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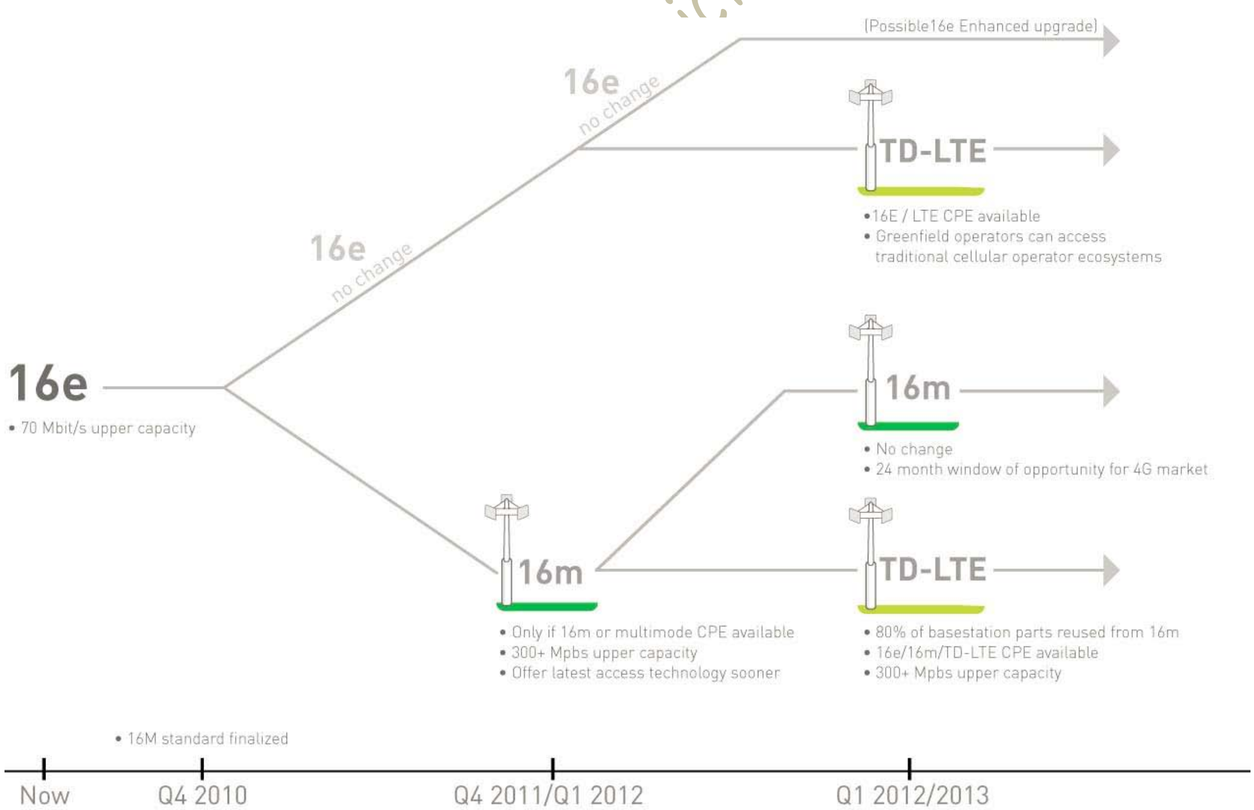
LTE & WiMAX Blog

Migration Strategies for WiMAX 1.0 | Harish Vadada

Last few days have been an eye opener for NBA fans – the King left Cleveland! And the owner of Cavs got upset, and wrote an open letter to LeBron – but has anybody given a thought what LeBron as person might be feeling - a need to fulfill his dream and willing to take a pay cut in the process? So, why am I taking about NBA and LeBron? Well WiMAX is in a similar position, a great technology and ecosystem that is still in the process of discovering its potential, and achieving maturity. The way it has been deployed and the speeds it generates is 3G+, but there is a vast potential for it to achieve better which has remained untapped.

WiMAX Forum is working on the 802.16m specs but there are no takers for it, yet. Yota – a Russian WiMAX provider has stopped rollout of WiMAX, Indian spectrum auction is over but the tide seems to have turned the TD-LTE way. Clearwire has taken a timeout and said that they will evaluate their strategy and decide whether to go TD-LTE or WiMAX Rel.2. All this news sound like a death knoll for WiMAX technologists and evangelists, are they with the team that is losing out? A defeated technology always takes a backseat, and will remain a niche. Will that be the way WiMAX will go? It might be the most probable way – so what happens to the operators who have deployed WiMAX 1.0, will they survive the race towards 4G supremacy? What will happen to the operators who have deployed WiMAX, will they have a migration strategy in place or cut their losses and migrate to 3GPP ecosystem? Let us explore the possibilities and pros and cons for every move and a deeper understanding of the evolution of the ecosystem.

