Improving Indoor Coverage:

How WiMAX Modems Can Play a Major Role in the Subsystem

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Abstract

With WiMAX indoor traffic taking up more than 80% of total WiMAX traffic, WiMAX Operators are faced with the pressing need to improve indoor coverage. Contrary to common belief that WiMAX Modems are merely variables in the WiMAX subsystem, this whitepaper discusses how WiMAX Modems can play a major role in the subsystem, particularly in improving indoor coverage.

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Executive Summary

The growth of WiMAX has been tremendous. Maravedis predicts that there will be an accumulated 55 million WiMAX subscribers by the end of 2012. While the growth deserves to be applauded, there is a significant concern in terms of providing quality indoor coverage to meet user expectations.

Indoor coverage has always been a known challenge for wireless technologies and it does not differ with WiMAX, though high spectrum utilization and throughput are the prominent advantages of this technology.

As such, WiMAX Operators around the world have an urgent need to optimize indoor coverage as most often users access the network from indoor locations. According to Senza Fili Consulting, 75% of WiMAX Operators estimate that over 80% of their subscribers will connect to the WiMAX network from indoors.

A contributing factor towards poor indoor coverage is WiMAX' high operating frequency range, which makes it difficult for radio waves to penetrate through buildings. Currently, numerous initiatives focus on the backend system (Radio Access Network or Core Network) to optimize the network, however, at the end of the day, indoor coverage remains unsatisfactory.

This whitepaper encourages the WiMAX industry to view this issue from a different perspective. We see that WiMAX Modems can play an active role as part of the subsystem to improve indoor coverage, contrary from current perception that modems merely extend connectivity to end users.

There are 4 methods that can be employed by WiMAX Modems to enhance indoor coverage:

- Improving uplink reception through antenna technology
- Use of appropriate antenna type
- Optimal modem placement
- Boosting indoor coverage with WiFi

With these methods in place and simultaneous advancement in base station technology, indoor coverage issue can surely be tackled to provide excellent user experience.

Importance of Indoor Coverage

WiMAX is fast gaining momentum and is widely adopted by many residential and business subscribers worldwide. In fact, according to WiMAX Forum®, 2009 concluded with approximately 523 deployments globally, a 28% increase compared to 2008.

WiMAX in general promises ubiquitous connectivity, access for both fixed and mobile devices and supports bandwidth-hungry applications without sweat. However, similar to other wireless broadband technologies in the market, the underlying issue for WiMAX remains in providing high performance indoor coverage. Here lies the challenge, as most users would connect to WiMAX while indoors. In fact, according to Senza Fili Consulting, 75% of WiMAX Operators estimate that over 80% of their subscribers will connect to the WiMAX network while indoors.

More often than not, indoor users have longer sessions and use more bandwidth intensive applications, resulting in the need for Operators to ensure high capacity in addition to optimized indoor coverage. Therefore, for best-in-class user experience, improving indoor coverage is becoming a very crucial task.

Frequency vs. Coverage

Most WiMAX Operators operate in the 2.3GHz, 2.5GHz, or 3.5GHz frequency range. At these high frequencies, radio waves tend to have high transmission loss, poor ability for diffraction, and most importantly, poor building penetration capability. According to Andrea Goldsmith in her book Wireless Communications, there is a 6dB penetration loss for glass window and 13dB loss for concrete walls.

With this in mind, indoor performance is further reduced when signals are required to penetrate walls. Figure 1 illustrates this by comparing the signal strength performance between a wall and window. As a result of having lower penetration loss, signals that penetrate the window emerge stronger (proved by the higher signal strength as shown in Figure 1) and translates into improved indoor performance.

