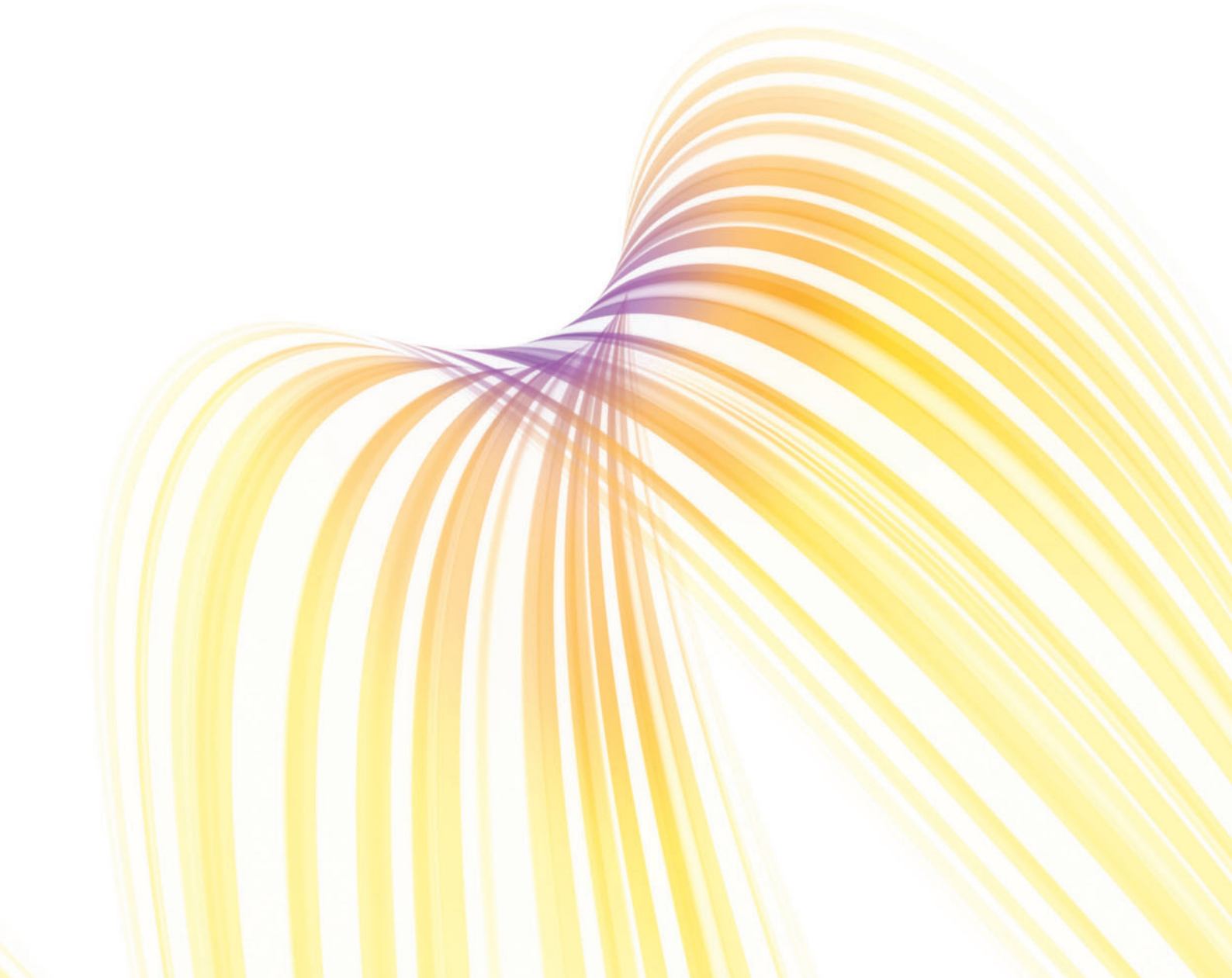
White paper

Long Term Evolution (LTE) will meet the promise of global mobile broadband

Nokia Siemens Networks



Contents

Executive summary

Broadband has become a ‘must have’ for both businesses and consumers. At the same time, the way in which consumers and businesses use communications services is evolving, with wireless delivery of broadband services offering a new level of flexibility and “go anywhere” connectivity.

Mobile operators need to invest in their own networks to support these changing needs and deliver innovative new services. LTE will create an enhanced broadband market and has the potential to transform how users receive, consume and interact with information and content distributed over mobile networks. Rather than being a new air-interface, LTE is about building a complete ecosystem that will meet market demands for the next decade. Deployed on a mass-market scale, the benefits, not just for individual users but communities and businesses, could be considerable. A super fast, efficient and highly reliable mobile network will support the delivery of a wide range of services to multiple devices. This will not only improve the user experience, but will drive efficiency gains for businesses using mobile services, allowing the rollout of new applications such as M2M (machine to machine) and supporting the exchange of information within community-based projects.

The LTE ecosystem will be complex, as symbiotic relationships exist between the various elements within the system. Clearly, several different customer segments will be served by LTE, with different devices meeting a variety of needs.