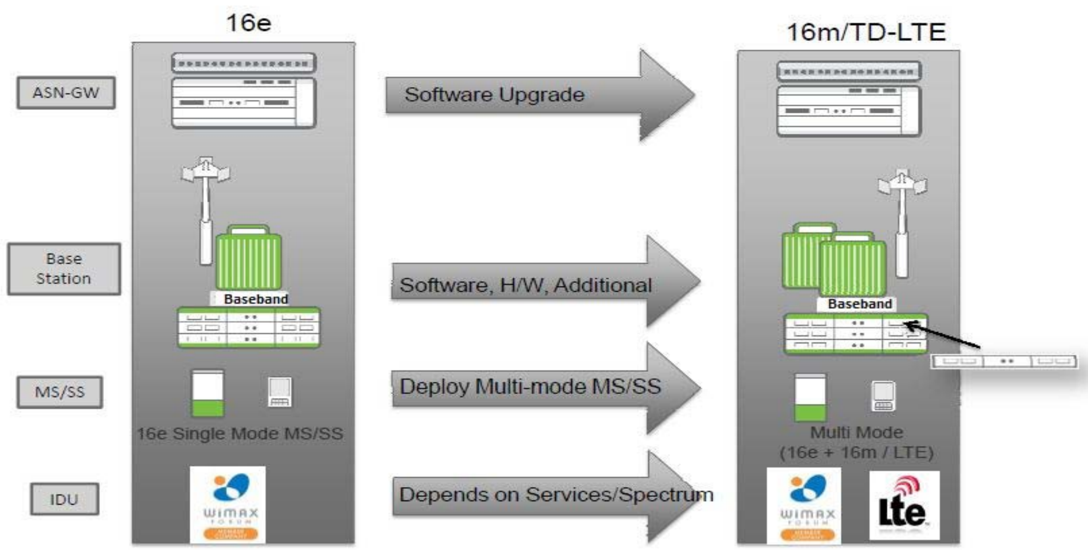


Two main contributors for any WiMAX operator on the evolutionary path to newer 4G wireless technologies would be availability of spectrum and broad device ecosystem support. Sufficient amounts of Time Division Duplexing (TDD) spectrum are not available for all operators in all applicable frequency bands to allow for simultaneous or multi-carrier migrations. This spectrum availability issue will restrict some operators from deploying 16m or TD-LTE. In turn, a lack of deployable spectrum will limit the device ecosystem that vendors will support. Service providers offering applications in niche frequencies will just have to cope with high device costs if they do intend to compete in the 4G market. However, the most important element in the consideration of spectrum availability and ecosystem support will be the presence of interoperable 16e/LTE or 16m/LTE end-user access devices for the still unfolding 4G roadmaps.

WiMAX 2.0

WiMAX forum released a progress report earlier this year explaining the 802.16m, enhancements and technology concerns. In December 2006 the IEEE launched an effort to further evolve the IEEE 802.16 Wireless-MAN OFDMA specification. This amendment, known as 802.16m, is designed to meet or exceed the requirements of IMT-Advanced (the 4th generation of cellular systems). With a number of stringent requirements for backwards compatibility, the 802.16m amendment will provide the basis for WiMAX System Release 2 and provide existing WiMAX operators a graceful migration path to gain performance enhancements and add new services. As was the case for 802.16e-2005, 802.16m is designed to support frequencies in all licensed IMT bands below 6 GHz and include TDD and FDD duplexing schemes as well as half-duplex FDD (H-FDD) terminal operation to ensure applicability to the wide range of worldwide spectrum assignments. This release should be able to address these:

- Increased Coverage and Spectral Efficiency
- Increased Capacity for Data and VoIP
- Lower Latency and QoS Enhancements
- Interworking with other Wireless Networks
- Power Conservation
- Other Advanced Features and Supported Services



