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Internet of Things: The Budding Area of Mobile IoT Technologies (LTE-M and NB-IoT)

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Abstract - This paper explores the growing field of mobile IoT technologies and looks at the requirements and characteristics of these technologies. With a deeper focus on Long Term Evolution for Machines (LTE-M) and Narrow Band-Internet of Things (NB-IoT), we look at how different industry operators and governments have provided service for these technologies. The paper also looks at edge computing an issue that arises with Mobile IoT Technologies. In cases where solutions have been developed, we explore the design and deployment process. Findings proved that mobile IoT Technologies specifically LTE-M and NB-IoT will be a great asset to IoT Technologies.

Keywords - *Mobile IoT, Narrow Band-Internet of Things (NB-IoT), Long Term Evolution for Machines (LTE-M), IoT Technologies, Edge Computing, Low Power Wide Area Networks (LPWAN).*

1. Introduction

The mobile industry has developed and standardized a class of dedicated cellular technologies. These Mobile IoT networks support devices requiring broad coverage, a long battery life, and low cost, yet secure, connectivity across rural and urban locations [1]. The Internet of Things, which connects uniquely identifiable things to the Internet, keeps growing and evolving. Several devices around the world are being connected. Different communication mediums are required to connect these devices. Connecting these devices come with different requirements. Some require long-range communication, others fast-speed communication, and others, low power communications.

2. Characteristics of IoT

The Internet of things is vast, and therefore, one cannot simply use one definition to exhaust what it entails altogether. However, certain vital characteristics define the IoT. These are things, connectivity, data, communication, intelligence, and action [2]. Things refer to anything that can be connected, be it living or inanimate. These range from electronic devices to plants, animals, human beings, and even trees. Connectivity refers to the ability to connect several things. Several sensors aid in connectivity Retrieving data from several connected devices is crucial to IoT. Devices are in different proximity, and communication is required among them to enable effective sharing of information. Intelligence is gathered from the data retrieved through various analysis mediums and techniques. An example is machine learning. Having all this info without working on it makes IoT almost useless. Acting on the intelligence from the data gathered and stored is a driving force to IoT.

3. Requirements

Despite the promising features, IoT implementations are a bit challenging due to the variety of connected devices. Every IoT implementation should involve edge computing, data ingestion and stream processing, management of devices, analytics, and integration with business systems. IoT has specific standards. These are ZigBee, IPv6, LoRaWAN (Long Range Wide Area Network), and Constrained application protocol (CoAP) [3]. These standards offer different services such as low power and long-range communication. However, in recent times certain technologies have been developed to address specific peculiar issues like edge computing. Cellular networks have evolved massively in this area. Cellular networks have progressed rapidly to ensure stable and reliable connectivity to the billions of connected devices. Certain standard technologies known as Mobile IoT technologies have been dedicated to this purpose. Mobile IoT refers to low power wide area (LPWA) 3GPP standardized, secure operator managed IoT networks in the licensed spectrum [4]. In recent years, this industry of mobile IoT has been budding. This may be attested to the several advantages mobile IoT brings. Mobile IoT technologies offer long-range communication and low power consumption, and they ensure connectivity in rural and urban areas. Additionally, Mobile IoT networks offer high security. Mobile IoT uses a dedicated spectrum band to avoid interference, and SIMs (Subscriber Identity Module) have closed circuits integrated into them [1].

4. Key Enabling Technologies of Edge Computing

Edge computing is a distributed technology architecture in which client data is processed at the network's periphery, as close to the originating source as possible. A critical issue that arises from both Mobile IoT technology and IoT technologies, in general, is Edge Computing. Today's businesses are awash in an ocean of data, and vast amounts of data can be routinely collected from sensors and IoT devices operating in real-time [5]. With the rate at which data comes in, the traditional computing paradigm built on a centralized data center and everyday Internet is not well suited to moving endlessly growing real-world data streams. Some challenges with the traditional managing method are *bandwidth limitations*, *latency issues*, and *unpredictable network disruptions*. *Edge computing* is a modern way of dealing with processing large amounts of data promptly. Instead of transmitting raw data to a central data center for processing and analysis, edge computing moves some portion of the storage and compute resources out of the central data center and closer to the source of the data itself. Edge computing can be problematic if the right resources are not available[4]. However, there are certain technologies that make edge computing easier. Some of these technologies are Amazon Web Services (AWS), Greengrass, EdgeX, Cisco IOx. Additionally, certain groups in the industry are currently playing a major role in facilitating edge computing. Some of these are; EdgeX Foundry, ETSI Multi-access Edge Computing (MEC), and Living Edge Lab [6].

ETSI initiated Multi-Access Edge Computing (MEC) to promote and accelerate the advancement of edge-cloud computing in mobile networks. *MEC* can satisfy the communication requirements of ultra-high reliability and ultra-low latency in 5G-enabled vehicular networks since it provides an Internet service environment and cloud computing capability for wireless access networks[7].