Consumer expectations of applications will drive future bandwidth requirements. M2M traffic applications will become more bandwidth-intensive, while we are already seeing a significant increase in P2P traffic in many networks. Overall, several factors will drive the market for LTE connectivity and mobile connectivity in general.

LTE networks will be commercially deployed around 2010–2012, mostly in newly available spectrum during the initial years and in existing spectrum later on. It will also be deployed as a direct extension of 2G networks in areas where 3G networks are sparse.

Terminals will be available to work with these LTE networks, as a development of the HSPA terminals but also as the enablers of the new services and applications made possible by the technology.

As a consequence, it is important to understand how LTE will complement HSPA and the HSPA evolution. How will LTE support existing services? What will the corresponding market be in infrastructure and terminals? Why and when operators should move towards deployment of LTE?

Mobile broadband is already a reality. It is a plug and play solution – easy to use, with no additional subscription needed and not limited to hotspots. With embedded modems, for example in notebooks, this is the first step to a more consumer oriented market. Data services are currently experiencing real success, resulting in a dramatic increase in traffic on HSPA networks.

However, revenues will remain constant or profits will increase only slightly. Hence, there is a huge need to drive Total Cost of Ownership down.

This traffic will be supported by software upgraded equipment running in the 2,6 GHz bands (but also in existing 2.1 GHz, 900 MHz ,1800 MHz) and those to come (700 MHz, AWS, 850 MHz and 1900 MHz in the North American Region).

LTE will provide higher capacity than HSPA and HSPA evolutions, stemming from its better spectral efficiency and shorter latency. Operators will decrease their cost per MByte by making the choice to deploy LTE instead of HSPA. And LTE will bring benefits related to refarming, especially when less than 5 MHz bandwidth is available.

A number of operators may currently have no plans to deploy LTE because they are still too busy rolling out their HSPA networks and need to secure their ROI. However, it should be borne in mind that cell splitting, back-haul and core upgrades can be costly and need to be used optimally. It may be more cost-effective to move to LTE/SAE after deploying the second HSPA carrier.

For this reason, the rationale for building a substantial “Ecosystem” depends on:

- Willingness of operators to invest in new systems like LTE when there is a positive business case.
- Fulfilling the promises for delivery of LTE deployment within the current projections of 2010–2012.
- The deployment expectations of LTE in the US/Europe/Asia and their impact on other regions. More than 20 operators have made the commitment to deploy LTE. Currently, LTE is driven by operators in Japan (NTT DoCoMo, KDDI and Softbank), the USA (Verizon, AT&T and Telus), Australia (Telstra and Optus), and Europe (T-Mobile, Vodafone, Telefónica and FT Orange and others).
- Deciding on a realistic migration strategy. Deployment and operation of multiple networks is too expensive and a long phase-out period may be needed for GSM in some markets and 3G in other markets.
- How quickly a harmonized frequency plan (e.g. 2.6 GHz and digital dividend spectrum) can be accomplished and frequency made available.

The industry at large sees a viable market and has already committed significant financial and human resources to LTE/SAE.

LTE is the natural next step

Mobile broadband will exceed 50% penetration in the next five years. What platforms will be used? In markets such as Austria, 60% penetration has been achieved already with a tremendous growth of 30–45% CAGR per annum, making mobile broadband one of the most quickly adopted communication services.

Many operators have also reported an explosion of traffic, driven mainly by USB (dongles), Ultra Mobile PCs (such as eeePC) and smartphones, i.e. iPhone like devices. The latter have generated an 8–30-fold increase in traffic, while the Nokia N95 and N98, bundled with vertical services such as security, content for music and TV, have also made a major contribution.

LTE is an emerging technology standard that is being developed by 3GPP. The process of formalizing and establishing the standard is continuing. It will be finalized by the end of first quarter 2009 with trials carried out during 2009 and the first commercial deployments from 2010 onwards. Significantly, LTE also represents the next step in the evolution of the GSM/WCDMA/HSPA cellular network family to support the delivery of a range of services requiring high data rates similar to those in a PC-based environment. It is the natural response to operator needs as defined in a recent NGMN Ltd (Next Generation Mobile Networks) white paper, an initiative of leading international operators.

Although there is a very strong drive towards LTE, with several operators making a clear commitment to the technology, the leading players in the ecosystem as a whole are still figuring out how to accelerate its uptake and how and when it will position itself in a market that will still be deploying HSPA.

Compared with existing and competing technologies, LTE will enable significant further development and more efficient delivery of the new data-rich services. The widespread use and acceptance of these services is likely to raise the need for an evolved UMTS/HSPA, due to continued cost pressure. These were among the key factors considered in the development of the LTE (FDD and TDD versions) standard.

Defining LTE

By LTE, we mean an evolutionary step from the existing infrastructure to the LTE radio access network and the System Architecture Evolution (SAE) core network. Taking the advantages of its radio characteristics, which are based on OFDM (Orthogonal Frequency Division Multiplexing) principles, LTE is a major breakthrough in terms of performance levels beyond what will be practical with CDMA approaches, particularly in larger channel bandwidths. It will coexist with both 3G systems and 2G systems, fitting into current operator owned spectrum, or into new spectrum to be acquired. Although LTE supports a scalable bandwidth from 1.4 up to 20 MHz, a 20 MHz bandwidth will be needed to achieve its optimum performance and cope with the expected data traffic growth.