Spectral Efficiency

Improvement in the link budget over WiMAX System Release 1 of at least 3 dB with the same antenna configuration. Alternatively the improved link budget can be translated to increased cell edge user throughput resulting in a two times improvement over WiMAX System Release 1. Several other enhancements included in IEEE 802.16m will improve spectral efficiency for data services. These enhancements include:

• Extended and improved MIMO modes with emphasis on multi-user MIMO (MU-MIMO) on both DL and UL to enable support for up to 8 data streams in the DL and up to 4 data streams in the UL.
• Improved open-loop power and closed-loop control
• Advanced interference mitigation techniques including fractional frequency reuse and inter-base station coordination
• More efficient use of pilot tones with new sub-channelization schemes and a cyclic prefix of 1/16 vs. 1/8 to reduce layer 1 overhead in both DL and UL
• Enhanced control channel design on both DL and UL with

  - Reduced overhead
  - Improved coverage through power boosting and optimized channel coding
  - HARQ protection for control messages

The net result of these enhancements will provide more than 2 times improvement in average channel spectral efficiency.

Data Capacity: The spectral efficiency enhancements described in above leads directly to increased channel data capacity and increased peak data rates.

Multi-Carrier Support: The IEEE 802.16m amendment also supports channel aggregation of contiguous or non-contiguous channels to provide an effective bandwidth up to 100 MHz The channels do not need to have the same bandwidth nor do they need to be in the same frequency band. This capability will enable operators with access to multiple channels or licenses to achieve significantly higher peak and average data rates than is achievable with individual channels. Aggregating several 20 MHz channels, for example, could support peak data rates exceeding 1 Gigabit/sec.

VoIP Capacity: With persistent and group scheduling, faster HARQ retransmissions, rate matching, optimized QoS support, and the other spectral efficiency enhancements described in the previous section, VoIP capacity is significantly increased with 802.16m.

Latency improvements with IEEE 802.16m are achieved with the use of a new sub-frame based 4 frame structure rather than a fixed 5 ms frame as used with WiMAX System Release 1. This enables faster air-link transmissions and retransmissions resulting in shorter user plane and control plane latencies. Latency objectives for IEEE 802.16m are:

- Link Layer/User Plane: < 10 ms DL or UL
- Hand-Off Interruption: < 30 ms
- Control Plane, Idle to Active: < 100 ms

In addition, some of the 802.16m features already cited will enhance the end-user experience.

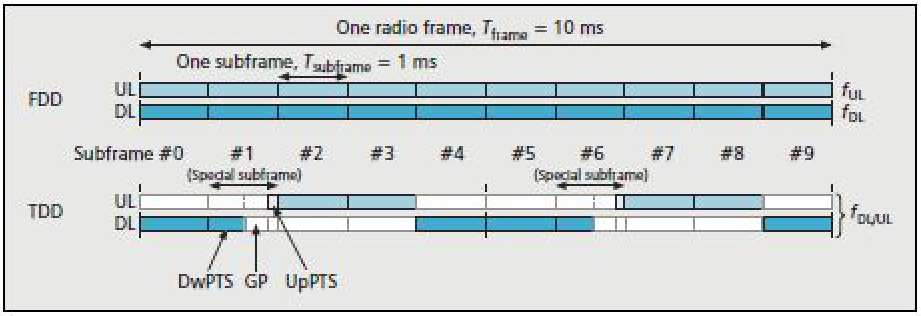
• The use of femto-cells can lead to higher average user throughput for users at the cell edge or indoors.
• 802.16m provides a shorter handoff interruption time to other Radio Access Technologies including - Wi-Fi Networks, 3GPP: HSPA, LTE, and LTE Advanced, 3GPP2: 1x-EVDO
• Idle Mode efficiencies like broadcast traffic without the need to register with a specific base station.
• Enhanced Multicast Broadcast Services (E-MBS) to provide greater broadcast and multicast spectral efficiency and support for switching between broadcast and unicast services.
• Enhanced GPS-based and Non-GPS-based Location Based Services (LBS) using triangulation schemes with < 30 seconds latency for location determination.
• Enhanced security with more advanced encryption schemes assuring confidentiality of user identity and user-generated data packets (e.g. location privacy and user identity protection).
• Mobility: An IEEE 802.16m mobile station will maintain a connection up to 350 km/hr and in some cases 500 km/hr depending on the operating frequency band.
• Self-Organizing Network (SON) features to enable self-configuration and self-optimization. Self-configuration enables true plug and play of network nodes and cells as well as fast reconfiguration and compensation in cases of failure. Self-optimization ensures optimal network performance with respect to service availability, QoS, network efficiency, and throughput under changing traffic and environmental conditions.

