

COLLISION-FREE RESIDENTIAL ACCESS

CAMBIUM'S POINT-TO-MULTIPOINT WIRELESS BROADBAND NETWORKS USE MULTIPLE TECHNOLOGIES TO DELIVER HIGH THROUGHPUT, RELIABILITY AND SCALABILITY.

The customer is always right. No business knows that better than communications service providers offering wireless broadband Internet access to residential communities. The pressure is constantly on them to deliver wireless service that's clear, consistently fast and available 24/7. Whenever there are network issues, customers make their dissatisfaction known loud and clear. And they're not afraid to play their ultimate card and change service providers. In the highly competitive wireless communications market, dissatisfied customers can and do change providers virtually as soon as they have a poor service experience.



How do some service providers keep their customers consistently satisfied – and satisfied so much that they recommend the service provider to their friends and neighbors?

These service providers plan and deploy high-speed wireless networks with proven technology that's able to give their customers exactly what they want. They deploy networks delivering broadband connectivity that allows customers to enjoy high-speed and low latency voice, data and video service with high availability and a minimum of interference and outages. Of course, they also have to take care of their own business cases. They seek out network solutions that allow them to provide this exemplary service with a high-degree of cost-effectiveness; they must choose a platform that minimizes both capital and operating expenses. Last, but far from least, successful service providers must choose a network solution that enables them to grow their subscriber base and revenues. Deploying a network with the ability to scale elegantly enables service providers to easily add new customers without adversely affecting quality of service for existing customers.

RESIDENTIAL BROADBAND OPTIONS

The most basic decision residential service providers must make is which type of network technology to deploy. The choices basically come down to two. Recently there has been a lot of discussion centered on utilizing 802.11-based networks, especially the new 802.11n technology. But is this contention-based solution the best option for outdoor wireless broadband residential access networks? Cambium's Point-to-Multipoint (PMP) wireless networks are a proven solution that is already serving millions of residential customers around the world.

Both options offer reasonable solutions, but there are major differences between the two that can affect customer service and therefore customer satisfaction and business success. These differences fall into four main performance categories:

- **CONSISTENCY.** PMP residential access networks are proven to deliver consistent and predictable coverage, bandwidth, latency and performance. Contention-based systems are generally not optimized for outdoor usage and tend to provide less consistent coverage which may lead to an increased number of service calls and maintenance dispatches.
- **CAPITAL EXPENSES.** PMP networks are cost-efficient to deploy, utilizing a relatively small number of towers that can continue to be leveraged as the network grows. Contention-based systems offer a relatively low initial access point cost. However, as more customers are added to the network additional access points and towers are required to expand the system.

- **RELIABILITY.** PMP residential access networks have an exceptionally low outage rate that leads to minimal customer complaints and increased customer satisfaction. Operating expenses are mostly incurred in growing the network. Networks using contention-based systems face increased operating expenses – tech support, troubleshooting, maintenance truck rolls – from customer service complaints caused by network reliability issues.
- **SCALABILITY.** PMP technology enables service providers to deploy, expand and extend their networks more efficiently with the ability to serve hundreds of subscribers from each access point. Contention-based systems, on the other hand, are optimized for indoor hot spots and normally only able to serve a few dozen subscribers per access point.

COLLISION VS. SYNCHRONIZATION

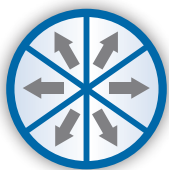
How do the 802.11 and PMP technologies differ? 802.11 networks are based on solutions initially developed for indoor, noise free environments. This indoor WiFi technology is not adapted to handle the increase in noise levels caused by higher amounts of interference in unlicensed outdoor environments. 802.11 networks are contention-based solutions relying on unscheduled access. This results in "collisions" in which signals must vie for access to channels, an issue that can lead to serious delays and availability problems that can lead to an increasingly dissatisfied customer base. The problem only gets worse as an 802.11 network gets larger with collisions occurring more and more frequently.

"We grew more and more dissatisfied with the performance of our initial network. About three years ago, we made the decision to replace our existing infrastructure (with the Cambium PMP network.)"

