WHITEPAPER

locate, communicate, accelerate

LTE – Delivering on the mobile broadband promise

Driving the 4G revolution with improved bandwidth and latency

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Executive Summary

LTE is the latest generation mobile network technology, and the fastest growing standard in telecoms history. With the exponential increase of video-rich content and remote data storage, LTE has been designed to meet the growing demands of the internet for both human-to-human, human-to-machine and machine-to-machine communications.

LTE will accelerate and enhance numerous technology trends including last-mile connections, multimedia-rich web applications, security and cloud computing. This whitepaper briefly summarizes the history of mobile data networking, and how LTE's bandwidth and latency improvements will change the face of the web.

LTE: the world's fastest growing telecom standard

Digital mobile communication was born in the 1990's as an offshoot of the fixed wired telephony industry in the form of 2G GSM, which initially offered voice as the primary service. Later on, data was added as a lower priority "add-on" feature, first as SMS for text messaging and then as packetized data through GPRS and then HSPA. Interestingly, SMS, the first commercially available mobile data service, today generates over 100 billion dollars in annual revenue worldwide!

Two cellular network generations later, **data has taken over as the driver of mobile network technology.** Voice, now a commodity, has been replaced by multimedia-rich applications and services as the main revenue generator. This is why operators are rapidly rolling out 4G LTE, making it the **fastest growing telecommunications standard in history** (see figure 1).

LTE promises to deliver a whole new level of bandwidth and quality of service for both mobile human-operated devices as well as for human-to-machine and machine-to-machine applications that require affordable, high-bandwidth, high-quality and low-latency wireless connectivity.

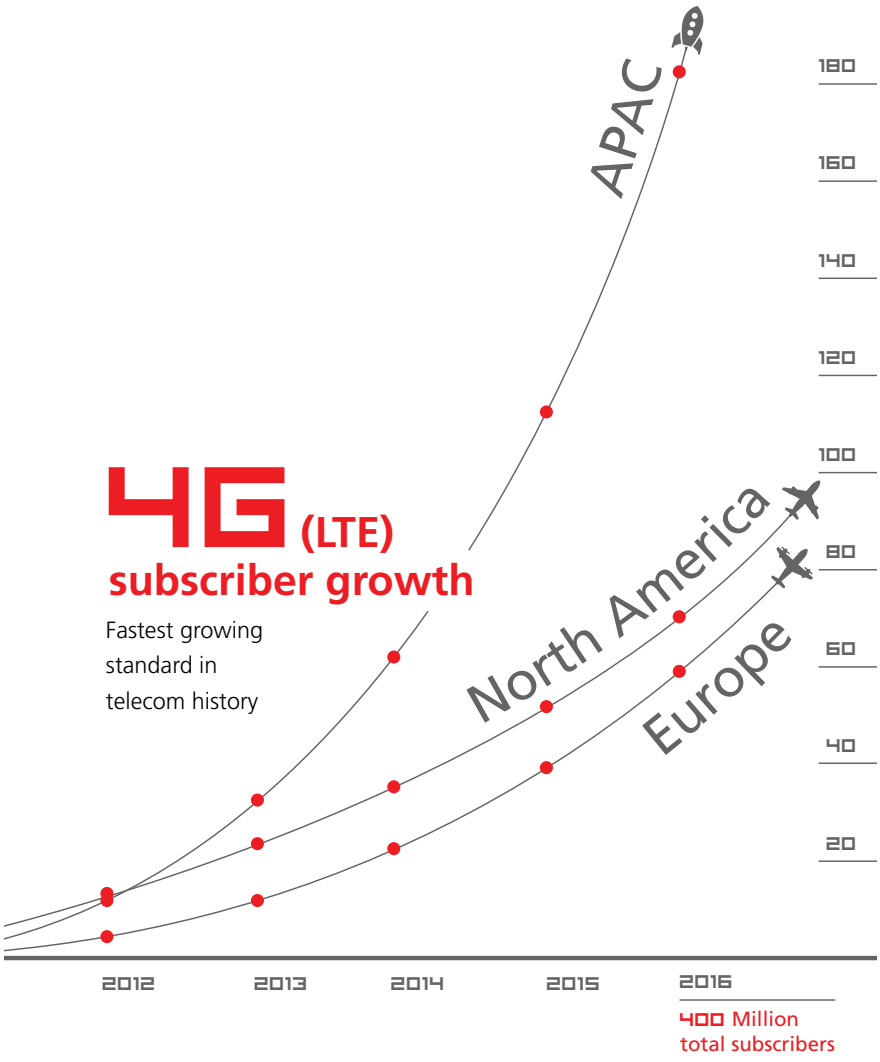


Figure 1:
Data has become the driver of mobile network technology, this is why operators are rapidly rolling out 4G LTE, making it the fastest growing telecommunications standard in history.

