

Drive Mobile WiMAX Adoption with
Versatile Modems



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APPLICATION NOTE

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Abstract

Mobile WiMAX has tremendous potential with its advantage of mobility and high bandwidth support. In reality today, approximately 65% of subscribers worldwide use WiMAX for fixed purposes which undermines WiMAX's mobile promise.

How can WiMAX Operators play their part in driving the adoption of Mobile WiMAX in their countries? The answer lies in having versatile modems that provide excellent performance indoors and outdoors to answer the call of mobility.

This paper defines versatile modems from a technical and user perspective and explains how this type of modem can promote the take up of Mobile WiMAX.

WiMAX Walks the Fixed and Mobile Talk

WiMAX has an advantage. Though designed as a mobile technology, it was born fixed and is growing up mobile.

Fixed Usage

WiMAX's early deployment of IEEE 802.16d was catered for fixed (indoor) usage as an alternative to wireline broadband. The next evolution of WiMAX, IEEE 802.16e was designed for mobility, though at present, 65% of subscribers worldwide still use WiMAX as their primary broadband connection at home. This is due to several factors:

- For many subscribers, especially in emerging markets, WiMAX is the first broadband technology made available to them and the standard evolution in broadband begins with fixed/indoor use before going nomadic or mobile.
- In developed markets, WiMAX reaches out to underserved areas and replaces dial-up connections.
- In terms of user preference, WiMAX gives them the liberty to engage in data-intensive applications such as online games and video. These applications are best enjoyed while stationary position via large screens.

Going Mobile

Being able to offer fixed and mobile broadband (through the same technology) is definitely an edge to WiMAX Operators. Many leading greenfield operators such as P1 and Clearwire initially took fixed services to the market and began to introduce nomadic services as network deployments and coverage improved. Today, 35% of subscribers worldwide have embraced Mobile WiMAX, however, majority of the usage is confined to nomadic access and not true mobility. This is likely contributed by the following:

- Most WiMAX Operators have been in business in average of 2 years which is insufficient to rollout nationwide coverage for true mobile services.
- There is a lack of embedded devices such as smartphones and netbooks in the market that enable true mobile WiMAX.

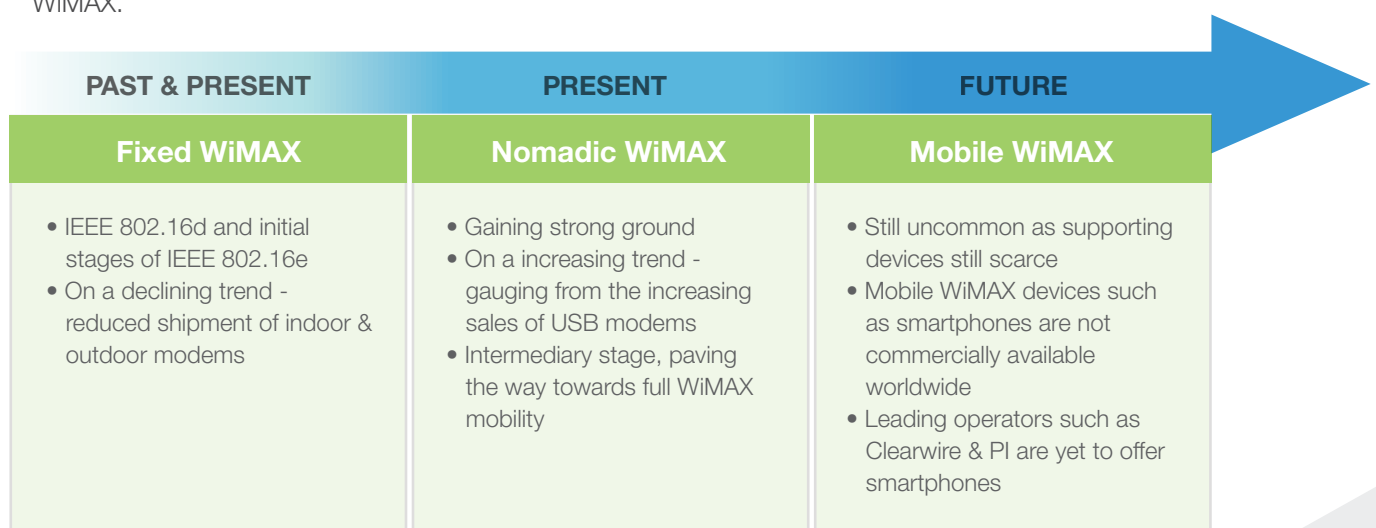
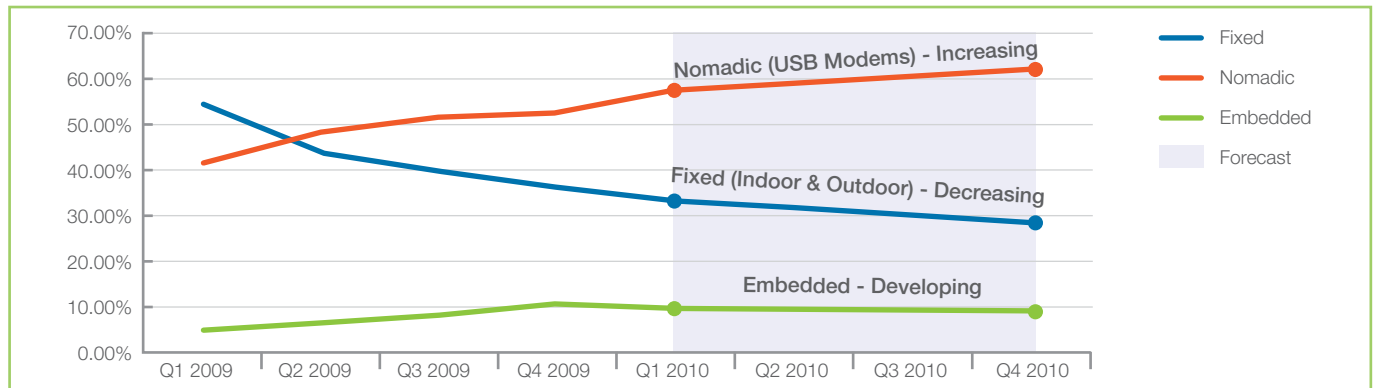


