



WIMAX 1.5 for Operators

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1. Introduction

Mobile WiMAX is one of the promising technologies, and it promotes low-cost deployment and service models as well as Internet friendly architectures and protocols. This paper briefly overviews the current version of mobile WiMAX, mobile WiMAX Release 1.0, which is based on IEEE 802.16e-2005, and expands on the upgraded version, mobile WiMAX Release 1.5, which is based on IEEE 802.16-2009. Release 1.5 enhances wimax performance as compared to its predecessors. This release will support operators with improved data rates, higher coverage and allow new services to be offered in their current Radio networks. Recently WiMAX Forum has published network specification for release 1.5. In this paper we will delineate the key enhancements of WiMAX release 1.5 that will help operators to deliver the best out of their wimax networks. We will broadly cover the following aspects in the current whitepaper.

- Release 1.5 PHY , MAC and network features
- Significance of release 1.5 to network operators
- Migration aspects of release 1.5

2. WiMAX Release 1.5 feature Description

Table 1, provides an overview of mobile WiMAX roadmap for standards and products. The first release labeled as Release 1.0 has more than 70 commercial deployments and has a matured ecosystem built around. The other two, Releases 1.5 and 2.0 are short-term and long-term migration, respectively, and their brief summaries are provided in this section. The corresponding IEEE baseline standards for Releases 1.5 and 2.0 are IEEE 802.16 REV2 (IEEE, 2008) and IEEE 802.16m (IEEE, 2006b), respectively. Each new generation of the technology needs changes in the profile and/or the standard itself.

Table 1: WiMAX Release features ¹

Release 1.0	Release 1.5	Release 2.0
ASN anchored mobility, 3 ASN profiles	Persistent scheduling for reduced MAC overhead	Reduced Latency
CSN anchored mobility	Femto Cell* introduction	Multihop Relays
(CMIP, PMIP)	Load balancing	Self-organizing capability (SON)
IPv4 & optional IPv6	BF+MIMO , UL MIMO (optional)	Enhanced VoIP support
Idle mode and paging	GPS & non-GPS based location services	Enhanced MCBCS (both static and dynamic multicasting)

EAP-based authentication	Enhanced Multicast & Broadcast services (MCBCS-APP and DSx)	Enhancements to LBS
Mobile, portable, nomadic, fixed	Wimax-WiFi-Bluetooth coexistence	Mobility: up to 500 km/hr
Pre-provisioned/static QoS	Ethernet services	Backward compatibility
Pre- and Post-paid RADIUS Accounting	Public Safety & emergency services	
Roaming (RADIUS only)	O & M Features OTA pre-provisioning & device management (OMA & TR69)	
O&M Features Network discovery/selection	PCC /PCRF (Dynamic QoS and policy based charging)	
Load balancing	USI (Universal service interface)	
	WIMAX SIM	
	ROHC	
	Lawful intercept	

* release 1.6 candidate

2.1 Support of FDD/HFDD Operations

Full duplex operation (F-FDD) utilizes transmission in downlink and uplink simultaneously ,but requires more expensive duplex filters as well as parallel two branch transceivers, one for the transmit operations and other for the receive operation. With the introduction of Half Duplex FDD (H-FDD) systems in WiMAX, operators can deploy wimax in FDD frequencies and still keep a check on Mobile station prices as the existing TDD based chipsets can be reused to support H-FDD systems. The operation is based on splitting the 802.16 frame into partitions which will be used by two distinct groups

of mobiles having separated the control channels such as downlink and uplink MAPs, fast feedback channels and HARQ ACK channels.¹

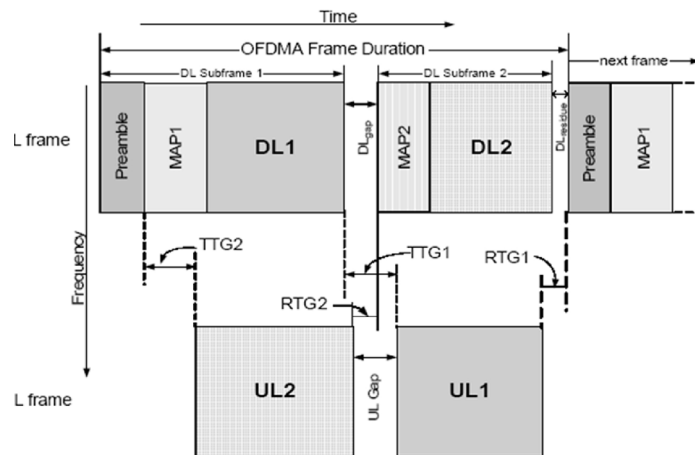


Figure 1 : HFDD Operation

2.2 New Band Classes

New band classes (introduced in WiMAX Forum Certification Profiles) will be added in Release 1.5, mostly to provide a solution for FDD bands.

