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OSS RAN Implications of LTE

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Contents

1 What is LTE?

It seems that every 10 years, the mobile phone industry develops a new, improved radio standard which offers lower costs, higher speeds and better quality. The first generation analogue systems of the 1980's gave way to 2G GSM (launched in 1991), then 3G UMTS (launched in 2002). CDMA networks also evolved in a similar timescale through IS95 (now cdmaOne) and EV-DO.

LTE (Long Term Evolution) is a radical new radio interface planned for commercial launch in 2010. With the GSM family of standards now dominating the global market with over 87% share of subscribers, the previously competing CDMA operators such as Verizon and KDDI Japan have also adopted the same common standard.

Just as the radio interfaces for 1st, 2nd and 3rd generation were based on totally different transmission technologies, so it is with LTE. Two different schemes are used:

- OFDM (Orthogonal Frequency Division Multiplex) for the downlink
- SC-FDMA (Single Carrier Frequency Division Multiple Access) for the uplink

The first version of the LTE standard was formally approved by the 3GPP standards committee in December 2008. As with all new standards, further clarifications and optimisations will be added in each new update.

What are the Benefits of LTE?

The primary objectives of each new radio interface have been to deliver higher performance and better user experience at lower cost. LTE achieves this in different ways:

- Faster Data Speeds: Headline data rates of over 100Mbit/s have been demonstrated in laboratory conditions. This not only enables services which require higher speeds, but drastically reduces the time for any data interaction to be sent and received.
- Fits Wide Range of Spectrum Bands: One reason that some operators had been reluctant to adopt 3G is that each carrier requires a full 5MHz of paired spectrum. LTE has been designed to operate in the limited 1.5MHz carriers commonly deployed in North America, yet also expand to 20MHz carriers which would allow much faster data rates.
- Efficient Use of Spectrum: By squeezing more bits per second per sector per Hertz through the available spectrum, operators can deliver the same capacity with fewer cellsites, or more capacity from the same cellsites. Estimates are of between 2x and 5x greater throughput compared to 3G.
- Self-Optimising and Self-Organising: In the early days of mobile networks, it was not uncommon to find radio planning departments with hundreds of staff. These carefully designed and tuned the performance of the radio network using complex predictive analysis tools and configuration of many parameters. LTE includes processes which allow each individual cellsite to analyse its own environment and negotiate with nearby cellsites to agree the best settings on an ongoing basis. This will reduce the size of radio planning teams and also increase overall network performance, resulting in fewer dropped calls and better quality.
- Improved Data Services: There are several improvements compared to 3G systems, which have been designed from the ground up to improve end-to-end data services. The few seconds delay common with starting up 3G data sessions will reduce to milliseconds. Latency will also drop to milliseconds, which combined with higher processing power in handsets will substantially improve the end-user browsing experience and enable a range of new applications. The transition to an all-IP core network should also increase the range of applications available.

But there are Some Drawbacks

LTE is associated with SAE (System Architecture Evolution), a new streamlined all-IP core network. It is likely (but not mandatory) for voice calls and other services to use the new IMS core network. This requires service providers to build and rollout new core network elements at the same time as LTE, adding complexity when managing and delivering services across both types of network. Supporting the same services across both 2G/3G and LTE/IMS will add complexity, cost and risk.

The high performance of LTE will provide an excellent platform for a wide range of new services and applications. This will include so-called “Over the top” IP voice services, such as Skype, Fring and Vonage. Mobile network operators may lose or reduce premium prices charged for basic voice calls.

Wider Global Adoption

LTE has been adopted as the next step in the evolution of both GSM and CDMA networks, and endorsed by almost all large mobile network operators in America, Europe and the Far East. This has justified substantial R&D investment from many vendors and created a highly competitive market. The expected high volumes of product will quickly reduce unit costs and widen available expertise.

The common standard will also build on the existing roaming arrangements, whereby users can take their handsets and use them abroad.