Figure 1: The evolution of WiMAX, from fixed to mobile – a summary

WiMAX Walks the Fixed and Mobile Talk

WiMAX devices available today include indoor, outdoor and USB modems, as well as embedded devices such as handhelds and netbooks. Usage trends (as of 1H2010) show that WiMAX is highly used for nomadic purposes, which is proved by the increasing number of WiMAX USB modems shipped, compared to indoor/outdoor modems, which show a decreasing trend. On the other hand, WiMAX embedded devices comprising of handhelds and netbooks are yet to hold significant presence globally. One of the reasons contributing to the slow progress in this category of devices is that Mobile WiMAX chipsets are not optimized for low power consumption, thus resulting in less than optimal battery life for handheld devices.

In the months to come, Greenpacket foresees this trend to continue and embedded devices to continue development till the end of 2010.



Source: Maravedis & Greenpacket Marketing Intelligence

Figure 2: Current and future trends in WiMAX devices for Mobile WiMAX (IEEE 802.16e)

The Need for Versatile Devices

Different types of WiMAX modems cater for different use case scenarios. As such, they may have an advantage from one perspective but limiting from another. For example, indoor modems are optimized for indoor performance but provide zero mobility. However, USB modems provide great portability but slacks in terms of indoor performance.

Does this mean that subscribers have to live with a trade-off in order to enjoy mobility with WiMAX? Greenpacket does not think so. Not if there are versatile devices that pave the way for Mobile WiMAX. What do we mean by versatile devices? These are devices optimized for indoor performance, coupled with the mobility advantage of USB modems. It is envisioned to provide subscribers with mobility anytime and anywhere, even indoors.



Figure 3: Greenpacket's Shuttle, a versatile modem combining the features of an indoor and USB modem

To realize this vision, Greenpacket developed 'Shuttle' (refer to Figure 3), a WiMAX USB modem that provides versatility and is ideal for both indoor and outdoor usage. Its features provide excellent indoor performance, while the USB form factor enables mobility.

What makes a versatile modem? What characteristics make Shuttle ultimate for indoor and outdoor use? To better understand the capabilities of versatile devices such as Shuttle, it would be educational to briefly understand the usage features of indoor, outdoor and USB modems as well as the technical aspects that enables the versatility.

Battle of the Modems – User Needs

Majority of subscribers are pretty oblivious to the technical specifications of a modem. Their primary concern is the verb qualities of the modem, in other words, “what can this modem do for me?” “Does it offer mobility?” “Is the device affordable?” “Do I get good coverage in my house?”

To understand what subscribers want from their broadband, Greenpacket conducted a worldwide survey, comprising of respondents from across different industries. Among the factors measured include speed, price, mobility, personal access, aesthetics and indoor signal quality, 74% of respondents stressed that indoor signal quality was important to them – this further supports the fact that a large percentage of subscribers access broadband from indoor locations. On the other hand, 33% responded that mobility was important. This concludes that subscribers need a device that gives them the freedom to move around and yet provides best possible indoor coverage.

The table below summarizes factors subscribers ponder upon in relation to broadband and how different types of modems measure up.

Note: The objective of this study is to compare performance of different types of modem ie USB, indoor and outdoor. It is not a competitive study.