2.3 Enhanced MIMO/BF Operations

Closed-loop operations for MIMO and BF are optionally considered to further improve the throughput and coverage beyond Release 1.0 which contains only open-loop MIMO and BF features. In Release 1.5 Codebook-based Closed-Loop MIMO, Band AMC MIMO, and UL 2Tx MIMO is introduced.

2.4 Enhanced MAC Performance (Particularly Improved VoIP Capacity)

Release 1.0 is highly optimized to data communication such as TCP/IP. The nature of the data traffic implies 'bursty' transmission demand. To properly serve such a demand, Release 1.0. Technology uses the mechanism of downlink and uplink MAPs which are control messages transmitted each frame, that is, every 5 ms. While this is good enough for bursty traffic, support for streaming (VoIP, video) data needs further optimization. The idea for optimization is to use persistent resource allocation so that a single MAP message provides information on periodic resources assignment matching the needs of a specific stream. Persistent allocation can be especially effective in supporting VoIP since VoIP traffic is periodic in nature and there is less need to change the MCS level for a certain amount of time period. However, there can be a variation in the wireless channel during the persistent allocation with the fixed MCS. In that case, power control (for example, the existing power control mechanism in the uplink and

¹ WiMAX Forum , www.wimaxforum.org

the different power boosting in the downlink) can be used as the link adaptation mechanism to compensate the wireless channel variation.

2.5 Extended and Enhanced Networking Features²

Simple IP: Simple IP specification allows IP address allocation without Home agent.

Location based Services:(Location based services with cell Id or GPS assisted)Location Based Services will permit operators to leverage value added services, typically associated with applications providing special information to the subscriber of the service, through knowledge of the SS/MS location, e.g., driving location or nearest restaurants etc. This capability can also be used to make use of the user's location information within access network internal operations, such as location assisted handover, and traffic and coverage measurement.

Universal service interface: Universal Services Interface (USI) is a framework for specifying required WiMAX network interfaces towards trusted third party iASPs (SLA between SP and iASP MAY be required). USI is intended to create a solution for service providers to generate additional revenue.

Multicast and broadcast services: MBMS is a point-to-multipoint service in which data is transmitted from a single source entity to multiple recipients. Transmitting the same data to multiple recipients allows network resources to be shared. MBMS architecture enables the efficient usage of radio-network and core-network resources, with an emphasis on radio interface efficiency. NWG 1.5 specifications support both type of MCBCS-DSx and MCBCS-App.

PCC/PCRF: Dynamic QoS control and charging rule control with IMS –PCRF

IMS interwork: P-CSCF discovery with DHCP option

Lawful interception: Lawful intercept with intercept in ASN-GW, HA and AAA

Coexistence of Wi-Fi/WiMAX and Bluetooth is planned in release 1.5.

² <http://www.wimaxforum.org/resources/documents/technical/release>

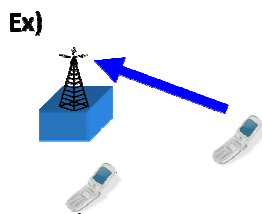
3. Significance of Release 1.5 for operators

3.1 Link Budget Improvements in release 1.5

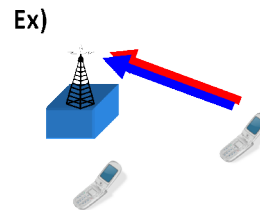
In Release 1.5, some improved features related to MIMO such as Codebook-based Closed-Loop MIMO, Band AMC MIMO, and UL 2Tx MIMO are added.

Uplink MIMO : The majority of the terminals that we have in current mobile wimax networks are 1 Tx in uplink and 2Rx in Downlink. Support of two receive antennas in downlink allows systems to work in advanced antenna configuration like STBC(space time block codes) and SM (spatial multiplexing) to achieve higher spectral efficiency and ability to transfer data at low SINR conditions.