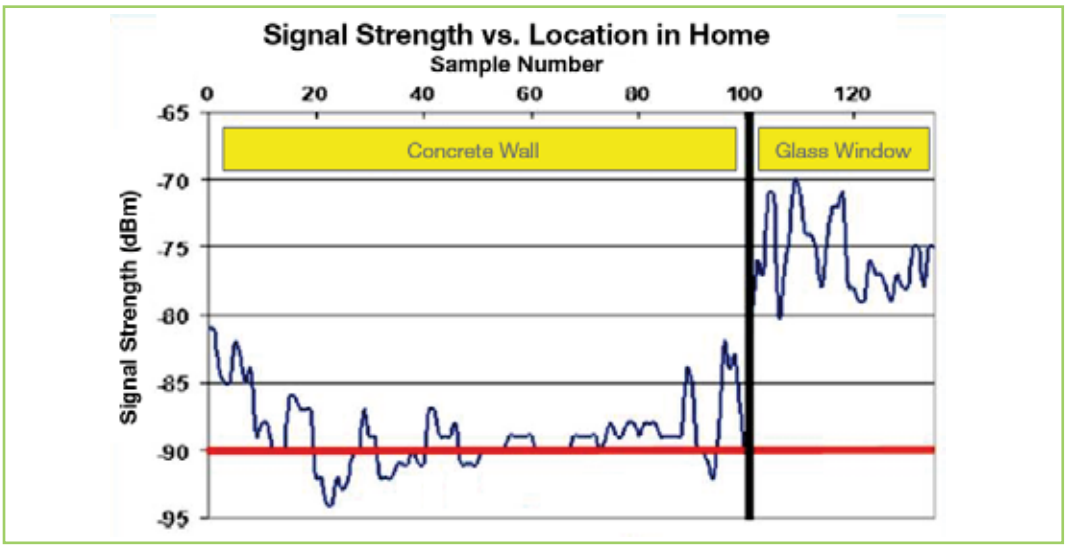


Figure 1: Indoor signal strength performance – comparison between a concrete wall and glass window

Additionally, due to the high frequency bands of WiMAX which weakens indoor penetration capabilities, the coverage distance achieved is lower. Figure 2 compares the indoor and outdoor coverage distances for dense urban, urban and rural areas across the 2.5GHz and 3.5GHz frequency bands. It is evident that 3.5GHz (the highest WiMAX frequency) produces shorter coverage distance. *(Note: Results for 2.3GHz frequency band is very close to 2.5GHz and hence, have been omitted from this chart.)*

