



Motorola Point-To-Point Solutions and WiMAX

Reliable, high-throughput backhaul for WiMAX networks



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Introduction

WiMAX (Wireless Interoperability for Microwave Access) is a broadband wireless access technology that gives users an alternative to access broadband services – specifically high-speed Internet access. WiMAX is an international standard for delivering voice, video and data over microwave RF (Radio Frequency) spectrum to stationary or moving users – thereby making broadband communications available virtually anywhere.

Hundreds of companies have contributed to the development of WiMAX, creating an open, collaborative technology standard that is already making great strides toward significant worldwide adoption. WiMAX delivers high performance connectivity with the most advanced telecommunications technologies, including Scalable Orthogonal Frequency Division Multiple Access (SOFDMA), all IP architecture, Multiple-Input Multiple-Output (MIMO) and Smart Antennas.

Tremendous cost savings can be realized from the low-complexity design, all IP foundations and economies of scale. With the availability of low-cost WiMAX chipsets, WiMAX is positioned to:

- Permeate all expanses of consumer electronics
- Provide the connections that will drive the next wave of mobile broadband applications
- Play a key role in the evolution of wireless networks on a global scale.

The WiMAX Forum

The name “WiMAX” was introduced to the marketplace by the WiMAX Forum, an industry trade group comprised of over 400 companies including equipment manufacturers, service providers and system integrators. The WiMAX Forum’s mission is to promote the adoption of broadband wireless networks based on the IEEE 802.16 family of standards. A chief concern of the Forum is to help ensure the compatibility and interoperability of equipment from various equipment manufacturers by establishing certification procedures.

Motorola is a member of the WiMAX Forum Board and helping to support the broadband wireless industry in the development of standards that benefit the end user and help make wireless broadband available to all

Motorola’s wi4 WiMAX

Motorola is leading the charge for a healthy WiMAX landscape with significant investments in resources, research and development, all aimed at bringing best-in-industry WiMAX solutions to service providers and network operators. Motorola is committed to addressing the full scope of operator deployment needs and end-user demands.

With its experience in wireless broadband and heritage in mobility management, Motorola is uniquely positioned to address the WiMAX market with its comprehensive wi4 WiMAX solution offerings, including:

- End-to-end technology and service solutions
- Broad portfolio of WiMAX infrastructure
- World-class WiMAX devices
- Fixed and mobile solutions
- Flat, IP-based network architecture
- MIMO, Smart and advanced antenna capabilities
- Low cost, low power WiMAX chipsets
- Flexible hardware and software-defined radios
- Full operations and management systems
- Next generation IP core solutions

Point-to-Point and WiMAX

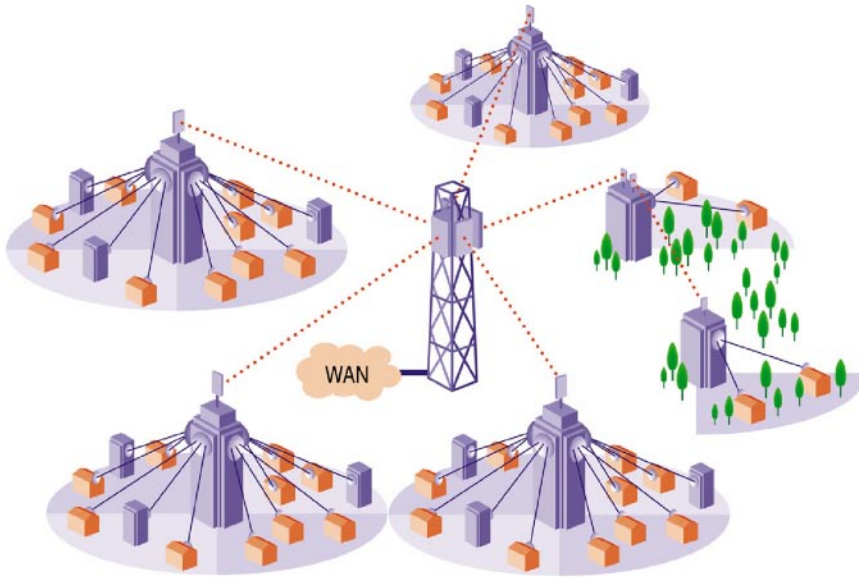
In addition to its wi4 WiMAX solutions, Motorola provides wi4 Fixed Point-to-Point (PTP) Layer-2 Wireless Ethernet Bridges that can be extremely cost-effective and reliable complements to a WiMAX network. However, what exactly is the relationship between such point-to-point systems and a WiMAX network, since WiMAX is a point-to-multipoint technology?

