

Redefining Broadband Wireless

The key value of any wireless product is its ability to deliver the necessary **capacity** over an area of **coverage** at a **cost** that enables a favorable return on investment.

The impediment to achieving this simple goal is RF signal attenuation, which imposes constraints when balancing the contradictory objectives of **close proximity** (to enhance capacity) and **long range** (to extend coverage and lower costs). For example, a point-to-multipoint base station at a tower provides high capacity to subscribers in close proximity but capacity lessens over distance. To resolve capacity degradation, a point-to-point link can be deployed from the tower to a remote point-to-multipoint base station optimally situated to provide better proximity and increase capacity but at a significant increase in costs.

The best way to summarize the mutual exclusivity of close proximity and long range is the expression:

“Cost, Coverage, and Capacity: Pick Any Two”

Broadband wireless, therefore, is defined by these limitations:

1. Low cost and long range, but with low capacity
2. Low cost and high capacity, but only at short range
3. Long range and high capacity, but at a high cost

SkyPilot, however, has a patented broadband wireless system that helps overcome these limitations. Although still bound by RF signal attenuation, SkyPilot is able **to provide breakthrough economics to wireless operators by extending coverage and improving capacity** through an innovative wireless architecture called SyncMesh™.

SyncMesh – Redefining Broadband Wireless

To confront the seemingly impossible goals of high capacity, long range, **and** low cost, SkyPilot developed a patented Synchronous Switching broadband wireless system. These systems, when coordinated by the **SyncMesh™** protocol, dynamically align high-gain directional antennas throughout an entire network of interconnected base stations.

With this architecture, every base station covers 360° through eight individual 45° antennas. The base station **dynamically switches** between these high-gain (18 dBi) antennas to provide both long-range point-to-multipoint links to CPE as well as long-range point-to-point links to other base stations. By dynamically interconnecting base stations with point-to-point link, SyncMesh can enable multi-hop wireless networking, with each base station functioning as a "relay" to extend the total coverage area. Therefore, with dynamic antenna switching, each system integrates a point-to-point backhaul, multi-hop relay, and point-to-multipoint base station within a single system to extend range and keep costs low.

Note, however, that SyncMesh does not simply repeat the signal, since that is an inefficient and wasteful use of spectral capacity. Instead, SyncMesh **coordinates and synchronizes transmissions** to maximize network-wide capacity. By allowing multiple simultaneous narrow-beam transmissions, SyncMesh mitigates self-interference and leverages spatial diversity to maximize spectrum reuse, resulting in efficient capacity utilization throughout the entire spectrum.

With the SyncMesh protocol coordinating the alignment of directional antennas, SkyPilot has been able to redefine broadband wireless as:

“Cost, Coverage, and Capacity: Pick Any Three”

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Coverage Extension

To extend the coverage served by each cell tower, SyncMesh uses a combination of high-gain directional antennas and multi-hop relaying at every base station in the network. High-gain directional antennas are, of course, one of the best methods to increase range since it increases the link budget for both transmit and receive. They also enable many of the advanced SyncMesh features such as spectral reuse and self-interference mitigation.

Long Range Point-to-Point Backhaul Links

At synchronized time slots, each and every SyncMesh node dynamically switches to the optimal high-gain antenna for transmission coordination. Since each backhaul link has a directional 18 dBi antenna at each end, the SyncMesh nodes leverage 36 dBi of gain to provide a line-of-sight (LOS) link of up to 10 miles/16 km. These links can also support non-line-of-sight (NLOS) through OFDM modulation; however, the ranges of NLOS links vary, of course, depending on the type and amount of obstructions.

Multi-Hop Relay Range Extension

Through the multi-hop relaying capability, each base station can act as a relay node as well. This allows the range covered from a cell tower to extend over multiple hops, with each "hop" extending range by up to 10 miles/16 km as indicated earlier. With multi-hop relay capabilities, the reach from the tower is no longer limited to a single base station; instead, the reach from the tower can be greatly extended through a series of interconnected base stations.

Long Range Point-to-Multipoint Links

The same dynamically switched 18 dBi antennas are also used for point-to-multipoint links. With point-to-multipoint, the base station connects with SkyConnector customer premise equipment (CPE), which also has a high-gain directional antenna. With these high-gain antennas, high-power radios, and OFDM links, the base station can provide LOS links to CPE as far away as 7.5 miles/12 km.

Coverage Fill-in by Routing Around Obstructions

Extending coverage is not just about pushing out the boundary of a coverage cell – coverage extension also applies to filling in coverage holes. Since SyncMesh provide multi-hop relay capabilities, remote base stations can be routed around obstructions to easily reach and fill-in any holes in coverage.

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Capacity Efficiencies

SyncMesh is specifically designed to make the most efficient use of available spectrum over an entire mesh of base stations. When the entire mesh of directional links is viewed as a whole, the SyncMesh protocol enables multiple links to transmit using the same frequency with limited self-interference through a distributed synchronous protocol. This enables optimal spectrum reuse throughout an entire coverage region to increase the total “goodput” per second of airtime.

OFDM with Adaptive Modulation

All SyncMesh links use OFDM to provide the best ability to close high-modulation rate links, even in NLOS environments. The links are constantly monitored and modulation rates periodically adapt to any changes in the wireless environment to ensure optimal performance.