Network Operators and the Mobile Broadband Promise

During the 1990's and 2000's, operators fought hard for time-based voice revenues and also flirted – unsuccessfully – with new "pay-per-use" models for data traffic. Users had rapidly come to expect voice to be a free or almost-free service! This forced mobile operators to increase air time and add ever more voice subscribers in order to pay for the increasing costs of their network infrastructure. The very success of the mobile phone revolution had driven Average Revenue Per User (ARPU) lower and lower.

Although data services were seen as a way to reverse the declining voice revenues, operators tried to charge for data on a "per use" basis. In an attempt to create new revenues, operators also served up their own branded content and services (the "walled garden" approach), still working with a "voice oriented" mind-set. This made these early data services very expensive and unattractive to use, and just served to delay the adoption of data services on mobile devices.

Meanwhile, on the fixed-line side of the internet, an **insatiable demand for web based interaction and services grew over high-speed DSL and cable networks** which started to proliferate in the early 2000's. This resulted in an astounding increase in internet traffic and applications. This multimedia-rich "broadband internet experience" quickly became an **essential part of everyday life** for hundreds of millions of people in the developed world.

The spread of this "broadband internet revolution" onto mobile devices began later with the launch of the Apple iPhone in 2007. Although the original iPhone only supported EDGE (at 236 kb/s) it was the first phone designed to fully access the web directly, bypassing the walled garden approach of mobile operators at that time.

The combination of a "designed-for-internet" device with a refocusing of operators away from the declining pay-per-use charging models towards "all you can eat" data subscriptions combined to create a massive shift in the industry, launching the smartphone revolution.

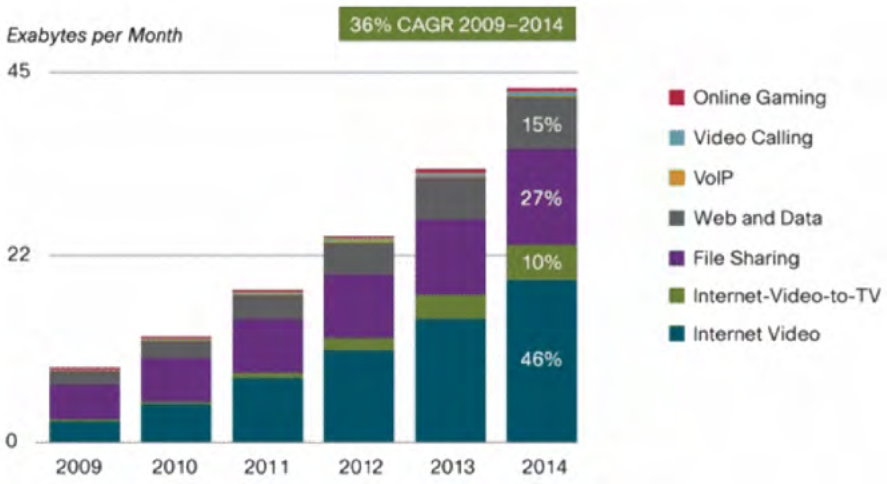


Figure 2:
Internet Traffic Growth (2009 - 2014), Source CISCO

Five iPhone generations later, mobile internet users expect the same high-speed, fixed-line internet experience on their mobile devices as they go about their daily lives.

What applications do people use, and which ones are growing the fastest in terms of traffic generated? **Web traffic today is made up primarily of Video** (such as YouTube, IPTV, Netflix, and hulu), and File Sharing (such as MediaFire, Dropbox, FilesTube, and RapidShare). Other traffic, including web surfing, VoIP, and gaming, together make up only 20% of total bandwidth. Refer to figure 2.

This enormous adoption of video-rich services has generated a growth in internet traffic from about 75 Petabytes (1015) per month in 2000 to over 30 thousand Petabytes per month in 2012. 2G networks are hopelessly underpowered, and 3G "best effort" networks are struggling to cope due to inherent protocol limitations.

Video enhanced applications are clearly driving the growth in internet traffic. To meet this challenge today and in the future, operators are rapidly turning to LTE.

Figure 3:
LTE has 4 key advantages over 2G and 3G networks

Introduction of 4G "Long Term Evolution" (LTE)

3G was only capable of providing sufficient bandwidth during the initial stages of internet growth, but will not be able to scale to meet the expected demands of a large number of simultaneous mobile internet users. Supporting the mobile broadband internet revolution required a new standard designed from the ground up to support mobile broadband internet access.

To meet the anticipated demands on the network, LTE possesses four key advantages over 2G and 3G technologies:

1. **High gross bandwidth,** up to 150 Mb/s down and 50 Mb/s up in today's networks. This is sufficient to stream 8 simultaneous HDTV channels.