The *MEC* reference architecture consists of two functional areas -- Host and Management -- with the management layer comprising both host and system-level administrative entities. Combining these functional elements provides the foundation required to operate a distributed environment for instantiating and scaling mobile applications and services in a highly granular and dynamic manner[8]. Figure 1 shows the pictorial view of the MEC architecture [9].

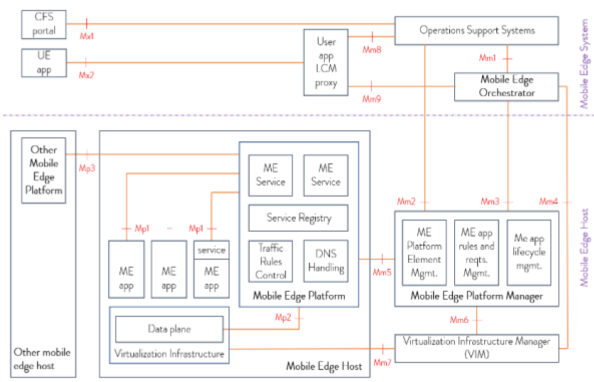

Figure 1: Multi-Access Edge Computing reference architecture, per ETSI GS MEC 003 v1.1.1

5G network slicing is another key enabling technology of Mobile IoT. 5G network slicing is the use of network virtualization to divide single network connections into multiple distinct virtual connections that provide different amounts of resources to different types of traffic[10]. This technology greatly helps in flexibility in providing service. There is higher protection of data due to the segregation of connections. An added advantage of this technology is that problems can easily be identified and fixed. Figure 2 shows a pictorial view of a 5G network that has been sliced [11].

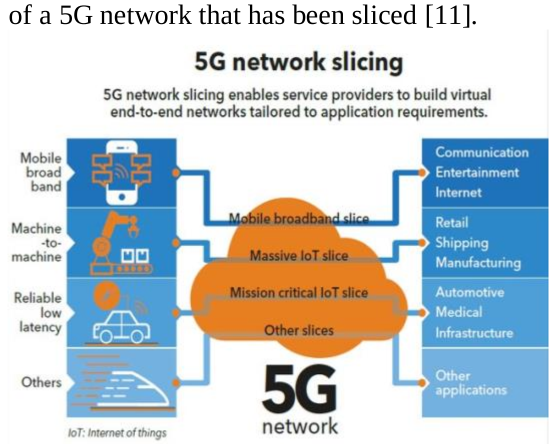

Figure 2: 5G network slicing

5. LTE-M and NB-IoT

LTE-M and NB-IoT are technologies designed for IoT applications that are low cost, require long battery lives, use low data rates, and usually operate in mostly inaccessible locations. This is a deviation from traditional IoT technologies such as Wi-Fi, GSM and Bluetooth. Both LTE-M and technologies are based on open standards, and the hardware for both technologies is simplified and easy to use. Although both LTE-M and NB-IoT are suitable for IoT communications, they have features that make them more suitable for a use case. Hence, certain conditions should be considered before using either of them. Table 1 shows the features, advantages, and disadvantages of LTE-M and NB-IoT [12].

Table.1 – Features, Advantages and Disadvantages of LTE-M and NB-IoT

Conditions	LTE-M	NB-IoT
1. Voice Readiness	LTE-M is designed for voice with Voice over LTE and can also be used for Voice over IP with full-duplex	Not suitable for this function
2. Remote control devices.	LTE-M is needed for a fast and consistent response	NB-IoT can handle use cases where a delay of minutes is acceptable.
3. Moving Devices	LTE-M is the better choice for moving devices as it has been designed for this from the start.	NB-IoT is designed for static devices it can lead to interruptions if devices are moved.
4. SIM LOCALISATION-EUICC	LTE-M is more suited for this function because, The bandwidth of LTE-M is also more suitable for transmission of SIM profiles	Not all operators support the combination of NB-IoT and SMS which means that eUICC cannot be initiated in many networks.
5.Internet Competence	LTE-M is using standard IP-protocols which makes it straightforward to develop applications.	NB-IoT is using tailormade protocols requiring specific application development and competence.

6. Operators in Ghana

According to research from Bundle Comm, the major mobile operators in Ghana are; Vodafone Ghana (Ghana Telecom, OneTouch), MTN Ghana (formerly ScanCom, Spacefon Areeba), Tigo Ghana (Millicom Ghana, Mobitel), Merger with Airtel Ghana, Expresso, Airtel Ghana (Zain/Celtel, Westel), Glo Mobile, Mobile Virtual Network Operators (MVNOs), M2M. Figure 3 shows regions Vodafone's implementation of NB-IoT, LTE-M, and LPWA are available[13]. Currently, South Africa is the only country in Africa where Vodafone has implemented NB-IoT. Ghana is not included in this list.