Spatial Spectral Reuse

One of the main benefits of the mesh-wide coordinated transmission pattern is the idea of “spatial spectral reuse”. Since SyncMesh coordinates all of the dynamic directional links, multiple simultaneous transmissions occur on the same frequency, effectively reusing the spectrum throughout the entire coverage region.

High Modulation Rates

Since SyncMesh nodes all carry multi-hop point-to-point backhaul, they can easily be deployed in close proximity to subscribers. This allows the ability to convert “cell edge” low-modulation subscribers to high-modulation subscribers through better proximity. With this capability, the network-wide average modulation rate increases and optimizes the “goodput” by enabling more frequent higher-throughput transmissions throughout the network.

Self-Interference Mitigation

As a result of dynamically switching directional antennas and synchronizing the reuse of the spectrum, SyncMesh uses spatial diversity to effectively mitigate self-interference, resulting in further improving modulation rates and overall spectral efficiency.

Linear Capacity Scalability through Spectral Layering

Since SyncMesh maximizes the spectral efficiency of a single frequency by optimally reusing the channel over a wide coverage range, it enables the use of alternative channels to linearly scale capacity. “Layering” alternate channels throughout the coverage region makes maximum use of available frequencies.

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Breakthrough Economics

Through the technical advantages of greater coverage range and more efficient spectrum utilization, a large amount of bandwidth can be propagated from a single capacity injection point. When combined the other SyncMesh features, this leads to significant economic advantages.

Multi-Hop Coverage Extension Reduces Towers Costs

Multi-hop backhaul greatly increases the coverage radius of a single tower, thereby reducing the number of towers required to provide broadband services over a given coverage area. Reducing the number of towers required directly lowers the associated tower acquisition and lease costs as well as the number of leased or microwave backhaul connections required for each site.

Integrated Backhaul, Relay, and Base Station Reduces Capital Costs

The unique integration of a point-to-point backhaul, a multi-hop relay, and a point-to-multipoint base station leads to a significant reduction in network capital costs. Since these distinct functions are not discrete products, there are no additional costs because they are simply integrated into a single networking system. The ability to reuse the radio for different functions by dynamically switching directional antennas lowers the overall costs of deploying broadband wireless.

In addition, there is only a single point-of-attachment. He said we should mention that 360 coverage for Gateways and Extenders means you only need to pay for one attachment to a tower. Most of the company's that rent tower space charge for each attachment.

Automatic Discovery and Automatic Antenna Pointing Reduces Operating Costs

The ability of SyncMesh to automatically discover all nodes and dynamically and automatically point directional antennas leads to a dramatically decrease in operating expenses. Since each SyncMesh product can covers 360° by dynamically switching to any of eight separate 45° directional antennas, there is no manual antenna pointing required, regardless of whether the links are point-to-point, relay, or point-to-multipoint. SyncMesh automatically discovers all nodes and automatically configures each and every link, which reduces the operational cost associated with deploying an advanced broadband wireless network. This minimizes the "hands-on" operational expertise and reduces the overall time to deploy.

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Additional Benefits Derived from SyncMesh

In addition to all of the aforementioned benefits, the SyncMesh architecture also provides additional features that provide benefits to wireless operators.

Best-Path Routing, Dynamic Rerouting, and Self-Healing Failover

SyncMesh has the ability to determine if multiple routes are available and to choose the optimal path. In addition, if modulation rates change or the network configuration changes, the mesh of interconnected point-to-point backhaul links can automatically and dynamically adapt. This optimizes throughput and can provide self-healing capabilities in case of failures.

Latency Guarantees

Since SyncMesh is a synchronized protocol, it can provide low latency, low jitter, and guarantees for latency-sensitive traffic such as VoIP.

Wireless Backhaul for Wi-Fi Access

With the synchronous mesh network operating in the 5 GHz frequency band, it allows each mesh node to also provide Wi-Fi access services. All SkyPilot mesh nodes are available with Wi-Fi access points (APs) at 2.4 and 4.9 GHz. This allows Wi-Fi access to be spread over large coverage areas.

“Ethernet In/Ethernet Out”

Each SyncMesh network is a full Layer 2 network, which results in “Ethernet In/Ethernet Out” across the network. This Layer 2 architecture supports virtual LANs (VLANs) and a full range of Layer 3 protocols including IPv4 and IPv6. In addition, when used as the backhaul for Wi-Fi access, mobile devices are not required to renew their IP address since they are not crossing subnet boundaries.

Frequency Flexibility

Each high-gain directional antenna support a range of frequencies from 4.940-6.075 GHz. This allows each node to provide frequency flexibility and give operators the ability to change to new frequencies as required.

Summary

Although all wireless products are bound by the laws of physics, innovations solutions can help alleviate some of the fundamental constraints. The SyncMesh protocol leverages the notion of high-gain directional antennas to increase range and capacity, but through its patented method of switching between antennas, still provides the cost advantage associated with omnidirectional antenna systems. In the end, SkyPilot has been able to redefine broadband wireless to

“Cost, Coverage, and Capacity: Pick Any Three”