LTE will support any compliant multimode device – in particular, seamless interworking with LTE and WCDMA/HSPA and GSM as an inherent part of the 3GPP LTE/SAE standard as well as interworking with CDMA networks.

In order to realize the full benefit of LTE, the System Architecture Evolution (SAE) is required in the core network architecture (defined by 3GPP). SAE provides a flat, fully IP based network architecture, consisting of only one node in the user plane of the Core network and thus guaranteeing optimal scalability and therefore reduced cost per bit. As a circuit switched network is not available anymore voice service will be supported as VoIP.

LTE, the natural choice

Many of the attributes of LTE make it a favorable choice for incumbent GSM operators:

- Operators' decisions are entirely driven by business cases and on a higher level, by the stock market. By creating long-term economic sustainability for mobile broadband, LTE will improve Total Cost of Ownership (TCO) compared with HSPA.
- LTE networks will interconnect seamlessly with 3GPP and 3GPP2 legacy networks, providing the convenience of keeping the existing global roaming agreements and giving the ability to seamlessly hand-over to the GSM/WCDMA or CDMA networks when LTE coverage is not available. This allows for a smooth upgrade path from an existing 3GPP/3GPP2 network, where LTE can be deployed in phases and still provide ubiquitous connectivity.
- LTE can be deployed in existing FDD spectrum alongside GSM or UMTS and "grow" in that spectrum in several steps as more subscribers are converted to LTE.
- With the TDD LTE version, the operators who own TDD spectrum will have the possibility to deploy TD-LTE, the TDD version of the LTE standard. Hence, they will have the flexibility required to offer mixed services to meet their customers' needs.
- 3GPP technology can use the economies of scale from GSM/WCDMA, which account for more than 85% by market share of today's mobile connections. This will have a significant impact on future LTE infrastructure and handset costs.
- LTE not only improves the throughput in the air interface and reduces the latency, it also introduces an architecture designed for IP backhaul. The backhauling will need to handle capacities of 100 Mbps and more. Therefore, the expectation is that traditional E1/T1 connections will not be scalable cost-effectively and more cost-efficient Ethernet connections will be used.
- It can operate in different frequency bands with various channel bandwidths. This enables Multi-access Base Stations in the long term to also support GSM and/or WCDMA.
- LTE supports a self-organizing network feature, which brings major OPEX savings.

For all the above reasons, LTE is likely to be more attractive to incumbent operators.

LTE opens up many business opportunities

Market trends and explosion of mobile traffic

Some 93.5% of WCDMA networks now offer HSPA services, with 247 commercial HSPA networks now available in more than 110 countries. There are now more than 1276 HSPA-enabled devices available, including mobile handsets, notebook PCs, data cards, wireless routers and USB modems. As of September 2009, there are more than 79 million HSPA connections worldwide.

Of the approximately 3.5 billion subscribers worldwide, 3G accounts for 350 million, with more than 30 million added every quarter. Analysts estimate that by 2015, the number of total 3G subscribers is expected to surpass 2G subscribers. This is five years less than it took 2G to overtake analogue networks.

LTE is forecast to reach 32.6 million subscribers globally by 2013. The Asia-Pacific region will lead in LTE deployments with about 12 million subscribers, followed by Western Europe with 9.9 million subscribers. North America will be third with 6.7 million subscribers and Eastern Europe will follow with roughly 1.9 million subscribers. Latin America will have about 1.5 million subscribers, followed by Africa and the Middle East with a few hundred thousand subscribers on LTE networks.

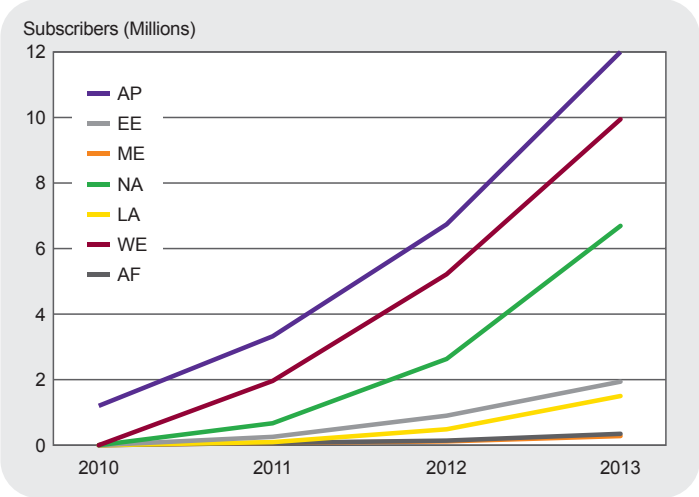
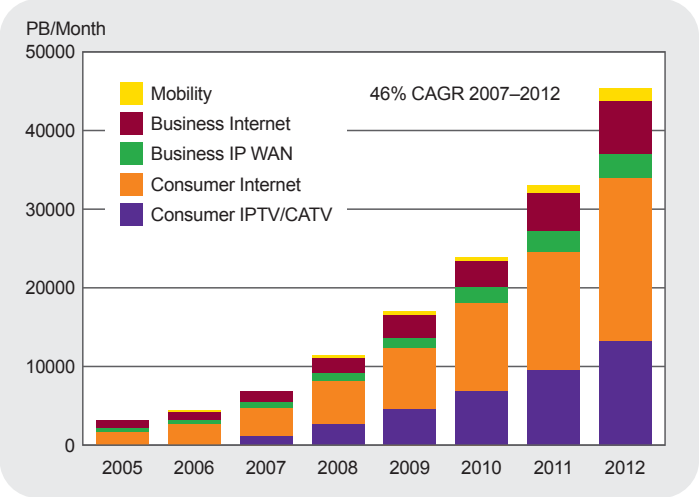