This migration path will be very seamless and the most logical path to ensure for operators that have 802.16e systems today.

TD-LTE

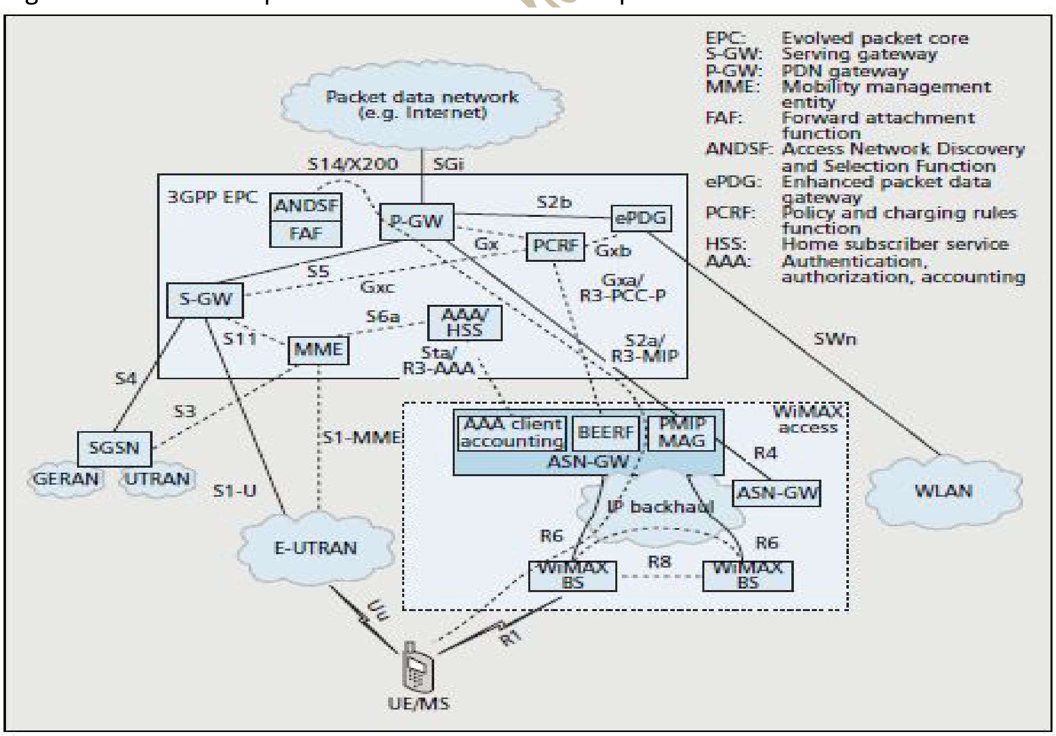
LTE from its inception was designed to provide a single radio interface supporting both FDD and TDD to provide an even larger economy-of-scale benefit to both duplex schemes. Virtually all of the physical-layer processing is identical for FDD and TDD, enabling low-cost implementation of terminals supporting both the FDD and TDD modes of operation. According to Monica Paolini from Senza Fili consulting – *"TD-LTE throws a wrench into this picture. LTE becomes much more intriguing--almost disruptive. "*

And that in itself is the very basis for LTE ecosystem, it is almost as similar to the WiMAX standards, but has the advantage of already available WCDMA/UMTS customer base that will be migrated to LTE. Some of the advantages like the possibility for different uplink and downlink bandwidths, enabling asymmetric spectrum utilization.



Depending on regulatory aspects in different geographical areas, radio spectrum for mobile communication is available in different frequency bands of different sizes and comes as both paired and unpaired bands. Paired frequency bands imply that uplink and downlink transmissions are assigned separate frequency bands, whereas in the case of unpaired frequency bands, uplink and downlink must share the same frequency band. An essential part of any TDD system is the provisioning of sufficiently large guard periods during which equipment can switch between transmission and reception with no overlap of signals to be transmitted and received. In LTE, guard periods are created by splitting one or two subframes, referred to as special subframes, in each radio frame into three fields: a downlink part (DwPTS), a guard period (GP), and an uplink part (UpPTS).