We are witnessing a more urgent adoption of LTE amongst CDMA operators, keen to achieve the substantial cost and performance benefits. UMTS/HSPA operators are also planning to adopt LTE, but with less urgency. Some are continuing to invest in HSPA+, which offers some of the promised benefits of LTE such as higher data rates (up to 21Mbit/s), lower latency and improved battery life. Other HSPA operators have indicated they plan to skip HSPA+ and move more directly to LTE.

Where and When will LTE be First Deployed?

Over 120 operators worldwide have declared their intent to rollout an LTE network in the next few years. These are broadly grouped into four categories:

- CDMA Operators: including Verizon Wireless US and KDDI Japan. With the CDMA Development Group adopting LTE as their evolution path, CDMA operators are keen to catch up with the cost effectiveness and high performance of competing technologies.
- HSPA Operators: Whilst we can expect most current UMTS/HSPA operators to migrate to LTE in due course, several have indicated they plan to skip HSPA+ and move more quickly to adopt LTE because of the higher performance and lower cost.
- Emerging Markets: A surprising number of cellular operators, often with limited or no 3G capability, have announced plans for LTE. This would provide broadband services in areas which don’t currently have wireline alternatives.
- China Mobile: Being such a large operator, with almost 500 Million subscribers, its decisions impact the industry substantially. Having been required to adopt a Chinese specific variant of the 3G UMTS standard, the operator is reported to be enthusiastic about rejoining the mainstream as soon as practicable.

What’s Involved in LTE Deployment?

Spectrum

The first essential requirement for any mobile network service is availability of licensed spectrum. Potential LTE operators must either acquire new frequencies, or re-farm their existing 2G and 3G spectrum by slowly migrating their subscribers with new handsets.

When 3G UMTS was developed, spectrum regulators across the globe generally agreed to set aside frequencies at 2100MHz. Although a few countries including North America did not follow this path, it helped accelerate adoption through standardised products with the same characteristics.

This approach has not happened for LTE. The standard allows operation at a wide range of different frequencies and band sizes from 1.5MHz to 20MHz. It is likely that fresh spectrum will be auctioned in the range between 2 and 3GHz, such as in the UK where specifically 2500MHz to 2690MHz is of particular interest.

North American operators are likely to use frequencies auctioned in 2008 at both 700MHz and 1900MHz. Verizon has announced plans to use the 700MHz frequency released from the transition from analogue to digital TV for this purpose.

As with any mobile cellular system, lower frequencies tend to provide longer range and better in-building penetration which is beneficial for coverage. Higher frequencies have lower range, but this can allow better frequency re-use, and therefore higher overall capacity in dense urban environments.

New Basestations

Over 80% of a cellular network's equipment and operating costs are associated with the RAN – the Radio Access Network. Basestation product costs (measured by cost of a voice traffic channel) have been declining year-on-year since the first cellsites were sold. The large market has attracted powerful competitors, such as the newer Chinese vendors, and physical manufacturing operations for most vendors have been moved to the Far East.

A problem that existed with the migration to 3G was that completely new basestations were required. Existing 2G sites were doubled in size with additional antenna, basestation equipment and any associated cooling and power requirements. Often a separate outdoor cabinet was provided – effectively doubling the equipment and running costs.

For LTE, leading vendors have provided basestation architectures which can support all of 2G/3G and 4G in the same cabinet, substantially reducing the impact of upgrade. New antenna may well be required, particularly where different frequencies are used. For highest performance, up to 4 new antenna per sector (known as 4xMIMO) would be used, which may be restricted by individual site planning permission or local leasing agreements.

Arguably, RAN vendors have been clever to promote these multi-standard basestations because it reduces the opportunity for open competitive tender from other suppliers and consolidates their position within their existing accounts.

The close interworking between the 2G/3G/4G radio network means that opportunities to build and manage a 4G only radio network are reduced, since it makes more commercial sense to manage these as a single operation. Either all 2G/3G/4G would be outsourced or none.