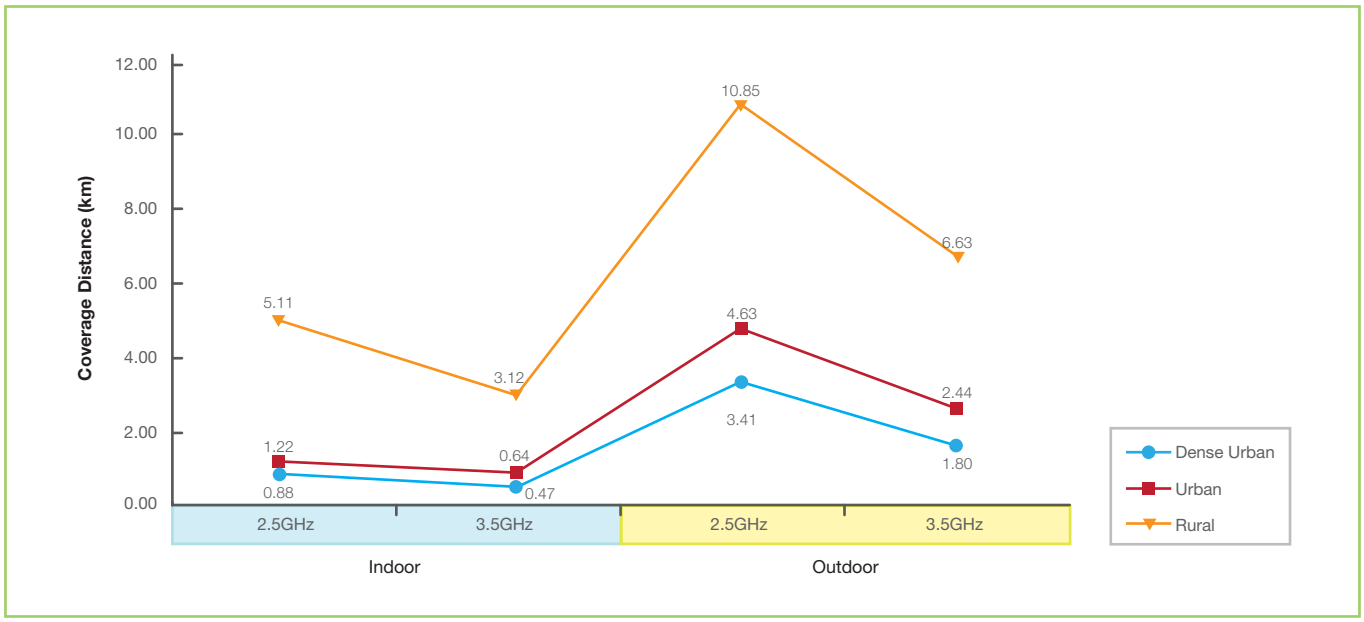


Figure 2: Indoor coverage distance offered by different WiMAX frequencies

Indoor Coverage Improvement Strategies for WiMAX

In short, lowering the frequency is probably the answer to improve indoor coverage. While the WiMAX industry is looking forward to accelerated developments on the lower frequency band, 700 MHz, experts believe it might take a couple of years to reach full fruition considering the vast technical specifications involved.

What then is a more immediate and effective solution to improve indoor coverage?

Look at WiMAX Modems as part of the Subsystem

Generally, the wireless broadband industry focuses on the backend system (Radio Access Network or Core Network) to optimize network, particularly in improving indoor coverage. As far as WiMAX is concerned, WiMAX Modems are often treated as a connectivity access device for end users, whose role is merely to transmit and receive. It is time the device receives more credit and is trusted with a more important role - improving indoor coverage.

There are 4 methods which can be employed by WiMAX Modems to play a part in improving indoor coverage:

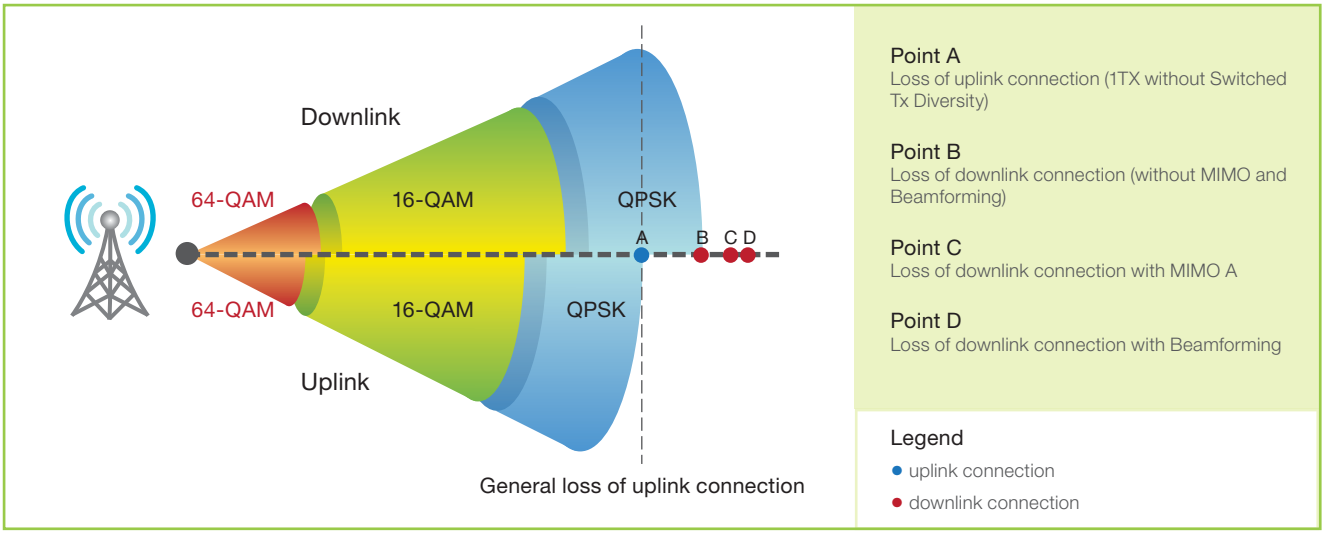
- Improving uplink reception (through next generation antenna technologies)
- Use of appropriate antenna type
- Optimal modem placement
- Boosting indoor coverage with WiFi