In the context of a WiMAX network, point-to-point bridges, including those provided by Motorola, will be used primarily to backhaul traffic from WiMAX cell sites to the wider area network. This will often be a direct link from a WiMAX base station to a connection point that goes to the wider area network. In rural areas or where lower-capacity cell sites are situated, the point-to-point links can be “daisy-chained” between two or more cell sites before connecting to the wider area network.

In addition, point-to-point technology can be used to provide a high-capacity link from the wider area network to a single user (such as a large enterprise) where the WiMAX CPE capacity is insufficient.

Meeting WiMAX Backhaul Requirements

Motorola's PTP 600 Series Point-to-Point Wireless Ethernet Bridges can seamlessly carry WiMAX traffic from cell sites to the wider area network.



In the above diagram, the red dotted lines represent Motorola PTP 600 Series point-to-point links.

Operating at speeds up to 300 Mbps and distances up to 124 miles (200 km), the bridges meet a number of key requirements for operators who need to backhaul WiMAX traffic, including reliability, high capacity, low latency and ease of installation and use. Motorola's PTP 600 Series bridges can deliver up to 99.999% availability in non-line-of-sight environments, across long-distance line-of-sight paths, over water and open terrain, even in extreme weather conditions, due to the unique combination of technologies included in every system:

- **Multiple-Input Multiple-Output (MIMO)** – MIMO transmits multiple signals which are de-correlated temporally and spatially. Being de-correlated, each path fades at different times, and the receiver is able to select the best signal at any time, resulting in better performance and link availability. Each radio radiates multiple beams from the antenna, the effect of which significantly protects against fading, while increasing the probability of making a connection and reading the transmitted data.
- **Intelligent Orthogonal Frequency Division Multiplexing (i-OFDM)** – In addition to MIMO transmitting the data twice, i-OFDM sends transmissions over multiple frequencies, or sub-carriers. The multiple sub-carriers allow higher channel bandwidth and higher resistance to:

- (a) Multi-path interference which occurs when objects in the air gap split a beam into parts that travel different paths and interfere with each other at the receiver
- (b) Frequency selective fading which occurs when amplitudes of arriving signals cancel each other out at the receiver

In typical radios these issues can present real communications problems, but with the Motorola PTP radios, *i*-OFDM helps the radios re-correlate the interfering signals, improving the chance of receiving the signal through reflective behavior.

- **Adaptive Modulation** – This technology ensures maximum throughput optimized for the radio path, even as path characteristics change. The transmitter and receiver negotiate the highest mutually sustainable data rate – then dynamically “upshift” and “downshift” the rate as radio frequency (RF) conditions change.
- **Dual Polarized Antennas** – Two transmitters and two receivers are used to establish a link, enabling four different transmitter/receiver combinations. By creating four distinct transmission beams, the chances that data will get through increase significantly.
- **Advanced Spectrum Management with Intelligent Dynamic Frequency Selection (i-DFS)** – *i*-DFS automatically changes channels to avoid interference and combat link fading without user intervention. At power-up and throughout operation, the radio scans the band (500 times a second) and automatically switches to the clearest channel. The 30-day, time-stamped database alerts the network operator to any interference that does exist and provides statistics to help analyze these patterns. This Advanced Spectrum Management capability creates virtually interference-free performance in the band.
- **Built-in Security** – Each PTP radio is pre-programmed to communicate only with a matched partner at the opposite end of a link, eliminating “man-in-the-middle attacks.” Added security is provided through a unique scrambling mechanism that secures over-the-air transmissions. Plus an optional layer of security can be applied with FIPS-197-compliant, 128- or 256-bit AES encryption.

Because WiMAX and Motorola's PTP 600 bridges are wholly IP-based solutions, they can seamlessly integrate into an operator's IP network.

Spectrum Utilization and Interference Mitigation

Currently, the Motorola PTP 600 Series solutions operate in the 5.4 and 5.8 GHz unlicensed bands. Because WiMAX standards are being developed primarily for the licensed bands, there is no issue of the PTP backhaul links using the WiMAX spectrum. This allows network operators to utilize their licensed spectrum – which was purchased at a premium – to serve the end-user experience, rather than using their licensed spectrum for backhaul.

