GSMA

MOBILE IoT IN THE 5G FUTURE

NB-IoT and LTE-M in the context of 5G

NB-IoT LTE-M

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1. Mobile IoT in the 5G Future

Mobile operators provide secure connectivity and higher value services enabling a complete range of IoT solutions for consumers and businesses. Mobile IoT delivers trusted, cost effective low power wide area capability today, while forming the foundation of the 5G future and supporting IoT growth on a massive scale.

Leading mobile operators, global vendors and developers are launching NB-IoT and LTE-M networks as an integral part of their long term 5G IoT strategies. Mobile IoT refers to low power wide area (LPWA) 3GPP standardised secure operator managed IoT networks in licensed spectrum. In particular, networks designed for IoT applications that are low cost, use low data rates, require long battery lives and often operate in remote and hard to reach locations. Existing cellular networks are evolving to deliver service to billions of new devices providing complete IoT connectivity in the 5G era.

NB-IoT and LTE-M are 3GPP standards that are both are set to coexist with other 3GPP 5G technologies, so fulfilling the long term 5G LPWA requirements.

This future is now assured, as 3GPP has agreed that the LPWA use cases will continue to be addressed by evolving NB-IoT and LTE-M as part of the 5G specifications, so confirming the long term status of both NB-IoT and LTE-M as 5G standards.

In order to complete the 5G system support for NB-IoT and LTE-M, 3GPP is also investigating options for the 5G core network to support NB-IoT and LTE-M radio access network. This will enable a smooth operator migration path to 5G NR frequency bands while preserving NB-IoT and LTE-M deployments. Overall, there are three major use cases for 5G

- Mobile IoT / Massive IoT / LPWA
- Critical communications
- Enhanced mobile broadband

Mobile IoT delivers connectivity on a massive scale today and will continue to do so in the 5G future enabling key IoT applications such as smart metering to help reduce energy consumption, smart logistics to enhance distribution efficiency and smart environmental monitoring to reduce city pollution.

2. Introduction

Since the first 3GPP release of NB-IoT and LTE-M specifications in 2016, the growth in the number of connections and networks across the world has accelerated. At the end of March 2018, there were a total of 43 commercial NB-IoT and LTE-M networks launched[1]. Those looking to deploy LPWA solutions can already do so today on these networks.

With the dawn of the 5G era, this paper explains how both NB-IoT and LTE-M technologies are an integral part of 5G, and that 5G from the LPWA perspective, is already here today. This paper goes on to highlight that both NB-IoT and LTE-M will continue to serve LPWA 5G use cases, and will coexist alongside other components of 5G which meet the other various 5G use cases. As the same operators deploying both NB-IoT and LTE-M will also deploy other components of 5G, these operators are keen to leverage their investment and so 5G was designed exactly with this in mind.

Detailed technical aspects of 5G, NB-IoT and LTE-M are out of scope of this paper.

ABBREVIATIONS

TERM	DESCRIPTION
3GPP	3rd Generation Partnership Project
5G NR	5G New Radio
IoT	Internet of Things
LPWA	Low Power Wide Area
LTE	Long-Term Evolution
LTE-M	Long-Term Evolution Machine Type Communications
MTC	Machine-Type Communications
NB-IoT	Narrowband IoT

[1] Refer to https://www.gsma.com/iot/mobile-iot-commercial-launches/ for the most up-to-date information

3. Mobile IoT and 5G

WHAT IS MOBILE IoT?

Mobile IoT is a GSMA term which refers to the 3GPP standardised Low Power Wide Area (LPWA) technologies using licensed spectrum bands such as NB-IoT and LTE-M.

LPWA technologies possess the following characteristics:

- Low power consumption that enables devices to operate for many years on a single charge
- Low device unit cost
- Improved outdoor and indoor coverage compared with existing wide area technologies
- Secure connectivity and strong authentication
- Optimised data transfer for small, intermittent blocks of data
- Simplified network topology and deployment
- Network scalability for capacity upgrade

LTE-M is the industry term for the Long-Term Evolution (LTE) machine-type communications (MTC) LPWA technology standard introduced by 3GPP in Release 13. LTE-M supports lower device complexity, massive connection density, low device power consumption, low latency and provides extended coverage, while allowing the reuse of the LTE installed base. The deployment of LTE-M can be done “in-band” within a normal LTE carrier, or “standalone” in a dedicated spectrum.