Figure 3: How WiMAX Modems can play a role in improving indoor coverage

Improving Uplink Reception (Through Next Generation Antenna Technologies)

There are many technologies introduced by base stations such as 4T4R MIMO A, radio unit on top of tower to reduce feeder loss and higher transmission power. Unfortunately, these technologies do very little to boost uplink reception which is often the bottleneck that limits indoor coverage. Uplink connection is usually weaker than downlink, as uplink connection is enabled by an indoor modem transmitter which has lower power (200mW) compared to that of a base station transmitter (10W). Hence, the coverage of uplink connection is always limited.

Figure 4 illustrates the downlink and uplink connection coverage using various antenna technologies. The loss of uplink connection (Point A) comes at a distance much earlier than loss of downlink connection (Points B, C & D) and at this point, indoor modems can no longer connect to the base station. Even though MIMO A and Beamforming can extend downlink reception (Points B, C & D), these technologies do not contribute in boosting uplink reception.



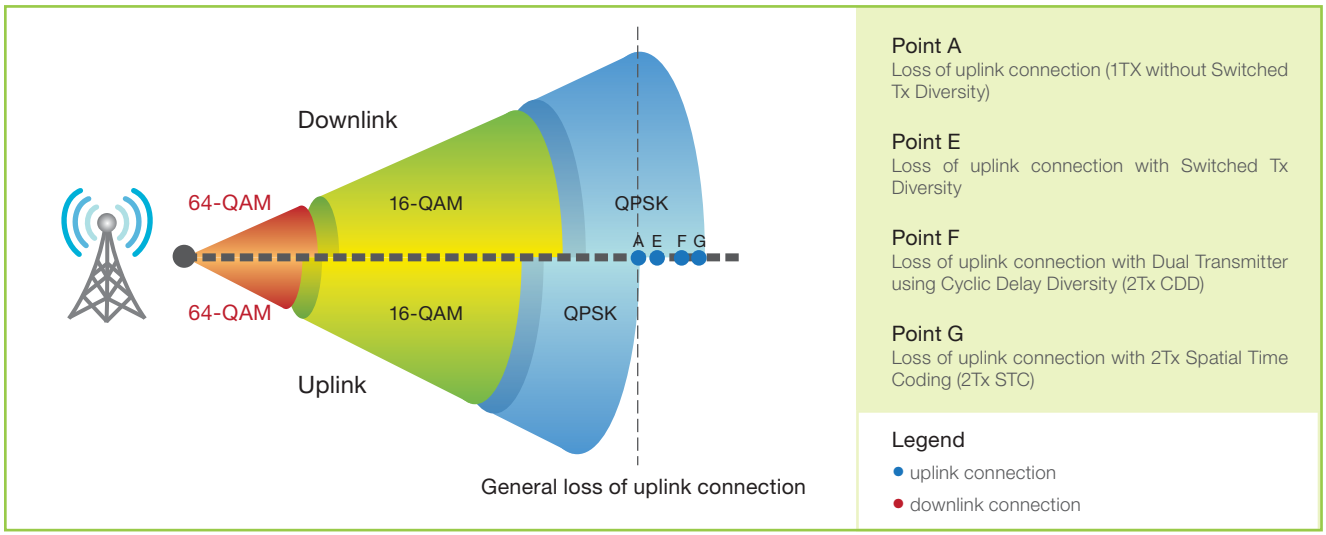
Source: Sequans Communications, 2009

Figure 4: Uplink and downlink connection coverage of different antenna technologies