Figure 1. Forecast LTE Subscribers, World Market Forecast: 2010–13 [Source: ABI research, 2008].

Currently, operators are facing an explosion of traffic in their networks. While operators want to encourage data usage by offering a specified limited monthly data volume as flat rate data packages, they are also aware of the current network capacity limitations. In fact, some operators implement policies to prevent customers from operating servers on the wireless networks and creating capacity issues. The migration to flat-rate pricing is leading to commoditization of wireless network capacity and an erosion of revenue.

In addition to the HSPA traffic explosion reported by operators, the IT industry forecasts that global IP traffic will nearly double every two years through 2012:

- P2P is growing in volume, but declining as a percentage
- In 2010 Internet video will surpass P2P in volume
- Internet video is now approx 25% and will account for close to 90% of consumer traffic by 2012
- Mobile data traffic will double each year from now through 2012



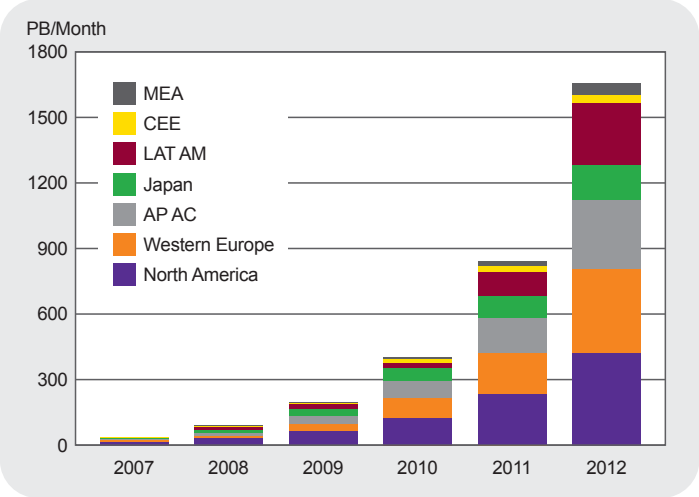


Figure 2. Source: Cisco whitepaper "Approaching the Zettabyte Era" – 16 June 2008.

This means video is expected to account for the majority of mobile traffic, which will grow faster than the usage of fixed USB dongles.

Furthermore, the younger generation has grown up on YouTube and P2P services and is expected to be the primary generators of the data traffic explosion. In order to cope with the future flood of traffic, operators will require a new access technology and flatter network architecture to provide the QoS and bandwidth at affordable cost to users. Besides this, backhaul is critical for the deployment of next generation networks and must be scalable and flexible to allow a dynamic allocation of bandwidth.

With today's broadband, consumers are accustomed to paying a flat rate no matter how many bytes they burden the network with, subject to a fair use policy. Fair usage flat rate tariffs enable cost transparency, thus increasing the usage rate, which is not the case with circuit switched voice service. It would be otherwise difficult for consumers to know how much data they are downloading for a specific service and thus estimate the costs.

This means a new ecosystem needs to be built around a changing market landscape, where user expectations are constantly increasing. Deployed on a mass-market scale, the benefits, not just for individual users, but communities and businesses, could be considerable. Consumer studies have shown that people want to be able to use the services they are experiencing today via fixed broadband access everywhere and at any time. A super fast, efficient and highly reliable mobile network will support the delivery of a wide range of services to numerous devices. This will improve not just the user experience, but drive efficiency gains for businesses using mobile services, enabling the rollout of new applications and community-based projects and accommodating the traffic increases of the future.

Spectrum is needed urgently

Interviews and surveys have shown that the operators' interest in LTE is more complex than is widely understood in the market. While LTE's improved bandwidth and spectral efficiency are a draw, the standard will also bring about a converged, native IP network. Both have appeal, but the core upgrade will likely come first (~2010), with the upgrade to the access network occurring around the same time depending on the operator business cases and regional needs, or from 2012 and beyond.

Furthermore, LTE needs to be available on time and deliver better performance and capacity than HSPA,otherwise there is a substantial risk that operators will continue to deploy on the HSPA road map and consider LTE in their next investment life cycle. Nevertheless, some operators might choose to deploy LTE in parallel; while rolling out HSPA and HSPA evolutions in urban and suburban areas where high capacity and performance are needed to meet rapidly growing traffic demands. This is critical if regulators do not consider the urgency of freeing up spectrum on time, spectrum that needs to be at least 20 MHz per operator to leverage the performance of LTE. The risk is particularly imminent for Europe, which may lose a competitive edge in mobile Internet due to the delay in spectrum allocation. The US and Asia have already conducted their tenders, and network deployments in LTE/SAE are already planned, while Europe remains very fragmented.

