White Paper on WiMAX Backhaul at 70/80 GHz

Introduction

WiMAX promises to bring high-speed data connectivity to a wide coverage area, opening up ubiquitous internet access without costly investment in wire-line infrastructure. A lot of consideration has been given to the access portion of WiMAX networks: the fixed and mobile specifications 802.16-2004 and 802.16e-2005 respectively have both been ratified; the first WiMAX certified fixed products are available and mobile products are expected in late 2006. The WiMAX Forum, an industry group of nearly 400 member companies, estimates that there are already more than 150 announced commercial trials and deployments of fixed WiMAX networks.

Despite this, little attention has been devoted to WiMAX backhaul needs and evolution. With multi-sectored antennas likely and high data throughput possible, conventional point-to-point (PTP) wireless transport solutions will quickly reach capacity. Recently released spectrum at 70 and 80 GHz is allowing a new generation of high speed radios to be realized. Data rates to gigabit-per-second and beyond are possible in cost effective radio architectures, opening up a host of new applications including economic altering WiMAX wireless backhaul networks.

A WiMAX Network's Building Blocks

To provide blanket, ubiquitous WiMAX coverage of a wide geographical area, several basic building blocks are required.

- A fiber node (or POP – Point of Presence) to provide connectivity to the metropolitan Wide Area Network (WAN) or existing Internet infrastructure.
- A high capacity wired or wireless PTP backbone, often called the transport or backhaul network, to carry the high capacity traffic from the fiber POP to each WiMAX Access Point (AP) at locations relatively close to the end users. Ideally a ring configuration of consecutive PTP links is used because of the rotational diversity it provides. If one point in the ring was to fail, full network integrity is maintained by simply rerouting traffic in the opposite direction around the ring, allowing time for maintenance and repair to be undertaken without any costly system outages.
- A WiMAX point-to-multipoint (PTMP) data delivery system consisting of the APs providing the data connectivity to the many Customer Premise Equipment (CPE) devices at each subscriber's location.

An example of this concept is shown in Figure 1 (page 2). The number of links deployed will depend on the equipment employed, the area to be covered, the geographical location and topology of the network.

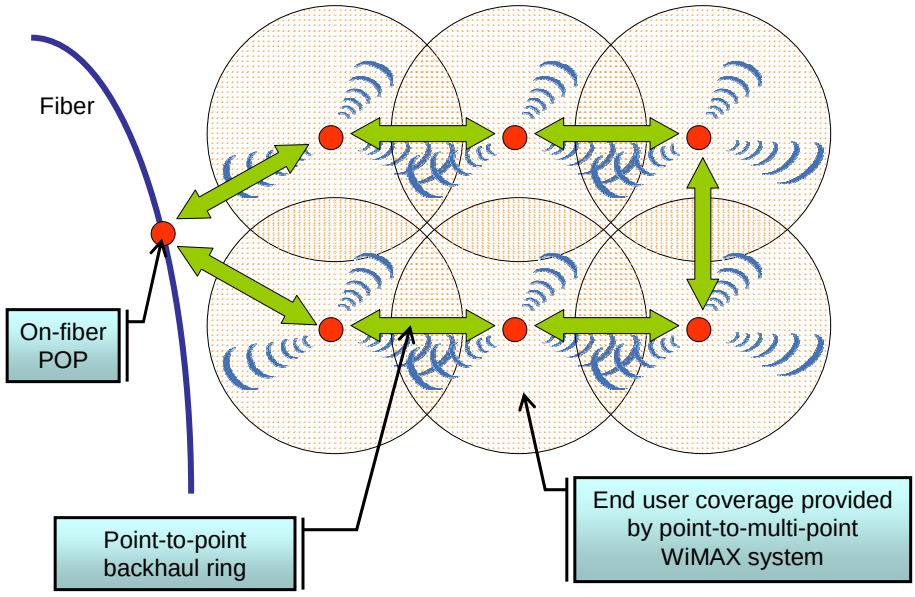

Figure 1: Typical WiMAX network's building blocks.

WiMAX Backhaul Alternatives

A WiMAX backhaul network is used to transport high data rate traffic from the fiber POP around the rest of the network. Such a backbone can be built using wired or wireless technologies. Wireless is usually preferred due to the high costs of trenching fiber in dense modern conurbations, or of leasing fiber from incumbents. Costs of laying new fiber in urban environments can run from $250,000 to upwards of $1,000,000 per mile. The leasing costs of 45 Mbps (DS3) circuits average around $3,000 per month. Furthermore, existing fiber networks are poorly placed to serve end-customers. USA data shows 95% of the 750,000 US commercial locations with 20 or more employees are not served by fiber. Existing copper wiring is not a consideration because of its limited data handling capabilities. Wireless, because of its cost effective economics, fast time to install and commission, and scalable flexibility is therefore the natural choice for WiMAX backhaul.

When selecting wireless backhaul equipment, a WiMAX network architect faces many design decisions and trade offs. Three important questions are:

- What frequency and associated performance characteristics?
- What data rate is available and what is the reliability of delivery?
- Licensed or unlicensed technology?

What frequency and associated performance characteristics?
The WiMAX service provider will have likely placed a lot of effort into obtaining the WiMAX frequencies. These frequencies will probably have been secured through a nationwide auction at a significant cost (both financial and time) to the service provider. By necessity, the service provider will want to extract the maximum revenue and financial return from his investment, and so should devote this entire spectrum to the access portion of the network, and use a different frequency band for the network backhaul. This makes economic sense as well as engineering sense, as using a different frequency for backhaul will significantly simplify network design and interference planning.

