

## LTE and WiMAX Comparison at a Glance



Issue	LTE	WiMAX
<b>Definition</b>	<ul style="list-style-type: none"> <li>• Long Term Evolution (LTE) is a new radio standard being defined in 3GPP that is based upon the same technology (OFDMA-MIMO) as WiMAX.</li> <li>• LTE networks will require new client devices and service providers will need to purchase new radio access network (RAN) equipment in addition to upgrading their backhaul capacity and core networks to handle additional IP-based traffic.</li> </ul>	<ul style="list-style-type: none"> <li>• WiMAX is a high performance, next-generation wireless solution available today, employing a proven, OFDMA-MIMO based solution based upon the IEEE 802.16 standard.</li> <li>• IP-OFDMA (IEEE 802.16e) is included in the IMT-2000 family of mobile wireless interface standards. WiMAX is supported by a broad, open and innovative ecosystem including more than 530 member companies in the WiMAX Forum.</li> <li>• WiMAX addresses a range of profitable business models with much lower cost per bit than other available technologies, making it suitable for connecting remote villages in India or delivering mobile Internet services in downtown Seoul.</li> </ul>
<b>Overall Timing</b>	<ul style="list-style-type: none"> <li>• The LTE radio air interface is still in the standards development process, with an expected completion in 2009.</li> <li>• LTE access networks are designed to connect to a new, all IP core network. This new network standard (SAE) is also still in the 3GPP standards process with an expected completion of the air interface standardization in mid 2009.</li> <li>• Initial infrastructure is expected in late 2009 with initial commercial deployments of LTE in 2010 or later. Lab and demonstration trials are in process.</li> </ul>	<ul style="list-style-type: none"> <li>• The latest revision of the IEEE 802.16 standard (802.16e) was completed in December 2005.</li> <li>• WiMAX access networks connect to an all IP-based core network, the standards definition of which was completed in March 2007.</li> <li>• Over 407 fixed and mobile WiMAX networks have been commercially launched in 133 countries.</li> <li>• KT's WiBro network was the first commercial deployment of a Mobile WiMAX network based upon the 802.16e standard. Recently, Sprint's Xohm service was launched in Baltimore, Maryland.</li> <li>• The first WiMAX products were certified in January 2006 (fixed) with the first Mobile WiMAX products receiving the WiMAX Forum Certified™ seal of approval in April 2008.</li> </ul>
<b>Spectrum Availability</b>	<ul style="list-style-type: none"> <li>• Either new spectrum or the re-farming of wide swaths of 2G spectrum will be necessary to free up sufficient spectrum to deploy LTE in wider channels for high speed broadband.</li> <li>• In U.S., operators are expected to deploy LTE in the 700 MHz or perhaps 1.7/2.1 GHz bands; whereas in Western Europe, LTE will be deployed in the 2.5 GHz band. The process to allocate spectrum for LTE in China is in its infancy.</li> <li>• LTE supports FDD spectrum. LTE's adoption of TDD is coming along only with support of China Mobile in China – potentially delaying it.</li> </ul>	<ul style="list-style-type: none"> <li>• WiMAX networks have been deployed in the 3.5 GHz band in every region.</li> <li>• WiMAX is being deployed globally in the 2.5 GHz band in countries such as the U.S., Japan, Taiwan, Russia and Mexico.</li> <li>• WiMAX has been deployed in the 2.3 GHz band in South Korea, Malaysia and Singapore with future deployments anticipated in Vietnam, Thailand, Indonesia, Australia and Canada.</li> <li>• India approved auctions for 2.3 and 2.5 GHz in December 2008.</li> <li>• Multi-band devices are planned for support of WiMAX global roaming and expected to be ready in 2009.</li> <li>• Mobile WiMAX profiles for 700 MHz and 1.7/2.1 GHz bands will be approved in 2H'08.</li> <li>• Mobile WiMAX Rel 1.0 currently supports TDD spectrum, which is more efficient than FDD for dynamic data traffic. However, to accommodate operators with FDD spectrum the WiMAX Forum plans to include FDD in WiMAX standards in Rel 1.5.</li> </ul>