Heavy cost pressure

Operators are looking for more bandwidth and efficiency and lower costs. Mobile broadband will reach mass-market adoption when data rates match that of today's wireline networks and the data plan price point reaches $20–30/month. Depending on the market LTE is seen as one of the few technologies that can feasibly support this price point. It also supports operations in both the paired spectrum and unpaired spectrum and allows efficient use of spectrum for both legacy and future wireless frequency bands. Channel bandwidths of 1.4–20 MHz are supported. The wide industry support for LTE ensures economies of scale, providing cost-efficient solutions.

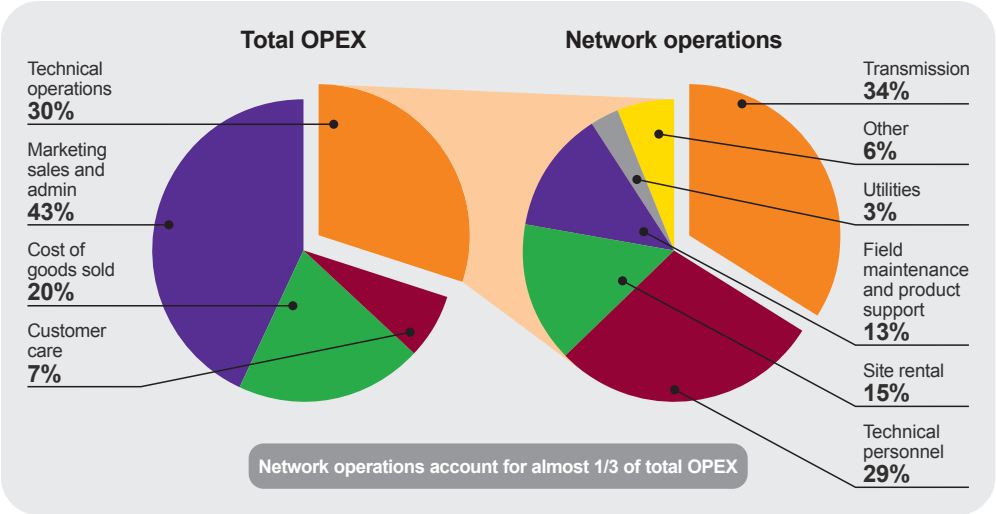


Figure 3. Breakdown of total OPEX and network operations OPEX.

Royalty rates are an important cost factor. The vendors' global IPR initiative states that they are committed to "a single digit percentage figure and respectively "a single digit $ figure" for embedded modules, compared to 3G rates of 15% and higher, which was conducive to new players and innovation, particularly in the market for embedded modules.

Moreover, operators are looking for new revenue streams, because revenues are stagnating, particularly in voice services. Other reasons for seeking to reduce cost pressure are:

- Increased usage while ARPUs remain flat
- Complex services provisioning
- Subscriber churn
- Terminal subsidies

Other cost pressures come from the need to generate additional business and brand awareness, and to enable fast service provisioning that includes Internet based, third party service packaging across various access networks.

In terms of OPEX pressure, operators would like to see lower complexity and simpler networks.

Their interim objective is motivated by near-term business realities, such as CAPEX/resource constraints, consumer spending uncertainties and intensified competition. However, they will invest in upgrading their legacy SONET/ATM based transport network to a native Ethernet/IP-based LTE/SAE packet core between 2010 and 2015.

The CAPEX efficiencies afforded by a flat Ethernet/IP mobile core is also likely to help operators overweight their CAPEX dollars to software upgrades of their existing 3G network equipment. This will help with scaling up the available throughput – and hence service quality, variety, and ARPU – of their consumer and business mobile broadband service offerings.

Figure 4 illustrates the traffic increase slight rise in revenue and the continuing need for investments in existing networks. LTE lowers the operators' cost per Mbyte, as their technologies are decoupled to a large extent from traffic volume.

LTE offers high spectral efficiency and is based on a flat network architecture with scalable network elements. It enables the reuse of existing site infrastructure such as antennas, feeder cables, antennas, masts, hardware racks and power supply elements. For all these reasons, we are confident that it will support much cheaper capacity upgrades than the deployment of new base stations based on existing technologies. LTE does, however, require a handset replacement cycle.

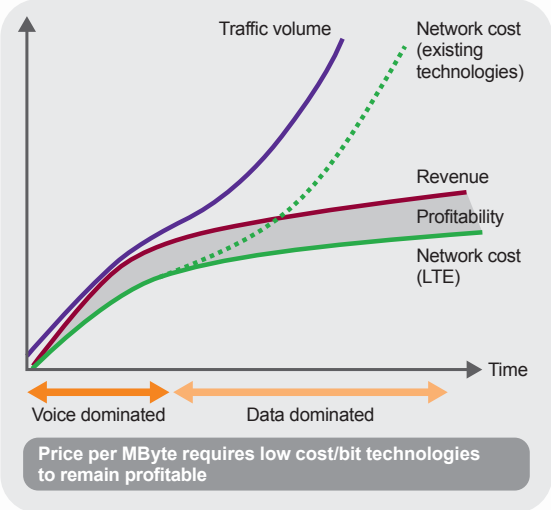


Figure 4. Revenue trends do not correspond with traffic growth.

