White Paper

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LTE-Top 12 Challenges

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Overview

Without a doubt, mobile broadband is today's growth engine for the telecom industry. The emerging picture is clear: consumers want mobile broadband, and they want it now. This is indeed phenomenal growth so far, but let's put this in perspective of what is still to come: according to industry organization GSMA, there are ~4.3B wireless users in the world, of which 80 percent are voice-only GSM users, while only 9 percent are 3G WCDMA and HSPA users (i.e., voice + data users). Thus the growth opportunity for mobile broadband (data) is at least 3B subscribers—and there's a good chance that many, if not most, of them can be captured in the next 5-10 years.

To keep up with this surging demand, networks operators around the world are looking to roll out 4G networks and Long Term Evolution (LTE) is the global front runner. Yet as the excitement for LTE begins to build, scratching beneath the surface reveals many nontrivial challenges that still need to be overcome for successful network deployment—and more importantly, for broad consumer adoption. In this series of articles we explore the top 12 challenges that need to be addressed for LTE success.

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1. Spectrum Harmonization

One of the key benefits of GSM networks has been seamless roaming across countries and continents, largely because of harmonized spectrum spanning large parts of the world. LTE infrastructure is being designed to operate in different spectrum bands of different sizes, however, ranging from 1.25MHz to 20MHz. [For LTE max potential data rates, 20MHz FDD contiguous spectrum is required.] To truly support seamless global roaming, harmonized spectrum will be needed—otherwise the burden is shifted to terminals (e.g., handsets or mobile devices) to support multiple frequency bands, which adds time, expense, complexity and inefficiency to the equation.

Today, LTE-land is far from achieving harmonized spectrum. The three main emerging options for LTE spectrum allocation are:

- *Digital Dividend:* In the U.S., the 700MHz band has already been auctioned and Verizon plans to deploy LTE in it with a single 10MHz carrier. Currently in Europe there is a strong push to free up common 800MHz bandwidth across all countries; however, this remains an open and somewhat contentious issue with the regulators.
- *2.6GHz:* Spectrum in 2.6GHz is available in large parts of the world and can serve as harmonized spectrum. However, there are a couple of important attributes to the 2.6GHz frequency band. First, relatively poor propagation characteristics will significantly impact indoor coverage, an issue already quite visible in the 3G HSPA networks deployed in the 2.1GHz band. Second, poor propagation characteristics also translate into smaller cell radius—hence the need for more cells, which adds expense and complexity. Lastly and most importantly, frequency has a direct impact on network costs, as both OpEx and CapEx increase significantly with higher frequency.
- *2G/3G Spectrum Re-farming:* There are a few spectrum re-farming options available, such as at 2.1GHz (for 5MHz carriers) or the GSM 900MHz band (for 5MHz or less carriers). [Note: One related topic is GSM sunset; this is discussed further down in the article.] NTT DoCoMo in particular has shared its plan for using one of its UMTS carriers for LTE initially.

There are no clear answers for LTE spectrum allocation and harmonization; this complex issue needs to be addressed by the industry in strong collaboration with regulators—otherwise seamless roaming across LTE networks will remain just a vision.

2. Voice over LTE

One of the touted benefits of LTE is the converged Evolved Packet Core (EPC), which is a true 'All-IP' core and hence should carry all types of traffic—voice, video and data. However, most of the standardization work has focused on the data aspects of LTE and voice has been somewhat neglected. Different operators are giving different priority to this issue; in fact, some of the early adopters are looking at data-only services for their initial LTE network rollouts.

Clearly, the full OpEx and CapEx benefits of a converged EPC can only be realized when all traffic types are carried over a single, unified core. The issue of standardization of voice over LTE gets even more complicated when we bring into the mix the interlocking of LTE with different types of legacy networks including GSM, HSPA, CDMA2000, WiMAX and WiFi.