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<b>Devices and Pricing</b>	<ul style="list-style-type: none"> <li>No devices available (no approved specification from which to build devices, LTE specification may not be approved until 2009)</li> </ul>	<ul style="list-style-type: none"> <li>Based on an open Internet model, WiMAX enables multiple device models -- traditional "cellular" models where the device is subsidized by the carrier and/or models where consumers purchase one or more devices in retail and connect to the service provider of their choice.</li> <li>Available today: USB dongles (some with MP3 players, storage and mobile TV capability), PC cards, dual mode HSPA/WiMAX &amp; EV-DO/WiMAX smartphones, notebooks and MIDs. For more information, please visit <a href="http://www.ktwibro.com/ktwibro/terminal/tmn_main.html">http://www.ktwibro.com/ktwibro/terminal/tmn_main.html</a>.</li> <li>100+ WiMAX Forum Certified™ devices by year-end 2008</li> <li>1,000+ WiMAX Forum Certified™ devices expected by 2011.</li> </ul>
<b>Services and Service Models</b>	<ul style="list-style-type: none"> <li>No services available as yet.</li> <li>Few operators are looking at fixed services under the LTE business model, impacting economies of scale and decreasing the flexibility of the technology.</li> </ul>	<ul style="list-style-type: none"> <li>Broadband data services supporting fast download and upload speeds and low latency for voice, video and multimedia (gaming) services.</li> <li>Supports fixed, nomadic, portable, and mobile usage models.</li> <li>Prepared to support Global roaming based on activity lead by WiMAX Forum with its Roaming Readiness program available December 2008.</li> </ul>
<b>Performance</b>	<p><b>LTE Peak Rates*:</b></p> <ul style="list-style-type: none"> <li><b>172.8 Mbps DL / 50.4 Mbps UL</b> (assumes 2x2 MIMO DL / 1x2 SIMO UL, 1/1 code rate, 20MHz channel bandwidth and 64QAM modulation)</li> <li><b>144 Mbps DL</b> (2x2 MIMO, 5/6 code rate and 20MHz channel and 64QAM)</li> <li>Target mobility of up to 350 km/hr</li> </ul> <p><i>* Note: 1/1 code rate numbers based on T-Mobile Trials ("Trials—Ensuring Success for Innovation", Joachim Horn, T-Mobile, NGMN Conference presentation, June 25-27, 2008). These numbers are extrapolated for a 5/6 code rate for better comparison with WiMAX and to reflect that most operators will want a coding rate which supports error correction..</i></p>	<p><b>Rel 2.0 DL Peak Rates: Timing: 2011+</b></p> <ul style="list-style-type: none"> <li><b>175 Mbps</b> (assumes 2x2 MIMO, 1/1 code rate, 20 MHz channel and 64QAM)</li> <li><b>145Mbps</b> (assumes 2x2 MIMO, 5/6 code rate, 20 MHz channel and 64QAM)</li> <li><b>350 Mbps</b> (4x2 MIMO, 1/1 coding, 20 MHz at 64QAM)</li> <li>Target mobility of up to 350 km/hr</li> </ul> <p><b>Rel 1.5 Peak Rates: Timing: Q4 2009</b> (assumes 2x2 MIMO DL/1x2 SIMO UL, 5/6 code rate, 20 MHz and 64QAM)</p> <ul style="list-style-type: none"> <li>144 Mbps (DL) and 69 Mbps (UL)</li> <li>Mobility of up to 120 kilometers/hr</li> </ul> <p><b>Rel 1.0 Peak Rates 1.0: Available Now.</b> (assumes 2x2 MIMO, 10 MHz, 64 QAM)</p> <ul style="list-style-type: none"> <li>45 Mbps (DL) and 13 Mbps (UL); note: assumes DL to UL ratio of 3:1, UL assumes DL to UL ratio of 1:1</li> <li>Mobility up to 120 kilometers/hr</li> </ul>

