ERICSSON WHITE PAPER
Uen 284 23-8267 | April 2015

LTE RELEASE 13

EXPANDING THE NETWORKED SOCIETY

LTE evolution is a key component in the realization of the Networked Society, where everyone and everything that benefits from a connection will be connected. LTE release 13, currently under standardization in 3GPP, is the next step in the LTE evolution. It will significantly increase user data rates and overall capacity, as well as support new use cases and further strengthen LTE as a vital part of future radio access.

INTRODUCTION

LTE is deployed on a wide scale, providing mobile broadband services to hundreds of millions of people. Initial LTE deployments were based on the first set of LTE specifications, releases 8 and 9, but over time more advanced features from later releases of the LTE specifications have been deployed.

The first major step in the evolution of LTE – also referred to as LTE-Advanced – occurred as part of 3GPP release 10, which was finalized in 2010. Release 10 extended and enhanced the LTE radio-access technology in several dimensions. The most popular new feature was the introduction of carrier aggregation to improve the possibility of exploiting fragmented spectrum allocations and to support wider bandwidth – and consequently higher data rates – than the initial LTE releases.

LTE continues to evolve, and 3GPP is currently working on release 13. This release will improve and enhance LTE in several aspects, and strengthen its capacity to serve as a platform for the Networked Society by providing data access and sharing anywhere and anytime for anyone and anything. This paper provides an outline of LTE evolution, focusing on the ongoing standardization work for release 13.

Figure 1: LTE evolution.

KEY CHALLENGES

The amount of traffic in wireless networks has grown tremendously, and there are no indications that this growth will slow down. Although estimates of the traffic demands for future mobile-communication systems vary, they all predict a massive increase in traffic demand [1]. This increase will not only come from traditional human-centric usage, but also from the increasing number of machines communicating: for example, surveillance cameras, smart electrical grids, connected homes, and intelligent transportation systems. Consequently, future LTE networks must be capable of handling this massive traffic increase.

A subsidiary challenge to supporting the requirements of machines communicating is supporting a much larger number of devices compared with today. Two examples of such devices are wirelessly connected sensors and actuators. The Networked Society implies billions of these devices being connected. Each device will typically be associated with very little traffic, implying that, even jointly, they will have a limited impact on the overall traffic volume. However, the sheer number of devices to be connected provides a challenge; for example, in terms of efficient signaling protocols. Low device cost, in the order of a dollar, and low energy consumption, for example the possibility to run on a single AA-type battery for 10 years, are other important aspects of what can be termed massive machine-type communications (MTC).

Meeting increasing user experience expectations in terms of latency, reliability and data rates is yet another challenge. Whereas the first mobile communication systems offered voice services, today's LTE networks offer mobile broadband services that include video streaming and media delivery. In this context, not only higher peak data rates are of interest but also the availability of sufficiently high data rates essentially everywhere. In addition to performance requirements from current and future human-centric applications, new use cases – including machines and devices as well as public safety, proximity and broadcast services – result in a very wide range of requirements.

Consequently, mobile broadband enhancements and expansion into new use cases are foreseen to be in the scope of LTE release 13. More specifically, enhancements addressing network capacity and user experience for mobile broadband include:

- licensed assisted access (LAA)
- carrier-aggregation enhancements
- multi-antenna enhancements
- latency reduction.

Furthermore, the expansion into new use cases includes:

- MTC
- device-to-device communication.

It should be noted that enhancements are also foreseen in other areas such as indoor positioning, multicast services and terminal receivers, including interference mitigation and more receive antennas.

LTE RELEASE 13 ENHANCEMENTS

LAA

Spectrum is fundamental for wireless communication, and there is a never-ending quest for more spectrum to meet the challenges of increased capacity demands and higher data rates.

The two most common types of spectrum are licensed and unlicensed spectrum. Licensed spectrum, where the operator has an exclusive license for a certain frequency range, is used by LTE as well as other cellular systems. Licensed spectrum is key to superior performance and essential for QoS, as the operator can control the interference situation in the network.