Some of the primary options under consideration for carrying voice over LTE are:

- *Circuit Switch Fallback (CS Fallback):* This is an attractive option that enables operators to leverage their legacy GSM/UMTS/HSPA networks for carrying voice traffic. With CS Fallback, while making or receiving a voice call the LTE terminal suspends the data connection with the LTE network and sets up the voice connection via the legacy network. CS Fallback completely offloads the voice traffic to legacy 2G/3G networks, which of course requires operators to maintain their legacy CS core network. CS Fallback is an attractive short-to-mid-term option as it enables operators to further leverage their existing legacy infrastructure but, in the long term, other options will be more appealing to fully reap the benefits for the converged EPC.

- *IMS-based VoIP:* The IP Multimedia Subsystem (IMS) option supports Voice over IP (VoIP) over LTE networks directly. In addition, this option leverages Single Radio Voice Call Continuity (SRVCC) to address coverage gaps in LTE networks. While the initial voice call is established over the LTE network, if the user goes out of the LTE coverage area then the call is handed off to the legacy CS core network via support from the IMS core. This option does provide an interesting rollout strategy to operators that have a strong IMS core as it allows them to transition to VoIP from the start while leveraging existing legacy assets for voice continuity outside of LTE coverage areas.
- *Voice over LTE via Generic Access (VoLGA):* An initiative led by T-Mobile, VoLGA essentially extends the application of 3GPP's GAN standards to carry voice over LTE networks. This approach has strong appeal to network operators who have already deployed Unlicensed Mobile Access (UMA) solutions and can leverage them to enable voice delivery over LTE. The VoLGA architecture introduces a new network element called VANC (VoLGA Access Network Controller) that enables interlocking between the LTE network and the legacy CS core network.

At this time it is only fair to say that there are multiple options under consideration for supporting voice over LTE networks, and the industry is a long way from reaching consensus on a standardized approach.

3. Small or Large Cells

Historically, 2G and 3G networks were built with the philosophy of "build it and they will come," and the good news is that consumers have adopted these technologies—although for 3G there was nearly a four-year delay in adoption uptake. With femtocells, operators now have a new tool in their kit as they consider deployment options—namely an "inside-out" rollout strategy for delivering LTE data rates in the indoor environment (e.g., home, café, airport, etc.), while leveraging their UMTS/HSPA networks for macro coverage.

With LTE femtocells, operators can deliver dedicated capacity to consumers in their homes and offices, and as LTE adoption increases over time there will be a tipping point when the LTE macro network deployment business case becomes solid and should thus proceed. In other words, the inside-out rollout strategy eliminates Return on Investment (ROI) risks. Another aspect that needs to be considered is the bundling of femtocells with devices (e.g., providing a home base station with every new netbook or smart phone purchase). These devices generate huge amounts of data traffic and this traffic can easily be offloaded from the macro-cellular network, thereby significantly lowering the price/bit of delivery.

The "small or large cell" issue is also tied to spectrum, and for LTE, network operators can consider dedicated carriers for macrocells vs. femtocells. For example, the 2.6GHz band might not be suitable for macrocells, but it is very well suited for femtocells. Femtocells greatly increase frequency "re-use" in the indoor environment and are the cheapest capacity augmentation solution available today. It remains to be seen how operators will deploy LTE networks, but it is certain that the 4G network will no longer be a homogenous macro-only network; femtocells will definitely be part of the picture.

4. Backhaul

Network operators face two challenges when it comes to LTE backhaul:

- Adding raw capacity
- Realizing full mesh backhaul

Because wireless networks are spectrum limited, typically the bottleneck so far has been on the air interface. LTE will shift the capacity bottleneck from the air interface to the backhaul link between base stations and the core network. This challenge is across the board, from macrocells to femtocells. For macrocells, a large part of the current backhaul infrastructure is comprised of bundled T1/E1s, but these will not suffice for 100Mbps+ data rates. Similarly, for femtocells the current IP broadband infrastructure is mainly comprised of DSL and cable modem links, but these are insufficient for carrying 100Mbps+ data rates.

LTE's flat network architecture eliminates the Radio Network Controller/Base Station Controller (RNC/BSC)-like aggregation node in the Radio Access Network (RAN), which is both good and bad. While this simplifies the network architecture and reduces latency (on paper, anyway), in the real world it creates a completely new challenge: how to realize a full mesh backhaul between eNodeBs. Remember, in LTE networks the eNodeB needs to communicate with peer eNodeBs in order to support handoff functions—both control plane and data plane.

