TECHNOLOGY

Overview

Tsunami™ Multipoint Wireless Ethernet Systems: Extending Coverage with Near-Line-of-Sight

For service providers and enterprises deploying wireless systems, reaching the maximum number of users with the simplest deployment possible is the ultimate goal. While maintaining an unobstructed line of sight (LOS) between transmitters and receivers is always ideal, it is not always possible in a world full of trees, hills, mountains, buildings, and other obstacles. To continue to expand coverage and improve service reliability, ISPs and enterprises must implement technologies capable of operating in less-than-ideal conditions, where only a near line of sight (NLOS), also referred to as "loose" line of sight, is available.

Line of sight: An unobstructed path between two locations, where one could use binoculars to see clearly from Point A to Point B.

Near-line of sight: Objects such as trees partially obstruct a signal as it travels from Point A to Point B.

Non-line of sight: Obstacles such as multiple buildings, mountains, or dense jungle completely obstruct a signal moving from Point A to Point B.

This Technology Overview provides a high-level introduction to the NLOS features available in Tsunami Multipoint Ethernet Systems. These features enable service coverage in some NLOS environments by combining an adaptive equalizer with high-gain directional antennas to neutralize the effects of multipath interference. Tsunami Multipoint is not designed to operate in non line of sight conditions.

What Is Multipath Interference?

When an RF wave bounces off a tall object (such as a building) or a low object (such as a lake or pavement) as it travels between two points, a duplicate of the original signal is generated. The distance traveled by the two signals is different, causing them to arrive at their destination at different times. This time differential causes the signals to overlap and merge into a single distorted signal at the receiving end. The interaction between direct signals and duplicate reflected images causes multipath interference.

With true LOS propagation, multipath interference does not exist, since there are no objects close enough to the direct LOS path to create reflected signals with significant strength. It is much more of a problem in dense urban areas and corporate campus settings where buildings, trees, and other fixed objects partially obstruct the LOS. In these NLOS situations, reflected signals can reach the receiver first, maintaining relatively higher power levels. A reflected signal might cancel out the original signal, causing it to fade, or it might combine with the original signal to amplify the wave, increasing the risk of interference with other transmissions.

Either way, the resulting distorted signals can quickly degrade network performance with inefficient spectrum use and threaten to cause intermittent service disruptions for subscribers. To mitigate the effects of multipath interference, the multiple signals must be combined at the receiving end and restored to the primary signal's initial state. There are several ways to accomplish this, including adaptive equalization and OFDM (Orthogonal Frequency Division Multiplexing).

Adaptive Equalization vs. OFDM

Invariably, technology innovations create divisions in the affected industry. In the case of near-LOS strategies, there are two main competing approaches: adaptive equalization and OFDM, which is offered in technologies such as 802.11a Wireless LAN products. While both approaches have merit, Western Multiplex chose to utilize adaptive equalization to optimize bandwidth use and data throughput while minimizing costs:

- In tests using the same modulation mode (16QAM, rate-3/4), our engineers found that adaptive modulation can provide superior data throughput, transmitting at 59 Mbps in an occupied bandwidth of about 27 MHz compared to OFDM transmitting at 32 Mbps at about 17 MHz.

- Adaptive equalization yields performance equal or superior to OFDM at a lower cost by limiting the amount of required hardware. For example, some variations of OFDM use two antennas at the receiving end and require high-power cable at the base station, adding significantly to deployment costs.

It is important to note that if no signal is available, no signal can be regenerated. Plain attenuation caused by obstructions such as buildings, dense foliage, mountains, or hills can weaken a signal to the point that no service can be delivered no matter what strategy is employed. Not even the most sophisticated technology can compensate for a signal that has been attenuated to nothingness. Tsunami Multipoint's NLOS capabilities can expand coverage under circumstances where some signal is available.

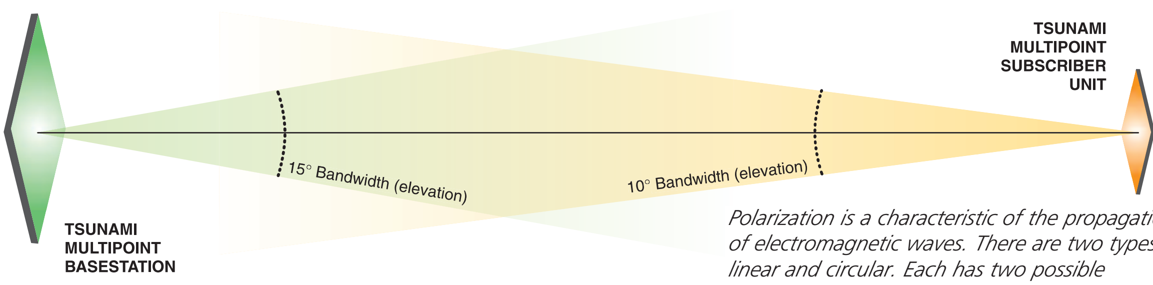
Tsunami Multipoint Adaptive Equalizer

The TDMA-based Tsunami Multipoint adaptive equalizer compensates for the signal degradation that occurs when multiple copies of the same signal arrive at the receiver through different reflected paths. It can accommodate significant delays between signals, which allows reliable operation even where considerable multipath interference is present.