Wave 2 Rel.1 , current systems (SIMO)

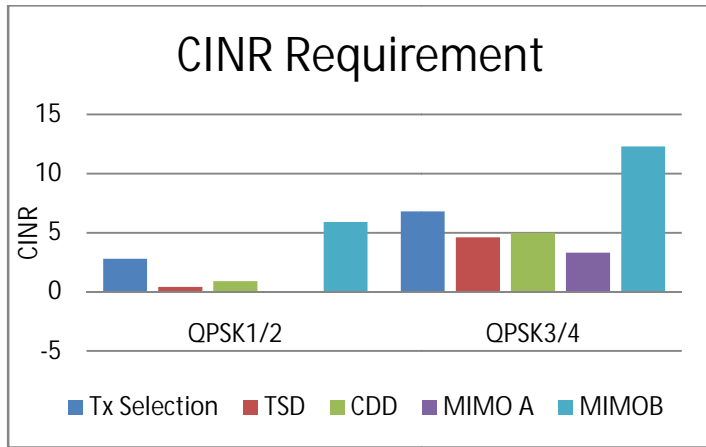


Single-user MIMO (2TX in Uplink), 1.5 Optional



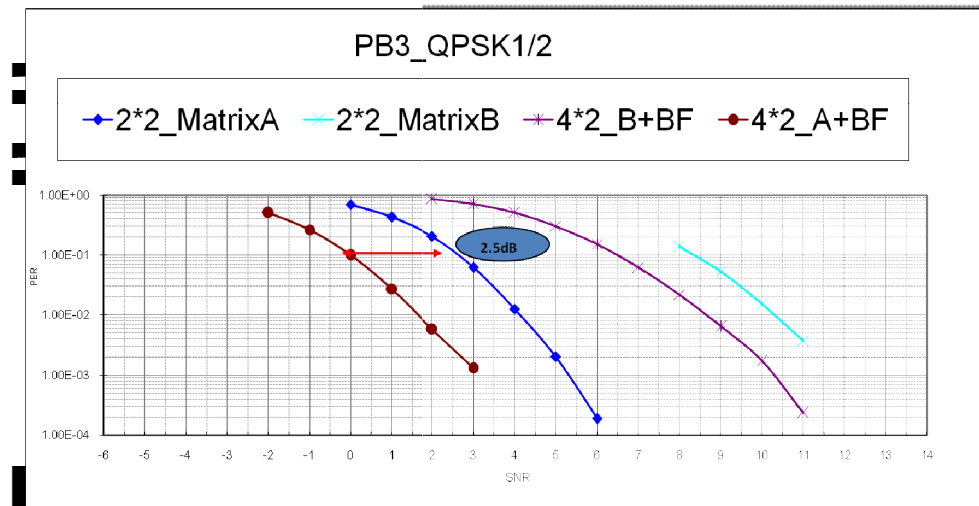
- BW/Coverage/Reliability/QoS improvements for devices operating in Nomadic usage scenarios (CPEs, MIDs, Laptops, PC-cards)
- System wide coverage benefits (site density reduction) for Nomadic deployments
- UL Capacity/Performance Requirements (symmetricity in uplink traffic)

There are Varsity of ways by which operator can leverage 2Tx to their full advantage and the most common and easy to implement option would be to use diversity techniques or uplink beamforming, as they do not require and software change in Base Station or amendments in standards. Little coordination with base station will allow operators to gain full advantages of 2Tx based advanced MIMO techniques like Marix A in and MIMO B . Release 1.5 has incorporated UL MIMO (MATRIX A & MIMO/Beamforming) as optional feature. The amount of link budget gain anticipated due to 2TX could be in the range of 2-4 db in uplink. The additional 2-4 db gain in uplink has potential to reduce 20 percent base station in coverage based deployment.



Use of MIMO A mode in 2Tx is more beneficial at cell edges as it provides reliable data transmission³. On the other hand, MIMO B requires higher SINR but has distinct advantage of improving capacity over single transmitted antenna device.