2. **Efficient sharing** of the gross bandwidth between a large number of users, allowing cost-effective allocation of data to different end device requirements, and simultaneous handling of high-bandwidth human-to-human and low-bandwidth machine-to-machine traffic.

3. **Reduced Operating Expenditure (OPEX)** through a simplified network architecture and better spectral efficiency (double that of HSPA and thirty times that of UMTS).

4. **Guaranteed maximum latency,** typically around 10 ms, below the threshold of human perception.

These attributes combine to bring users affordable mobile data services with high quality of service and satisfying responsiveness supporting content-rich, interactive applications such as on-demand video, social media, voice, web, gaming and cloud-based applications.

LTE: the wireless "last mile"

LTE's first role will be to deliver the Cable/DSL broadband experience to mobile devices. Put simply, there will be no discernible difference between your fixed line experience at home, and your mobile device. When this service is available, it is only a matter of achieving the same price point as fixed line services before the LTE "last mile" connections replace Cable and DSL connections: the edge of the internet will become purely wireless.

One of the first major applications of LTE will be in **mobile routers** to create WiFi hotspots in public transportation, at events, in city centers, apartment buildings and remote locations.

LTE Human-to-Human mobile applications

Figure 4:
LTE will add a new, video-enhanced dimension to mobile services

Not only will LTE replicate the fixed-line broadband internet on handheld devices, it will add a new dimension to mobile services. The content that users wish to access at home is often different than the desired content when travelling. This is where location data will greatly enhance services available to mobile LTE subscribers. Paired with accurate location based on GPS/GNSS (or other) positioning system, LTE will be able to bring a visually rich range of location based services to mobile users. Some examples:

- **Enhanced shopping and tourism**
  Vision is our primary sense, accounting for more than 80% of all information we receive about the world. Video-rich LTE services will therefore improve many services, for example the mobile shopping and tourism experience.

- **Multimedia navigation**
  Beyond a virtual thumbtack and a red route drawn on a map, LTE will allow users to see and interact with destinations before they actually arrive, and preview landmarks along the way.

New social media applications

Today's internet generation are typically experts at online social media by the time they are 12. Applications such as Facebook and Twitter have become a primary method of communicating with friends, family and colleagues. Currently based mainly on text and photos, LTE will allow easier integration of real-time or cached video into social networking, enhancing the nature of online social interaction.

LTE and Cloud-based applications

Figure 5:
Cloud computing and LTE are complementary technologies, each one driving the adoption of the other.

A general computing trend is the **migration of both professional and consumer applications to the cloud.** This is manifested in such widely used enterprise CRM, ERP, Financial and Online Meeting applications such as SalesForce, SAP, Oracle Fusion and GoToMeeting.

In the consumer space, applications such as Facebook, Google Cloud, Vimeo, Spotify and Dropbox allow users to interact with each other and offload storage and processing of large amounts of data to the cloud. The data is stored, processed, and delivered from servers thousands of miles away. Fast access and minimal delay (latency) during both upload and download is crucial.

Cloud Computing is thus driving two trends in mobile devices:

- **Offloading of mass storage and processing** of large amounts of data to the cloud, allowing the mobile device to be smaller, require simpler electronics and software, with much lower power consumption.

- **Increased requirement for a high-speed wireless pipe** to upload and download data, with perceived instantaneous response.

  Both these trends are **well-supported by LTE. Cloud computing and LTE are thus complementary technologies,** each one driving the adoption of the other.

LTE Machine-to-Machine applications

In addition to human-to-human applications, LTE is also creating new opportunities for improved human-to-machine and machine-to-machine interaction and communications. Examples of high-bandwidth applications include mobile routers, remote surveillance systems, facial recognition systems, digital signage, vending, point-of-sales and telehealth terminals.

LTE's guaranteed **low-latency is especially attractive for time-critical applications** such as industrial control, vehicle safety, traffic control and financial systems where split-second reaction times are crucial for industrial robots as well as automated financial transactions.

Another important aspect of LTE-connected devices is **extremely simple installation:** no cabling is required. A high-bandwidth enterprise-grade network can be setup instantly and managed remotely with virtually no hardware configuration, and vastly reduced IT costs.

Ultimately, **LTE connected devices will exceed human users:** the number of wirelessly connected M2M devices is forecast to exceed all other types of connected devices by 2020, see figure 6.