Usage Factors	USB	Indoor	Outdoor
Mobility	★★★★★	★	★
Indoor Coverage	★★	★★★★★	★★★★
Multi-user (Broadband sharing)	★	★★★★★	★★★★
Bandwidth Limit	★★★	★★★★	★★★★
Price	★★★★★	★★★	★

■ Shuttle’s advantage

Table 1: Comparison of subscriber needs and how USB, indoor and outdoor modems fair in meeting the needs

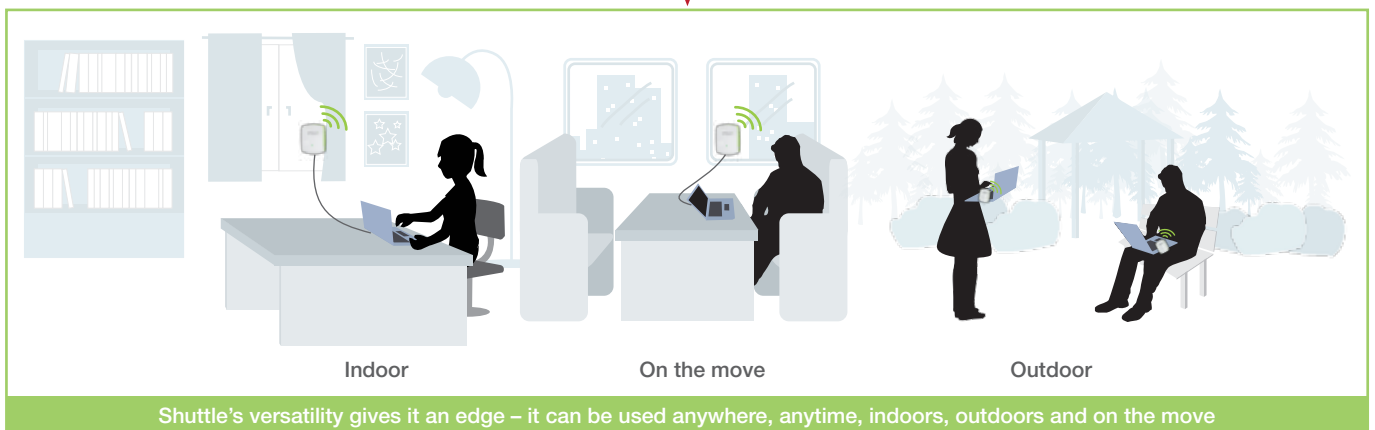


Figure 4: Shuttle is excellent indoors, outdoors and on the move

Battle of the Modems: Technical Aspect

The quality and capabilities of a modem, regardless its type is determined by its technical specifications, consisting of a combination of various components including antenna, chipset and power amplifiers playing the major roles. The quality of these specifications results in excellent usage conditions.

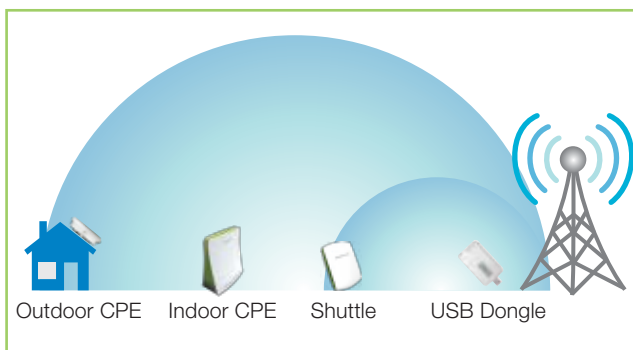
The following table gives a general comparison on common technical aspects between USB, indoor and outdoor modems. The results are based on a study conducted by Greenpacket on various WiMAX modems available in the market.

Note: The objective of this study is to compare performance of different types of modem ie USB, indoor and outdoor. It is not a competitive study.

Usage Factors	USB	Indoor	Outdoor
Transmission Power Refers to the maximum limit of power (dBm) of the modem in sending signals back to the base station (uplink). Having a higher transmission power indicates that the modem has a stronger ability to transmit signals to the base station. This is an important factor for indoor use and to serve subscribers at cell edge locations.	★ ★ ★	★ ★ ★ ★	★ ★ ★ ★
Antenna Gain A higher antenna gain improves the antenna's ability to receive signals from the base station which is an important element for indoor use.	★ ★ ★	★ ★ ★ ★	★ ★ ★ ★ ★
Data Rate The speed at which data is downloaded.	★ ★ ★ ★	★ ★ ★ ★ ★	★ ★ ★ ★ ★
VoIP Modem's support for VoIP services.	★	★ ★ ★ ★	★ ★
WiFi Modem's support for WiFi services (WiMAX-in; WiFi-out)	★	★ ★ ★ ★	★ ★ ★
Power Consumption Power supply required to operate the modem.	★ ★ ★ ★	★ ★	★

■ Shuttle's advantage

Table 2: Comparison of technical specifications of USB, indoor and outdoor modems



Greenpacket's Shuttle is a league of its own, combining the benefits of indoor/outdoor and USB modem to provide the mobility of a USB modem at the performance level of indoor modem:

- Its high transmission power and antenna gain improves indoor reception and uplink performance.
- With data rate almost equivalent to indoor/outdoor modem, subscribers enjoy faster Internet surfing experience.
- Low power consumption preserves (laptop's) battery life for extended usage periods.

Figure 5: Shuttle, a versatile device that functions as a USB and indoor modem

Why Do These Specifications Matter?

Transmission Power – Compensates Link Budget Imbalance

A common concern in the wireless industry, including WiMAX is the link budget imbalance. This is due to difference in transmission power between the base station (typically, 40dBm) and the modem (average of 23dBm), which creates a link budget imbalance between the downlink and the uplink.