Operators will need to make significant investments in their backhaul infrastructure as they deploy LTE. Eventually, in order to comprehensively address the backhaul challenge, operators will use a full range of technologies including microwave, fiber/Ethernet, CATV Ethernet and potentially WiMAX. Whether operators deploy their own backhaul solutions or continue to lease backhaul for LTE remains to be seen. It will also be interesting to see what role pure backhaul leasing providers will play in LTE networks.

5. Self Organizing Networks (SON)

Self Organizing Networks today represent a noble goal that operators and vendors alike are striving to pursue. The core principle is to completely eliminate the need for cumbersome radio network planning: as new cell sites are added in the network, neighboring cells dynamically learn about the changes in the neighboring radio environment, recalibrate their configurations, and adjust accordingly to minimize interference and update neighboring cell lists for handoff support. The eventual goal is to have "zero touch" installation.

Presumably SON will enable quick network rollouts and upgrades and should greatly reduce the OpEx typically associated with planning and managing radio networks, and the architects of the Next Generation Mobile Network (NGMN) clearly mandated SON as a key requirement for 4G networks. Different RAN vendors claim to have solutions for SON, but these are still far from meeting the noble goal of "zero touch." Most of these solutions today are Operations, Administration, Maintenance & Provisioning (OAM&P)-centric and address only a subset of complete SON requirements. Current solutions can potentially address certain aspects of SON, but there are many corner cases where these solutions break and thus SON will remain a research and innovation area for the next few years. Eventually the industry needs standardized SON specifications so that solutions from different vendors can co-exist simultaneously in the RAN—but we are still a few years away from realizing this.

6. Security

Secure delivery of traffic over LTE networks requires dealing with a range of issues:

- Securing the air interface to avoid eavesdropping, sniffing, theft
- Securing the all-IP core network (i.e., the EPC)
- Securing the all-IP devices

3GPP has chosen Snow3G as the stream cipher for encryption algorithms UAE2 and UIA2; the cipher works on 32-bit words and supports both 128- and 256-bit keys. Because this is the 3GPP standard, LTE gear needs to support Snow3G and the challenge is that current generation chipsets do not provide on-chip accelerators for Snow3G. As a result, Network Equipment Providers (NEPs) have to find alternative solutions, including FPGA-based acceleration to meet line rate performance requirements. Radisys' ATCA-PP50 packet processing blade is a rare example of a solution that incorporates a mezzanine for Snow3G acceleration.

Being all-IP, the EPC is susceptible to all kind of security attacks just like any traditional IP network such as a Local Area Network (LAN). EPC gear needs to support a large number of IPsec terminations for securing data and control plane communications. In addition, the EPC needs to be protected from Distributed Denial of Service (DDoS) attacks and thus comprehensive Intrusion Prevention and Detection Systems (IPS/IDS) need to be deployed.

Like it or not, LTE devices will be prone to all kinds of attack—and the iPhone's recent SMS-related memory corruption issue highlights the kind of challenge that next-generation devices and networks face. Quick fixes, quick rollouts and quick updates will be essential to stay ahead of (or at least keep pace with) evolving IP-based threats. Network operators will need to put in place virus-scanning solutions in the EPC. In addition, service providers will need to plan how to update subscribers' devices in case a security attack is unleashed that requires defensive "vaccine" downloads. In essence, traditional enterprise security solutions will now need to find their way into the EPC as LTE networks are deployed; the issue is that these solutions need to be scaled to meet core network demands and performance requirements and need to be hardened to meet carrier-grade equipment requirements.

7. Devices and Terminals

As operators get ready for LTE trials, some of the key questions are: "When will the devices and terminals be ready—and what will they be like?" It is not yet clear whether operators will roll out LTE services with data-centric devices—such as data cards, dongles and netbooks—or whether we will see fully-featured LTE smart phones that support voice, data, video and all the other services. Most observers anticipate that data cards and dongles will be available earlier, followed by smart phones, but then again it is possible that we might have another big surprise from Apple!

