



## 5G Key Technologies Enabling IoT Applications

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### Abstract

5G reaps the benefits of the increased maximum throughput. Wireless communication technologies have constructed foundations as significant anchors for IoT due to its ubiquitous capability. The lasting growth technology improvements and innovations in 5G systems are expected to be the main efficient access strategies to accelerate IoT applications. This letter elaborates the recent advances on 5G key technologies and applications for IoT.

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### Introduction

On behalf of one of the critical emerging 5G services, Internet of Things (IoT) will govern the number of connected terminals and impact 5G patterns, Quality of Experience (QoE) and Quality of Service (QoS), all of which will influence backhaul specifications. Accomplishing with the aggregate data demand and network capacity demand soar up, more eNodeB will be scheduled to meet the QoS that is critical for IoT to be successful.

One of major objectives of 5G services is to supply ultra-high capacity per terminal, improve spectrum efficiency. Along with the development of autonomous networks and manufacturing industries, the demand for increment capacity will be exponential growth. Billions of "Green" terminals (wearables, computers, tablets, smart automation equipment's and smartphones) is expected to upgrade. The massive appearance of machine-to-machine IoT services will augment in the number of connected devices, more automatic devices, in a huge boost in the total number of connected devices.

The remainder of this letter is structured as follows: Section 2 examines the essential aspects in IoT use cases that drive the evolution of 5G technologies. Section 3 gives significant information on emerging LAA technology improvements that develop IoT along with new MTC characteristics. Sections 4 innovates mesh networking and

coexistence design and overviews the application of LTE MTC for 5G system. A summary concludes the letter in Section 5.

### IoT Use Cases

#### Ad Hoc Networking

IoT platform has rapidly self-organized networking capability and could interoperate with the network layer to support corresponding services. In order to transfer the information, the vehicle networks and transportation infrastructures can be quickly self-organized.

#### Sensor Network

IoT use sensor to collect information which is the fundamental component that experience the universe and provides applications and services. Due to the diversity of sensors such as speed, pressure, temperature, humidity, height, video, image, voice and location sensors, information detected by these sensors transform comprehensively.

#### LTE-A MTC

LTE-Advanced technology, the soul of 4G network connectivity, will evolve to supply attacking characteristics that provide a large number of high performance and low cost IoT devices. These devices extend coverage for

challenging locations, energy saving for applications requiring long battery life and optimizations to deploy very large numbers of devices per cell.

LTE-based MTC solutions create development in diverse entities of MTC ranging from home and industrial automation to consumer electronic devices such as connected wearables. LTE-based MTC solutions serve as one type of IoT service on the strength of its ubiquitous connectivity, more efficient energy saving, higher coverage and faster data rates of up to 1 Mbps [1].

## Automotive

Cellular mobile services are enabled to supply connectivity to the surrounding automobile as the demand for ubiquitous coverage and bi-directional real-time communication to the advantages of vehicle networks.

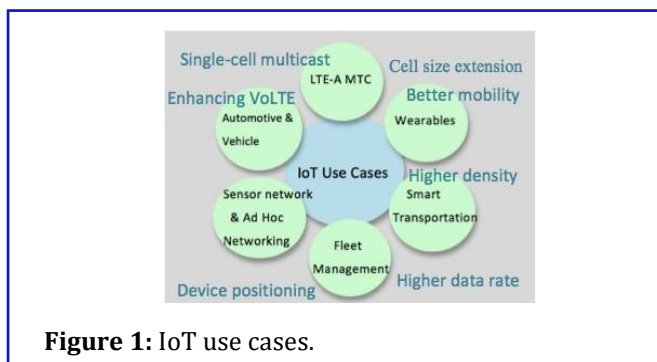
The evolution of vehicle technology has foreseen an increment in Vehicle-to-Infrastructure (V2I) use cases such as telematics solutions, Vehicle-to-Cloud (V2C), Vehicle-to-Vehicle (V2V) and Vehicle-to-Pedestrian (V2P) communication such as vehicle safety management and real-time automobile control. IoT networks will further augment the capabilities of connected automobile and facilitate faster transmission of more information generated by V2V and Vehicle-to-Everything(V2X) use cases.

## Fleet management

The cellular IoT fleet management application requirements include ubiquitous connectivity, extended coverage, accurate positioning, high data rates. Novel capabilities of 5G cellular technologies produce new generations of infrastructure that will empower superior capabilities and higher throughput such as wireless IP-based video which ultimately improves operation efficiencies.

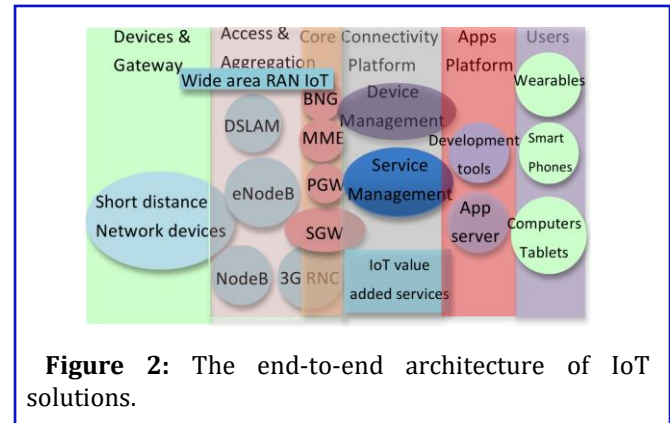
## Smart transportation

Cellular technologies LTE provide real-time collection of massive information from road sensors, cameras, vehicles, drivers and pedestrians to assist streamline monitoring traffic flow. **Figure 1** summarizes the above application scenes in IoT use cases.