Downlink Coverage improvement with MIMO+BF profile: Operators can leverage 4/8 transmit based MIMO A +Beam forming based configuration which can provide additional 6 db downlink link budget gain as compared to 2*2 Matrix A based system.



4*2 means 4T on BTS side and 2R on CPE side, and it doesn't mean 2T4R of BTS.

DL 4T VS 2T , 2.5dB Matrix A gain and 3dB power gain to enhance the coverage.

Summary of expected coverage improvement ;Parameter	Uplink Gains	Downlink gains
2Tx in Uplink	2-4 dB	NA
4Tx MIMO A + BF	NA	2.5 db+ 3db (power combining)
4RX Receive diversity	2-3 dB (Depends on antenna element isolation)	NA

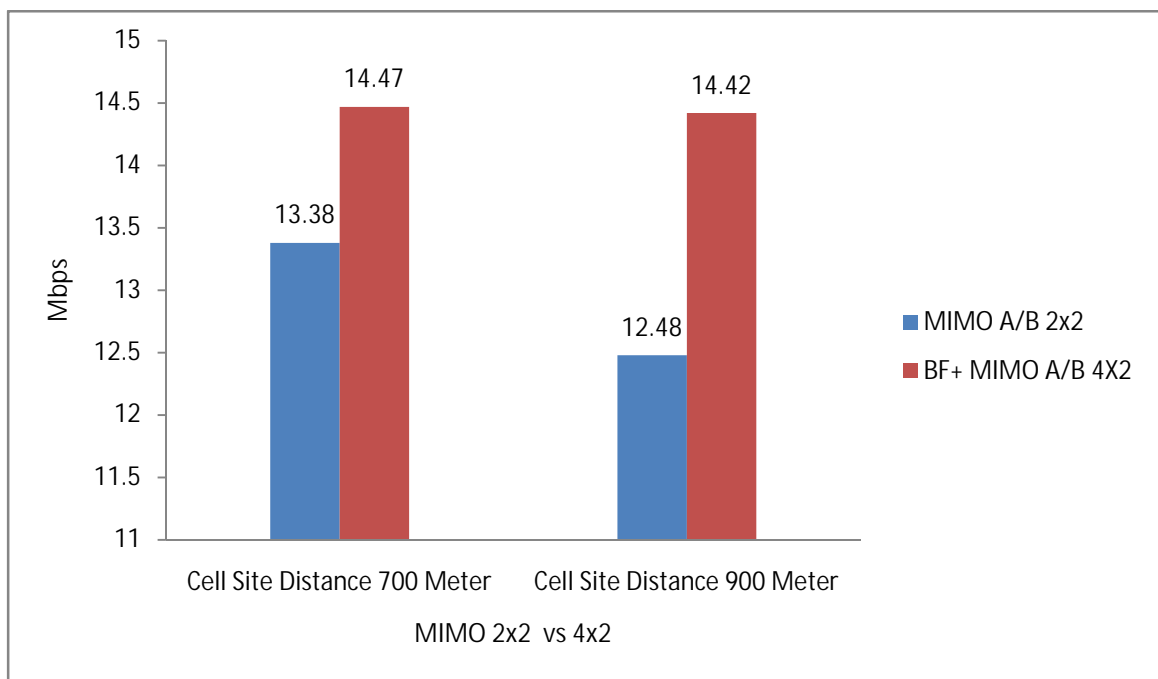
³ WiMAX Forum , TWG

3.2 Capacity improvements in release 1.5

64 QAM Support in Uplink: It is observed that peak downlink data rate in release 1.5 will be the similar to release 1.0. However, the peak data rate in uplink will be increased with the support of 64 QAM modulations. Please note that release 1.0 based systems has support of 16 QAM in uplink. The amount of improvement will depend on radio conditions and frequency reuse pattern, but on an average operator can expect sector improvement in the range of 5 to 10% in uplink due the introduction of 64 QAM. The support of uplink MIMO B can further improve capacity in uplink.

Capacity enhancement with DL Beam-forming: Two distinct advantage which operators can leverage with beamforming + MIMO A/B based systems over 2x2 MIMO systems are;

- a) Overall sector performance can be improved by 8-15 % with the introduction of MIMO+BF profile in downlink. Cell edge user performance will also benefit due to beam forming profile.
- b) Beam-forming profile will also assist in reducing overall interference in the network.