Demand for flexible spectrum usage

The past five years have seen extensive deployment of third-generation (3G) 'universal mobile telecommunications system' (UMTS) wireless networks the world over. Invariably, this has been in UMTS's 'native home', the so-called high bands. To date, these deployments have largely been in two of the nine bands defined by the Third Generation Project Partnership (3GPP) for UMTS: the 2100 MHz band in much of the world and the 1900 MHz 'Personal Communications Services' (PCS) band in North America.

However, times are changing for UMTS. There is a distinct push to see UMTS rolled out in the low bands defined by 3GPP for UMTS – 900 MHz and, to a lesser extent, 850 MHz.

There are two key short-term drivers behind the push for UMTS in the low band: the improved indoor penetration (typically 30%) that can be achieved at 900 MHz compared with 2100 MHz and the greater coverage areas that can be achieved at 900 MHz. The latter promises a reduction in total UMTS cell count of around 60%, which brings great advantages in rural deployments. The marginal cost of carrying one minute of traffic on UMTS is less than the equivalent traffic on GSM. A judicious balance of guard band allocation and co-location filtering will be required. Although 5 MHz offers an ideal UMTS HSPA channel to cover distance, there are two main issues to bear in mind:

- Not all operators have been allocated the same amount of frequency in the 900 MHz bands or have their own frequency in the extended 900 MHz frequency bands.
- In addition, many GSM 900 MHz networks have reached their full capacity with GSM traffic, and operators cannot free up 5 MHz.

In both cases, LTE offers a clear advantage thanks to its scalable bandwidth.

It is most likely that operators will deploy LTE services in frequency bands like the newly licensed UHF band in the US. Discussions are continuing Europe and the rest of the world, where the digital dividend could use some of the spectrum for LTE. In addition, some countries in Europe and other regions have already started planning for the 2.6 GHz band. Whereas some operators plan to deploy LTE in the 700 MHz or AWS (1.7–2.1 GHz) spectrum, others plan to deploy LTE in their existing 1800 MHz spectrum.

In a later phase, it is most likely that operators will refarm the spectrum currently used for GSM and HSPA and deploy LTE in their existing spectrum (850 MHz, 1900 MHz, 2.1 GHz) when LTE becomes a mass market technology.

In terms of the channel bandwidths over which LTE will be distributed, most operators expect 10 MHz to be most commonly used. In cases where 20 MHz is available it will be used to achieve better throughput especially in urban areas on 2.6 GHz. Other regions will use other frequency bands where 10 MHz or 20 MHz is allocated.

Current operator positioning

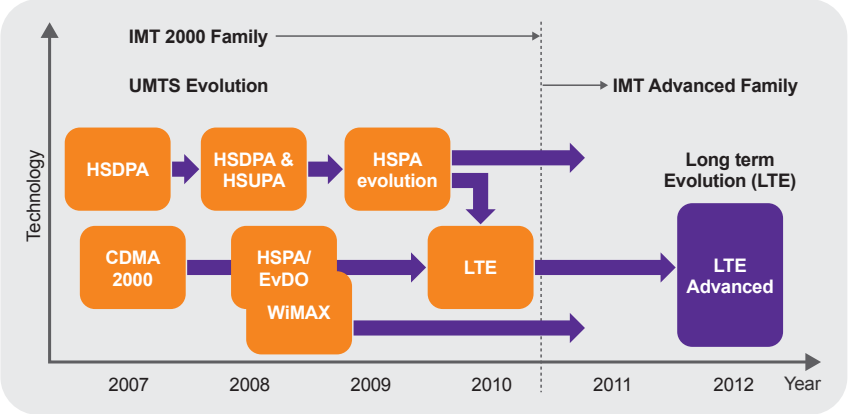


Figure 5. Innovative solutions needed for urban areas.

Whether the industry is truly accelerating LTE development or just creating the perception of that acceleration, the pressure to do so is definitely there. Much of this pressure comes from the deployment of disruptive mobile technologies, mostly in areas where a service provider wants to offer broadband services but lacks a fixed infrastructure, or where a new service provider wants to enter a competitive market where DSL and/or cable are available.

Operators looking to get a head start could begin by deploying multi-technology base stations today. Once a range of LTE devices become commercially available, upgrading their product platforms to support these new standards will be a simple and cost-effective upgrade. This is a strategy being adopted by over ten operators in some of the regions where they operate.

The commitment of Vodafone, AT&T, Verizon Wireless and a handful of other global operators to LTE has established an early market for what was once a technology of the far future. As a result, vendors have pushed development timelines from their original estimates of 2011 to as early as 2009 for field trials and 2010 for commercial deployments. Decisions to adopt LTE have been made by Vodafone, the Japan-based NTT DoCoMo, Softbank and the US-based AT&T, and several operators, including China's leading telecom operator China Mobile, the UK-based Vodafone and the US-based Verizon Wireless are testing LTE technology. In addition, KDDI, the Japanese CDMA operator, has decided to implement LTE for its next generation network. KDDI's competitors NTT DoCoMo and Softbank have also chosen LTE. The new network should be complete and in use in 2010.