Narrowband IoT (NB-IoT) is a 3GPP radio technology standard introduced in Release 13 that addresses the LPWA requirements of the IoT. NB-IoT is characterized by improved indoor coverage, support of massive number of low throughput devices, low delay sensitivity, ultra-low device cost, low device power consumption and optimized network architecture. Like LTE-M, NB-IoT can be deployed “in-band” within a normal LTE carrier, or “standalone” for deployments in dedicated spectrum. Additionally, NB-IoT can also be deployed in an LTE carrier’s guard-band.

> “NB-IoT and LTE-M, as deployed today, are part of the 5G family”

WHAT IS 5G?

At its conception, 5G was envisioned to enhance the human user experience and to enable various machine-related use cases [1][2][3][4][5]. To this end, one of the pillars of 5G is to allow multiple access technologies such as satellite, WiFi™, fixed line and 3GPP technologies to interwork in order to serve the diverse 5G use cases. This paved the way for 3GPP technologies such as NB-IoT and LTE-M to become part of the 5G family.

While 5G headlined with ever higher data rates and lower latency, this aspect is mainly focused on the human user enhanced mobile broadband and real-time control use cases. Conversely, for the machine-related use cases considered as low power wide area (LPWA), the requirements are at the other end of the spectrum where low bit rates and latency tolerance are the norm.

In order for 5G to serve the variety of use cases, often with diametrically opposing requirements, 5G systems manage this by dynamically allocating the network resources depending on the use case.

The 5G requirements defined by ITU-R [1][2][3] and 3GPP [6] broadly cover three main use cases [4]:

- **Mobile IoT/Massive IoT/LPWA:** improved network coverage, long device operational lifetime and a high density of connections. This is also known as mMTC (Massive MTC)
- **Critical Communications:** high performance, ultra-reliable, low latency industrial IoT and mission critical applications. This is also known as Critical IoT, URLLC (Ultra Reliable Low Latency Communications)
- **Enhanced Mobile Broadband:** improved performance and a more seamless user experience accessing multimedia content for human-centric communications

The 5G use cases are also depicted with a few examples in the following diagram.

All the three main use cases are covered by 3GPP in the 5G specifications. However, in the initial phase of 5G specifications, the main focus was on the support of Enhanced Mobile Broadband use cases [4].

For Mobile IoT LPWA, a range of use case categories is presented in the figure below. NB-IoT and LTE-M have already been designed to address the requirements from these use cases, including requirements on support of large numbers of devices, low device cost, ultra-long battery life, and coverage in challenging locations, and these requirements [6] still apply for Massive IoT in the 5G context. In addition, there is an ITU-R requirement on supporting a high connection density in terms of number of connections [1][2][3] that can be supported in a given geographical area and spectrum allocation [10][11].

MOBILE IoT / MASSIVE IoT / LPWA USE CASES

NB-IoT AND LTE-M ARE PART OF 5G

As it is expected that both NB-IoT and LTE-M will fulfill the 5G LPWA requirements, 3GPP has indicated to ITU-R [7][8] that both NB-IoT and LTE-M will be proposed to ITU-R as meeting the ITU-R requirements. The results from initial studies are available in [9][10][11], and a number of other studies are currently being conducted as part of the 3GPP assessment of the ITU-R requirements.

To further support the view that NB-IoT and LTE-M support the 5G LPWA requirements, 3GPP has agreed that the LPWA use cases will continue to be addressed by evolving NB-IoT and LTE-M as part of the 5G specifications [12].

As a consequence, NB-IoT and LTE-M as deployed today are part of the 5G family.

NB-IoT AND LTE-M WILL COEXIST WITH OTHER 5G COMPONENTS

As new 5G components that support 5G use cases in addition to LPWA are specified and rolled out in future, it is envisaged that NB-IoT and LTE-M will continue to coexist alongside these other 5G components.

