Long Term Evolution: Deployment Options and Challenges

LTE is the wireless industry's answer to quench the bandwidth and user experience thirst of today's new breed of wireless applications. However, operators need to identify an optimal approach to bring LTE to market which is both cost effective, as well as allows them to gain or retain competitive advantage.

Introduction

The need for mobile broadband grows every day, as the digital lifestyle goes mobile and blurs the lines between cell phones, handheld media devices, PCs and televisions. Users want to replicate their desktop experience on their mobile device, including real-time video conferencing, publishing, and social networking. High-bandwidth applications such as YouTube are courting mobile users, further taxing already-stressed carrier networks.

With the download speed of up to 21 Mbps and upload speed of 5.8 Mbps, High Speed Packet Access (HSPA) has emerged as the technology to offer high speed mobile broadband services. HSPA enables service providers to offer mobile broadband services using the same resources in the access network that are used to deliver voice calls and other services.

However, the thirst for more speed and enhanced user experience with bandwidth heavy applications has led to further evolution of the mobile networks to deliver better coverage and user experience.

The 3GPP Long Term Evolution (LTE) of 3G Networks improves the user experience further. The LTE standard was developed to create mobile technology that delivers high data rates and supports bandwidth-heavy applications such as file sharing, video, and broadband Internet, all at a reduced cost per bit compared to EDGE, 3G, WCDMA and CDMA. LTE offers true mobile broadband with an all-IP architecture designed for end-to-end QoS with high throughput and low delay, making it perfect for lots of users using multimedia-rich applications. In addition to offering a greatly enhanced user experience, LTE also offers a larger number of connected devices per cell versus incumbent technologies, helping scale mobile value added services faster than ever before.

Now the question becomes – how can equipment manufacturers and carriers bring LTE to market quickly in today's cost-sensitive environment? Two paths to LTE are emerging: carriers who are committing to LTE immediately, and those who are

taking a phased approach, deploying 3G+ technologies in the near-term and migrating to LTE in the future.

LTE: Technology Overview

LTE supports flexible bandwidths, from 1.25MHz up to 20MHz as well as both Frequency Division Duplex (FDD) and Time Division Duplex (TDD), allowing deployment flexibility and co-existence with other radio access technologies. LTE supports the highest spectral efficiency – 100Mbits/Sec in a 20 MHz band. Peak download rates are 326.4 Mbit/s for 4x4 MIMO antennas, 172.8 Mbit/s for 2x2 Multiple Input Multiple Output (MIMO) antennas for every 20 MHz of spectrum. Peak upload rates are 86.4 Mbit/s for every 20 MHz of spectrum.

This spectral efficiency results in lower cost per bits than 2.5G and 3G technologies. There can be at least 200 active users in every 5 MHz cell (i.e., 200 active data clients), with an optimal cell size of 5 km, 30 km sizes with reasonable performance, and up to 100 km cell sizes supported with acceptable performance.

Unlike HSPA, which is under the R99 UMTS Architecture, 3GPP-LTE is has evolved a new core network architecture – the Evolved Packet Core (EPC) – a flatter architecture with a reduction in the number of network elements, and allowing for connections and handover to existing wireless access technologies (namely GSM, CDMA and WCDMA). Because of a flatter architecture, LTE delivers high throughput with low latency/sub-5ms latency for small IP packets enabling real-time experiences.

Table 1. Value Added Services in an LTE environment

Service category	***Current environment***	***LTE environment***
Rich voice	*Real-time audio*	*VoIP, high quality video conferencing*
P2F messaging	*SMS, MMS, low priority e-mails*	*Photo messages, IM, mobile e-mail, video messaging*
Browsing	*Access to online information services, for which users pay standard network rates. Currently limited to WAP browsing over GPRS and 3G networks*	*Super-fast browsing, uploading content to social networking sites*
Paid information	*Content for which users pay over and above standard network charges. Mainly text*	*E-newspapers, high quality audio streaming*

	based information.	
Personalisation	*Predominantly ringtones, also includes screensavers and ring backs*	*Real tones (original artist recordings), 3personalized mobile web sites*
Games	*Downloadable and online games*	*A consistent online gaming experience across both fixed and mobile networks*
TV/ video on demand		*Broadcast television services, true on-demand television, high quality video streaming*
Music	*Full track downloads and analogue radio services*	*High quality music downloading and storage*
Content messaging and cross media	*Peer-to-peer messaging using third party content as well as interaction with other media*	*Wide scale distribution of video clips, karaoke services, video-based mobile advertising*
M-commerce	*Commission on transactions (including gambling) and payment facilities undertaken over mobile networks*	*Mobile handsets as payment devices, with payment details carried over high speed networks to enable rapid completion of transactions*
Mobile data networking	*Access to corporate intranets and databases, as well as the use of applications such as CRM*	*P2P file transfer, business applications, application sharing, M2M*

Source: UMTS Forum, *Towards Global Mobile Broadband* (August 2008)

Path to LTE

As service providers decide how to migrate to LTE, they are taking one of two approaches (see Figure 1):

1. *Committing to LTE today*: Carriers including Verizon and DoCoMo, who have 3G networks based on non-3GPP technologies, are targeting full LTE deployments. These companies are hoping to achieve a considerable first mover advantage with differentiated services, ubiquitous coverage and increased data rates over a single IP based network infrastructure - while ensuring interoperability with other networks which they hitherto lacked. However, they will face significant challenges in critical areas such as CAPEX, equipment to support constantly evolving LTE standards, readiness of IP

backhaul capabilities across the entire wireless network, and the availability of wireless spectrum in different geographies.