On the uplink, the equalization adaptation is computed in the Tsunami Multipoint Base Station and transmitted back to the Subscriber Unit. On the downlink, an adaptive equalizer is implemented in the Subscriber Unit. In addition, the Subscriber Unit implements a precoder, or pre-equalizer, that is "trained" by using information from the downlink equalizer and computations from the Tsunami Multipoint Base Station. This precoding reduces multipath when transmitting to the Base Station.

Tsunami Multipoint Directional Antennas with Circular Polarization

Tsunami Multipoint radios use directional antennas with circular polarization to transmit and receive a relatively narrow beamwidth of radio energy. By effectively limiting the potential multipath field, these antennas reduce the difference in propagation times between direct and indirect signal paths. As a result, reflected signals that would otherwise prove hard to equalize can be handled by a relatively simple equalizer.



Polarization is a characteristic of the propagation of electromagnetic waves. There are two types: linear and circular. Each has two possible orientations: vertical or horizontal for linear, and right- or left-sided for circular. For any link to function properly, the antennas at both ends must use the same type of polarization and be set for the same polarization orientation.

Using circular polarization offers benefits in multipath situations because as a left-hand transmission is reflected, it switches to right-hand polarization. The new right-hand signal is then rejected by the left-hand receiving unit, leaving the antenna free to receive the stronger direct-path signal.

In addition, the extremely high gain of the directional antenna enables the system to withstand considerable signal loss as signals attenuate through obstacles.

Tsunami Multipoint in Real-World NLOS Environments

To evaluate what Tsunami Multipoint technology could deliver outside of the engineering lab, Western Multiplex tested a Tsunami Multipoint system in a Southern California residential neighborhood with a significant amount of foliage that obstructed the LOS. In this test, a Base Station set to 20 Mbps was able to reach 56 out of 80 Subscriber Units randomly located within three miles of the Base Station, providing 70% coverage (see Figures 1 & 2).

In another Southern California test, Tsunami Multipoint was able to provide service to a Subscriber Unit with no clear line of sight to the Base Station (see Figure 3). This was achieved by using propagation via diffraction.

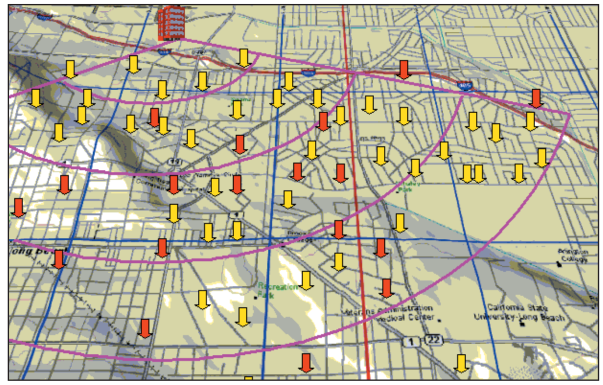


Figure 1: Map of area covered in Southern California field trial.

Optimizing Coverage with Tsunami Multipoint

Tsunami Multipoint Wireless Ethernet systems combine high-gain directional antennas with an advanced adaptive equalizer to provide service in NLOS environments. While results will be highly dependent on specific deployment environments, field tests have demonstrated that this innovative technology is a viable solution for service providers seeking to increase potential coverage areas, and enterprises looking for increased flexibility in campus environments.

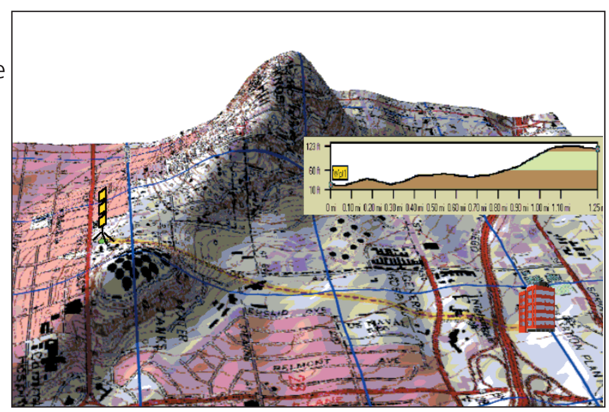


Figure 3: Example of Subscriber unit operating without LOS.

Proxim Corporation
2115 O'Nel Drive
San Jose, CA 95131

tel: 800.229.1630
tel: 408.731.2700
fax: 408.731.3675

TT8-0203