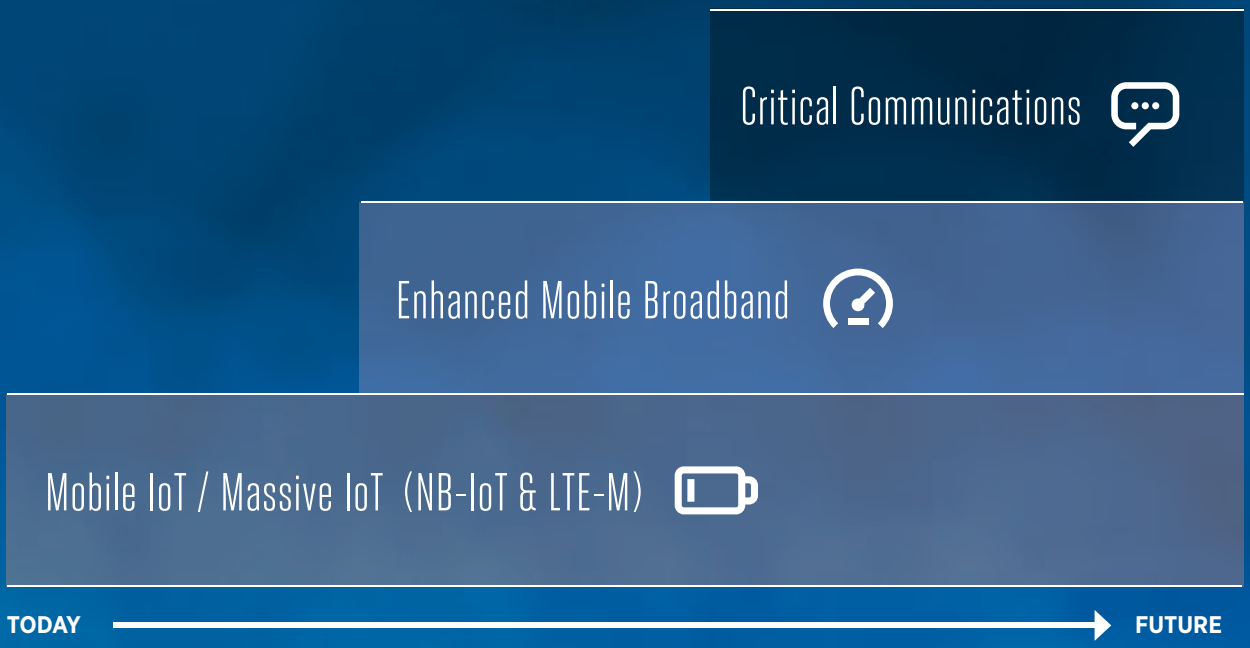
5G New Radio (NR) was designed to support diverse deployment models, spectrum usage and device capabilities. One of the deployment scenarios that is supported from the start of 5G NR work in 3GPP is to allow LTE-M and NB-IoT transmissions to be placed directly into a 5G NR frequency band [14].

> “5G NR was designed to support diverse deployment models, spectrum usage and device capabilities”

In order to complete the 5G system support for NB-IoT and LTE-M, 3GPP is also investigating options for the 5G core network to support LTE-M and NB-IoT radio access networks [13]. This will enable a smooth operator migration path to 5G NR frequency bands while preserving NB-IoT and LTE-M deployments.

To further illustrate this point, the following diagram shows the various 5G network components that are built up and deployed over time. It highlights that NB-IoT and LTE-M network components already operational today will continue to do so and eventually coexist as other 5G NR components, e.g. enhanced mobile broadband and critical communications, are deployed in the same networks at a later point in time.