In spite of the existence of technologies that help narrow the imbalance gap (for example, subchannelization gain of the uplink, downlink boost for remote users, additional gain provided by the use of downlink MIMO and receive (rx) antennas at the base station), a link budget imbalance of 6dBm remains. In many cases, the imbalance is particularly limiting in terms of uplink coverage which results in an average increase of 30% in the number of sites required to serve the planned area. Having more sites translates to higher TCO spend.

How does Shuttle help?

Due to the link budget imbalance, particularly on the uplink route, a modem with higher transmission power has a stronger capacity to “communicate” with the base station. This characteristic compensates the imbalance and boosts uplink performance.

Indoor modems are commonly designed to have higher transmission power as compared to USB modems to compensate losses due to indoor/material penetration which is normally in the range of (18-25dBm) depending on the morphology and usage scenario. As such, USB modems which have lower transmission power functions poorer in indoor environments. To combat this, Shuttle provides an intermediary between both modem types coupling high transmission power and mobility.

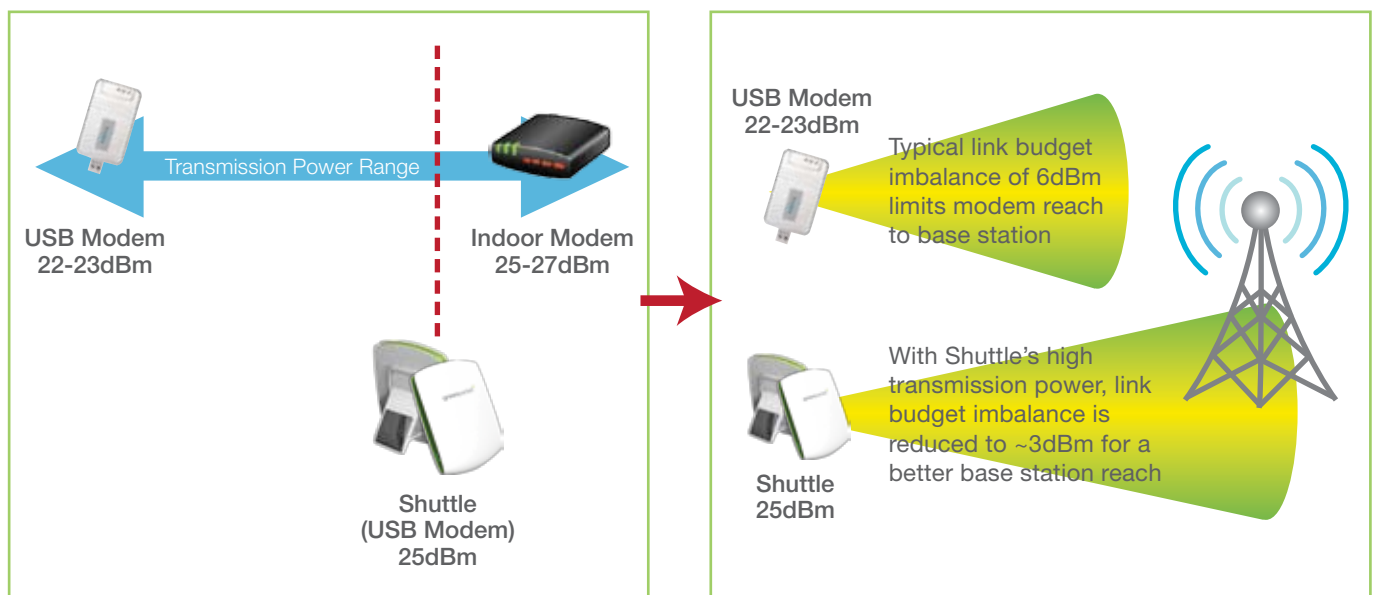


Figure 6: Shuttle has a high transmission power for a better base station reach



**Shuttle To
The Test!**

Test # 1: Shuttle Field Test on Transmission Power

To demonstrate the transmission power advantage of Shuttle, Greenpacket conducted a test at a cell edge. With its high transmission power, Shuttle continues to transmit while the conventional USB modem ceases transmission.

Parameter	Shuttle	USB Modem
Receive Sensitivity (RSSI)	-81.27 dBm	-93 dBm
CINR	15.74 dB	6 dB
Modulation	QPSK 1/2	N/A
Transmission Power	14 dBm	N/A
Average Download Speed (Mbps)	4.6 Mbps	N/A
Average Upload Speed (Mbps)	2.0 Mbps	N/A

Shuttle continues to transmit while conventional USB stops transmitting.

Test # 2: Shuttle vs. Indoor Modem

The purpose of this test was to compare the performance of Shuttle with indoor modems to exemplify Shuttle's at par performance with indoor modems.

Parameter	Shuttle	Indoor Modem
Receive Sensitivity (RSSI)	-92 dBm	-97 dBm
CINR	13.5 dB	16.75 dB
Average Download Speed (Mbps)	4.3 Mbps	4.4 Mbps
Average Upload Speed (Mbps)	820 Kbps	920 Kbps

Shuttle performs almost at par with indoor modem.

