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Introduction

Mobile WiMAX and 3G cellular have one thing in common: Indoor coverage is key to their success in both the consumer and enterprise markets, particularly when the operator is using the technology to displace wireline rivals. Some operators and infrastructure vendors believe that femtocells – base stations similar to Wi-Fi access points in terms of size and coverage – are a viable option for ensuring seamless coverage inside homes, offices and other places that the macro network can't adequately cover.

Mobile WiMAX Femtocells: Big Challenges to Thinking Small

Mobile WiMAX femtocells may be beneficial in some deployments, especially in suburban or rural residential areas, where it might not be cost-effective for operators to deploy a dense network of macro base stations. A femtocell strategy may provide a viable alternative by allowing operators to focus their capex dollars on dense urban or office-park environments, while leveraging femtocells to increase their overall coverage map.

However, many business and technical challenges need to be solved for an operator's femtocell strategy to be successful. For example, a mobile WiMAX femtocell inside a home may lead to increased customer care calls because the subscriber is basically operating a mini base station, while an outdoor femtocell may require additional technology to avoid co-channel interference with WiMAX macrocells. Even indoor femtocells may be susceptible to – or create co-channel interference with – the macro network, depending on factors such as building materials. Another issue is whether the market uptake of femtocells will produce a cost structure that eliminates the need for operators to heavily subsidize femtocells. Unresolved, all of these factors could end up adversely impacting operators' capex and opex costs.

This white paper looks at the technical and business issues surrounding mobile WiMAX femtocells, as well as alternative and complementary technologies such as Unlicensed Mobile Access (UMA). It also covers the key challenges that operators and vendors face when relying on femtocells in a mobile WiMAX deployment, particularly those networks deployed over the next several years.

How Femtocells Work

A variety of factors affect mobile WiMAX (IEEE 802.16e) signal coverage inside homes, offices and other buildings. One example is metallic window tinting, commonly used in commercial construction, which can attenuate signals by 20 dB or more. Another is stone, such as the limestone and granite often found in older high-rise buildings in New York City. Although these factors also affect other wireless technologies such as cellular, they're particularly challenging for mobile WiMAX because WiMAX is deployed primarily at high frequencies such as 2.5 GHz and 3.5 GHz, which have difficulty penetrating buildings.

One way to improve in-building coverage is to increase the power of nearby base stations, focus the antennas at buildings, or both. This technique works, but it has unwelcome by-products, such as sending signals into unintended areas where it creates interference. An alternative is to deploy additional base stations, but that can be expensive and time-consuming, especially if there's community opposition or stringent zoning laws, as is often the case.

This situation is a major reason why service providers and infrastructure vendors are looking for another alternative to improving in-building mobile WiMAX coverage. Some promote the idea of using femtocells, which essentially are miniature base stations in terms of physical size, coverage area and functionality. Like Wi-Fi access points, femto-cells are intended to cover a small area, such as the inside of a home. Depending on the design, each femtocell supports four to 10 users. Ideally, mobile WiMAX femtocells also should be as affordable as Wi-Fi access points, with an industry consensus that retail price points should be well below \$200 – a challenge discussed in a following section.

Challenges to Using Femtocells for Mobile WiMAX

By 2011, the annual worldwide market for femtocells – across all technologies, including WiMAX – will reach nearly 19 million units, according to an October 2006 report by ABI Research. Another independent research firm, Ovum, estimates that the Western European market will be about 17 million by 2011. These conservative forecasts are at odds with the bullish outlook of many femtocell vendors.

Another reason why ABI's and Ovum's forecasts are noteworthy is that there is already a significant and growing number of vendors planning to produce femtocell products and related components. But a market of only 19 million units won't be big enough to sustain that many companies, particularly small vendors. Low sales volumes also mean that small vendors won't have the necessary revenue to scale up production and meet an operator's order of, for example, hundreds of thousands or even millions of femtocells in support of a WiMAX roll out. Meanwhile, investors in those companies could become impatient waiting for the femtocell market to grow and end their support, forcing some vendors to close. These variables directly affect service providers because they can't afford to bet the success of their WiMAX service on a vendor that might not be around.

WiMAX femtocells have several major technological and business challenges, including:

Cost – Mobile WiMAX generally is perceived as a “disruptive” technology, which means that it is marketed as an alternative to incumbent technologies – such as DSL and 3G cellular – that are faster and cheaper. So in order to compete, WiMAX femtocells must be viable for use by a wide variety of customer types rather than just (for example) business users. The industry consensus is that a WiMAX femtocell should be priced less than \$200. Femtocells that cost significantly more would require a significant operator subsidy, which increases the amount of time before those customers become profitable.

Note that some mobile WiMAX operators want to eschew subsidies altogether. One example is Sprint Nextel: At the NXTcomm 2007 show, CTO Barry West said that unlike cellular, where subsidies are the norm, mobile WiMAX devices should not be subsidized. “In order to keep costs down, you can’t subsidize the device,” he said. This strategy is noteworthy because it highlights the pricing pressure on manufacturers of mobile WiMAX user devices, including femtocells. The less willing operators are to subsidize femtocells, the more challenging it becomes for vendors – particularly small ones – to produce products that have mass-market affordability.

Analysts have identified cost as a major hurdle for wide use of mobile WiMAX femtocells. For example, ABI Research says that for all femtocells, regardless of technology, “the real challenge today is balancing price with functionality. In order to get an affordable product on the market as early as possible, it is likely that most designers will opt for a basic feature set. However, manufacturers and carriers alike will need to evolve this feature set rapidly to take advantage of the femtocell offering’s full potential.”

