UNDERSTANDING 4G LTE TERMINOLOGY

1. Introduction

When it comes to wireless broadband standards, there are too many acronyms to keep track of. None are more important than LTE and 4G. This Application Note has been written in response to questions received from customers. It hopes to clarity the terminology and explain the relevance to the Internet of Things (IoT)

2. Understanding the Terminology

4G, short for "Fourth Generation," is a specification laid down by the International Telecommunications Union (ITU) in 2008. The ITU set standards for 4G connectivity, requiring all services described as 4G to adhere to a set of speed and connection standards. For mobile use, including smartphones and tablets, connection speeds needed to have a peak of at least 100 megabits per second, and for stationary uses such as mobile hot spots, at least 1 gigabit per second.

When the standard was announced, these speeds were unheard of in the practical world. They were intended as a target for technology developers at a point in the future that marked a significant jump over the current technology. Over time, the systems that power these networks caught up, not just in the sense that new broadcasting methods have found their way into products, but the previously established 3G networks have improved to the point that they can be classified as 4G.

LTE stands for Long-term Evolution and is not as much a technology as it is the path followed to achieve 4G speeds. For a long time, when your phone displayed the "4G" symbol in the upper right corner, it did not really mean it. When the ITU set the minimum speeds for 4G, they were unreachable. In response, the regulating body decided that LTE, the name given to the technology used in pursuit of those standards, could be labelled as 4G if it provided a substantial improvement over the 3G technology.

Since there was such an enormous gap between the old 3G standard and the new 4G, companies wanted to make sure their customer base knew they were receiving better service than just 3G, so they came up with a workaround. That workaround was misuse of the term LTE. The original idea was that LTE represented the "Long-Term Evolution" toward the 4G standard. What marketers figured out was that they could present it as something greater than that standard if they simply added "4G" before it. Hence, "4G LTE" became widely used. A more accurate term would have been "3G LTE to 4G" but that does not have the same appeal.

3. Categories of Service

LTE consists of a range of different categories of modem, which can be integrated into mobile phones, tablets, and Internet of Things (IoT) devices. These different categories include the following which are most found in low data-rate IoT devices:

- CAT-NB1 (also referred to as NB-IoT)
- CAT-M1

- CAT-1
- CAT-4

Although cellular technologies go from CAT 0 to CAT 19, these are the technologies commonly used for IoT applications such as connected vehicles. In general, as you progress down the list above, the power consumption, data-rate, and price of the devices increases considerably. When comparing specifications and capabilities of different catagories, it can be difficult to know what level of capability is required for your IoT device.

3.1. NB-IOT and CAT-M1

Firstly, although these newer, low-energy cellular technologies are grouped together, they are not the same. Most hardware that supports one also supports the other, so you can typically get both capabilities in a single radio. These are very new technologies and will grow in geographic deployment in the years to come.

- Very low power
- Provide superior range over CAT-1 and CAT-4 modems
- Lowest cost of any cellular radio
- In the case of CAT-M1, deploys using existing cellular infrastructure
- Secure

The trade-off for the lower power, low price, and improved range of the NB-IoT and CAT-M1 technologies is that the data-rate is lower.

- CAT-M1 – 1 Mbps
- NB-IoT – 200kbps

For typical industrial sensors or an interface to some CAN data, CAT-M1 is the perfect technology. The data-rate achievable with CAT-M1 allows for Over the Air (OTA) firmware updates; this is more difficult with NB-IoT. CAT-M1 is intended for applications where the modem can be mobile, moving from tower to tower. NB-IoT does not cell switch for mobile applications and expects the modem to stay in the vicinity of a single tower. Although the radio in Senquip sensor gateways supports CAT-M1 and NB-IoT, Senquip prefers to support CAT-M1 because of the cell switching and higher data-rates that support OTA.

3.2. CAT-1

This is the oldest and most deployed of IoT connectivity technologies. LTE CAT-1 can support high data-rate IoT products with enough throughput to support streaming video in mobile applications. The maturity of the technology makes it broadly available in most geographies. This technology is a little more expensive than NB-IoT and CAT-M1, but has the following advantages over those technologies:

- Higher data streaming throughput (10Mbps)
- Lower latency for wake-up applications
- Broader global coverage

If you need to deploy a solution broadly for mobile equipment (touching dozens of countries), need to offload a fairly large amount of machine data in a hurry, or require support for streaming video or other data-intensive content, then CAT-1 is the technology to use. Senquip supports CAT-1 in regions where CAT-M1 coverage is not available.

3.3. CAT-4

LTE CAT-4 modems are the fastest widely available radios. These modems can achieve data-rates of 150 Mbps, more than ten times the throughput of their CAT-1 counterparts.