## Functional architecture in IoT Gateway

**Figure 2** depicts the end-to-end architecture of IoT solution. The network device can be connected to a local gateway *via* a short distance network such as WiFi, Zigbee, Bluetooth, directly to a wide area network such as the mobile cellular network. The gateway devices can be connected through a wireline access network.



The gateway connects the local communication between the IoT devices and bridges the local network to the wide area network. To support a larger number of devices per cell with new features such as group-based paging, messaging and improved load management.

## Access network

The Radio Access Network (RAN) is shared traffic across consumer and IoT. Traditionally, mobile networks have been planned for low latency, high throughput consumer traffic. MTC optimizations to 5G is used to extend coverage for low throughput devices deep deployed within buildings such as in basements which consequentially reduce signaling traffic and device cost and improve battery life. Meanwhile, IoT optimized wide area networks which are under developed and deployed.

## Cellular core network

5G core network functions make two major forces for IoT services and devices. One is the current ongoing MTC and another is the application of Network Functions Virtualization (NFV) and Software-Defined Networking (SDN) technologies in the 5G core network that create novel capabilities that can enable a plenty of use cases more efficiently including IoT. MTC is concentrated on 5G cellular system enhancements for IoT services and develop for low complexity, low cost and low power consumption as well as efficient small data transmission devices.

NFV and SDN technologies build a modular based core network architecture where the core network can be dynamically 'scaled' and 'sliced' depended on IoT use cases, categories of devices. It is conceivable that a

network operator can create mobile core instances suitable for IoT. The blending of these novel technologies will lead to an access agnostic and 5G core network that will back up the various use cases of telecommunications.

## Connectivity platform

By designing a platform for handling SIM pre-provisioning, provisioning, activation, deactivation and self-diagnosis of device communication issues, the demand for bulk provisioning has driven 5G operators to reduce their operations cost.

The connectivity platform comprises a communication server that analyzes, stores and transfers message routing and protocol translation, essentially collecting information from devices and making them available to applications. Data communications server belongs to the application platform. The management platform consists of device management functions for firmware configuration, diagnostics and upgrades and application life cycle management.

## Application platform

A Development and Execution Application Platform (DEAP) is planned to create and realize the application for IoT solutions. The application platform is consisted of the fundamental functions for diverse applications: collect, store and process data and transmit valuable statistics to customers of frontal application. The application platform has the communication server, a rule engine for processing data and a database for storing device data. Application Program Interface (APIs) easily uses the services of the platform. It provides remote and automatic operation, administration, management and provisioning. Network domain virtualization includes virtual Radio Access Networks (vRAN)/vAccess, vCore and virtual Operations Support Systems/Business Support Systems (OSS/BSS) for dynamic scalability.

## Advancements in LTE for MTC

LTE IoT is a suite of two complementary narrowband technologies eMTC and NB-IoT. They deliver optimized performance and efficiency for a wide range of Low-Power, Wide-Area (LPWA) Internet of Things. Shared eMTC and NB-IoT delivers new efficiencies for the massive IoT such as single Rx antenna, half-duplex, PSM, eDRx, TTI bundling, overload control, overhead optimizations. Supporting narrowband operation, NB-IoT enables low-cost modules optimized for small, infrequent data transmissions. Utilizing a narrower bandwidth Positioning reference signal (PRS) with higher repetition factors that extends range.

## Seamless coexistence of different services

LTE IoT broadens IoT use cases and expands into unlicensed spectrum [2]. It established a solid foundation

for connecting the massive IoT, by scaling down complexity, lowering power, deepening coverage and increasing device density. It continues to extend into the unlicensed spectrum that will enable new standardization LTE-U, LAA, eLAA for private IoT networks.

Mesh networking is multiple-hop mesh with WAN management on unlicensed spectrum for LTE D2D low power devices. MTC/IoT services are promising to coexist seamlessly with 5G broadband services, therefore IoT operators can efficiently incorporate them with existing LTE-A networks. Coexisting with LTE unicast services, eMTC single-cell multicast group messaging service and NB-IoT single-cell multicast firmware upgrade service facilitates the efficient communication. Downlink remains OFDM-based for coexistence with other services.

## Mature, interoperable global ecosystem

We are driving broad ecosystem adoption of LTE IoT. Global cellular connectivity to a wide variety of IoT applications generate LTE multimode modem supporting Cat-M1 + Cat-NB1 + E-GPRS which is one example of cost-optimized, flexible and scalable chipsets tailored to power IoT. Supporting dynamic mode selection with flexible configuration.

## Always-available, ubiquitous connectivity

LTE provides a scalable IoT connectivity platform. LTE Cat-1 delivers scalable performance and seamless mobility for high performance IoT use cases. eMTC Cat-M1 optimizes TTI bundling and repetitive transmissions for the broadest range of IoT applications with high-reliability and lower latencies. NB-IoT Cat-NB1 provides extreme optimizations on relaxed timing requirements, lower-order modulation and single-tone UL transmissions for low cost/power, high throughput, delay-tolerant IoT use cases.

## Conclusion

This letter leads the LTE IoT evolution to connect the massive Internet of Things. Resource Spread Multiple Access (RSMA) for grant-free uplink small data exchange transmission is new LTE Radio Access Technology (RAT) solutions towards 5G cellular technology for mission critical MTC devices which demands low latency, low cost/power, high mobility/flexibility, high reliability, high data rates, high coverage.

## References

1. 4G Americas (2015) Cellular technologies enabling the IoT.
2. Qualcomm Technologies (2017) Leading the LTE evolution to connect the massive internet of things.