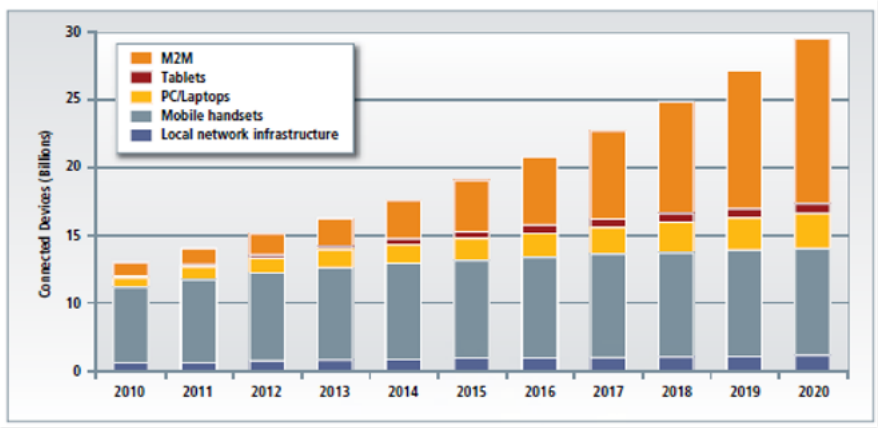


Figure 6:
The growth of M2M applications
(Source: GSM Association)

LTE and M2M bandwidth requirements

Although typical data rates for M2M communication today are much lower than the data rates for which LTE is designed, specific M2M applications will be either created or enhanced to take advantage of the available bandwidth. Some new potential M2M applications include:

- Vending machine monitoring with video commercial display
- Retail terminals displaying product demonstrations or live helpdesk
- Remote wireless surveillance cameras
- Telehealth terminals providing remote diagnosis and healthcare
- Multimedia signage and advertisement displays
- Facial recognition systems used in homeland security
- Wireless router for in-car infotainment systems
- Unmanned video drones used for security, traffic, accident, crowd control and fire monitoring

One fact to consider: with every previous mobile generation standard, traffic has grown to occupy all available bandwidth. LTE will be no different!

The future is LTE

LTE is destined to be the long term future of all cellular networks, and the last network standing as 2G and 3G networks are eventually phased out. Many M2M operators already consider LTE as the natural choice for long term service applications.

In the case of remotely installed devices, retro-fitting hundreds or thousands of remote units is expensive. It may therefore be wise to design with the technology of the future in mind. This means either already designing with LTE modem technology, or at least future-proofing your hardware design such that the modem upgrade is as cost-effective as possible.

Figure 7:
u-blox' TOBY-L1 4G LTE module series

LTE and u-blox

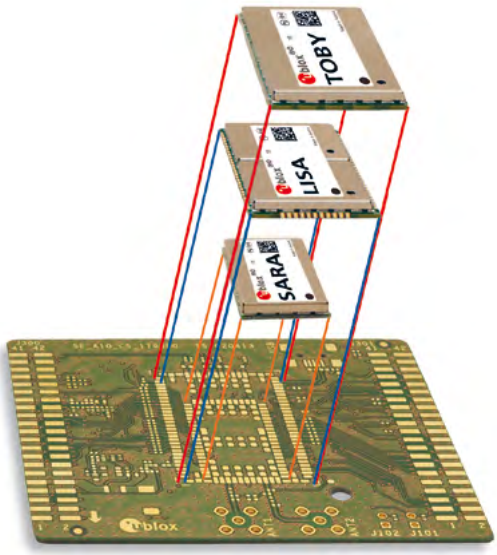
At u-blox we are excited about the 4G LTE-connected future and are working with pioneering companies right now to bring new products to market. We recently launched the TOBY-L1 range of compact, cost-optimised LTE data modems, which are targeted at embedded wireless M2M products.

TOBY LTE module: key features

- LTE-only LGA module in a very small form-factor: 24.8 x 35.6 x 2.8 mm
- LTE Cat. 3, 100 Mb/s download, 50 MB/s upload
- Easy migration from u-blox UMTS, CDMA and GSM modules
- Variants for Verizon (USA) & European operators
- Extended temperature range: –40 to +85°C
- Manufactured in ISO/TS 16949 certified production sites

2G – 3G – 4G nested design

TOBY is layout-compatible with u-blox' SARA 2G and LISA 3G modules series to give designers the flexibility to future-proof their hardware designs. This is the core of u-blox' "nested design" philosophy: maintain form factor and software continuity to allow customers to easily upgrade their products with each new generation of u-blox modules.



The key benefit is simple: customers do not need to keep changing their PCB designs whenever u-blox introduces an improved version of its module products. Simply drop in the next generation module on the existing PCB footprint and start testing!

Figure 8:
u-blox nested design philosophy: SARA 2G, LISA 3G, and TOBY 4G module series are footprint compatible

About u-blox

Swiss-based u-blox (SIX:UBXN) is a global leader in positioning and wireless semiconductors for the consumer, industrial and automotive markets. Our solutions enable people, vehicles and machines to locate their exact position and wirelessly communicate via voice, text or video.

With a broad portfolio of chips, modules and software solutions, u-blox is uniquely positioned to enable OEMs to develop innovative personal, professional and M2M solutions quickly and cost-effectively. With headquarters in Thalwil, Switzerland, u-blox is globally present with offices in Europe, Asia and the USA. (www.u-blox.com)

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