There are several technologies that can improve uplink performance. One of the popular method is Switched Tx Diversity which requires an extra antenna and includes an algorithm to determine transmission based on the path of the better antenna. This method allows the modem to transmit radio signals from the best antenna to improve overall transmission signal strength, with the slight tradeoff of an extra switch and minimal loss of power.

An improved method available is Dual Transmitter using Cyclic Delay Diversity (2Tx CDD) which requires two power amplifiers (PA) and two antennas. This method can further improve the overall transmission signal strength. Aside from 2Tx CDD, an alternate method with added performance is 2Tx Spatial Time Coding (STC). However WiMAX R1.5 base stations must be able to support STC for users to enjoy better uplink performance.

Figure 5 (next page) explains how uplink performance can be extended via Switched Tx Diversity (Point E), Dual Transmitter using Cyclic Delay Diversity (Point F) and 2Tx Spatial Time Coding (Point G). It is important to note that only one of these technologies can be used at any one time.



Source: Sequans Communications, 2009

Figure 5: Uplink performance can be extended via next generation antenna technologies

Use of Appropriate Antenna Type

Antenna design is often regarded as a black art. There are many factors that can affect antenna performance. For example, factors such as material, length, type and antenna design contribute to the actual antenna gain.

The common type of antennas used is patch antennas and omni antennas. Patch antennas are made up of one or several conductive plates that are spaced above and parallel to a ground plane. This design enables patch antennas to have radiation patterns that are very directional. On the other hand, omni antennas are made from a piece of conductive material generally orthogonal to the ground plane. This design enables omni antennas to radiate signals perpendicular to the antenna uniformly.

Figure 6 below illustrates the 3D radiation pattern for patch and omni antennas. The color red specifies the most sensitive location or area with the highest gain relative to the antenna. From the diagram, it is obvious that patch antenna has strong directionality, hence, the modem has to be placed correctly to ensure that the modem surface that emits radiation patterns face the base station for optimum performance.

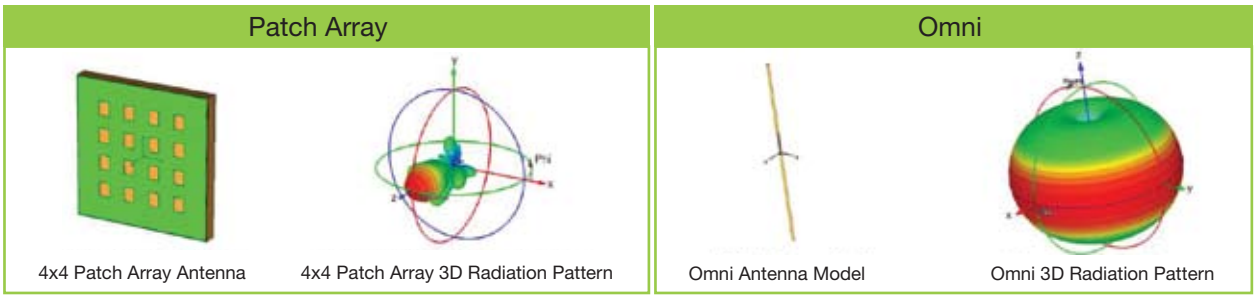


Figure 6: Patch and omni antenna radiation pattern

However, omni antenna radiates signals uniformly in one plane and does not need to face the base station in a pre-conceived manner. Hence, it is ideal for indoor usage where the exact location of the nearest base station is difficult to determine.