What data rate is available and what is the reliability of delivery?
The data rates delivered by WiMAX access points will vary enormously depending on the configuration of the network, the location of the subscribers and the system flexibility required. The 802.16-2004 specification defines a maximum data rate of 70 Mbps. In practice, in a typical cell radius deployment of 2 to 3 miles, systems are expected to deliver capacity of up to 40 Mbps per channel. Broadcast towers will likely consist of multiple APs – probably four to six WiMAX radios each broadcasting over 90° down to 60° sectors respectively. Therefore backhaul requirements for each tower location will be several hundred megabits per second. Future WiMAX releases could demand more, meaning additional flexibility needs to be accounted for. Consider the WiFi evolution, where initial speeds of 2 Mbps have been increased almost one hundred-fold, progressively through 11 Mbps, 54 Mbps and now to 108 Mbps through ongoing specification revisions. Who knows how far WiMAX will progress in the future?

Licensed or unlicensed technology?
Licensed technology provides guarantees of protection from interference, intentional or otherwise. In return for a license fee, the user is given effective ownership of the required transmission spectrum, with full federal protection for that piece of spectrum.
Unlicensed technology provides no such guarantees. Given the high data rates required for WiMAX backhaul and the loss in revenue generating potential when such a system goes down, network designers will always choose licensed technologies.

A WiMAX radio is a poor choice as a backhaul solution. The WiMAX standard is designed to operate as a PTMP system and is highly inefficient when configured in a PTP architecture. Practical throughputs of only a few tens of megabits per second are realizable. In addition, the WiMAX backhaul radio would use up valuable spectrum better allocated to generating revenue on the access part of the network. Conventional microwave radio is a better although still limited choice for WiMAX backhaul. Available at frequencies from 5.8 GHz unlicensed or 6 to 40 GHz licensed, microwave PTP systems are limited to practical data rates of up to 155 Mbps or perhaps 300 Mbps or so in more exotic configurations. This is because these frequencies are heavily regulated with only narrow channels available to individual users. Typically maximum channel sizes of 28 MHz in Europe or 30 MHz in USA are the widest available, meaning high

complexity, high cost radios are required to squeeze data rates of 150 Mbps into such channels.

A Better Backhaul Alternative – 70/80 GHz

In 2003, the Federal Communications Commission (FCC) made a historic ruling, opening up 13 GHz of spectrum at frequencies much higher than had been commercially available before. This spectrum provides for the first time the means to provide economical broadband connectivity at true Gigabit data rates and beyond. The FCC ruling also permits a novel licensing scheme, allowing users cheap and fast allocations to prospective users. A 10 year license can be applied for, granted and purchased in less than 30 minutes for the cost of a few hundred dollars. Then-FCC Chairman Michael Powell heralded the ruling as opening a "new frontier" in commercial services and products for the American people.

In 2005, the Commission for European Post and Telecommunications (CEPT) released a European-wide frequency channel plan for fixed service systems in these bands. The following year, the European Technical Standards Institute (ETSI) released technical specifications covering these bands. Together this provides the framework under which 70/80GHz products can be sold into Europe.

Of particular interest is the 10 GHz of bandwidth at 70 and 80 GHz. Designed to co-exist together, the 71 to 76 GHz and 81 to 86 GHz allocations allows 5 GHz of full duplex transmission bandwidth; enough to transmit a gigabit of data (1 Gbps or GigE) even with the simplest modulation schemes. With more spectrally efficient modulations, full duplex data rates of 10 Gbps (OC-192, STM-64 or 10GigE) can be reached. With direct data conversion and low cost diplexers, relatively simple and thus cost efficient and high reliability radio architectures can be realized.

Propagation characteristics at 70 and 80 GHz allow for transmission distances in excess of 1 mile with carrier class performance. Atmospheric absorption at these frequencies is comparable to the popular microwave bands of 23 and 38 GHz. Rain does cause additional attenuation, but fortunately world-wide rainfall statistics are well documented and radio paths can be planned accordingly.[1] Historical data for the USA shows that currently available commercial equipment can achieve gigabit per second connectivity with calculated 99.999% weather availability (equivalent to only 5 minutes of weather outage per year) over 80% of the country with links of approximately1 mile. For a lower 99.9% available, distances approaching 3 miles can be routinely achieved.

[1] From the Crane Rain Model which is based on a nominal worst case rain year.

Summary

WiMAX is an exciting technology that promises to bring high-speed data connectivity over wide coverage areas. There has been much focus on the access side of WiMAX networks, with little thought devoted to backhaul needs and evolution.

For most WiMAX sites, fiber connections do not exist, so wireless provides the most compelling backhaul solution. Being designed as a PTMP technology and using up the valuable spectrum better allocated to access, WiMAX radios themselves are a poor backhaul alternative. Sophisticated network designers therefore select conventional licensed microwave radio for their backhaul needs. These provide a solid solution, but are limited to data rates of around 150 Mbps in cost effective configurations. The more demanding WiMAX applications will have backhaul requirements that exceed this, and experience with other wireless technologies such as WiFi that has experienced a multiple increases in speed in the few years since it was introduced, has shown us that flexibility needs to be built into systems to avoid costly system upgrades or rebuilds in the future.

70/80 GHz radio systems provide a compelling alternative to conventional microwave for WiMAX backhaul applications. They offer the advantages of extremely high data rates, a flexible growth path, plus all the benefits of interference immunity guaranteed by licensed technology. Best of all, the inherent simplicity of a 70/80 GHz radio means it can be offered at a price competitive to a conventional high data radio, significantly broadening the business case of any WiMAX operator.

About the Author

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