Stig Pettersen
Co-Founder, TotalNett
Norway

THE CAMBIUM PMP DIFFERENCE: GPS SYNCHRONIZATION

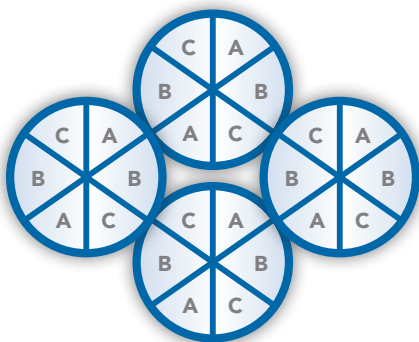
ALL APs TRANSMIT AT THE SAME TIME



ALL SPS TRANSMIT AT THE SAME TIME



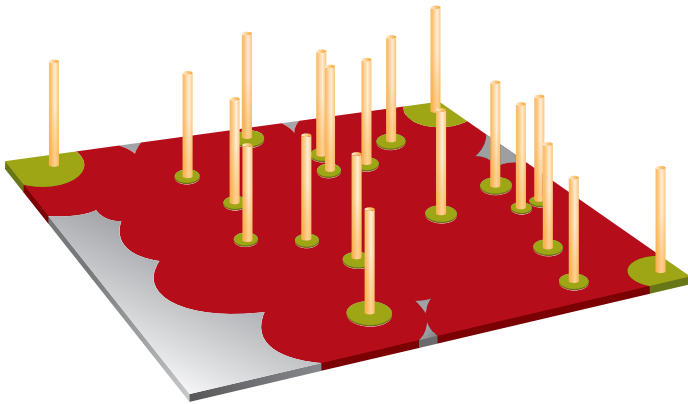
THIS REDUCES SELF INTERFERENCE AND ENABLES NETWORKS TO BE CO-LOCATED



PMP networks differ in their fundamental core technology. PMP networks are not contention-based. Instead they provide scheduled access utilizing advanced GPS synchronization. Providing access in this manner removes the "collision" factor and allows PMP networks to scale up in a much more efficient and easier fashion to support a higher number of Subscriber Modules.

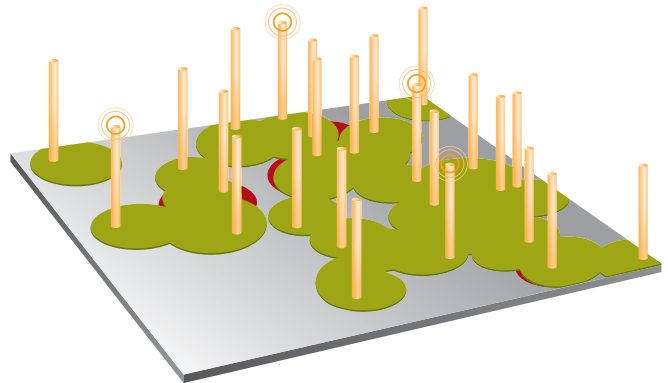
SAMPLE NETWORK COMPARISON: OUTDOOR WAN RESIDENTIAL ACCESS

COMPETITIVE SYSTEM



POOR COVERAGE IN AN UNSYNCHRONIZED DENSE DEPLOYMENT DUE TO HIGH INTERFERENCE LEVELS

CAMBIUM PMP



PMP COVERAGE IN A SYNCHRONIZED DENSE DEPLOYMENT – LARGE AREA OF GOOD COVERAGE WITH LITTLE SELF INTERFERENCE

ADVANCED GPS SYNCHRONIZATION

Cambium PMP solutions use GPS synchronization. This capability enables all the Access Point (AP) modules in the network – whether there are hundreds or even thousands – to transmit at precisely the same time to Subscriber Modules (SMs) and to receive at the same time from SMs. This network wide synchronization of APs and SMs eliminates delay-causing traffic collisions and subsequent retransmissions while preventing radio signals from bleeding into the signals of other modules in the network, which can cause signal degradation or disruption known as self-interference. The ability to virtually eliminate self-interference allows the cost-efficient physical co-location of network equipment along with the ability to use multiple frequency overlays on existing towers throughout the network.

EFFICIENT FREQUENCY RE-USE

GPS synchronization enables efficient frequency reuse. This capability provides superior cost-effectiveness for service providers by allowing them to use the limited number of channels available within a frequency band to serve a higher number of subscribers as the network grows. Conversely, without GPS synchronization, contention-based systems tend to offer very poor spectrum reuse. 802.11 network expansion and increased throughput capacity become more difficult and more costly to incorporate. Bottom line, service providers with contention-based systems need more and more spectrum in order to serve additional customers.

CONSISTENT, PREDICTABLE THROUGHPUT

GPS-synchronized channel access enables Cambium PMP networks to deliver exceptional aggregate throughput per channel, providing the consistent performance residential customers expect. Sure, at 3:00 a.m. traffic is scant and virtually any type of system can handle the demand for bandwidth. What happens at 3:00 p.m., however, when traffic surges? Collisions and disorderly channel access cause performance degradation and delays that customers can't and won't ignore. Unlike networks based on contention-based systems, maximum throughput in Cambium PMP networks is available through peak periods as demand increases.

CO-LOCATION AND COVERAGE

Cambium PMP residential access networks' GPS synchronization capabilities help expand coverage and eliminate coverage gaps. One solution for accomplishing thorough coverage requires the ability to co-locate equipment on towers or sites. Co-location enables service providers to install multiple access points either on the same tower or on towers at distances ranging from across the street to across the city. This is especially important as the network grows and adds more subscribers. From a business case standpoint, fewer towers need to be constructed or rented and fewer locations need to be monitored and maintained, which can significantly lower CAPEX and OPEX. The results are significant: more throughput delivered to the coverage area, less chance of coverage gaps and more satisfied customers.

“The Cambium product has not only the best cost/performance ratio of any product we found on the market, we found it to be the most stable and the most reliable.”