Antenna

Issue #1 – Antenna Gain

A modem's antenna plays an important role in establishing a robust downlink connection. With a higher antenna gain, the antenna has a stronger intensity power and therefore, the modem holds a better ability in receiving signals from the base station.

Why is antenna gain essential for a quality connectivity? It gives indoor penetration advantage. In wireless transmission, higher frequencies dampen the signal's ability to penetrate surfaces. In the case of WiMAX, with (high) frequency ranging from 2.3GHz to 3.5GHz, indoor penetration is often a concern. The effect is more adverse in the 3.5GHz operating frequency. Hence, a high antenna gain is required to absorb signals from base station.

Most USB modems have an antenna gain of 2-3dBi which is insufficient for indoor conditions (indoor modems typically have 5dBi antenna gain). For improved indoor coverage, some USB modems have an auxiliary docking component which contains an (additional) antenna to give the USB modem a total antenna gain of 5-6dBi (similar to indoor modems). However, this solution incurs extra cost and is not practical for mobility.

Issue #2 – Antenna Direction

Aside from the intensity, the directional qualities of the antenna (direction from which the antenna receives signals) further impacts the process of obtaining signal from the base station.

The common type of antennas used is patch antennas and omni antennas. Patch antennas are designed to have radiation patterns that are very directional, while omni antennas radiate signals in 360o as shown in Figure 7 below. 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 i.e. facing the base station for optimum performance.

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

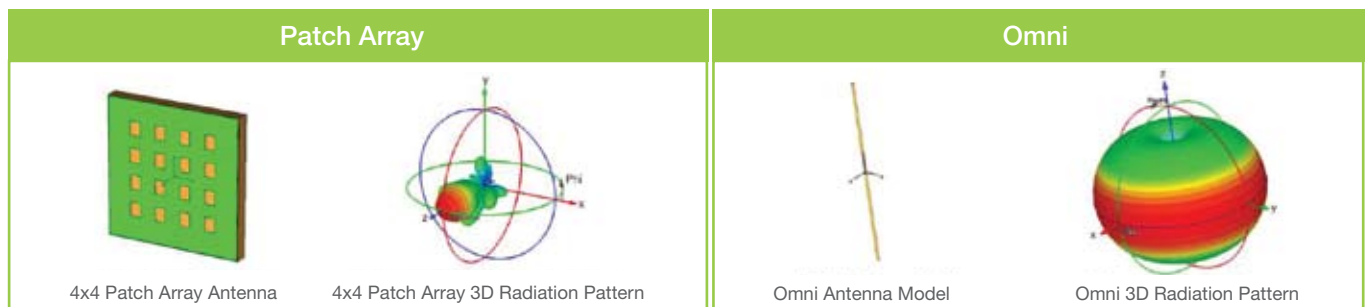


Figure 7: Patch and omni antenna radiation pattern

How does Shuttle help?

Shuttle is built-in with a 5dBi antenna that equals an indoor modem. This gives Shuttle superior indoor and outdoor performance without the need for supplementary docking station.

Additionally, Shuttle is equipped with useful, small and light-weight accessories that aid in enhancing indoor coverage.

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Mount Shuttle on a window or wall for best signal reception to improve indoor coverage.

An accompanying USB cable allows subscribers to connect Shuttle to the laptop.

Suction Cap for Window/Wall Mounting



2

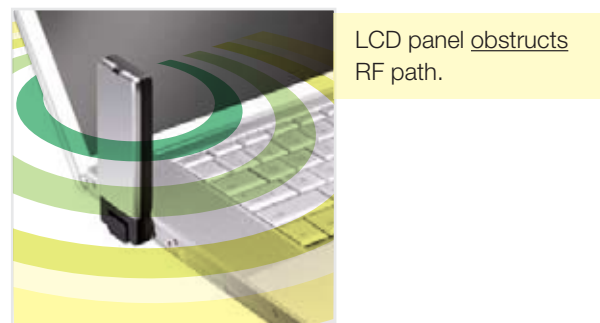
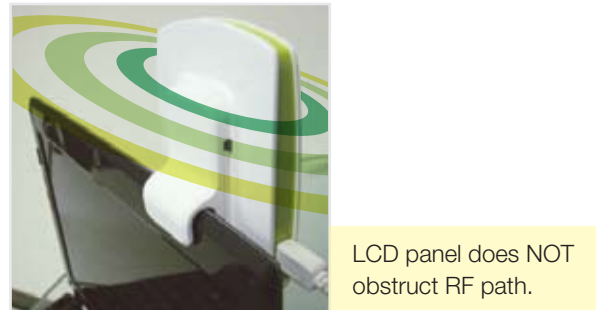
A USB modem affixed to the laptop is subject to signal shielding by the LCD panel.

Shuttle can be placed on the desktop (indoor use) or mounted to the top of LCD panel – this improves RF path and mitigate interference with the laptop for improved signal reception.

