2020 Vision for LTE

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The new mobile communications technologies invented and ensuing capabilities provided to operators and end users since inception of cellular around 30 years ago are outstanding. While development goals have evolved significantly over the decades, the pace of innovation continues unabated. At the heart of the world-leading mobile technology ecosystem, since 1998, is standardisation by the 3GPP producing a major release of technical specifications every year or two.

Following the introduction of an entirely new air interface with LTE in Release 8, and with various enhancements subsequently, upcoming Release 12 and beyond will be as significant as ever in the industry's quest to extend mobile broadband availability, provide much more consistent service quality, and economically satisfy demand for spiralling data growth in face of spectrum scarcity and other constraints.

The 3GPP Technical Specification Group responsible for Radio Access Network technologies met for a two-day workshop in Slovenia earlier this month to consider what should be evaluated for implementation in Release 12. Forty-five mobile technology vendors and operators took part, with 250 people attending the event. Presentations, comments and conclusions are available for anyone to access via the 3GPP web site. On the basis of consensus among this 3GPP membership and further study work, Release 12 will most likely be "frozen" in 2014, with commercial implementations beginning a couple of years later and extensive worldwide adoption toward 2020.

The Generation Game

Successive mobile generations are typically depicted in technological terms. For the world's mobile operators following the standards path, first laid by ETSI and then 3GPP, 1G analogue was followed by 2G TDMA-based GSM, then 3G wideband-CDMA-based UMTS and 3G/4G OFDMA-based LTE. However, concurrent with each generational shift have been profound advances in the capabilities, economics and availability of network, device and service offerings.

Outdoor coverage in urban areas and along highways for predominantly car phone use by a privileged minority was provided by 1G networks. Introduction of 2G since the early 1990s substantially increased voice capacity and reduced costs. Cellular soon became economic for

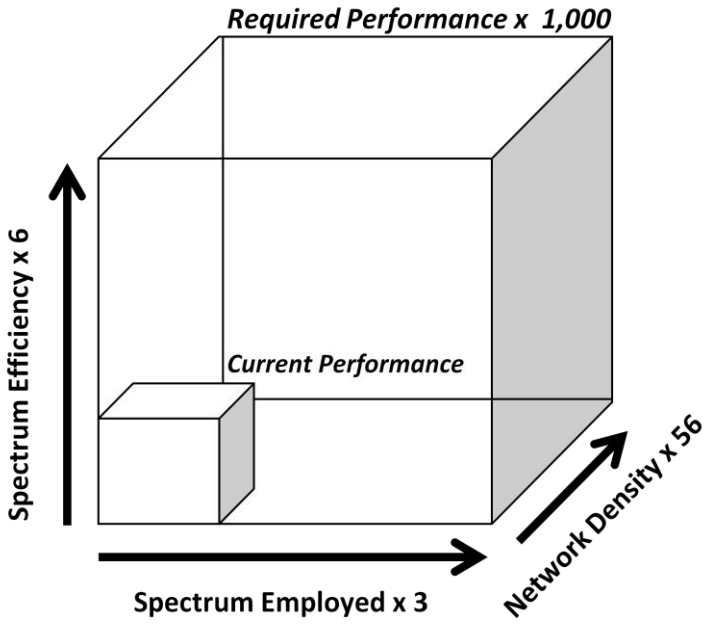
mass-market consumer adoption in any nation. The result is 6 billion GSM subscriptions for voice and text worldwide today. The addition of 3G since the early 2000s provided further voice capacity and then, with HSPA, the higher speeds and lower latencies required to stimulate significant mobile broadband use. Enhancements to established 3G technologies and introduction of LTE with Releases 8-11 have made headline-grabbing news, with peak data speeds in the tens of megabits per second—1,000 times faster than a decade earlier with GPRS. What more could anybody possibly need or want?

We are still at just the beginning of the mobile broadband revolution. The extent of market development and user adoption for mobile web, apps, multimedia and location capabilities, among others, is comparable to the early stages of the switch from 1G to 2G. Mobile broadband, while impressive where available and for those who use it, was only a pursuit for a small minority until the last couple of years. Coverage remains patchy, with insufficient capacity in many places; and erratic service quality, including highly-variable data speeds—from cell-to-cell and from cell centre to cell edge.