Backhaul Transmission

The high data rates and capacity available through each basestation has a consequential effect on the transmission capacity between cellsites and the central switching centers. The rapid traffic growth of 3G has caused an increase of up to 10 times, and LTE is likely to grow this by a further order of magnitude. With peak traffic loads concentrated on perhaps 10% of cellsites, backhaul transmission capabilities are rising from 4Mbit/s in 2G systems to something around 400Mbit/s.

This enormous growth in capacity is causing operators to switch transmission technologies and re-architect their entire transmission network. The balance between in-house and 3rd party leased transmission is being carefully scrutinised. Many operators are actively deploying Ethernet transmission, both over fibre and point-to-point wireless links to meet this demand.

Capacity planning for the backhaul transmission network is now even more important, where the design choices for each of tens of thousands of individual circuits must be made to meet overall cost and strategic objectives.

Many operators are reviewing the OSS management tools they have in place to determine if they can satisfy management of this rapidly changing environment.

Handsets

With the primary benefit of LTE associated with high speed data services, we can expect USB data dongles to be the first devices offering this capability. With LTE likely to be available only in limited areas at launch, such data dongles will need to be multi-mode – probably 2G/3G/4G capable.

Qualcomm has been leading the field with its Gobi module that is capable of not just 2G and 3G, but also CDMA and GSM/UMTS – effectively operating across all countries and markets globally. These are being integrated into laptops to make them compatible with 3G everywhere. Extending this to include LTE is on their roadmap and will make for a highly desirable product, with high volumes bringing economies of scale.

Smartphones, which also benefit from high performance/low latency data, are likely to be next. These will require not just the new radio interface, but additional software to work with the new IMS core network whilst maintaining feature transparency. Although CDMA networks are likely to be amongst the first to roll out LTE, mobile handset vendors are unlikely to want to invest heavily in a wide range of dual-mode CDMA/LTE devices. Mainstream handsets, such as the iPhone, may well have an LTE capability at an early stage. This will encourage these early CDMA operators to provide coverage across large areas quickly in order to encourage uptake.

At the low cost end of the handset market, 2G and 3G technologies are already well down the cost curve. A 2G chipset sells for less than $2 today. Licence fees due to early patents are starting to expire, reducing costs further. It will be many years before LTE can compete on cost alone, and high volumes in emerging markets are built on straightforward voice and text capabilities.

New Features

The improved data capabilities and associated all-IP network will stimulate creation of a wide range of new services and even new types of devices for applications so far unthought–of.

The recent explosion in applications available for the iPhone and Google Android, together with the accessibility of downloading from an Application Store (App Store) highlights the potential.

Alternative Approaches

“Inside-Out” LTE deployment

picoChip, a leading silicon design company, have argued that in order to provide the high data capacity expected, the answer is to provide many more cellsites. Where capacity in a sector can be increased by a factor of 2 to 5 through upgrading to LTE, increases of 10 to 20 times can be achieved by deploying many more small, low powered cellsites. These miniature basestations, called femtocells, are connected via broadband internet and be either be directly installed and used by individual customers or by the operator. Since more than 40% of handset usage is indoors, of which a substantial proportion is at home, this approach could be used to rollout millions of cellsites to those more likely to use it.

Spectrum Refarming

Rather that buy additional costly spectrum exclusively for LTE, some operators may choose to re-allocate existing 2G or 3G spectrum to the new standard. Small amounts could be allocated initially, with more being transferred as a greater volume of capable handsets are active on the network. Regulatory issues may initially prevent this approach, and in some cases the appropriate paired spectrum may need to be swapped with competitor networks. The improved long range and in-building penetration of these lower frequencies may justify this approach earlier in the rollout lifecycle.