Desktop Stand Feature - Indoors



LCD Mount – On The Go





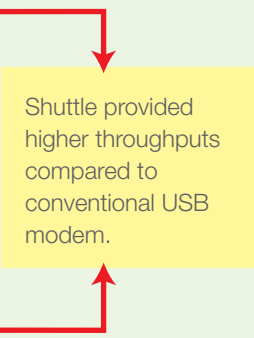
Shuttle To The Test!

Field Test on Antenna Gain

A field test was conducted to prove the throughput capabilities of Shuttle as a result of having a higher antenna gain. Shuttle provided higher throughputs compared to conventional USB modems.

Modem Location: 900m from base station

Parameter	Shuttle	USB Modem
Receive Sensitivity (RSSI)	- 76.43dBm	-84 dBm
CINR	9.53 dB	7.3 dB
Transmission Power	14 dBm	20 dBm
Downlink		
Modulation	16QAM 3/4	QPSK 1/2
Average Download Speed (Mbps)	8.1 Mbps	3.8 Mbps
Maximum Download Speed (Mbps)	10.1 Mbps	4.1 Mbps
Uplink		
Modulation	QPSK 3/4	QPSK 1/2
Average Upload speed(Mbps)	1.3 Mbps	0.593 Mbps
Maximum Upload speed(Mbps)	1.5 Mbps	1 Mbps



Shuttle provided higher throughputs compared to conventional USB modem.

Data Rate

In an indoor scenario (due to the nomadic nature of USB modem), subscribers might move around with the laptop and USB modem from one room to another. This would drop the CINR and cause the modem to change its modulation, which in relation affects the throughput. As a result, subscribers will experience fluctuating throughput levels, affecting the Internet browsing experience.

How does Shuttle help?

The blend of high transmission power and antenna gain enables Shuttle to engage a consistent and wider modulation range. A wider modulation range keeps the modem (Shuttle) in the same modulation regardless where subscribers move within the home.

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Figure 8 illustrates this scenario – the conventional USB modems changes 3 modulations within the home, from 64QAM > 16QAM > QPSK, which would cause instable throughput. Meanwhile, with Shuttle, subscribers enjoy good modulation, between 64QAM and 16QAM, giving subscribers a more consistent throughput.

Note: This diagram is for illustration purposes only. In real life, close proximity between a house and base station is not recommended.

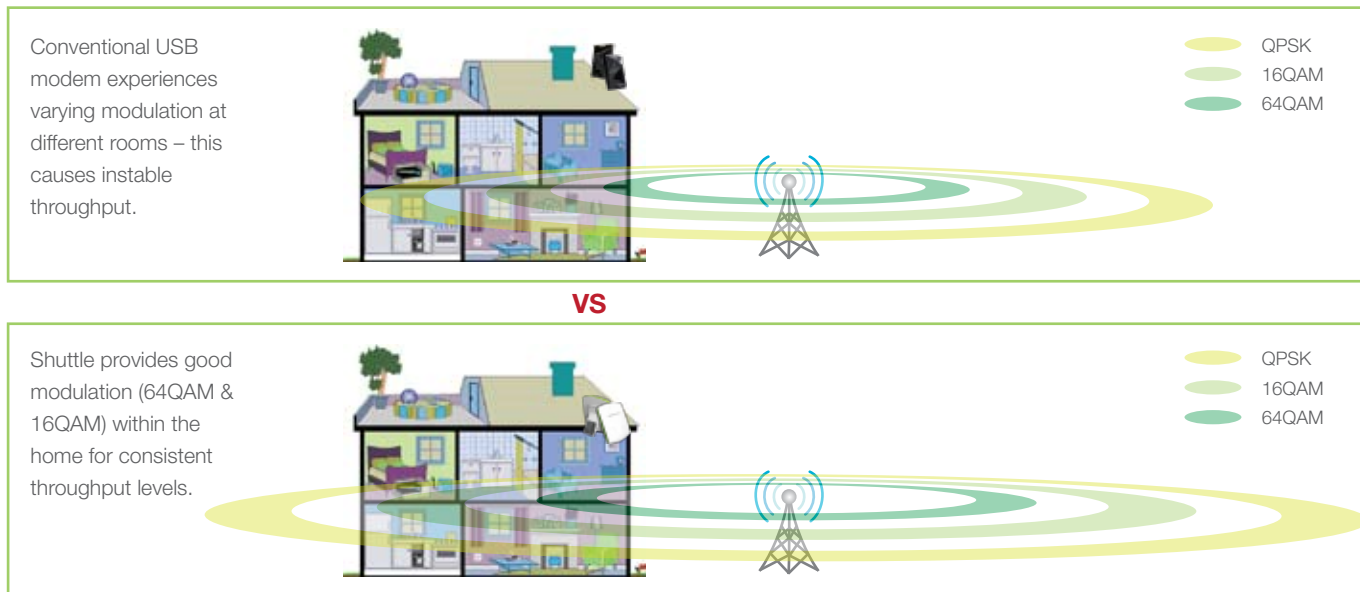


Figure 8: Modulation range for Shuttle vs. conventional USB Modem



Data Rate Stability Test

A field test was conducted to demonstrate Shuttle's data rate stability. With a more consistent modulation, healthier and stable data rates are achieved. On the other hand, the data rates for conventional USB modem were irregular, resulting in a low average throughput rate.