While making major improvements on all these fronts to satisfy the current base of users and existing usage profiles, there is also the pressing need to satisfy massive growth in data traffic. This is widely-recognised, among 3GPP members and external observers, to have doubled each year and is set to continue growing rapidly. This will result from new services, such as highly connection-persistent cloud services, heavier usage per user all around and yet more people trading up from voice and text to mobile broadband devices and service plans. Virtually all commentators expect a 15 to 30-fold traffic increase over five years and several expect this growth trend to last a decade to 2020, representing a 250-1,000-fold increase. How can all that be achieved; and at low enough costs to cover and be afforded by half the world's population, plus billions more machine-to-machine connections?

Alleviating the Capacity Crunch

The biggest challenge facing mobile operators and their technology suppliers is in satisfying this exponential growth in data traffic. The proportion of users with smartphone and other mobile broadband devices is increasing. These users are already the majority in several developed nations. Per user data demands are escalating with always on, always with you access to a burgeoning array of applications and services including those delivered from network-intensive video and cloud services. LTE networks are already providing headline speeds approaching 100 Mbps, but these are only possible under ideal conditions on lightly loaded networks and where user equipment is close to the base station radio antenna.



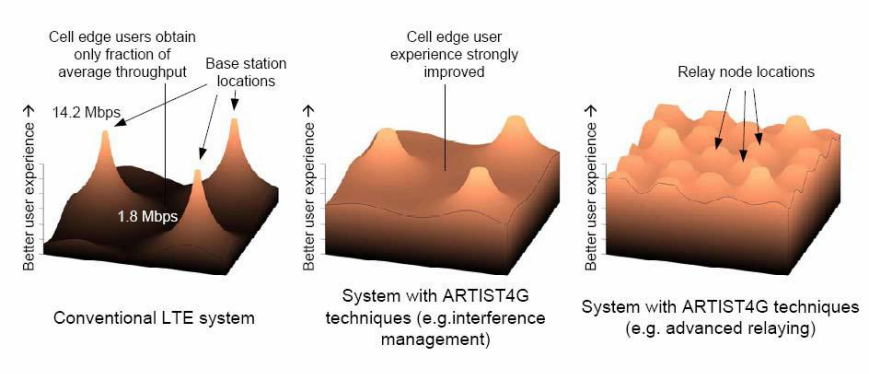
Many technologies and features introduced in previous releases are being enhanced and supplemented with new additions in Releases 12 and 13. These developments will increase network capacity, while also providing more consistent service quality, with the product of three compounding factors. Illustrative improvement figures of 3 x 6 x 56 = 1,008 were suggested by SK Telecom under three broad headings. The specifics were identified and described in contributions from many workshop participants.

- **3x increase in spectrum employed**
  Existing bands will be refarmed for more efficient use. New licensed bands, including higher frequencies for hot-spot demand zones will be introduced. This will all be used in combination with unlicensed spectrum, if suitable, while possibly exploiting cognitive radio techniques to access and manage the latter. TDD mode LTE is unleashing access to unpaired spectrum. Carrier aggregation including the combination of different bands and modes will increase total capacity, headline speeds and trunking efficiency.

- **6x improvement in spectral efficiency**
  A plethora of technologies are helping increase the amount of data transported per Hz of spectrum used, to reduce latency and increase speeds—with emphasis on average speeds achievable across the entire cell including cell edges. Improving consistency of service performance, rather than just peak speed—depending on time and place—is the key. Higher-order modulation to 256QAM, coordinated multiple point transmission and interference management techniques will improve cell-edge performance. 3D MIMO and massive antenna beamforming with arrays of as many as 64 antenna elements

enable additional frequency reuse within cell sectors. With strong consensus in 3GPP to maintain LTE's OFDMA air interface in the downlink, some 3G participants favour introducing something similar to improve uplink performance.