LTE makes this approach easier to implement than 3G UMTS, which has large 5MHz carriers – LTE can be squeezed into carrier bands as limited as 1.5MHz, which are common in North America.

TDD

Most mobile phone technologies used paired spectrum, where separate frequencies are allocated for the uplink and downlink. This is good for voice, which usually has a balanced traffic mix in both directions. Broadband data, such as web surfing, can have a much more asymmetric traffic mix, with much more being downloaded. By being able to adapt the time spent between uplink and downlink transmission, TDD can make very effective use of capacity where the mix of traffic is unbalanced.

A TDD version of the 3G UMTS standard, known as TDS-CDMA, was pioneered by the Chinese and deployed in volume by China Mobile. It seems unlikely this will be widely deployed outside the country.

A TDD variant of LTE is also being aggressively pursued by the Chinese, and is more likely to be accepted elsewhere. In addition to the benefit of better utilisation for asymmetric data services, this approach can also fit into small pockets of spectrum which are not large enough to provide paired bands.

Most operators are likely to adopt a “wait and see” approach. Once the system is proven in China, there is adequate choice of handsets supporting it and additional data capacity is required, we may see this being added into networks in areas of peak demand. It could take until 2015 to be significantly adopted outside China.

Competition

WiMAX

The jury is out as to whether WiMAX will gain enough market size and traction before LTE is widely available. The system is commercially deployed in hundreds of networks across the globe, most prominently by Clearwire in the US.

Without the legacy and ongoing compatibility issues, WiMAX offers an unburdened all-IP network with high speed broadband data.

Some commentators have suggested that WiMAX and LTE standards could be combined, since both use the same underlying OFDM radio transmission technology.

Metro WiFi

The low cost of individual WiFi hotspots has encouraged several new business models. City-wide WiFi provides blanket coverage in public urban areas. Earthlink are an example of a Metro-WiFi operator, who failed because their business model did not account for the high cost of connecting and maintaining large numbers of hotspots, and income from advertising and subscriptions did not match forecasts.

Domestic users have also found that interference from neighbours in dense city tower blocks limits throughput and causes congestion. Some WiFi enabled phones are more likely to attach to neighbouring unsecured WiFi access points than their own.

WiFi is very much here to stay in domestic, office and hospitality businesses offering WiFi as a managed service/ benefit to their customers (e.g. hotels, café's, public houses, travel hubs).

We are also seeing public WiFi services being widely available at public transport hubs. Service providers such as France Telecom, BT, Comcast and Cablevision offer access to these as an inclusive service free to their wireline broadband customers.

White Space Unlicensed Spectrum

One reason why WiFi is lower cost is that there are no spectrum fees associated with its use. The US FCC has agreed that some of the spectrum released by the transition to Digital terrestrial TV will be available for unlicensed use at comparatively high power levels of up to 4Watts. Without centralised management, it may well be abused in similar ways to Citizen's Band (CB), but does offer the promise of a mesh network which could bypass traditional licensed operators.

MediaFlo

This proprietary system operated by QualComm uses dedicated spectrum to broadcast TV to mobile phones equipped with this standard. It effectively offloads the high demands of mobile TV from the mainstream mobile network, taking advantage of broadcast and multicast techniques.

Arguably LTE can also provide the same functionality. It efficiently multicasts shared media streaming across all users in the same cell. By allocating LTE to more spectrum, the traffic mix would be balanced between all users of the available spectrum, rather than having dedicated bands for specific services.

2 How will OSS Differ for LTE?

LTE accentuates the issues already seen in growing 3G networks:

- Many more cellsites to manage, and therefore many more associated transmission links
- Greater transmission capacity required at specific high capacity cellsites
- Wider range of end-user services to provision and manage

Much the same as 2G and 3G?

When 3G was launched, it was deployed as a separate, parallel network. Many operators tendered competitively for suppliers, who were frequently different from encumbent 2G vendors. This led to complexity in managing geographical areas with overlapping 2G and 3G basestation types. The savings gained through competitive tender between suppliers justified extra complexity for the operations teams.