Parameter	Shuttle	USB Modem
Modulation	16QAM [CTC] ¼	16QAM [CTC] ¼
Max. Download Throughput	4.8Mbps	4.3Mbps
Ave. Download Throughput	4.8Mbps	866.7 Kbps
DU Meter Reading		

Shuttle demonstrates stable data rates which are important for user experience.

Versatile Devices – How Operators Benefit?

Best of Both Worlds – Mobile & Fixed

Versatile devices like Greenpacket's Shuttle are a classic example of hitting two birds with a stone – it allows WiMAX Operators to extend a differentiated service by offering optimum performance indoors and outdoors.

Currently across the world, broadband is not quite utilized effectively, for the following reasons:

- Pre-dominant fixed usage. WiMAX is used for fixed/indoor purposes only in emerging countries and underserved areas of developed nations as WiMAX is the first chance at broadband for subscribers in these countries
- Secondary broadband service for mobility. In developed countries, wireline services have penetrated home users due to their first mover advantage. Meanwhile, to supplement mobile broadband usage, users subscribe to a secondary broadband service, such as 3G or WiMAX.

As a result, subscribers are either losing out on the full potential of mobile broadband or having to dig deeper into their pockets to enjoy both fixed and mobile broadband. Through versatile devices, operators can promote the usage of a single technology, WiMAX, to serve fixed and mobile needs, an approach that aids in driving Mobile WiMAX adoption.

Best Possible Performance Indoors & Outdoors

Mobility is often associated with outdoor movement. However, many subscribers appreciate the convenience of being mobile even within indoor perimeters. Fixed modems limit movement indoors and constraint subscribers to the same location. With Shuttle, subscribers can enjoy WiMAX anywhere within their home as it can be taken anywhere within the home (along with the laptop) and subscribers can enjoy unparalleled indoor coverage.

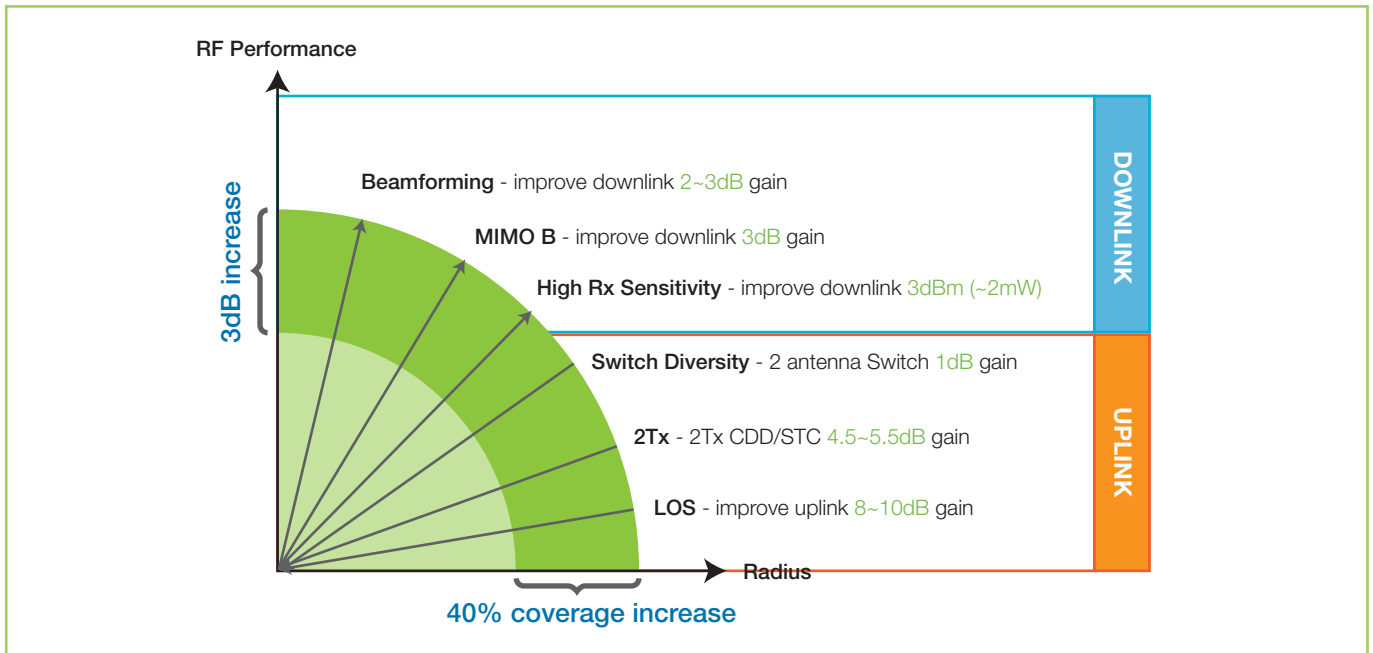
At the same time, WiMAX Operators admit that providing sound indoor coverage is one of their biggest concerns as macro base station deployment do not satisfy indoor coverage. Some resort to overlay networks (microcell, picocells) which incur additional cost. With Shuttle, operators can provide sound indoor coverage without having to install overlay networks.