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<b>Ecosystem</b>	<ul style="list-style-type: none"> <li>• LTE is supported by a number of mobile operators, a few of which have secured spectrum for the earliest commercial deployments in 2010. Most operators will deploy in the 2012 or beyond timeframe.</li> <li>• More than 250 member companies participate in 3GPP standards body.</li> </ul>	<ul style="list-style-type: none"> <li>• WiMAX has developed into an open, substantial and diverse ecosystem with the goal of driving down prices of a variety of devices that can deliver affordable and flexible broadband services.</li> <li>• 530+ members of WiMAX Forum comprising service, content, equipment, and silicon providers           <ul style="list-style-type: none"> <li>- 400+ networks have been deployed or are being actively planned for near term commercialization around the world in approx. 133 countries, including Sprint/Clearwire (US), UQC (Japan), Reliance, BSNL &amp; Tata (India), Iberbanda (Spain), KT &amp; SKT (S.Korea), Comstar (Russia)</li> <li>- 30+ companies providing PC Cards, USB modems, MIDs, and other personal devices</li> <li>- 7 of the top 8 mobile device manufacturers developing WiMAX products</li> <li>- 35+ suppliers building WiMAX base stations</li> <li>- 25+ companies provide chipsets and reference designs</li> <li>- Taiwan represents a strong example of growing ecosystem with 35+ ODMs and suppliers committed to delivering WiMAX CE devices</li> </ul> </li> </ul>
<b>PSatus of Standards and System Profiles</b>	<ul style="list-style-type: none"> <li>• Radio access standard expected to be completed in 2009; network standard expected in mid 2009.</li> <li>• No system profiles completed as yet. Schedule for certified equipment unknown– if certification process is adopted by 3GPP.</li> </ul>	<ul style="list-style-type: none"> <li>• Global standard for WiMAX based on IEEE 802.16e-2005 was ratified in December 2005</li> <li>• Multiple system profiles approved and commercial equipment built to profile specifications</li> <li>• Rel 1.0 Certification began in January 2007 with 100+ Certified devices expected by end of 2008</li> <li>• Rel 1.5 system profile approval expected 2H008; Certified testing in 2009 and product availability in 2010</li> <li>• IEEE 802.16m to be complete in Q4 09, Rel 2.0 profile approval in 2010 with Certified equipment expected in 2011</li> </ul>
<b>Technical Elements</b>	<ul style="list-style-type: none"> <li>• Air Interface: OFDMA (downlink) and SC-FDMA (uplink).</li> <li>• Targeted operation in both FDD and TDD modes.</li> <li>• Standard supports scalable channel bandwidths up to 20 MHz, covering 1.25 MHz, 2.5 MHz, 5 MHz, 10 MHz, 15 MHz and 20 MHz. (1.6 MHz channels are under consideration for unpaired frequency bands).</li> <li>• An increase in spectral efficiency of two to four times that of HSPA Release 6.</li> <li>• Packet-based all-IP end to end network.</li> </ul>	<ul style="list-style-type: none"> <li>• Air Interface: OFDMA in downlink and uplink.</li> <li>• Commercial equipment based upon five Release 1.0 system profiles for multiple spectrum bands available today (TDD-based)</li> <li>• For Rel 1.5, both TDD and FDD system profiles are supported.</li> <li>• Standard supports scalable channel bandwidths from 1.25 to 20MHz</li> <li>• Rel 1.0 has up to 2-3x higher spectral efficiency per sector vs. EV-DO Rev B and HSPA Rel 6.</li> <li>• Mobile WiMAX Rel 2.0 targets ~2x higher spectral efficiency than Rel 1.0 and channel BWs up to 40 MHz.</li> </ul>

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<b>Intellectual Property Rights</b>	<ul style="list-style-type: none"> <li>A few LTE patent owners have agreed to a framework where their royalty level for handsets will be capped at a single-digit percentage of the sales price (for laptops, single-digit dollar amount). Many key LTE players are not members of this agreement.</li> <li>If one adds up the public declarations to date from these select patent owners, they're already at 9% -- so once all LTE patent holders declare their rates, there may be little change in IPR scenario from 3G to LTE.</li> <li>If the model doesn't change for LTE, we can continue to expect an industry where new device entrants are deterred, especially from the CE industry.</li> </ul>	<ul style="list-style-type: none"> <li>The goal of the Open Patent Alliance (OPA) model supported by WiMAX Forum is an open, transparent, predictable and nondiscriminatory IPR licensing framework that will deliver a fair royalty rate to all.</li> <li>The OPA has announced the formation of an independent 'patent pool' to stimulate increased innovation, more new entrants and lower WiMAX device costs.</li> <li>OPA accelerates the ability for vendors to license WiMAX technology by providing one stop licensing for the essential patents held by OPA members.</li> </ul>
<b>Core Network</b>	<ul style="list-style-type: none"> <li>LTE e2e Network is encumbered by 3G legacy network protocols. Result is a network with many layers and proprietary protocols.</li> </ul>	<ul style="list-style-type: none"> <li>WiMAX network is a flat, simple all-IP network with few protocols. All protocols are IETF-based (IETF = Internet Engineering Task Force). Thus the WiMAX is simpler to implement.</li> </ul>

### CORE NETWORK DIAGRAMS