Summary of expected coverage improvement;

Parameter	Uplink Capacity	Downlink capacity
Beamforming +MIMO A/B	NA	8-15%
64 QAM UL	4-10 %	NA
UL MIMO B	5-10%	NA

Summary of Radio performance⁴

Parameter	Release-1	Release 1.5	Release 2	IMT Advanced
Peak spectral efficiency (b /s/ Hz/ sector) (Mixed Mobility)	6.2(2X2) 1.3(1X2)	6.5(2X2) 1.3(1X2, Without 64 QAM)	DL: 8.0/15.0 (2x2/4x4) UL: 2.8/6.75 (1x2/2x4)	DL: 15.0 UL: 6.75
Average spectral efficiency (b /s/ Hz/ sector)	1.3 (2x2) 0.7(1X2)	1.6 (2x2) 0.9(1X2)	DL (4x2) = 2.41 UL (2x4) = 2.0	DL (4x2) = 2.2 UL (2x4) = 1.4
Cell Edge Spectral (b /s/ Hz/ sector)	DL (2x2) = 0.09 UL (1x2) = 0.05	DL (2x2) = 0.09 UL (1x2) = 0.05	DL (2x2) = 0.09 UL (1x2) = 0.05	DL (4x2) = 0.06 UL (2x4) = 0.03
Latency	C-plane: 100 ms (idle to active) U-plane: 40-50 ms	C-plane: 100 ms (idle to active) U-plane: 40-50 ms	C-plane: 100 ms (idle to active) U-plane: 10 ma	C-plane: 100 ms (idle to active) U-plane: 10 ms
Mobility	Support up to 120 Kmph	Support up to 350 Kmph	Support up to 350 Kmph	0.55 at 120 km/h 0.25 at 350 km/h
Handover Interruption time	< 60 ms	<60ms	Intra frequency: 27.5 Inter frequency: 40 (in a band) 60 (between bands)	Intra frequency: 27.5 Inter frequency: 40 (in a band) 60 (between band)
Voip Capacity	12.5 (MHz) TDD	31.6 FDD	60 (DL 2x2 and UL 1x2)	40 (4x2 and 2x4) (Base coverage urban)

3.3 VoIP improvement in Release 1.55

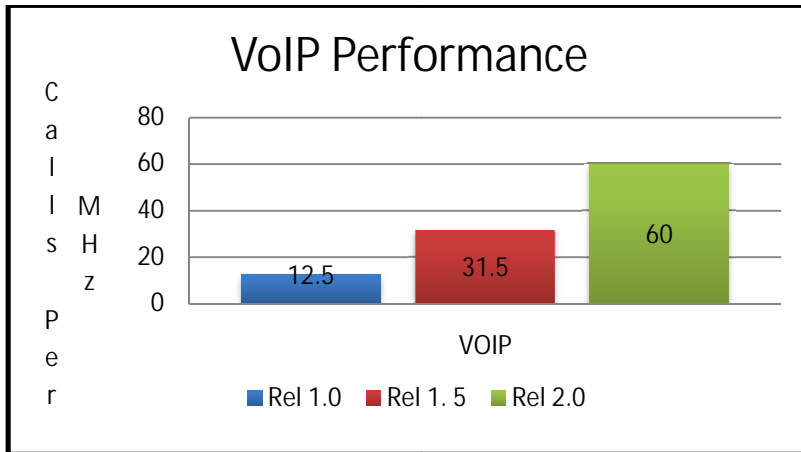
The existing Dynamic Burst Allocation scheme supports very flexible burst allocation in per-frame basis, but it can introduce large amount of control overhead with the small-sized bursts with periodic allocation characteristic such as VoIP. In the IEEE 802.16e-2005, there are several techniques to reduce the control overhead such as Compressed MAP and Sub-MAP, but further enhancement is required to improve the VoIP capacity of mobile WiMAX.