2. *Deploying 3G+ technologies like HSPA with Femtocells and migrating to LTE over the longer term:* Other providers with existing 3GPP-based 2.5G or 3G networks will typically look to monetize their current investments by deploying 3G+ technologies like HSPA, HSPA+ and Femtocell with a planned upgrade to LTE in the future. While this may be a much more cost effective approach that will deliver immediate revenue impact, there will be considerable interoperability challenges delivering a hybrid, multi-mode service.

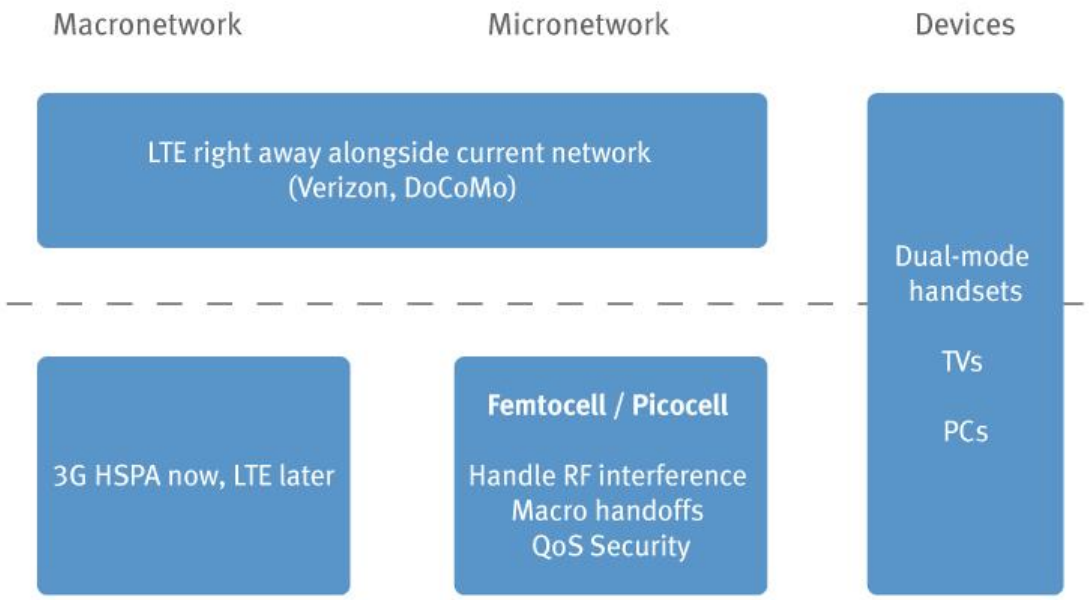

Figure 1: The Two Options to Deploy LTE

Figure 2 shows the migration strategies possible for operators with existing networks. LTE's flexible spectrum assignments allow a stepped approach to migrating from current technologies to LTE.