Unlicensed spectrum, on the other hand, is free but subject to much more unpredictable interference situations. QoS and availability cannot be guaranteed. On its own, unlicensed spectrum is thus less suitable for providing wide-area coverage and a superior user experience.

However, by combining licensed and unlicensed spectrum, the additional spectrum in the unlicensed band can be used as a complement to increase user data rates and overall capacity without compromising on coverage, availability and reliability. Release 13 will support this by using the carrier-aggregation framework already present in LTE.

Mobility, critical control signaling and services demanding high QoS rely on carriers in the licensed spectrum while (parts of) less demanding traffic can be handled by carriers using unlicensed spectrum. In 3GPP, this is known as LAA to highlight the fact that carriers in licensed spectrum assist the access to unlicensed spectrum. LAA targets operator-deployed small cells in the 5GHz band; for example, in dense urban areas, shopping malls, offices and similar locations. Initially, LAA will support downlink traffic with a later extension to handle uplink traffic.

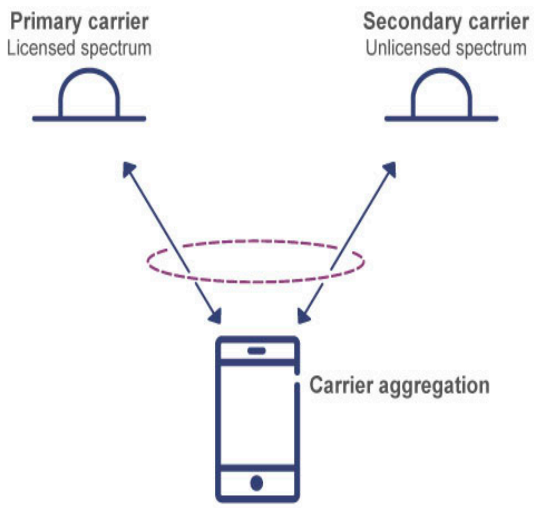

Figure 2: LAA.

One important aspect of LAA is the fair sharing of the unlicensed spectrum with other operators and other systems such as Wi-Fi. There are several mechanisms that enable this. First, the LAA node searches and finds a part of the unlicensed spectrum with low load, thereby avoiding other systems if possible. Release 13 will also include a listen-before-talk mechanism, where the transmitter ensures there are no ongoing transmissions on the carrier frequency prior to transmitting.

A complementary solution to exploit unlicensed spectrum is Wi-Fi integration. The primary purpose is to cater for existing Wi-Fi deployments, and several enhancements have already been introduced in previous releases. So far, the integration is handled in the core network and therefore cannot offer the full potential unleashed by LAA. Further work is relevant for release 13.

CARRIER-AGGREGATION ENHANCEMENTS

Carrier aggregation was first introduced in release 10, allowing operators to use their spectrum assets more efficiently to boost user throughputs and increase capacity. Currently, with aggregation of up to five carriers, bandwidths up to 100MHz are supported. However, in the 5GHz bands considered for LAA, there is already room for even larger bandwidths. More licensed spectrum is also expected to become available, for example in the 3.5GHz band, which can be used to increase network capacity and meet traffic growth.

In release 13, the carrier-aggregation framework will be extended to handle up to 32 carriers in both the uplink and downlink. This means that, in principle, LTE terminals will be able to handle bandwidths up to 640MHz, part of which can be located in unlicensed spectrum. Accompanied with latency reductions, this will enable tremendous data rates – also in combination with higher-layer protocols such as TCP.

MULTI-ANTENNA ENHANCEMENTS

Multi-antenna techniques such as multiple-input, multiple-output (MIMO) spatial multiplexing and beamforming are tools to improve spectral efficiency, which in turn translates into higher user data rates and network capacity. For this reason, multi-antenna techniques have been an integral part of LTE from the beginning, and enhancements have been continuously introduced with every standard release.

Figure 3: Multi-antenna enhancements.