- **56x higher average cell density**
  The addition of many small cells in HetNet configurations including macro, micro, pico femto, relay stations and even clouds of antennae will provide the biggest boost to capacity through extreme frequency reuse. With 70 per cent of traffic at home or in the office, buildings present both opportunities (e.g., access to power and backhaul) and difficulties (e.g., signal attenuation). Improved backhaul, and sidehauling via X2 interface (for inter-cell signalling), will support techniques such as baseband pooling and inter-cell coordination that can most efficiently and effectively orchestrate resources with the large arrays of radio heads that will be deployed in high-demand locations. There are initiatives to simplify management across cells with rationalised signalling and control maintained at the macro layer, and introduction of phantom cells in high-density small cell layers.



Source: Artist 4G

LTE takes Centre Stage

LTE has universal appeal and will soon predominate worldwide. The workshop participants overwhelmingly endorsed this as the definitive air interface standard for ongoing development. Whereas the US leads LTE with 70% of connections today, many other nations are moving to deploy LTE quickly. More than half of mobile subscribers in Korea will be using LTE within two years. LTE will provide the primary or only broadband access to billions of people in developing nations where fixed network alternatives are not available.

Meanwhile, operators wish to protect their investments in older technologies. They may not, for example, be able to refarm scarce spectrum from legacy technology use for several years. Release 12 will also include various enhancements that will improve spectral efficiency and service quality in UMTS networks using HSPA technologies. In addition to helping maximise coverage and roaming, legacy 3GPP standards facilitate competition among standards because vendors' strengths and strategies vary from technology to technology.

With LTE's preeminent position, this technology is also the principle focus for a variety of additional development objectives including:

- **Extending usage profiles and finding new ways of doing things**
  LTE has become the target platform for machine-type communications (machine-to-machine), public safety use and proximity services (device-to-device). Public safety users are plagued with interoperability problems among different emergency service providers, radio technologies and frequency bands that they believe focusing on LTE can help solve. Resilience to earthquake, tsunami and hurricane are increasingly important for these kinds of users. D2D is just like the good old walkie-talkie – pretty useful if the network has been wiped out in a natural disaster—while also employing and complying with LTE-based standardised technologies that can provide the highest performance most economically.

- **Energy, economics and environment**
  Network power and user equipment battery saving are important development objectives being spearheaded through 3GPP standards work. According to Telefonica, electrical power accounts for 30% of OPEX, of which 50% is for power amplifiers. Low power modes and solar energy sources reduce electric grid consumption, mitigate demand for costly diesel generation in remote locations and reduce carbon footprints. Flatter networks, with decentralised as well as centralised architectures (e.g., using baseband resource pooling and virtualisation) will also reduce the cost per bps of network capacity and per byte of data traffic transported.

- **Managing complexity, interoperability, compromising and automating**
  Mobile communications standards are increasingly extensive, complex and involve thousands of people in their development and implementation. This creates signification management and operational challenges, and trade-offs for 3GPP participants to weigh-up. Under-specifying or over-specifying, including too many options —many of which may never be implemented—causes problems in

interoperability testing. Balancing the benefits of backward compatibility with the costs and complexities incurred while creating enhancements requires compromise. There has been enormous success in achieving end-user and vendor interoperability through mobile standards since the introduction of GSM, but the costs of achieving highest levels of compatibility are not justified in every single case when interoperability is already possible through existing modes or bands. Self-organising network technologies for configuration, management and repair will help manage complexities in network operations, while automating or replacing costly functions such as drive testing.

Footnote for Headline Writers

Whereas 3GPP consensus is that capacity is far more important than speed, the upcoming enhancements to LTE will also increase data rates by a factor of 10 to in excess of 1 Gbps on the move in the wide area, and with 10 Gbps peak rates. That will continue to keep the headline writers and marketers satisfied. They can happily keep boasting about maximum speed increases, with these eye-popping figures, while the industry delivers some much more important improvements.

Keith Mallinson is a leading industry expert, analyst and consultant. Solving business problems in wireless and mobile communications, he founded consulting firm WiseHarbor in 2007. WiseHarbor publishes an Extended Mobile Broadband Forecast. This includes network equipment, devices and carrier services to 2025. Further details are available at:http://www.wiseharbor.com/forecast.html.