A successful migration to TD-LTE for a WiMAX system would be possible only if they are backward compatible and an Inter-RAT handover. This is possible with the Mobile IP (MIP) based hard handover called Vertical Handover (VHO). The MIP mechanism hides the heterogeneities of lower-layer technologies and provides a seamless handover between WIMAX-3GPP, though it has shortcomings like degradation of user experience and loss of buffered packets at the ASN and SGW.



Inter-Technology Handover

There are four general classes of Inter-RAT handovers, for service continuity between different technologies – 3GPP and non-3GPP including WiMAX, EVDO, etc.

Single Transmit Device with MIP (IETF RFC 3344)
This is simple MIP-based mobility using a device that is only capable of communicating in one technology at a time. Two examples of this approach are the single transmitter versions of the non-optimized inter-technology handover procedure defined in the 3GPP standards for inter-technology mobility between WiMAX and LTE and between EVDO and LTE. Since the device can only communicate with one technology, it must break its connection with the source network before it can establish a connection with the target. Depending on the technology, the signaling associated with getting access to and authenticating on the target network can be quite time consuming (on the order of several seconds) and cause a significant gap in the user's session.

Dual-Transmit Devices with MIP
For environments where the level of inter-standards cooperation is less pronounced or where there is an urgent need to get inter-technology mobility deployed quickly, the Dual-Transmit Device (DTD) approach is attractive. In this approach the device does a true make-before-break handover to prevent data loss or the need for retransmission. The device uses its second transmitter to register and authenticate on the target network while maintaining its existing data session on the source network. Once the preliminary work is completed, and the device is ready to receive data on the new network, it uses a supported Internet protocol such as Mobile IP to move the data stream from the source to the destination network. The LTE standards accommodate the use of MIP in combination with DTDs to support efficient inter-technology mobility between LTE and WiFi. The WiMAX Forum is also standardizing the use of DTDs with MIP with the primary goal of supplying mobility between EVDO and WiMAX.

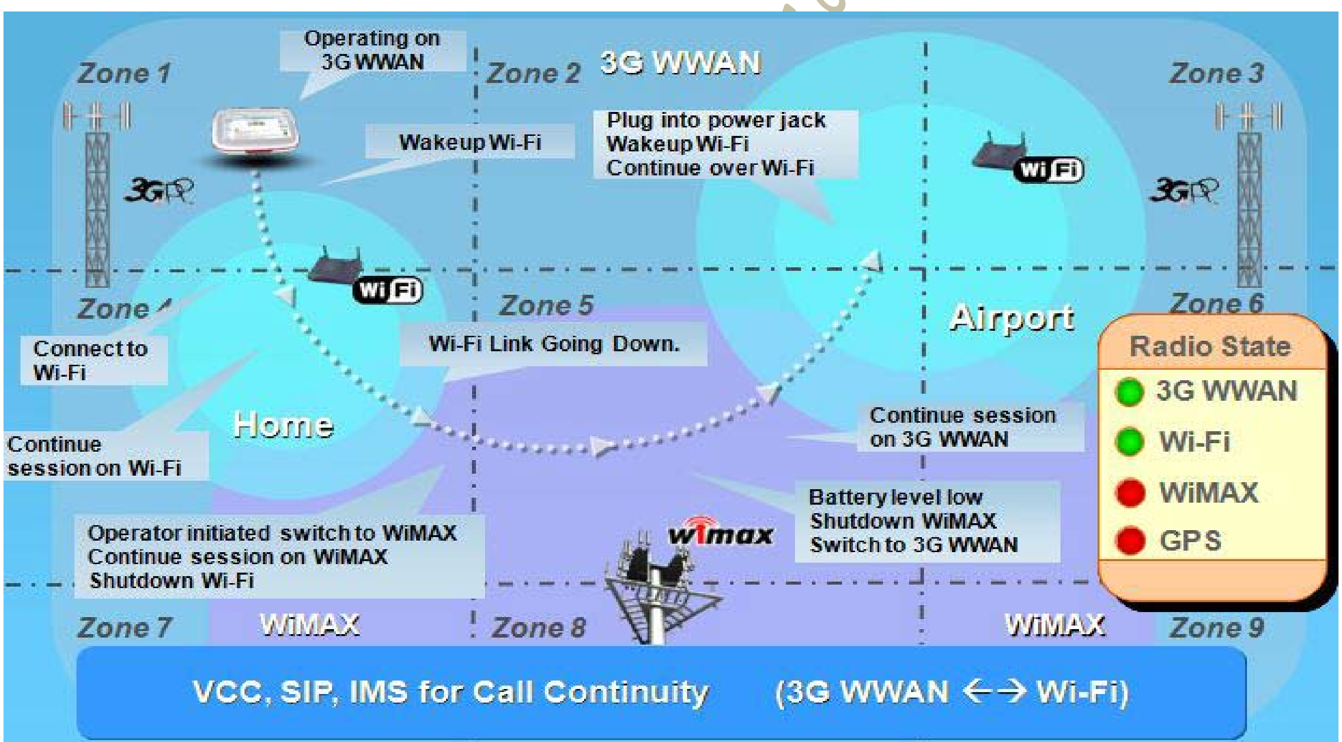
Access Network Interconnect
This requires the source and target access networks to be intimately connected in some way so that they can exchange control messages to help guide the movement of the device from one access technology to the other and to reduce the time that device is unavailable on either network. Historically this approach has been available for different generations of the same root technologies such as cdma2000 → EVDO or GSM → UMTS, and this approach is being carried forward to provide mobility between LTE and GSM or UMTS. In all these cases the old and new technologies were controlled by the same standardization body, and the interworking can be just as easily viewed as a backwards compatibility requirement as an inter-technology mobility requirement. With the introduction of LTE however, the limitation of access network interconnection to technologies covered by the same standards body is changing. With the help of its member organizations, the LTE standards body, 3GPP, is working closely with the EVDO standards body, 3GPP2, to define inter-technology handover procedures that include mechanisms for interconnecting the LTE and EVDO RANs. Handover mechanisms that include exchange of information between the source and target RANs are generally referred to as optimized handover in the LTE standards. Optimized handover will support low-delay inter-technology handovers that can support demanding applications such as VoIP and video streaming. Currently LTE-