LTE devices need to support Multiple Input Multiple Output (MIMO) in order to deliver high data rates—but this directly increases a device's complexity. One of the interesting things to watch will be whether the initial devices will support only 2x2 MIMO or whether some vendors will launch devices supporting 4x4 MIMO from the start. This choice is directly related to battery life, and while data cards and dongles might get enough juice from their hosting laptops and netbooks, smart phone designers have critical design challenges in front of them in terms of balancing battery life with MIMO support.

Yet another key issue with devices and terminals is the frequency bands that they will support—a factor which is directly related to spectrum harmonization and has significant impact on device complexity and costs.

Lastly, how much legacy support will be embedded in these devices? It is clear that LTE networks will not have nationwide coverage for a long while, and to support full mobility will these devices support both 2G and 3G fallback mechanisms? This question is directly related to an operator's LTE network rollout strategy and ties to choices the operator makes on how to support voice over LTE.

8. Traffic Management

As indicated at the top of this article, growing mobile broadband adoption is what is driving the need for LTE network rollouts. According to AT&T Wireless, one 3G iPhone user typically generates as much data traffic as 30 basic feature phone users. LTE greatly improves spectral efficiency (by 4X) and will be deployed in larger 20MHz bands for maximum bandwidth potential, but eventually these gains in data rates will be dwarfed by the faster rate at which overall data traffic is growing. Factor in netbooks, USB cards and dongles and the growing data traffic problem will only become bigger as Internet video and large peer-to-peer (P2P) file transfers migrate to LTE networks. Given this reality, traffic management will be essential. Deep Packet Inspection (DPI) gear is today being deployed in 3G networks as "bump-in-the-wire" solutions, but for LTE networks such DPI capabilities may be pre-integrated into Serving Gateways and Packet Data Network (PDN) Gateways.

Network operators have to make huge investments as they roll out their LTE networks, and yet the biggest threat they face is that eventually they will be reduced to being mere bit pipe providers. Over time network intelligence has migrated from the core (remember the Advanced Intelligent Network, AIN?) to the edge and access portions, and now very much to devices (i.e., consider the "app store phenomenon"). DPI technology enables operators to convert their bit pipes to "smart pipes" by empowering them to deliver tiered service level agreements (SLAs) to consumers and tiered bandwidth allocation to content providers.

DPI also opens up the opportunity for new revenue-generating opportunities such as targeted advertising because with DPI, operators can greatly improve the relevance of their ads.

Growing data traffic is also creating demand for Internet traffic off-loading gear. Essentially what mobile operators are looking for is the ability to offload Internet traffic at the edge of their networks and not be required to carry that traffic to (and through) their core networks. In LTE, there is not yet consensus on where the best point is to offload Internet traffic because there are no aggregation functions in the RAN. Will this require new bump-in-the-wire gear to be deployed for LTE? [And yes, Internet traffic off-loading and traffic management do not mix well if done improperly…]

9. Flat Rate Plans

Introduction of flat-rate, all-you-can-eat data plans were, if not the most important, a very critical factor for precipitating widespread mobile broadband adoption. At the same time, the introduction of these plans has set consumers' expectations and now they expect more bandwidth for less money.

The decoupling between traffic growth and revenue growth is the single biggest challenge that network operators face today. To understand the magnitude of the challenge, let's again look at some numbers: AT&T claims that each iPhone typically drives 30X more traffic than regular feature phones. A close look at AT&T's data pricing plan suggests that iPhone users are not paying even 3X more Average Revenue Per User (ARPU) compared to other feature phone users—yet they are driving 30X more traffic. To address these challenges, operators need to look at aggressively lowering the price per bit. Frankly, lowering the price/bit is what is forcing operators to look at network rollout strategies that incorporate femtocells and Internet traffic off-loading.