Why LTE/SAE is an essential evolutionary step

As the optimum evolution of 3GPP and 3GPP2 mobile technologies, published results of LTE versus WiMAX benchmarking indicate that in normalized metrics, LTE in the downlink is about 20% better in spectrum efficiency and average user throughput and much better in cell-edge user throughput. In the uplink, LTE is 50% better in both average and cell edge performance.

In general, LTE offers peak data rates of up to 173 Mbps in the downlink and 58 Mbps in the uplink, which is in practice faster than today's HSPA by a factor of 10. Latency will be exceptionally low at 10–20 ms, considerably boosting the end-user experience of services such as gaming and browsing, as well as the performance of true real-time applications such as VoIP and the throughput of TCP connections (e.g. HTTP page access).

LTE also has higher spectral efficiency than HSPA, so service providers can squeeze more data into their available spectrum. In addition, LTE uses spectrum in widths selectable from 1.4 MHz up to an impressive 20 MHz, whereas WCDMA uses a 5 MHz spectrum carrier. Due to the characteristics of OFDM, it has a much better average cell throughput compared to HSPA.

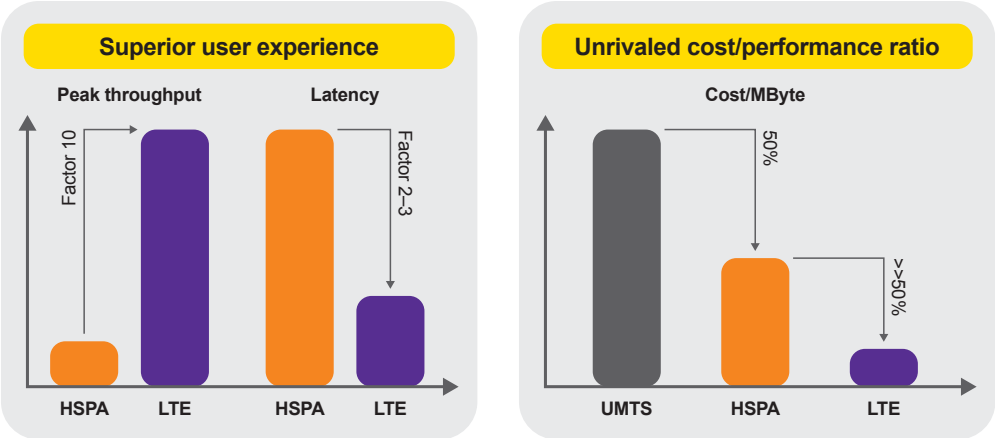


Figure 6. Evolutionary path for SAE.

Figure 7. Benefits of LTE compared with HSPA.

- **Simplified network**
  Flat architecture, fewer interfaces, All-IP, less interoperability testing
- **Efficient spectrum usage**
  Efficiency (OFDM) IMT 2000, harmonized spectrum, scalability from 1.4 to 20 MHz
- **Easy introduction**
  Open standardized interfaces, leverage globally available 2G/3G, affordable, range of devices
- **Capability to re-use existing services and enable new ones**
  Infrastructure re-use, smooth migration, legacy interworking
- **Network quality and security**
  Same high level as today's mobile networks

- **Increased peak throughput / cell capacity**
  173 Mbps downlink, 58 Mbps uplink, high performance at cell edge
- **Reduced response times**
  Total system round trip < 20ms
- **Seamless service access everywhere**
  Always best connected and best managed
- **High performance of new applications**
  Matching user experience with DSL
- ➡ **All this with full mobility!**
  VoIP with GSM mobility and quality, for example

This gives tremendous deployment flexibility to service providers, allowing them to apply more bandwidth in hotspots with high-capacity demands and use blocks down to 1.4 MHz to achieve basic low-cost nationwide coverage. Furthermore, LTE protects existing 3G investments by extensively re-using sites and network elements.

The high performance and low costs are also due to LTE's network-simplifying 2-node flat architecture for user data, in which the base station is connected to one element in the core network, the MME. Nokia Siemens Networks has a head start in flat architecture with its I-HSPA technology, which already uses the same architecture employed by LTE.

Clearly, LTE offers the best evolutionary path for service providers to upgrade their mobile broadband. The technology also carries wide industry backing with the LTE/SAE (System Architecture Evolution) Trial Initiative (LSTI) involving vendors, chipset manufacturers and mobile service providers collaborating to validate the LTE ecosystem.

The user benefits of LTE/SAE translate into revenue potential for the operator. To tap this potential and turn profits, operators must optimize both revenues and costs. Moreover, the need to improve cost efficiency increases as data traffic rises. Figure 6 on the previous page shows the relationship between network performance and cost for WCDMA/HSPA and LTE. LTE/SAE combines a more efficient air interface, a simplified network and improved service provisioning to achieve greater cost-efficiency and savings.