So far, 3GPP has mainly considered beamforming in the azimuth domain using the horizontal antenna arrays. However, especially in dense urban deployments, there is considerable performance potential associated with exploiting the elevation domain, even without necessarily increasing the antenna area compared with what is commonly used today.

In release 13, two-dimensional base station antenna arrays with up to 64 antenna ports are being studied for exploitation of both the azimuth and elevation domain. The large number of antenna ports allows both the azimuth and elevation domains to be exploited, for example by means of beamforming, sectorization and so-called multi-user MIMO, which involves simultaneously serving multiple users on the same frequency resource and in the same cell by using beams in different directions.

At the same time, specification of relevant radio frequency (RF) requirements for so-called active antenna systems (AASs) is being pursued. AASs, where RF components such as power amplifiers and transceivers are integrated with an array of antenna elements, offer several benefits compared with traditional deployments with passive antennas connected to transceivers through feeder cables. Not only are cable losses reduced, leading to improved performance and reduced energy consumption, but installation is simplified and the required equipment space is reduced. AASs are also an enabler for the multi-antenna schemes being considered for release 13. Specification of relevant RF requirements for AASs is thus crucial for practical usage of the multi-antenna enhancements studied in release 13.

LATENCY REDUCTION

Low latency was a key requirement in the development of LTE – not only to give a 'snappier' user feel than previous technologies, but because of the continuous quest for higher achievable data rates. Due to properties of the internet protocols, lower latency over the wireless interface is critical to realizing higher data rates in conjunction with carrier-aggregation enhancements. With the increasing data rates in LTE over the past couple of releases, it is therefore important to ensure that the achievable latency evolves in a similar manner.

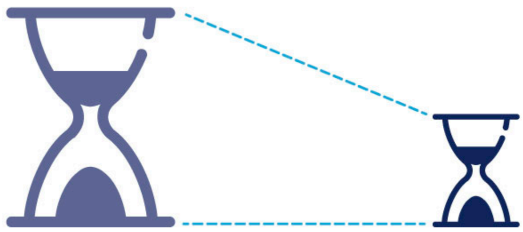

Figure 4: Latency reduction.

In addition, lower latency will also enable support for new applications. Some of the envisioned applications, such as traffic safety/control and control of critical infrastructure and industry processes, may require very low latency.

Consequently, with these two aspects in mind, 3GPP will, in release 13 and beyond, study and standardize enhancements providing reduced latency. Examples of technologies considered in this work are instant uplink access, transmission-time interval shortening, and reduced processing time in terminals and base stations.

NEW USE CASES

MTC

Within the overall vision of the Networked Society, the number of 'communicating machines,' that is, machines sending or receiving information via LTE, is expected to increase dramatically. MTC is a very wide term with vastly different requirements depending on the application, many of which are already well supported by LTE from the first release.

One important category of MTC is known as massive MTC, where low cost and low power consumption at the terminal side are significantly more important than high data rates. Examples of massive MTC use cases include remote reading of utility meters, control of door locks and street lights, road sensors for smarter traffic management, and various kinds of home automation.

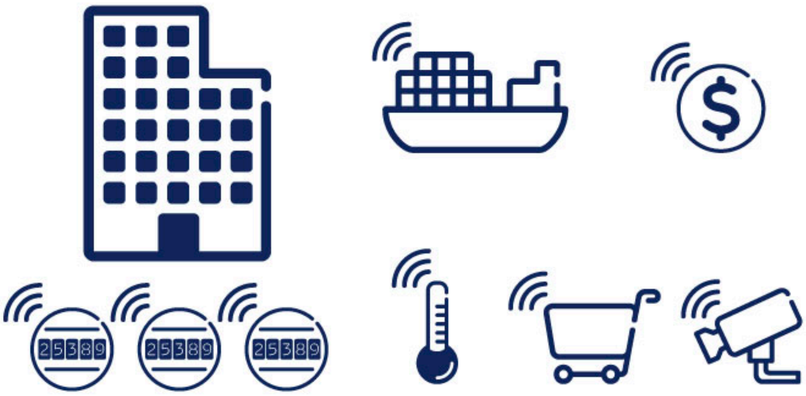

Figure 5: MTC.