Persistent Burst Allocation scheme is introduced in IEEE 802.16-2009 where the specific resources with the same modulation and coding scheme (MCS) level are being allocated to a MS periodically for a certain amount of time period. When the bursts are allocated through the persistent allocation, MS tries to decode the MAP at every scheduled frame. If there is no MAP for the MS at the scheduled frame, MS thinks there is no change in the resource allocation from the previous one through the persistent allocation and attempts transmit or receive in the allocated burst region. If there is a MAP for the MS at the scheduled frame, MS can get the information such as the change of persistent region or the de-allocation information, and follows the BS's direction. Persistent allocation can be especially effective in supporting VoIP since VoIP traffic is periodic in nature and there is less need to change the MCS level for a certain amount of time period. However, there can be a variation in the wireless channel during the

⁴ Beyond4g, <http://www.beyond4g.org/4g-resources/itu>

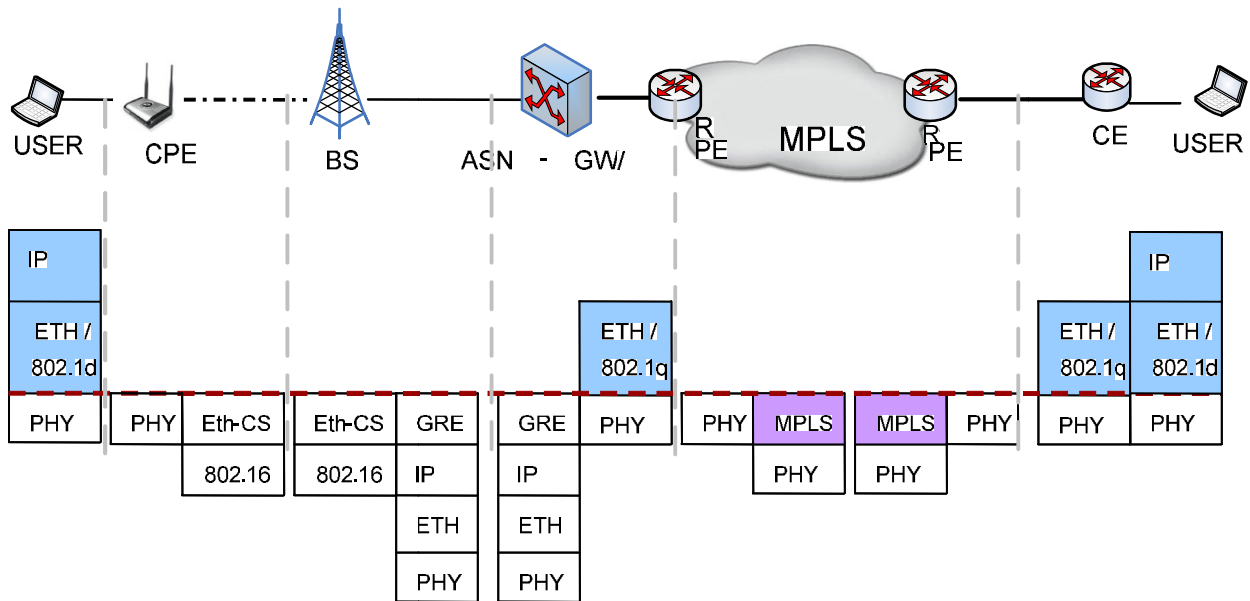
⁵ IEEE, Mobile WiMAX and Its Evolution Towards IMT-Advanced System

persistent allocation with the fixed MCS. In that case, power control (for example, the existing power control mechanism in the uplink and the different power boosting in the downlink) can be used as the link adaptation mechanism to compensate the wireless channel variation.



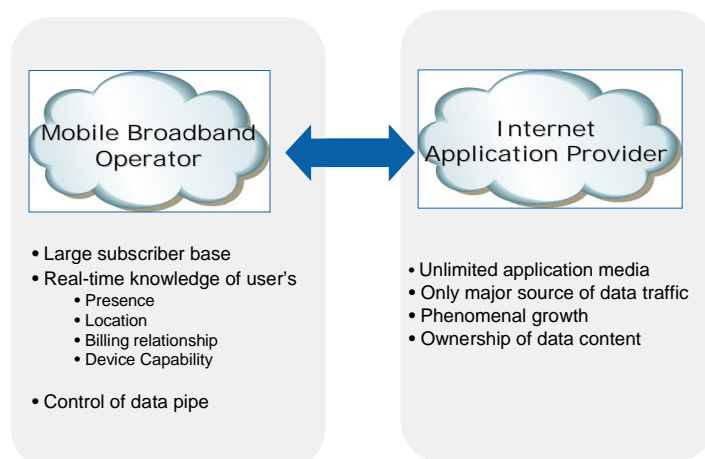
3.4 Ethernet services

A majority of WIMAX operators are Greenfield operator or has a background of IP based services. WIMAX Release 1.5 supports Ethernet based services which will enable operators to support layer-2-based services, such as PPPoE, VPDN, and VPLS.