Air interface performance and flexibility

Driving down cost per MB also entails improving the air interface's efficiency and applicability by:

- Increasing spectrum efficiency and cell edge bit rates, while allocating bandwidth flexibly by making the most of available spectrum.
- Operating in the 3G spectrum if necessary, alongside a 3G system and in soon-to-be assigned new spectrum.
- Gearing up to re-farm frequency bands such as GSM and possibly operating in lower frequency bands to exploit spectrum options and to maximize coverage at lower investment, especially in rural areas with lower traffic density. Re-farming GSM and CDMA requires a solution suitable for small bandwidth allocations. Nokia Siemens Networks has launched its standardized Multi-radio BS that will support LTE and GSM or, for the US, CDMA/LTE with software upgrades.
- Supporting fast service access to minimize system load and maximize the number of users served simultaneously.

Network complexity

The consensus is that the complexity of system architectures and diversity of protocols are major cost drivers for networks and terminals. This complexity and diversity can be mastered by:

- Simplifying the network architecture with a flat hierarchy and much fewer protocol conversions (or content mappings).
- Introducing open, streamlined interfaces and reducing protocol options.
- Employing IP-centric communication, equipment and VoIP throughout the core and radio networks.
- Making extensive use of low-cost backhauling such as carrier-grade Ethernet rather than E1/T1 based leased lines.
- Supporting self-configuring and self-optimizing network technologies to reduce installation and management costs (SON).

Service provisioning

Recent surveys indicate that user expectations for service provisioning are difficult to predict in the long term. In reality, analysts expect services to become a short-term business offering.

These are the key success factors to meet these challenges:

- Capability to create highly personalized services and deliver every type of service, including end-user self-provisioning
- Individual support for every type of access based on a common service control and provisioning platform
- Improved user experience for every service offering
- Diversified offerings, including flexible service bundling across all types of access
- Simple and transparent billing procedures which foster subscriber loyalty.

A bright future with LTE

The industry recognizes that making technology available is not sufficient to ensure sustainable advantages. It needs to find a win-win situation where individual users are motivated and able to use technology in ways that support the operators' business.

LTE will provide significant efficiencies over existing 3G technologies. Mobile service providers have expanded their portfolios to include a diverse range of mobile service elements in order to drive both usage and revenue growth. Due to the bandwidth-hungry nature of such services, widespread distribution to consumers is dependent on an effective delivery infrastructure.

LTE offers the most efficient evolution path, with maximum use of the network, at a reduction of cost per MB comparable to HSPA and for WCDMA, as predicted by the UMTS Forum and Analysys Research study of 2008.

The availability of handsets will drive the service uptake. Large screens, high-quality resolution and long battery lives are among the specifications that will enable effective delivery and an enjoyable user experience, especially for the services particularly suited to LTE.

LTE/SAE is geared towards reuse of as many system components as possible. Nokia Siemens Networks' LTE/SAE solution will enable early introduction to flat network architecture thanks to our early introduction of direct tunnel and I-HSPA as an optional intermediate step.

Complying fully with the 3GPP LTE/SAE standard, this high performance mobile broadband network will be reliable and interoperable. By enabling its smooth, early introduction, Nokia Siemens Networks will optimize the LTE/SAE solution's total value of ownership.

Glossary

2G	Second Generation
3G	Third Generation
3GPP	Third Generation Partnership Project
3GPP2	Third Generation Partnership Project 2
ARPU	Average Revenue Per User
ATM	Asynchronous Transfer Mode
bps	bits per second
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditure
CMOS	Complementary Metal Oxide Semiconductor
DSL	Digital Subscriber Line
EPS	Evolved Packet System
FDD	Frequency Division Duplex
GHz	Gigahertz
GPRS	General Packet Radio Service
GSM	Global System for Mobile communications
GSMA	GSM Association
HSDPA	High Speed Downlink Packet Access
HSPA	High Speed Packet Access (HSDPA with HSUPA)
HSPA evolution	HSPA Evolution
HSUPA	High Speed Uplink Packet Access
Hz	Hertz
IMT	International Mobile Telecommunications
IPR	Intellectual Property Rights
IP	Internet Protocol
ISP	Internet Service Provider
ITU	International Telecommunications Union
kbps	Kilobits Per Second
kHz	Kilohertz
LSTI	LTE/SAE Trial Initiative
M2M	Machine-to-Machine
Mbps	Megabits Per Second
MHz	Megahertz
msec	millisecond
NGMN	Next Generation Mobile Networks
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
P2P	Peer-to-Peer
RF	Radio Frequency
ROI	Return of Investment
SAE	System Architecture Evolution
TDD	Time Division Duplex
UMTS	Universal Mobile Telecommunications System
USB	Universal Serial Bus
µs	Microseconds
VoIP	Voice over Internet Protocol
WCDMA	Wideband CDMA

Nokia Siemens Networks Corporation
P.O. Box 1
FI-02022 NOKIA SIEMENS NETWORKS
Finland

Visiting address:
Karaportti 3, ESPOO, Finland

Switchboard +358 71 400 4000

Product code B301-00342-EF-200812-1-EN
Indivisual