Additionally, Zariot is a global IoT and M2M SIM with signaling security that has both tri-cut and embedded SIMs, eUICC. Currently, Zariot has partnered with InfoSource Limited is a leader in the Internet of Things (IoT) on the African Market and the preferred African Partner for Zariot [14].

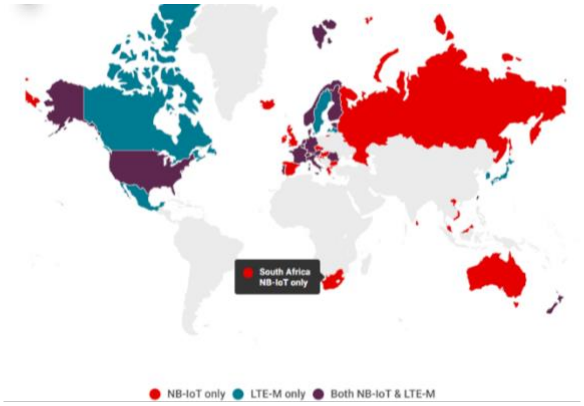

Figure 3: Vodafone implementation of NB-IoT & LTE-M

7. Opportunities for IoT Professionals

IoT professionals have an essential role in the cellular arena since the field adopts IoT systems to improve the quality of service. According to GSMA intelligence, the total IoT market will be worth $1.1 trillion In 2025. Some examples of roles that IoT professionals in this field may assume are IoT Foundation Roles (connectivity and service management), IoT Service Enablement Roles(infrastructure provider, IoT security and ecosystem orchestration) and IoT Solutions Roles (big data, analytics, and AI) [15].

8. Frequency Bands

The National Communications Authority is mandated by the Electronic Communications Act, 2008, Act 775 to "regulate the radio spectrum designated or allocated for use by broadcasting organizations and providers of broadcasting services per the standards and requirements of the International Telecommunications Union (ITU) its Radio Regulations as agreed to or adopted by the Republic." The ITU has three regions, and Ghana is in region 1. According to the Planned bands for Maritime mobile: 415 - 495 kHz; 505 - 526.5 kHz; 1 606.5 - 1 625 kHz; 1 635 - 1 800 kHz and 2 045 - 2 160 kH [16].

9. Government and IoT Deployment

Considering the future of IoT and its potential economic benefits, Governments should take specific steps to make the widespread use of IoT deployment a reality. Some governments have made positive advancements already. Some exciting areas of IoT deployment in the US are pedestrian safety and advanced disaster warnings. For pedestrian safety, companies like Iteris and Cisco are working together with officials from Las Vegas to build an intelligent roadway system that combines edge-processing, video detection, and analysis software that tracks the movement of bicycles and pedestrians. The government officials aim to use internet-connect traffic sensors with the IoT system to reduce congestion and traffic jams during travel times. In advanced disaster warnings, on Jan. 03, 2019, AT&T initiated an app that quickly alerts Los Angeles Country residents of possible earthquakes. This application seeks to leverage ground sensors to detect seismic activity exceeding 5.0 magnitude and send alerts to citizens [17].

10. Comparing Cellular IoT Technology to Wireless Technology

Finally, how do these Cellular technologies compare with other Wireless technologies for IoT implementations? They have certain constraints, and the type of IoT implementation informs the choice of communication medium. Wi-Fi transmits data in a medium range. Its range is about 46m indoors and 92m outdoors [18]. Wi-Fi is typically used in the home or at the workplace for internet access. Wi-Fi can be used in specific applications like a smart home thermostat, a security system for the home, sensor-based lighting, and others. Although Wi-Fi cannot transmit at very long distances, Wi-Fi offers high speed and bandwidth in the transmission of information. Cellular, on the other hand, can transmit long-range. Cellular is a vast area network that transmits data over miles. Cellular is deployed in several IoT applications. When a user uses google maps or listens to music, cellular is the driving communication force. However, a tradeoff with cellular technology is that it consumes much power compared to Wi-Fi. Wi-Fi and Cellular technologies are deployed based on what the situation demands. Table 2 shows a comparison between Wi-Fi and Cellular Technology[19].

Table.2 – Comparison of Wi-Fi and Cellular Technology

	Wi-Fi	**Cellular**
Range		
Bandwidth	Wi-Fi has a high bandwidth	Cellular has a good bandwidth slightly higher than Wi-Fi
Battery Life	Wi-Fi can consume power for the battery to last about 7 days	Cellular consumes more battery power
Network Type	Wi-Fi is a local area Network (LAN) which cannot transmit longer than 300feet	Cellular is a wide signal area Network (LAN) and can be transmitted anywhere there is a signal.

Conclusion

Mobile IoT Technologies specifically NB-IoT and LTE-M are promising areas in the Internet of Things. These technologies offer long range, low power and low bandwidth opportunities as compared to Wireless IoT technologies. Governments should therefore invest heavily into these technologies as this will greatly help with development.

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