high reliability services are very much achievable in the unlicensed spectrum.

Designing for Robust Reliability

How does a network operator design reliability into an unlicensed broadband wireless network? It starts with choosing inherently reliable wireless technology. Technologies that include interference avoidance mechanisms are strongly recommended. Examples of interference avoidance mechanisms include use of directional antennas. The longer the distance, the weaker the signal, but high gain antennas will better support the optimal combination of longer range and increased signal penetration. Higher power signals improve the signal-to-noise ratio meaning that the transmissions are less susceptible to interference. Systems with dynamic modulation can monitor the quality of a link and adjust the modulation rate to improve link margin and reliability. Wireless systems should have self-interference mechanisms including the ability to “listen” before transmit mechanism as well as utilizing a GPS synchronized protocols, such Time-Division Duplex (TDD) transmission control protocol that carefully schedules all transmissions throughout the network. In addition, an operator should consider an inherently reliable network topology, such as mesh, which supports redundant links, dynamic rerouting and failover.

Planning

In addition to implementing specific WAN technologies, RF Planning methodologies are also a critical tool in avoiding interference. One such tool is careful channel planning in which the operator identifies the channels least impacted by interferers. There are typically multiple channels within an unlicensed band to choose from. For example, in North America, there are 5 channels to choose from within the 5.7-5.8 GHz band. It is typical to perform an RF survey to choose the quietest channels in each deployment location. Another consideration when using unlicensed spectrum is that the edges of the band could be vulnerable to interference from other bands. An RF survey should look carefully at those band edges to make sure they are acceptable to use.

In addition to channel planning within a frequency band, products designed for unlicensed bands should supports multiple frequency bands within each geographical region. For example, in North America, in addition to the 5.8GHz band, the 5.2-5.3 GHz band (with 4 channels) and the 5.5-5.7 GHz band (with 11 channels) are available. Relocating out of band, e.g. use of 5.4GHz instead of 5.8GHz may be a viable option. Finally, it should also be noted that negotiation with other users is also a common way to resolve co-location issues through cooperative sessions with other users. In addition to channel and band planning and negotiation, the technology chosen may also enable more planning flexibility.

For example, a mesh topology supports more deployment flexibility than traditional point-to-multipoint technologies. Alternative route planning is an inherent part of the technology (i.e. identifying different mesh routing options around obstacles and interference). With a mesh topology, alternative location planning (identifying different sites that have reduced interference) is also much more flexible than it is for a point-to-multipoint system.

Finally, part of planning for reliability includes providing a safety margin that will help ensure that customers can always enjoy reliable service. This safety margin is known, in RF terms, as fade margin which is an allowance for fluctuations in signal strength caused by interference; transmitter or receiver movement; or reflections or scattering due to obstacles in the area. Many broadband wireless systems have a fade margin of 10 db. When you're designing for reliability in unlicensed spectrum, however, it's crucial to select technology that operates reliably with lower fade margins, even as low as 3 db.

Environmental Factors

Because unlicensed frequencies are noisier than licensed bands, they can be more susceptible to environmental factors. Leaves grow and impair the link between radios. Buildings and other structures can be built over time. New users of wireless equipment enter the scene. All of these factors can attempt to interfere with your wireless service. It all underscores the need for a system with inherent reliability and redundancy as well as the need for a robust network element management system. Such a network management system can provide an operator with real-time visibility of the network's performance and enable problems to be detected and fixed immediately.

The Right Hardware

There are other factors, unrelated to whether an operator is deploying in licensed or unlicensed bands, that are important in choosing technology that is highly reliable. Equipment that has been proven in the field and that has very low failure rates is recommended. Equipment that has been certified to suitable NEMA and IP ratings are good choices to handle various environmental conditions such as hot / cold temperature, precipitation, lightning and other environmental conditions. Ease of deployment and ease of use are also factors that impact the reliability of equipment. Other features to look for are low latency, firmware upgradable over the air, Layer 2 transport, and built in security (encryption and authentication).

