LANCOM™ Techpaper
LTE technology

Introduction

LTE, short for Long Term Evolution, is the new generation of cellular wireless communications and builds on the GSM/UMTS cellular standards. The term 4G is often used since this is the fourth-generation cellular standard. GSM is the second-generation (2G) and UMTS the third-generation (3G) standard. The LTE release 8 was developed by the Third Generation Partnership Project (3GPP) organization and was adopted by the International Telecommunication Union (ITU) in 2009. LTE provides theoretical transfer rates of up to 300 Mbps downstream and 75 Mbps upstream. The predecessors are limited to a theoretical maximum of 84 Mbps downstream and 22 Mbps upstream (HSPA+). However, it should be noted that a network cell is shared by multiple participants and thus the difference between theoretical and actual transfer rates can differ greatly.

Technical basis

LTE employs a variety of mechanisms to achieve such high data rates, and these are briefly explained in the following:

OFDM (Orthogonal Frequency Division Multiplexing) is a method of modulation in which the data stream is divided up between a number of narrow carrier frequencies. Should a narrow band of interference in the transfer medium interfere with a sub-carrier, this can be excluded from the data transfer without causing a major drop in the overall transfer rate. If just a single carrier is used, interference can lead to severe loss of quality or even connection loss. In addition, OFDM transmits a large number of bits in parallel on overlapping sub-carriers and the signal curve $S_{(OFDM)}$ by frequency is composed of the sum of all of the modulated carriers, as shown in Figure 1. In turn each carrier is individually modulated, for example by using QAM.

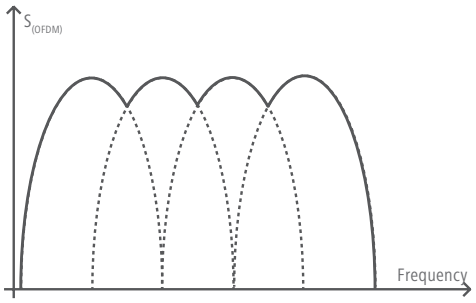

Fig. 1 Schematic OFDM signal with four carriers

QAM (Quadrature Amplitude Modulation) a modulation method that combines amplitude and phase modulation. The advantage of using QAM is that it is a higher order form of modulation and as a result it is able to carry more bits of information per symbol. Table 1 lists current modulation methods and their ratio of bit rate to symbol rate. It is evident that by selecting a QAM format of higher order, the data rate over a link can be increased. However, such higher order modulations also have their disadvantages in that they are more sensitive to noise and interference. LTE supports QPSK, 16QAM, and 64QAM modulation, which ensures high data throughputs.

Modulation	Bits/symbol	Symbol rate
BPSK	1	Equal to bit rate
QPSK	2	1/2 the bit rate
8PSK	3	1/3 the bit rate
16QAM	4	1/4 the bit rate
32QAM	5	1/5 the bit rate
64QAM	6	1/6 the bit rate

Table 1 Modulations: Ratio of bit rate to symbol rate

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MIMO (Multiple Input Multiple Output) uses multiple components for transmission and reception to achieve better link stability and higher data rates. The overall transmission power is divided between a number of antennas. MIMO uses multiple antennas at the base station and at the router to provide multiple parallel data streams. Figure 2 is a schematic diagram of a 2x2 MIMO system. It illustrates the different streams from the transmitter to the receiver.

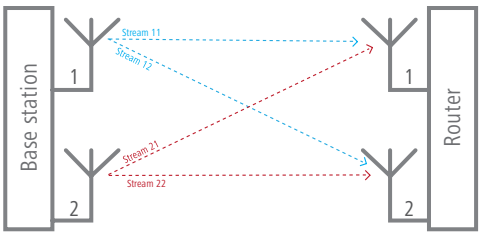

Fig. 2 Schematic diagram of 2x2 MIMO

The sum of the streams is also referred to as the matrix channel. The higher number of streams increases the spectral efficiency, and thus improves the data throughput. The stability of the link is also increased, which results in a lower error rate. The LTE standard supports up to 4x4 MIMO, which yields a matrix channel consisting of up to 16 streams.

LTE categories

The mechanisms mentioned above offer a multitude of different ways to implement LTE. In order to provide a clear structure, the LTE cellular standard is divided into five categories, each of which caters for different requirements.

The maximum transfer rate is the main feature distinguishing between the categories, and table 2 is structured accordingly. Note that some of these transmission rates are equal to and even exceeded by other standards. These data rates are based on a channel bandwidth of 20 MHz.

Cat.	1	2	3	4	5
Down	10	50	100	150	300
Up	5	25	50	50	75

Table 2 LTE category data rates in Mbps

In addition, the modulation is another factor responsible for the different data rates (table 3). Note that only category 5 additionally supports 64QAM in the upstream direction, and thus achieves the highest transfer rate.

Cat.	1	2	3	4	5
Down	QPSK, 16QAM, 64QAM				
Up	QPSK, 16QAM				QPSK, 16QAM, 64QAM

Table 3 LTE category modulations

The final factor distinguishing the LTE categories is the antenna configuration. The MIMO configuration required for each category is given in table 4.

Cat.	1	2	3	4	5
2x2	N.sup.	Mandatory			
4x4	Not supported				Mand.

Table 4 LTE category MIMO configurations

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Other advantages of LTE

High speed is not the only aspect that makes LTE stand out from other cellular standards.

LTE has very low latency and is thus ideal for VoIP services and video telephony.

Many LTE devices are backwards compatible with existing standards such as UMTS, which is useful in areas where LTE is unavailable. Backwards compatibility ensures high network availability for a better guarantee of connectivity.

It should also be emphasized that LTE data transmission is IP-based and thus makes full use of "Quality of Service" (QoS for short), which prioritizes data packets according to their intended use.

Also worthy of mention is that LTE is capable of moving between different radio cells without difficulty, even at high speeds.

LTE international

The preparations for LTE reached right around the world, and so it is fair to talk of the first truly global standard in cellular communications. However, not all countries operate LTE in the same frequency bands: While in Europe LTE is primarily available in the frequency ranges 800, 1800 and 2600 MHz, the frequencies used in North America, for example, are 700 and 1700 MHz. Thus, an LTE-enabled device cannot necessarily be operated in every country.

Application scenarios

The high speeds and low latencies make LTE a viable alternative to wired Internet access. This makes this technology particularly interesting for companies that do not have access to broadband Internet.

Similarly, LTE also provides a high-performance backup connection for scenarios where high-availability and high throughput rates are important, particularly where there is an interest in having an alternative means for maintaining data communications.

Summary

LTE is a forward-looking technology in cellular communications, which offers a number of advantages over its predecessors and which caters for many different fields of application.

LANCOM offers the LTE-capable VPN router LANCOM 1781-4G as the ideal solution for use in business environments. Applications include the provision of high-performance standard Internet access or a secure, high-speed backup connection.