Optimal Modem Placement

It is important to note that WiMAX signals are emitted through radio waves and careful indoor placement can significantly boost indoor coverage.

As such, WiMAX Operators should educate users on where and how to place their indoor modem. Firstly, by simply placing the indoor modem near the window that faces the nearest base station as shown in Figure 7 can improve the antenna performance dramatically. This is because radio wave penetration loss for glass (6dB) is much lower than the penetration loss for concrete walls (13dB or more).

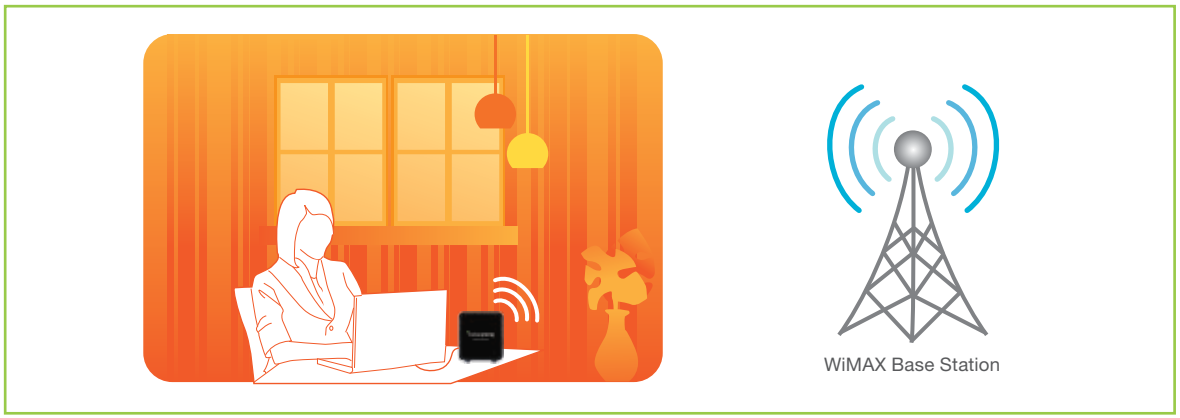


Figure 7: A WiMAX indoor modem facing a window with line of sight to base station improves antenna performance dramatically

Secondly, placing the modem near the window as opposed to a distance away from the window yields better throughtput as a result of improved indoor coverage. From observation and trial runs conducted, Greenpacket estimates a throughput reduction of 20-40% when the modem is placed 10m away from the window (and deeper into the room). However, this finding is subjective and may vary in different countries, depending on distance from base station and RF environments.

Boosting Indoor Coverage with WiFi

Some users might express that is it not always convenient to restrict computer usage to an area that is next to the window. Additionally, they might want the convenience and flexibility of sharing the wireless broadband connection through WiFi.

Therefore, using WiFi to complement WiMAX can provide advantages that improve indoor coverage. One of the ways of going about this is to use a WiMAX-WiFi combination modem also known as WiMAX Integrated Access Device (IAD) which enables WiMAX-In-WiFi-Out. WiFi and WiMAX transmitters are placed within the same modem so that the transmitters are able to connect to the respective WiFi-enabled devices and WiMAX base stations simultaneously.

For example, as illustrated in Figure 8 below, users can place the WiMAX indoor modem at an optimal location (generally next to a window) and enjoy WiMAX through the flexibility of multiple WiFi-enabled devices within the perimeters of the home or small office.

Figure 8: Place the WiMAX indoor modem near a window for better indoor coverage

However, having both WiMAX and WiFi in the same device comes with a price. In many countries, especially in Asia and US, WiMAX is offered on the 2.3GHz and 2.5GHz frequency band which almost coincides with the frequency band of WiFi which is 2.4GHz. When WiMAX and WiFi share approximate radio frequencies, interference can occur and jeopardize connectivity. To overcome the issue of interference, a carefully designed modem is required to allow both wireless technologies to co-exist in the same device.