Radio Access Network (RAN) vendors have had more foresight with their product plans for LTE, with many current basestation designs catering for 2G, 3G and 4G radio modules sharing a common platform. Rather than installing additional and often duplicating equipment from alternative suppliers, an extra 4G module can simply be installed into the existing cellsites to provide the 4G capability.

Radio planned tools and processes will be an extension of 2G and 3G – the current planning tools will support all three technologies and be used to evaluate the location of each new cellsite and capacity upgrades. The built in features of LTE, such as Self-Organisation and Self-Optimisation, should reduce the additional workload imposed by yet another new radio technology.

Higher Capacity of cellsites impacts backhaul transmission

Telecom Redux forecasts that the cost of backhaul in the US could increase from $2Bn to $16Bn per annum to meet forecast data traffic demands. Transmission capacity for the largest sites has grown from some 4 Mbit/s for 2G up to 40 Mbit/s for 3.5G and is predicted to require up to 400 Mbit/s for 4G – around 100 times the capacity for 2G.

With backhaul capacity already increasing dramatically from the additional load of burgeoning mobile broadband data, most 3G operators have already taken action to upgrade transmission. Sometimes this involves upgrading to higher capacity versions of the same technology. This can provide 4 or 16 times growth and may be appropriate in rural or lower capacity situations.

Compression and other optimisation can also make much more efficient use of the existing transmission capacity. Factors which can be taken into account are silent periods of conversations (both voice and data) and the highly asymmetric nature of broadband access. As traffic volumes grow, there is more opportunity for multiplexing across larger numbers of users without significantly impacting performance.

Impact of 3G/LTE drives backhaul transmission technology change

To fully benefit from the very high capacity of LTE, backhaul transmission will almost certainly need to change the technology used. Ethernet, through fibre and wireless, is seen as the ultimate choice, but is not available or suitable in all circumstances. There are still concerns about clock synchronisation (the IEEE 1588 standard addresses this) and the need to meet 2G and 3G transmission needs for shared sites.

With almost 4 million cellsites globally, and an estimated 10 million transmission circuits serving them, operations teams have to manage many moves, changes and upgrades on a daily basis. The problem was already complex for 2G and 3G, and will continue to grow in magnitude.

Without effective automated tools, operators will struggle to evolve quickly to transform their transmission networks in the most cost effective ways, whilst retaining accuracy and high quality.

The major RAN vendors all offer end-to-end solutions with a variety of technology solutions from fibre through wireless, and typically using Ethernet. Operators need systems in place which sit above these various vendors and knit together the fabric of the underlying network.

Managing Network Capacity is no longer restricted to cellsite radio capacity alone

In the days of 2G, the high cost of a cellsite and radio capacity compared to the backhaul transmission determined a simple rule. Each cellsite was provisioned with backhaul to match 100% of the peak transmission capacity. With voice calls and SMS being the bulk of traffic carried, this equated to one or two E1 or T1 lines per site.

Several factors have changed this strategy in recent years:

- Data traffic has grown to dominate the traffic mix
- The cost of basestations has been driven down
- BSC/RNC equipment have developed transmission resource sharing features
- Dedicated data backhaul standards have evolved, such as IP

This issue is exacerbated in 4G networks, where backhaul capacities of several hundred Mbit/s are reached.

This has led to a new skill of transmission capacity planning, which is handled in conjunction with radio network planning. The substantial growth in transmission costs, if not managed carefully, will affect the ongoing operation costs.