3.5 Universal service Interface

Universal Services Interface (USI) is a framework for specifying required WiMAX network interfaces 2 towards trusted third party iASPs (SLA between SP and iASP MAY be required). USI is intended to create a solution for service providers to generate additional revenue .



New Business Model Opportunity with USI

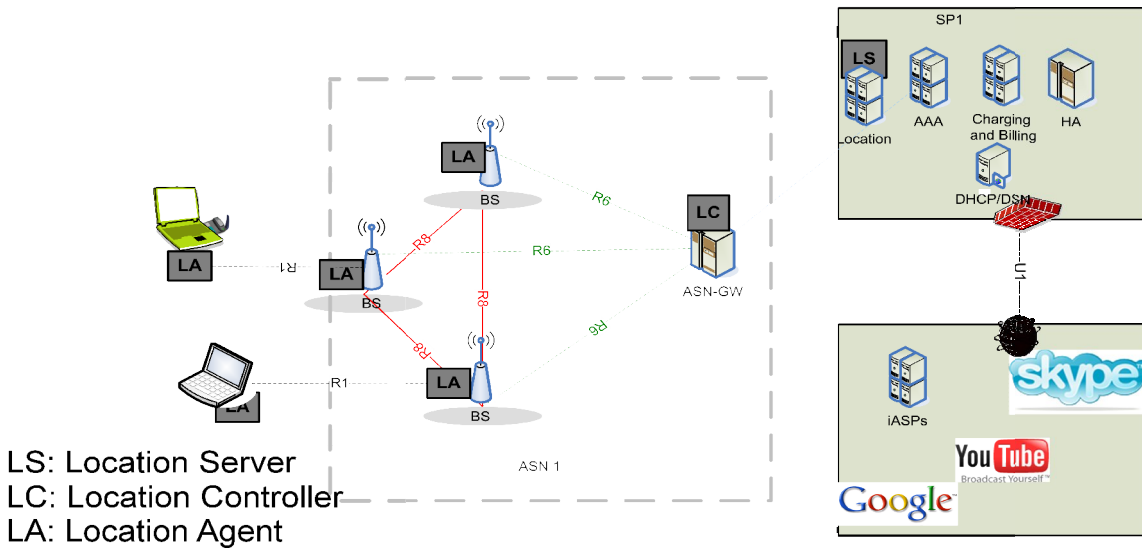
Internet is unlimited in media & source. From the recent trends it is evident that walled garden approach is no more the best way for content, consumer wants openness. The huge success of Apple App stores, massive data traffic in you tube & social networks are testimony for this approach. The idea is to collaborate with iASP with service provider intelligence (location, presence, new devices) & Quality of experience.

Services	iASP's	Remarks	New Business Model opportunity
Information Searching	Google, Yahoo		Tag Location
Social Networking	Face book, Orkut, Link din		Current Location +
Online Shopping	Ebay + bazee + Rediff shopping		Security during transaction + location specific Advertisement
Music Download	Groveshark, LastFM, Pandora	5 sec 89c to 99c,	QOS (Speed , Latency , Jitter)
Video upload/streaming	You tube , MySpace, Yahoo & google video	512 to 1024 kbps	QOS , Latency , space , etc
Video Download	Hulu, lmdb, surf the channel	Highest possible speeds	QOS like guarantee them one movie download in 5 mins etc
Online Gaming(multiplayer interactive)	PS3, Stars wire combine, Mafia, Mobsters	Heavy data rate	Low Latency ~25 ms
Mobile TV	Operator content	300 to 500 kbps	QOS, Latency <160 , jitter <50
Video call	Operator	300 to 500 kbps	QOS
Voip	Skype, Gtalk, yahoo	64 kbps	QOS , latecny (15