As for outdoor use, Shuttle also provides optimum performance to serve subscribers who love being outdoors and on the go! It is small and lightweight which makes Shuttle easy to be carried around.

CAPEX & OPEX Savings

Shuttle's antenna technology and high receive sensitivity increases the uplink and downlink gain by approximately 3dB which goes a long way in improving coverage by 40% as shown in Figure 9.

From Greenpacket's TCO estimation, with a wider coverage span (totalling to approximately 140%) WiMAX Operators will be able to reduce 30% of cell sites. This translates to 30% CAPEX and OPEX savings encompassing base station equipment and network maintenance.

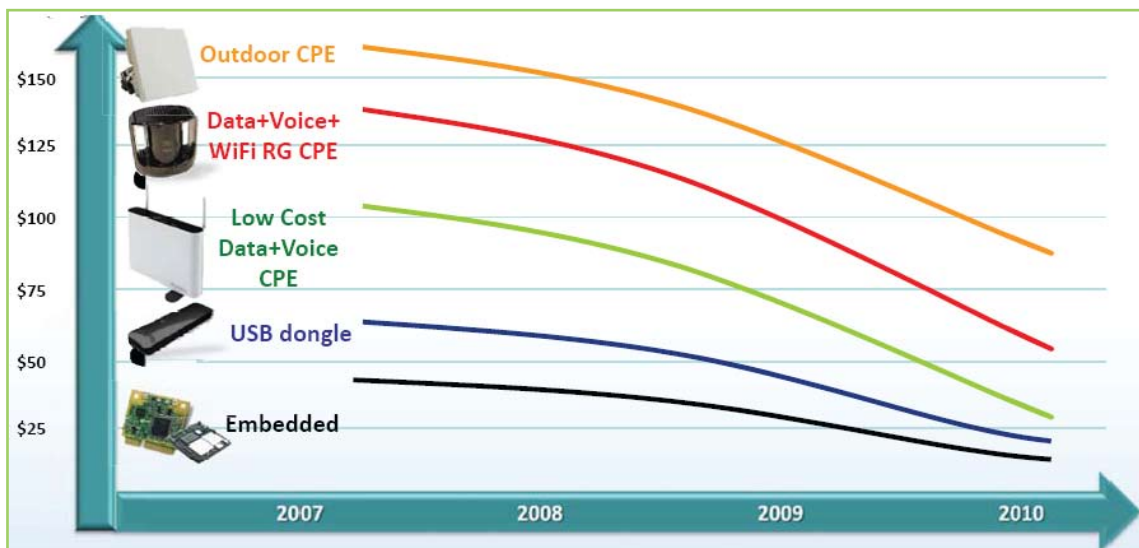


Source: Greenpacket Marketing Intelligence

Figure 9: Technologies that enable Shuttle to generate an additional 3dB gain.

Cost Factor & Creative Packaging

Although economies of scale are bringing down the cost of modems, indoor and outdoor modems cost more than USB modems, which translates to higher cost for the subscriber and operator (in the case of modem subsidy). The cost ratio for USB, indoor and outdoor modems is generally around 1.0 : 2.0 : 3.0 respectively – this proves it is more cost effective to offer USB modems. Additionally with Shuttle's outstanding indoor performance, it can be positioned as an ideal device for both mobile and fixed use.



Source: Sequans Communications

Figure 10: Price range of WiMAX devices

Aside from the cost factor, the versatility of Shuttle enables WiMAX Operators to introduce more creative packages via the same device, for example,

- Premium package for road warriors, highlighting Shuttle's mobility feature with high bandwidth caps.
- Economic package for youth/students who spend considerable time indoors. This package is more affordable than a fixed broadband package (with indoor modem) and has the flexibility of mobility.

Go Versatile Today for a Differentiated Service Offering!

Greenpacket invites you to take up the challenge of offering versatile modems like the Shuttle and increase the WiMAX adoption in your country. At Greenpacket, we understand the demands placed on Operators like you. That is why we furnish you with the power to offer subscriber more than just high-speed connectivity. Our innovation will provide you with endless ways to engage with today's sophisticated subscribers and enhance relationships.

With Greenpacket, limitless freedom begins now!

Free Consultation!

If you would like a free consultation or more information on Shuttle, feel free to contact us at marketing.gp@greenpacket.com (kindly quote the reference code, AP0710 when you contact us).

References

1. Opportunities and Risks for Embedding WiMAX in Consumer Electronics, Maravedis
2. Reaching Sustained Growth in the WiMAX Market, Senza Fili Consulting
3. Improving Indoor Coverage: How WiMAX Modems Can Play a Major Role in the Subsystem, Greenpacket

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.

For more information, visit: www.greenpacket.com.

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