Phil Walsh
Snap Broadband

LATENCY, JITTER AND CUSTOMER SATISFACTION

Latency can negatively impact residential customer satisfaction. Latency measures the time needed for signals to traverse the network. Jitter is a measure of the variability of latency. Both can interfere with performance and result in customer dissatisfaction. Caused in large part by network congestion, latency is responsible for annoying delays and interruptions in customer service, leading to problems in applications such as VoIP service, online gaming and video. In contrast to the load-driven inconsistent latency of contention-based systems, which may vary from 50 to 200 milliseconds at any given time, Cambium PMP networks deliver consistently lower, more predictable latency, typically five to seven milliseconds.

INTERFERENCE MITIGATION

In outdoor wireless broadband residential access networks there *will* be interference. How much it affects network performance and customer usability depends largely on the network technology. As a wireless pioneer and innovator with decades of experience in outdoor wireless communications, Cambium knows more about mitigating the effects of interference than virtually any other manufacturer. Cambium PMP networks are designed to optimize performance in interference-heavy unlicensed frequency spectrum. They utilize GPS synchronization to mitigate self interference, and many use the Cambium Air Interface Protocol to neutralize interference from external sources such as ambient noise and signals from other emitters using the same frequency. Together these technologies help ensure that the effects of interference will not adversely affect your network connectivity or performance, your end user satisfaction or your return on investment.

OUTDOOR WIRELESS RESIDENTIAL ACCESS TECHNOLOGY COMPARISON

| | CAMBIUM PMP | CONTENTION-BASED SYSTEMS | IMPLICATIONS |
|--------------------------------|---|--|---|
| MEDIA ACCESS | Scheduled Channel Access – deterministic and scalable regardless of load. | Contention-based – prone to collisions on loaded systems. | Without scheduled access, users will be dissatisfied with availability as more subscribers are added. |
| LATENCY/QoS | Consistent and Deterministic – critical for voice and video and T1 replacements. | Inconsistent and Unpredictable – increases with load. | Without consistent latency, network users will experience delays and potentially poor performance. |
| GPS SYNCHRONIZATION | Supported – provides efficient channel reuse and easy deployment in multi-sector / multi-site systems. | Not Supported – resulting in inefficient channel re-use, interference susceptibility and difficult deployment. | Unsynchronized systems perform inconsistently and poorly as subscribers are added. Use more channels to serve the same number of users. |
| THROUGHPUT AND CAPACITY | Higher aggregate real user throughput and system capacity for given channel width and available spectrum. Throughput is not impacted by load. | Lower throughput for given channel width. Real user throughput degenerates quickly with increasing offered load. | Low-density systems require more AP towers to be added to meet demand, adding interference and cost. |
| nLOS PERFORMANCE | Built for Outdoor – better resistance to interference and better links in nLOS environments. | Built for Indoor – less resistance to interference. | Poor technical performance will create problems for network users, causing many to switch providers. |

A VIEW TO THE FUTURE

In most cases, residential wireless service providers want to deploy networks that can grow quickly and easily, increasing both profitability and business sustainability. This places a premium on scalability. With GPS synchronization, enhanced frequency reuse and co-location capabilities, Cambium PMP residential access networks allow service providers to serve an expanding customer base more successfully, more efficiently and more profitably. Cambium PMP networks generally require less initial equipment to provide desired coverage and capacity.

But initial deployment is literally only the beginning. Cambium PMP networks also support significantly less costly network growth by offering the ability to serve an increasing number of subscribers using the same equipment. And new equipment can be added cost-effectively without having to change existing coverage or channel plans.

USE CASES

What's the most important factor in choosing a platform for an outdoor wireless broadband residential access network? Customer satisfaction. The question is will your first 500 customers recommend your service to the next 5,000? And in a growth-oriented business, will that 5,000 recommend your network to the next 10,000? The answer depends on performance and reliability, of course. But if you're intent on growing your business, it also depends heavily on elegant scalability with efficient channel reuse and co-location capabilities to provide a lower Total Cost of Ownership (TCO).

In some use cases, residential access networks are able to leverage 802.11-based technologies. These are typically smaller, less growth-oriented networks serving a limited number of subscribers in low-density, noise-free areas. In contrast, PMP is generally the optimum choice for service areas in which noise may adversely affect customer service and satisfaction and for which network expansion is a vital business objective.

"Finally, after a great deal of trial and error, we discovered the Cambium PMP wireless broadband solution. It's been meeting reliability and service requirements in unlicensed spectrum for many years now... at price points that are winning, and keeping, high-value customers."

Todd Bergstrom
CEO
3-dB Networks

ABOUT CAMBIUM NETWORKS

Cambium Networks provides world-class wireless broadband and microwave solutions for military, government, municipal and enterprise customers around the world. It currently has more than 3.2 million products deployed in thousands of networks in over 150 countries, with its breakthrough technologies providing reliable, secure, cost-effective connectivity that's easy to deploy and proven to deliver outstanding metrics. Cambium's ecosystem of partners, development engineers, and support teams work together to design and deliver innovative, forward-looking solutions that provide data, voice and video connectivity when and where it's needed.