3.6 Location based service

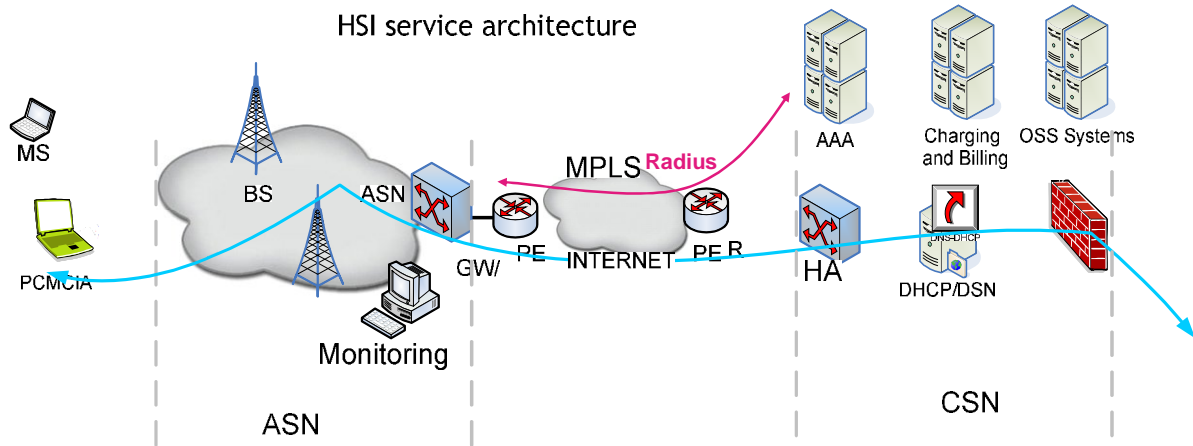
Location is seen as one the major new business model drivers in new mobile WiMAX Networks. A major difference between mobile broadband networks and fixed networks is that the former can be subject to location changes. This provides a huge opportunity for location based services (LBS) which have very broad potential to integrate with high performance mobile services. General LBS include the updating of maps, provision of information on the location of shops, service points, etc., depending on the location of the user.

As LBS become more intuitive to use, require regular updates when on the move and have access to the sophistication of applications like Google Maps and Google Earth, they are expected to drive network traffic to considerable volumes. Operators are strongly interested in LBS as a route to providing true personalized services, and, with true broadband connectivity, they will be able to take advantage of devices with embedded GPS to offer their own and third party services, e.g. using Google Maps or similar. Services such as these raise the possibility of new business models to be developed for charging users or specialist service providers for use of network capacity.



4. Migration aspects of Release 1.5

We have below identified migration aspects of all the candidate features of release 1.5.



Feature	Type of upgrade in ASN	Type of upgrade in CSN	Comments
Simple IP	Software	Software	
MIMO+BF	New Radios (4/8TRX systems) and Software	NA	New operators can buy higher antenna systems at start
2 TX in Devices	Additional RF chain to support 2 Tx in uplink		New operators can buy 2 tx based devices from the start,
Diameter	Software	Software	
LI	Software	Software	
ROHC	Software	Software	
PMIP V6	Software	Software	
LBS	Software	New Location server and associated software	
PCC/PCRF	NA	New PCC servers and new software's	
MCBCS	New Software's (MCBCS capable devices)	New Software's + Servers	MCBCS capable devices
USI	NA	Software+ Additional servers	
WiMAX SIM	NA	NA	

5. Conclusion

WiMAX systems based on release 1 have shown significant advantage over their 3G competitors when it comes to deliver all IP based data services over wireless. Mobile Data is one of the fastest growing segments in wireless, and mobile data traffic will grow at a compound annual growth rate (CAGR) of 108 percent between 2009 and 2014.⁶

We have presented that WiMAX Release 1.5 is an important interim step before operators can fully migrate to a completely new release to deliver the unprecedented growth expected in mobile data segment. WiMAX Release 1.5 has support for improved antenna systems which will help operators to delivery superior capacity and improved coverage .Operators who are planning voice over WiMAX will benefit with new persistence scheduling mechanism introduced in Release 1.5.

Location based services ,USI architecture, and Ethernet based services will allow operators to generate additional revenues from their commercial WiMAX networks and these initiatives holds the promise of much closer interworking with internet application providers and network service providers. Policy based charging and dynamic Quality of services will provide intelligent charging mechanisms to enable delivery of new services models.

⁶ CISCO VNI,
http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.html