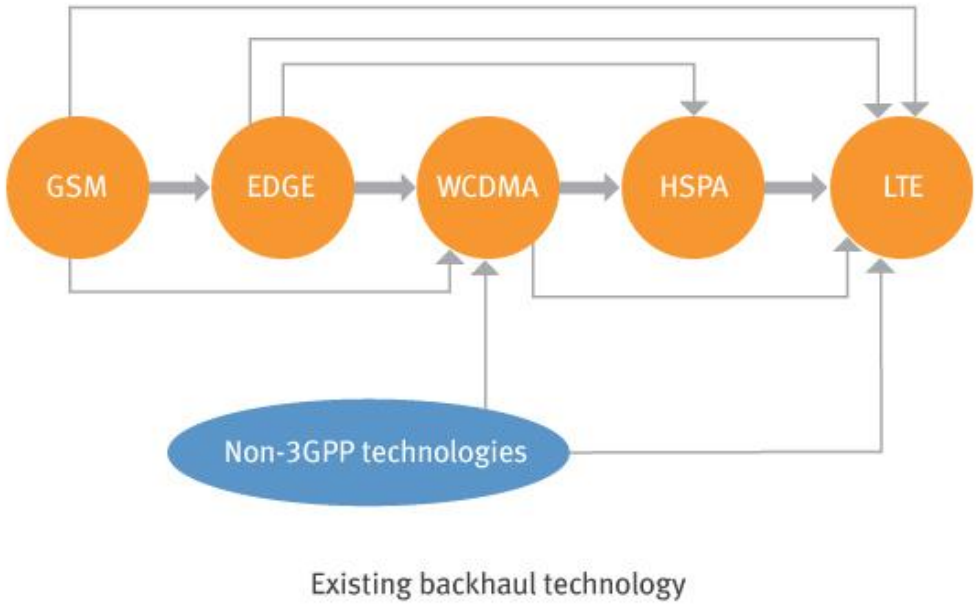

Figure 2. Migration Path to LTE

Committing to LTE Today

For operators using CDMA, a non-3GPP technology the path to LTE will be direct. While the LTE EPC architecture supports access from a trusted non-3GPP network such as CDMA EVDO(core network based on 3GPP EPC agreed in 3GPP and 3GPP2), there are several complexities to be overcome.

- *Dual mode handsets:* Dual mode handsets will be needed to provide complete service coverage as LTE is rolled out over time throughout the network. There are both single radio and dual radio options for dual mode handsets. Single radio handsets are lighter, less complex, and less expensive. In this scenario the handoff complexity is minimized since the handoff is mainly handled by the network. In dual radio handsets, the handset operates two radios connecting to both LTE and CDMA networks simultaneously, and the handoff complexity is handled mainly by the handset itself. In general, the single radio handset is preferred.
- *Single radio handset upgrades:* The CDMA RNCs will need to be upgraded to interface with the LTE mobility and gateway functions to provide make-before-break contact. This will enable seamless handoffs, particularly for real-time packet mode services.
- *Network integration:* Integrating security, authentication, QoS, policy, and charging across CDMA and LTE is complex, especially when the subscriber is roaming.
- *Voice call handoff:* In CDMA, voice is carried over 1xRTT a circuit switched technology while in LTE voice is carried over VoIP. To provide for voice call handoffs in either direction (CDMA to LTE and LTE to CDMA) a suitable voice

call continuity solution that transforms a circuit call to a VoIP call and vice versa will be needed.

Deploying 3 G + technologies like HSPA with Femtocells and Migrating to LTE over the Longer Term

Operators with current investments in 3GPP-based 2.5G or 3G networks are choosing to focus on 3G+ technologies such as HSPA and HSPA+, prior to migrating to LTE. The motivation here is to monetize current 3G-related investments and wait for the LTE technology to mature, prior to rolling it out. Since most data traffic originates and terminates indoors and even HSPA/HSPA+ solutions are faced with problems of poor indoor performance, operators are using Femtocells to solve issues that happen within the micro network, or within the user's four walls. Femtocell makes use of a small cellular base station to provide indoor coverage, and connects to the service provider's macro network via fixed broadband to provide mobile coverage. This allows users to get all of their voice, video, and data services from a single provider, and does not burden the mobile network with backhaul costs. There are multiple Femtocell architecture options and suitability depends on the existing macro network deployment. Depending on which fixed broadband connection is available, each base station can support 4-10 users.

As these operators migrate to LTE, they would need to offer services in the 2 to 3 GHz range where the ability of signals to penetrate through walls is poor. Thus, effective LTE deployment would require LTE Femtocells, which are a natural migration to 3G Femtocells that are being invested in today.

Additionally, the mixed roll-out of LTE Femtocell indoors over an existing macro network provides a compelling business case. Carriers can deploy wireless broadband as quickly as they can deploy base stations, with little impact on the density of the macro network usage. Compared to a complete LTE network deployment, this save carriers short-term deployment costs and allows them roll out LTE coverage gradually, starting in the most advantageous areas.

Key Challenges to Femtocell Deployment

While the business case is appealing, deploying a multimode solution is complex.

- *Femtocell base stations:* Femtocells must be able to effectively handle RF interference, location determination, auto-topology discovery, and up-link and downlink handoffs including those with incumbent technologies, real-time traffing QoS, and provide secure device management.
- *Femtocell network:* The network will need to provide multiple options which can handle a very large number of Femtocell nodes from signaling and device management aspects and much higher data plane traffic per subscriber.
- *Femtocell Architecture:* There are several Femtocell architectures (such as picocell, collapsed stack, SIP or IMS, HNB), and operators will need to evaluate these options for suitability, compatibility, and scalability of their core networks.
- *Network integration:* The presence of thousands or millions of Femtocells presents performance challenges to the core network.

- *Separate handset qualification:* There will be additional steps for operators to qualify dual mode handsets.

Conclusion

As LTE deployment becomes a reality, operators and vendors need to identify their LTE migration strategy in the very near future, if they have not already done so. This strategy needs to be driven entirely based on current deployment, demand on network for services offered by LTE, as well as competitive and other market related factors. Each deployment strategy comes with its own set of associated challenges which need to be addressed effectively for a successful LTE transition. Regardless of the chosen strategy, Aricent offers carriers and equipment manufacturers a complete set of LTE solutions and services, which help ease the migration and reduce investment risk associated with LTE.