They are also complex, expensive, require multiple antennas, and are power hungry. These modules are typically reserved for the handset market. Unless you need to aggregate a lot of data from a lot of machines, or provide streaming services to a large number of passengers onboard a vehicle, it is unlikely that the cost or complexity of this technology will be appropriate for an IoT application.

4. Conclusions

LTE describes the Long-term Evolution from 3G to 4G. LTE consists of a range of different categories of modem which can be integrated into mobile phones, tablets, and IoT devices. CAT-M1 is most suitable for low data-rate applications typical in most IoT applications because it has the best coverage and low power consumption. CAT-1 can achieve speeds required to stream video and has the best global coverage.

Senquip supports both CAT-M1 and CAT-1 versions of its sensor gateways, with CAT-M1 being preferred where coverage is available.

5. Appendix A – Introduction to All Cellular Technologies

5.1. GSM

GSM, which stands for Global Systems for Mobile Communications, is the fundamental standard for 2G technologies. Primarily used for mobile communication, it introduced Short Messaging Service (SMS) along with the ability to download content such as ringtones, logos, and picture messages from various service providers. GSM supports both voice calls and data, but the data transfer rate is quite low at just 9.6 Kbps.

5.2. GPRS

GPRS, or General Packet Radio Service, enhances GSM by providing faster data speeds. It's not a replacement for GSM but an extension to improve speed. Multimedia Messaging Service (MMS) is a key feature of GPRS, allowing users to send videos, pictures, and sound clips in addition to text messages. GPRS also enabled basic mobile internet access at dial-up speeds through WAP-enabled sites. It offers data rates of up to 171 Kbps using packet-based technology over GSM.

5.3. EDGE

EDGE, which stands for Enhanced Data Rates for GSM Evolution, is often referred to as Enhanced GPRS. It's a technology that works with existing GSM equipment with only minor modifications to achieve faster data speeds, bridging the gap to 3G. For this reason, it is often called 2.5G. EDGE allows for data transfer rates 3 to 4 times faster than GPRS and is considered a stepping stone towards 3G. EDGE is a digital mobile technology, while GPRS is more of a mobile data service. Although classified as a 3G radio technology, GPRS itself is packet-oriented.

5.4. 3G

The arrival of 3G revolutionized mobile communication, offering broader bandwidth and enabling more features like video calls and mobile TV. Starting at speeds of 384 Kbps, comparable to early DSL speeds, 3G brought much faster data rates, which have since increased to 3.6 Mbps and even 7.2 Mbps. GSM networks are not directly compatible with 3G, requiring new infrastructure. Telecom operators must install 3G towers in specific areas and operate both GSM and 3G radios where necessary. To use 3G's advanced features, users often need to upgrade their phones.

5.5. WCDMA

3G networks are based on WCDMA (Wideband Code Division Multiple Access), a mobile technology that significantly enhances the capabilities of current GSM networks.

5.6. HSDPA

HSDPA (High-Speed Downlink Packet Access) is often referred to as 3.5G. While it doesn't add many new features to WCDMA, it boosts data transmission speeds. WCDMA provides a maximum speed of 384 Kbps, whereas HSDPA can reach speeds of 3.6 Mbps or even 7.2 Mbps. Additionally, HSDPA has lower latency and more efficient packet scheduling compared to WCDMA.

5.7. 4G

The "G" stands for generation. 4G follows the progression from analog (1G), to digital (2G), to multimedia support (3G), and spread-spectrum transmission. "True" 4G refers to all-Internet Protocol (IP) packet-switched networks, delivering ultra-broadband (gigabit-speed) mobile access. It surpasses 3G in speed largely due to Orthogonal Frequency-Division Multiplexing (OFDM), a technology also used in Wi-Fi, ADSL broadband, and digital TV and radio. OFDM allows more data to be transmitted over the same radio frequency, while also reducing latency and interference by breaking the data into small chunks and sending them simultaneously across multiple frequencies.

5.8. 5G

5G, or Fifth Generation mobile technology, marks a significant improvement over 4G in terms of speed, latency, and connectivity. Capable of reaching speeds up to 10 Gbps, 5G supports ultra-low latency applications, such as real-time communications for autonomous vehicles, virtual reality (VR), and the Internet of Things (IoT).
5G uses higher frequency bands, specifically millimetre waves, which provide more bandwidth but require more base stations due to their shorter range. It also introduces technologies like Massive MIMO (Multiple Input Multiple Output) for higher data throughput and network capacity.

A key feature of 5G is network slicing, which allows for multiple virtual networks within a single physical infrastructure, enabling different services to operate simultaneously with customized performance characteristics. Although early 5G networks are available in some regions, widespread adoption will take time as infrastructure expands and 5G-capable devices become more common.

5G is expected to transform industries, from healthcare to transportation, enabling smart cities and a highly connected future.