Operators need to ensure they have three layers of OSS tools in place to properly address the issue:

- Accurate technical inventory, which holds the physical and logical information about the transmission network including every card, port and logical end-to-end circuit. This data should be refreshed from the live network on a regular, automated basis.
- Automated technical design processes, which handle the most common activities in transmission design. These processes will select, reserve and execute the planned changes for every new, upgraded and migrated equipment. Automation allows standard business rules to be applied, with engineers able to override or modify the standard selection where required – whilst still ensuring that a technically sound and complete solution is provided.
- Capacity planning, where both short term bottlenecks and longer term trends are identified, tracked and resolved. This leads to investment budgets being applied where they are most needed, looking forward rather than reacting to shortages or other constraints.

Greater opportunity for commercial agreements

With much larger costs involved, operators are investigating co-operation and outsourcing arrangements more enthusiastically. These range from simple site-sharing agreements, outsourcing of the entire RAN and joint ventures.

We are also seeing the use of 3rd party transmission changing. In some cases, operators are bringing more in-house; in others, there is more leasing of external services.

Several attempts to implement these schemes have failed, not at the commercial level, but on the technical side. Without the inventory and process tools in place, the cost and implications of separating service delivery from in-house to 3rd party or shared arrangement is not feasible. In extreme cases, there has been a disconnect between what the CEO level believed was commercially feasible and what the CTO/operations department could implement with the tools and systems they had in place.

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The impact of LTE is likely to drive the need for commercial co-operation further, and will stress the importance of having effective inventory, design automation and capacity management tools.

LTE should make RF planning simpler – but it isn't standalone

An enormous amount of thought and design has gone into making LTE easily to rollout and manage from a radio planning perspective. LTE includes both self-organising and self-optimising features, with each cellsite monitoring its own environment and adapting accordingly. This should reduce (but not eradicate) the need for RF planning engineers to tune the system to the same extent as for 2G and 3G.

However, LTE will co-exist with 2G/3G systems for many years to come – at least a decade if not longer. Most of the LTE operators will also have those systems in place, and will want to maximise the return on the cost of equipment already in place. They'll also want to capture roaming revenues from visitors from other countries which have not adopted LTE so quickly. It will also take some time for LTE handsets to become the vast majority of equipment through natural upgrade/replacement, and for LTE to reach the same coverage levels as 2G/3G.

When 2G networks evolved to 3G, particularly those using a radically different technology such as UMTS, they often chose different vendors through competitive procurement processes. This led to overlapping areas of 2G and 3G coverage handled by different vendors RAN equipment. Although the same RF planning tool would be used to determine the RF parameters for both 2G and 3G cellsites, there were often minor discrepancies arising. These included one-way handover between cells, mismatched 2G/3G neighbour cell lists and/or candidate handover cells many miles apart.

RF designers also determine the policy rules which drive the traffic onto 3G where available, such as using asymmetric handover, and direct traffic between bands (e.g 850/900/1800/1900 MHz) to optimise network capacity with end user performance. There are many clever proprietary handover algorithms at their disposal from the RAN vendors.

With LTE, operators will need to match radio parameters including neighbour lists between three different systems. There will be a need for additional cross checking, and design rules including handover policy across the different network technologies and frequency bands.

Again, the careful management of these rules and resulting radio parameters will be required to achieve optimal performance and end-user experience. This involves staging the parameters generated by RF planning tools and downloading them to the various vendors systems in a controlled manner.

3 Summary

An LTE Radio Access Network (RAN) won't be radically different in architecture from 2G or 3G. It will fit alongside, sharing cellsites and transmission capacity. It will deliver a much enhanced mobile data service - faster, lower latency and higher capacity. This will provide a foundation for a wide range of innovative new data services, operating on a wider range of mobile enabled devices.LTE will further accelerate the explosive growth in backhaul transmission capacity required for 3G. This adds a new problem of transmission capacity management which is essential to control operating costs. In addition to radio planning of the location and RF capacity/configuration of each cellsite, operations departments will need to carefully plan the capacity management and design of their transmission networks.

Operators who have the OSS toolkits capable of managing the demands of a combined 2G/3G/4G transmission network will be able to run their business at lower cost, able to respond to changing capacity demand and be much more competitive.

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