To expand LTE into an even wider range of massive MTC use cases, 3GPP is working on further enhancing LTE in terms of:

- reduced device cost
- reduced power consumption
- extended coverage
- handling massive numbers of devices.

The first steps were already taken in release 12 but release 13 provides further enhancements.

Currently, all LTE devices on a carrier must support the full carrier bandwidth of up to 20MHz and therefore, depending on the carrier frequency, typically support multiple bandwidths. This provides a great deal of deployment flexibility, and allows all devices to exploit the full performance of the bandwidth deployed. However, from a cost perspective, a single small bandwidth on the radio side such as 1.4MHz allows for simpler radio implementation and thereby lower device cost. As the data rates handled are low, this can be done without any negative impact.

Release 13 will therefore support the coexistence of 1.4MHz narrow-band devices with current LTE devices on a single, wider-band carrier. To further reduce cost, these low-cost MTC devices will operate using half-duplex and a single antenna, and will limit the data rate to 1Mbit/s – all without negatively impacting the performance of existing fully flexible LTE devices. A new lower device transmission-power class will also be introduced, allowing for the baseband and radio parts to be integrated on the same chip to further reduce cost. All in all, the enhancements to LTE are expected to bring device cost below USD 1 in volumes, thereby supporting a new range of MTC.

Power consumption is another important aspect of massive MTC. The power-saving mode introduced in release 12 allows a device to operate for more than 10 years on a single AA-type battery. Release 13 will further improve the power-saving mode to maximize the amount of time a device can sleep to save power. Since the devices support up to 1Mbit/s, even relatively large amounts of data can be provided in a short period of time, which is more power-efficient than a lower data rate over a longer period of time.

Coverage can be a crucial issue for some applications; for example, remote reading of utility meters located in the basement of a building. A coverage improvement of 15dB compared with current FDD networks is targeted. To achieve this, release 13 will employ various forms of repetition and power-boosting techniques. Although such techniques come at a cost in terms of overhead, the fraction of MTC devices requiring extended coverage is modest, and hence the overall system impact is fairly small.

DEVICE-TO-DEVICE COMMUNICATION

Device-to-device communication was introduced in LTE in release 12, providing basic communication functionality for public safety as well as in-coverage discovery for commercial use cases. Improvements in this area brought by release 13 include out-of-coverage and multi-carrier support for discovery. Relaying solutions to extend coverage will also be introduced, which can be an important solution for public safety; for example, to provide communication to rescue personnel deep inside buildings. Another improvement for public safety is the introduction of priorities, so that different groups of users can be given priorities to handle congested situations in a better way.

For all these cases, network support, when present, will be exploited to improve efficiency greatly, building on the initial design in release 12. The network can assist in device discovery, synchronization and security, to mention just a few of the benefits.

CONCLUSION

The vision of the Networked Society, where everything that benefits from being connected will be connected, places new requirements on connectivity. LTE evolution is a key component in this vision, providing high-quality connectivity for the future.

The next step in this evolution is LTE release 13. Enhancements in this release include LAA, which uses the carrier-aggregation framework to exploit unlicensed spectrum as a complement, and multi-antenna enhancements exploiting both the horizontal and vertical domains. These enhancements will improve overall capacity as well as user data rates. Latency reductions in release 13 will also help exploit these very high data rates, in combination with higher-layer protocols such as TCP.

At the same time, LTE will expand into new usage scenarios by providing improved support for low-cost and energy-efficient massive MTC devices through reduced RF bandwidth. Enhancements in direct device-to-device communication will provide improved support for public safety as well as various commercial use cases. Clearly, LTE is a very flexible platform that is continuously evolving to address new requirements and additional scenarios.

REFERENCES

[1] Ericsson, February 2015, Ericsson Mobility Report, available at:
http://www.ericsson.com/mobility-report

GLOSSARY

AAS	active antenna systems
LAA	licensed assisted access
MIMO	multiple-input, multiple-output
MTC	machine-type communications
RF	radio frequency