But adding features requires R&D work, a cost that has to be added into the femtocell’s price. This is an additional challenge, especially for smaller vendors. Considering that the femtocell market is already under enormous operator-induced pricing pressure even in its earliest days, it’s likely that many femtocell vendors – and their component suppliers – will struggle to meet operator requirements for both features and price. Femtocell vendors and their component suppliers also will experience pricing pressure from one another because the WiMAX space is already crowded and competitive.

On top of everything, femtocells have unique requirements compared to macro base stations. As a result, it’s not practical for a vendor to try to cut both development costs and time to market by simply re-packaging its macro WiMAX design for use in a femtocell product.

Finally, for any technology, cost is largely a by-product of volumes. As a new technology, mobile WiMAX will take several years to achieve the volumes that drive down product costs, including femtocells. This reality is a challenge for small vendors focused on WiMAX because their investors may become impatient and urge them to focus on products that have a faster ROI.

Integration with the macro network – This is actually a set of challenges. One issue is coordinating the femtocell with nearby macrocells to avoid co-channel interference between them. That coordination could be accomplished by adding GPS receivers to the femtocells so that the network knows exactly where each one is, but that approach adds cost and, in the case of indoor femtocells, requires installation near a window.

Another issue is the amount of variables that affect coverage and co-channel interference. One example is the variety of building materials used in residential homes and multi-dwelling units (MDUs). Different types of materials have different RF-attenuation characteristics, making it impossible for operators to identify every area where an indoor femtocell's signal might leak out and interfere with the macrocellular network – or with a neighboring subscriber's femtocell. The latter is a particular concern in close quarters such as MDUs and office buildings. All of these variables increase the likelihood that operators will have to staff up their customer care and RF engineering staffs to resolve a myriad of unanticipated problems.

Ruggedization and weatherproofing – If an operator deploys WiMAX femtocells outside of subscriber homes, such as around a neighborhood, they must be designed to withstand the elements. Weatherproofing and ruggedization increase the femtocells' cost and drive up operators' capex.

Quality of service – IMobile WiMAX femtocells generally rely on the customer's cable broadband or DSL connection for backhaul. As a result, that cable or DSL connection plays a major role in determining the mobile WiMAX femtocell's throughput, reliability, availability, quality of service and ability to support VoIP. The catch is that unless the operator providing the mobile WiMAX service also owns the cable or DSL network, it has no control over the reliability and availability of that backhaul connection. In that case, the cable or DSL transport becomes a potential Achilles' heel for the mobile WiMAX service.

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For example, if the DSL connection experiences an outage, the mobile WiMAX service provider is likely to be flooded with calls from customers wondering why they can't make calls or check e-mail on their mobile WiMAX devices. This scenario also could have a ripple effect on the macro network, where base stations struggle to keep up with the onslaught of traffic that's supposed to be carried partly by femtocells. Regardless of exactly how this scenario plays out, the operator incurs customer dissatisfaction and unexpected expenses, such as issuing credits to irate subscribers.

Business agreements – Because mobile WiMAX femtocells generally rely on the customer's cable broadband or DSL connection for backhaul, the broadband service provider and its customers may have to sign an agreement "leasing" the backhaul bandwidth to the wireless service provider. This agreement may not be as straightforward as it first appears. For example, the customer is operating a small base station and thus may qualify for a discounted rate for the bandwidth used by the wireless operator's femtocell. This type of arrangement can impact the broadband provider's assumptions about average revenue per user (ARPU), especially if a significant percentage of its customer base begins to use femtocells.

Portability – Customers are likely to move their WiMAX femtocells around their homes or from their old home to their new one. These changes can impact the network – and service quality for other customers – by suddenly creating interference in different places. A related issue is that government regulations covering femtocells are still murky in many countries. If a regulator considers a femtocell to be a base station rather than a consumer electronics product, then the operator would be responsible for ensuring that customers don't violate those regulations by moving them. Femtocell vendors could try to address those situations by, for example, adding features to their products that alert operators when they've been moved or tampered with, but those features also increase the cost that must be borne by the operator or its customers.

Support for other technologies

Depending on their business strategy, some operators may want WiMAX femtocells that support one or two other technologies, such as Wi-Fi and 3G. These additions add cost to the femtocell and create yet another challenge for vendors trying to meet operators' aggressive price-point targets.

Femtocells may eventually be useful for niche applications in mobile WiMAX, but it may be premature to bring these products to market today. One reason for taking a wait-and-see approach is that despite commitments and deployments by major operators such as KT and Sprint Nextel, the installed base of mobile WiMAX handsets and modems will remain small for the next few years in most markets.

Some operators are likely to leverage incumbent technologies that are widely deployed and that have a proven, favorable cost structure when used for in-home and in-office coverage. A prime example is Wi-Fi, which is already widely available in terms of coverage and in its installed base of devices, such as laptops and dual-mode handsets. Many operators that have committed to or deployed mobile WiMAX also already have public Wi-Fi mesh networks, making it easy to tap that resource as an adjunct to mobile WiMAX. Wi-Fi networks are generally deployed in public areas, such as hotel lobbies and cafés, in addition to customers' homes.

Some operators have deployed solutions – such as UMA – that support hand offs between Wi-Fi and another technology, such as cellular. As a result, they can leverage those existing solutions to support interoperability between mobile WiMAX and Wi-Fi. For some operators, this approach may be more attractive and cost-effective than a femtocell strategy.

Conclusion

Femtocells have many benefits for operators looking to roll out a mobile WiMAX network. For example, femtocells can enable subscribers to get access at their homes and thus removes the capex burden for operators to deploy the network in residential areas. Femtocells sound like a viable way to improve indoor coverage and help displace incumbent voice and data services. However, mobile WiMAX femtocells face major challenges such as integration with the macro network, pricing pressures, backhaul quality and support issues. These are among the major reasons why femtocells are likely to be a niche product during the first few years of mobile WiMAX service roll outs.

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