Service providers also need to figure out new ways to generate additional revenue. Offering tiered SLAs to consumers is one approach, but in the bigger scheme of things operators need to start looking at how to generate revenue from the other end of the pipe: content providers. At the end of the day, a carrier's wireless network is spectrum-limited and can only carry so much traffic. Offering Internet "highways" instead of best-effort bandwidth to content providers with guaranteed reserved bandwidths is the way to go, and presumably content providers would be willing to pay for this. Operators need to tear a page from the air travel playbook and, in a similar sense, charge different tariffs to business-class passengers than coach-class passengers. Ensuring that content providers get what they pay for is essential for operators to effectively monetize their LTE networks—otherwise we will see reduced investments in infrastructure and collectively everyone will suffer with degraded quality of experience (QoE).

10. Intellectual Property Rights

IPR battles and associated royalty payments were a significant impediment in 3G rollouts. Patent battles between Nokia and Qualcomm, which started in 2005 and finally ended in 2007 with Nokia paying $20M to Qualcomm, epitomize the challenge. Network operators caught in the crossfire have to re-plan their rollout strategies, make adjustments and face delays in making their networks operational. 3G handset manufacturers didn't go unscathed, either, facing endless negotiations with multiple parties on royalty payments.

Every new technology comes loaded with patents, but what really matters are patents that are classified as "essential patents"—those that are absolutely necessary for that technology. So the key question is who owns essential patents for LTE? Can operators and handset manufacturers go to a single organization and negotiate associated royalties, or are we again going to witness complex, lengthy, multi-party patent negotiations?

To streamline the LTE IPR costs, seven key players—Ericsson, NEC, NextWave Wireless, Nokia, Nokia Siemens and Sony Ericsson – collectively agreed to create a framework that limits patent royalties to a single digit percentage of handset sales price—and not to exceed $10 for LTE modems in netbooks. So is this issue really behind us? Not really, because missing from the agreement are key eco-system players like Qualcomm, Broadcom, Texas Instruments, Huawei, etc., who own parts of LTE's essential patents.

So while a noble attempt, so far the LTE IPR framework has fallen short. In addition, the United States Patent and Trademark Office (USPTO) is being flooded with patent applications for SON from large players and innovators alike. So we should all brace for another round of significant patent battles which can potentially delay LTE network rollouts.

11. Interoperability

A vibrant and robust ecosystem is essential for wide deployment and adoption of LTE. To achieve deployment flexibility and lower operation costs, network operators need a strong infrastructure and device supplier base. At the heart of this lies the interoperability issue: ensuring operators can mix and match equipment from different suppliers in their networks.

12. Two, Three, Four

Most operators currently have both 2G and 3G networks in service. As 4G LTE networks are rolled out, should these carriers then manage and operate three simultaneous networks—2G, 3G and 4G? In the near term the answer is obvious: operators will continue to keep their 2G and 3G networks going. For the mid- and long term, though, LTE once again brings the topic of GSM sunset to the forefront—or maybe 3G sunset.

Operators currently enjoy significant roaming revenues from their GSM networks [recall that 80 percent of worldwide wireless users are still on GSM technology]. Parting from this high margin revenue stream is not going to be easy. The issue also ties to spectrum re-farming, and spectrum is expensive.

Switching off GSM networks would enable operators to re-farm that spectrum, but there are many strict regulations around this spectrum in different countries including complete nationwide coverage requirements. Alternatively, operators might consider keeping their 2G networks going for awhile and switch off their 3G networks first, migrating those 3G users to LTE. There are no clear answers yet, but what is very clear is that operating three simultaneous networks is not a long term option.

One thing is certain: there are definitely interesting times ahead. Mobile broadband adoption has taken off; it is here, it is now, and it is (thankfully!) not going away. The "exa-flood" is coming—moving from terabytes to petabytes to exabytes—and operators need to start preparing their networks to handle massive data traffic growth. And while LTE is by far the leading technology of choice for 4G wireless deployment, as with any new technology there are significant challenges that remain to be addressed.

The opportunity is large and the demand is strong, and with these foundations in place it is only a matter of time before innovators find solutions to address the challenges. Radisys is doing its part by productizing leading edge technologies such as 40G ATCA platforms for fast pipes, LTE femtocells for cheap pipes, and DPI solutions for smart pipes.

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