The advantage of having the WiFi-WiMAX combination modem is that antennas can be optimally designed to isolate radio interferences in a highly controlled manner. In addition, since antennas are stationary within the modem, there is better control over the WiFi and WiMAX radio signals to ensure users gain the best WiFi and WiMAX connectivity in the same location.

Greenpacket's Edge: Paving the Way for Improved Indoor Coverage

Improving current WiMAX indoor coverage is an urgent need for most operators. At Greenpacket, through extensive R&D efforts, we have produced WiMAX Modems that go beyond merely enabling connectivity. Our modems are designed to work harder for WiMAX Operators, particularly in the area of improving indoor coverage.

Briefly, Greenpacket's next generation indoor modems boast of the following key features which make them ideal in boosting indoor coverage:

1. **Ideal to be placed near a window**
   The exterior design is able to withstand high temperatures and can be placed near the window for better coverage. Selected USB models have suction cups which can be fixed to a window for optimum indoor coverage.

2. **Boost indoor coverage with WiFi**
   Built-in WiFi capabilities for convenient wireless access around the home/SOHO.

3. **High gain omni antenna**
   Greenpacket's indoor modems are built with omni antenna that radiate and receive WiMAX signals from any direction for great flexibility in modem placement and all-direction performance. The high gain antenna ensures WiMAX signals are transmitted in spite of penetration loss, resulting in improved indoor signal indoors.

4. **Improved uplink coverage**
   Our modems deploy Switched Tx Diversity, a next generation antenna technology which intelligently selects the best antenna during transmission to increase signal strength for improved uplink performance.

Free Consultation

If you would like a free consultation on selecting WiMAX indoor modems that optimize indoor coverage, please contact us at marketing.gp@greenpacket.com (kindly quote the reference code, DWP0410 when you contact us).

References

1. Antenna Patterns and Their Meaning by Cisco Systems
2. DS230 Service Manual by Green Packet
3. DV230 Service Manual by Green Packet
4. A Practical Guide to WiMAX Antennas: MIMO and Beamforming Technical Overview by Motorola Corporation
5. Indoor, High-Capacity Coverage with WiMAX: How Are Operators Meeting The Challenge? By Senza Fili Consulting
6. Sequans Communications: from WiMAX to 4G by Sequans Communications
7. Wireless Communications by Andrea Goldsmith, Cambridge University Press

About Green Packet

Greenpacket is the international arm of the Green Packet Berhad group of companies which is listed on the Main Board of the Malaysian Bourse. Founded in San Francisco's Silicon Valley in 2000 and now headquartered in Kuala Lumpur, Malaysia, Greenpacket has a presence in 9 countries and is continuously expanding to be near its customers and in readiness for new markets.

We are a leading developer of Next Generation Mobile Broadband and Networking Solutions for Telecommunications Operators across the globe. Our mission is to provide seamless and unified platforms for the delivery of user-centric multimedia communications services regardless of the nature and availability of backbone infrastructures.

At Greenpacket, we pride ourselves on being constantly at the forefront of technology. Our leading carrier-grade solutions and award-winning consumer devices help Telecommunications Operators open new avenues, meet new demands, and enrich the lifestyles of their subscribers, while forging new relationships. We see a future of limitless freedom in wireless communications and continuously commit to meeting the needs of our customers with leading edge solutions.

With product development centers in USA, Shanghai, and Taiwan, we are on the cutting edge of new developments in 4G (particularly WiMAX and LTE), as well as in software advancement. Our leadership position in the Telco industry is further enhanced by our strategic alliances with leading industry players.

Additionally, our award-winning WiMAX modems have successfully completed interoperability tests with major WiMAX players and are being used by the world's largest WiMAX Operators. We are also the leading carrier solutions provider in APAC catering to both 4G and 3G networks and aim to be No. 1 globally by the end of 2010.

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