In due course, WiMAX solutions may be introduced in the unlicensed bands. In this scenario, Motorola's PTP bridges provide maximum spectral efficiency and incorporate sophisticated spectrum management techniques to avoid any interference between the point-to-point links and the WiMAX point-to-multipoint links. For example, the PTP systems (with Ethernet data rates up to 300 Mbps) are capable of backhauling the throughput requirements of up to 12 WiMAX base station sectors, occupying the equivalent of only three WiMAX channels. This leaves more channels available for WiMAX point-to-multipoint links with no performance penalty.

Cost Comparisons

Backhaul is one of the most costly components contributing to a WiMAX network's total cost of operation. With high-capacity and cost-effective wireless solutions, network operators can eliminate or reduce the more expensive, traditional approaches requiring multiple T1/E1 leased lines, DS3 lines or microwave systems, thereby reducing backhaul costs.

The following table provides throughput and cost estimates for a T1/E1 line, a DS3 line and a PTP 600 wireless link.

| Features | T1/E1 Line | DS3 Line | PTP 600 Wireless Link |
|--------------|-----------------|-------------------|-----------------------|
| Throughput | 1.5 Mbps | 45 Mbps | Up to 300 Mbps |
| Typical Cost | \$200-\$700/Mo. | \$5000-\$7000/Mo. | \$20,000 Per Hop |

Based on the above, one PTP 600 Point-to-Point Wireless Link can provide throughput equivalent to 200 T1/E1 lines or 6 DS3 lines. This makes PTP 600 links especially well suited for backhauling WiMAX traffic and delivering high-bandwidth connectivity for applications, such as streaming video, backhauling voice, video and data traffic and transferring large files (e.g., maps, blueprints, medical files, missing person images, etc.).

In addition, the cost advantages between a T1/E1 line or a DS3 and one PTP 600 link are significant.

- **PTP 600 Versus T1/E1:** To obtain throughput that is equivalent to one PTP 600 link, a network operator would need 200 T1/E1 lines, costing from \$40,000 to \$140,000 per month. In comparison, a PTP 600 link would cost \$20,000 plus a one-time installation fee.
- **PTP 600 Versus DS3:** A network operator would need at six DS3 lines at a cost of \$30,000 to \$42,000 per month to deliver the throughput of one PTP 600 link, costing \$20,000 plus a one-time installation fee.

It is easy to see that the cost justification for a PTP 600 Series solution is extremely advantageous when compared to the T1/E1 and DS3 alternatives.

Link Planning and System Management

Motorola provides a PTP Link Estimator tool that allows network operators to determine link performance characteristics prior to purchase, given certain assumptions about geography, distance, antenna height, transmit power and several other factors. After network-specific values are entered, the PTP Link Estimator will project link performance and throughput based on the data provided.

Operating range and data throughput are dependent on several factors, including:

- Path length
- Antenna height
- Obstructions (height and distance)
- Antenna type
- Site elevation and terrain

The benefit is that operators can optimize a link before deployment by changing input data to see the effect on performance. If a link calculation indicates low throughput, for example, a number of factors can be changed to see the improvement on throughput.

Once deployed, Motorola's PTP solutions support the WiMAX MIB (Management Information Base), enabling users to seamlessly integrate the solution into a complete end-to-end broadband wireless network that has the WiMAX "look and feel."

Conclusions

The Motorola PTP wireless Ethernet bridges provide carrier-class reliability and high-throughput for backhauling WiMAX traffic from cell sites to the wide-area-network. In addition, the systems can deliver high-capacity bandwidth to a single user alongside the WiMAX network in situations where the WiMAX equipment cannot provide the needed capability.

Because the Motorola PTP bridges offer maximum spectral efficiency and incorporate sophisticated spectrum management techniques, the systems will avoid interference between the point-to-point links and the WiMAX point-to-multipoint links.

While WiMAX has been optimized for access applications, Motorola's PTP bridges have been optimized for bridging and backhaul operations. When you add in the reliability, high-throughput, robust security, strong interference mitigation capabilities and ability to establish communications in challenging environments, you have a perfectly engineered solution for a variety of backhaul applications.

Finally, Motorola's PTP solutions offer significant cost savings over T1/E1 and DS3 lines, greatly reducing overall costs.



The Motorola wi4 Fixed Point-to-Point Wireless Ethernet Bridges – PTP 600 Series – are part of Motorola's MOTOwi4 portfolio of innovative wireless broadband solutions that create, complement and complete IP networks. Delivering IP coverage to virtually all spaces, the MOTOwi4 portfolio includes Fixed Broadband, WiMAX, Mesh and Broadband-over-Powerline solutions for private and public networks solutions.



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