Timeline of introduction of 5G components



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[15]	3GPP TS 38.104	clause 5.4.2.1 in "NR - BS radio transmission and reception", 3GPP http://www.3gpp.org/DynaReport/38104.htm
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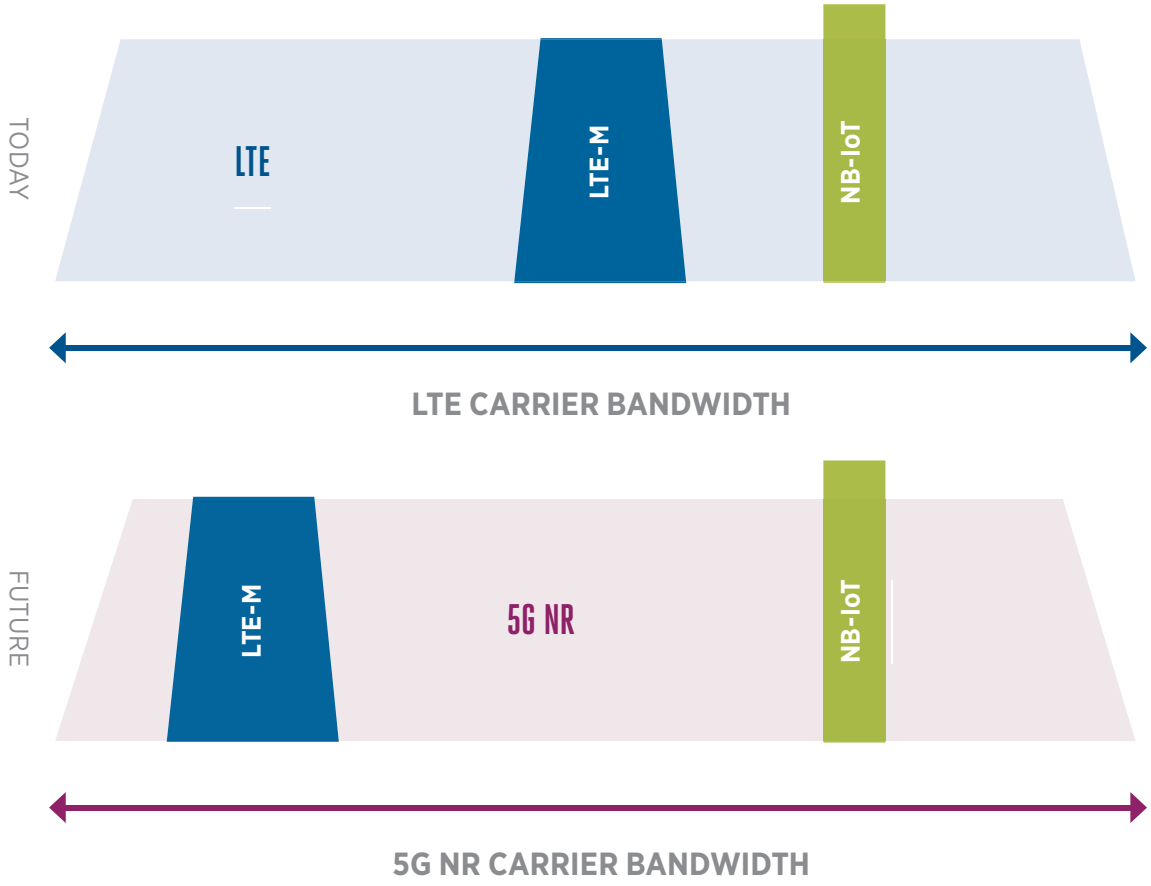
ANNEX

5G NR with in-band NB-IoT and LTE-M

The figures below show in-band operation for NB-IoT and LTE-M within LTE and 5G NR carrier bandwidths.



The in-band operation for NB-IoT and LTE-M within 5G NR carrier bandwidths is achieved by including:

(i) a 5G NR modulation numerology and frame structure compatible with LTE [14],
(ii) a 5G NR duplex frequency configuration allowing 5G NR, NB-IoT and LTE-M subcarrier grids to be aligned [15], and
(iii) support for "forward compatibility" configuration making it possible for an 5G NR user equipment (UE) to rate match around radio resources that are taken by non-dynamically scheduled NB-IoT and LTE-M signals [16].

These features help achieve the desired 5G NR, NB-IoT and LTE-M coexistence performance.

About the GSMA

The GSMA represents the interests of mobile operators worldwide, uniting nearly 800 operators with more than 300 companies in the broader mobile ecosystem, including handset and device makers, software companies, equipment providers and internet companies, as well as organisations in adjacent industry sectors. The GSMA also produces industry-leading events such as Mobile World Congress, Mobile World Congress Shanghai, Mobile World Congress Americas and the Mobile 360 Series of conferences.

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