The Bottom Line

While Radio frequency (RF) interference can impact the reliability of wireless deployments, the choice of technology and deployment methodology are critical to avoiding interference. If an operator chooses technologies with interference-avoiding mechanisms and designs the network with reliability in mind, the network will be reliable. As the number of network services over unlicensed bands increase worldwide, it is becoming clear that "unlicensed" can mean "reliability."

Trilliant SecureMesh WAN – the standard for reliability in unlicensed bands

Trilliant's SecureMesh WAN products are designed to achieve carrier-class capabilities for both metropolitan and rural wireless access networks. SecureMesh WAN uses a combination of technologies and methodologies to overcome RF interference enabling high reliability wireless services in unlicensed bands.

Sectorized Antenna Array with Directional Power Control

Trilliant SecureMesh WAN utilizes a sectorized directional antenna array consisting of 8 high gain 18 dBi antenna elements. Each element provides a 45° beam to provide a combined 360° omnidirectional coverage. By directing its RF energy at higher power through narrow antenna sectors, SecureMesh Trilliant WAN greatly reduces susceptibility to both internal and external interference. Such higher power signals support a combination of longer range and increased signal penetration. The higher power signals also improve the signal-to-noise ratio meaning that the transmissions are less susceptible to interference. The beam steered transmissions help avoid self-interference and enable optimal spectral and spatial re-use meaning higher capacities and densities.

Dynamic Link Optimization with Variable Modulation

The SecureMesh WAN system balances error rate and throughput by selecting the optimal type of modulation based on the quality of the link and the amount of interference seen. SecureMesh WAN supports a full set of modulation capabilities, including BPSK at 6 or 9 Mbps, QPSK at 12 or 18 Mbps, 16QAM at 24 or 36 Mbps and 64QAM at 48 or 54 Mbps. When a link is first established between two SecureMesh nodes, the various modulation rates are all tested with the receive power and packet error rate monitored for each. After this brief test period, the highest modulation rate with less than 0.5% packet error rate is selected. In an operating network, of course, retransmissions eliminate all errors in the actual traffic. The quality of every link, as determined by its packet error rate, is monitored constantly and adjusted as necessary. When heavy interference is detected, the modulation rate will be adjusted lower to improve link margin and reliability. If and when the interference is reduced, the modulation rate, and therefore link capacity, is automatically increased.

Traffic Synchronization to Deliver Peak Performance:

As with many other shared medium protocols, including Ethernet, Trilliant SecureMesh WAN nodes within range of one another must “listen” before transmitting, and only one node can transmit at a time. When a node “listens” before transmitting, it is inherently trying to avoid interference. Without such a technique, “collisions” would occur regularly, which would greatly inhibit the effectiveness of the network. In addition to the “listen” before transmit mechanism, SecureMesh WAN utilizes a GPS synchronized Time-Division Duplex (TDD) transmission control protocol that carefully schedules all transmissions throughout the network. This ability to synchronize traffic on a network-wide basis not only conserves over the air bandwidth by avoiding collisions, it helps to overcome performance degradation otherwise caused by a half-duplex implementation common in other wireless systems. By scheduling transmissions between nodes and by using the directional antennas, local collisions and other self-interfering inefficiencies typical when “sharing the air” are eliminated.

Robust Mesh Topology for Scalability and Reliability

SecureMesh WAN allows for multiple, redundant links among nodes and includes the ability to select the best end-to-end route through the network. SecureMesh WAN reroutes around links that fail completely or degrade significantly due to interference or other issues. Degradation is handled gracefully, first with changes in modulation rates and link costs, and then (if necessary) with rerouting along a better path. This rerouting is done quickly (within a few seconds of the link failure), intelligently, and in an end to end manner. The performance via these optimal routes is improved even more with directional transmissions that are synchronized network-wide at the maximum possible modulation rate.

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