EVDO optimized handover has made the most progress in the standards process, but optimized handover between LTE and WiMAX is also work by both WiMAX Forum and 3GPP.

Dual Transmit Device with SIP

Due to a variety of practical, technical and business factors, MIP can be difficult to implement in some environments leading to the fourth approach of DTDs coupled with the Session Initiation Protocol. SIP can often be used in conjunction with dual-transmit devices instead of MIP. Additionally, SIP is the only choice if there is a need to move data sessions between devices as well as between technologies – e.g. a requirement to move a video session from a plasma screen supported by a set-top box connected to a DSL link to an LTE mobile device. An obvious drawback to this approach is that it is only applicable for those applications based on SIP. Also it will not work for any application that is sensitive to a change in a correspondent's IP address (e.g. many applications based on TCP). Some additional standardization effort is needed to support inter-device and inter-technology mobility with SIP and IMS. The complete sets of standards were completed in 3GPP Release 9.

Inter-technology mobility offers operators the promise of extracting more value from their access networks and provides them with a powerful set of tools for matching network resources to application requirements. Inter-technology mobility is a key facilitator for the incremental rollout of an LTE network.



The IEEE 802.21 body is attempting to model an access-network-independent abstraction of inter-technology handover that could be used with any pair of access network types. Concepts developed by IEEE 802.21 for solving general inter-technology mobility problems (MIH – Media Independent Handovers), are being carried over into other standards bodies where they are adapted to resolve problems specific technologies. Also the Internet standards body, IETF, has been working closely with the wireless standards community to ensure that new internet protocols are well suited for wireless inter-technology applications (e.g. Proxy Mobile IP version 6 – PMIPv6 – and DIAMETER).

Conclusion

Whatever the outcome of the migration path choices for WiMAX operators, it shall be important for their survival as first mover advantage in the 4G market. As Mobile WiMAX operators plan their deployments, many anticipate making a full or partial migration to next-generation technology. In fact, it is not a question of whether to migrate, but rather of how to migrate. The ecosystem shall be defined by the standards – WiMAX Forum is slated to finalize the 2.0 standards by Q4 2010 and TD-LTE trials are still ongoing with production networks slated to roll out by 2012. So the question that needs answered is can they upgrade to 16m now but preserve an upgrade path to TD-LTE? Or is it better to maintain the network with 16e or 16e-Enhanced? I would think that available spectrum, developing ecosystem and operator partnerships would play a vital role in the decision making. RAN-sharing too should be taken into consideration as spectrum assets become scarce for operators as well as the fact that many operators have overpaid for the spectrum assets and a spectrum re-farming efforts gain momentum.