SAMSUNG

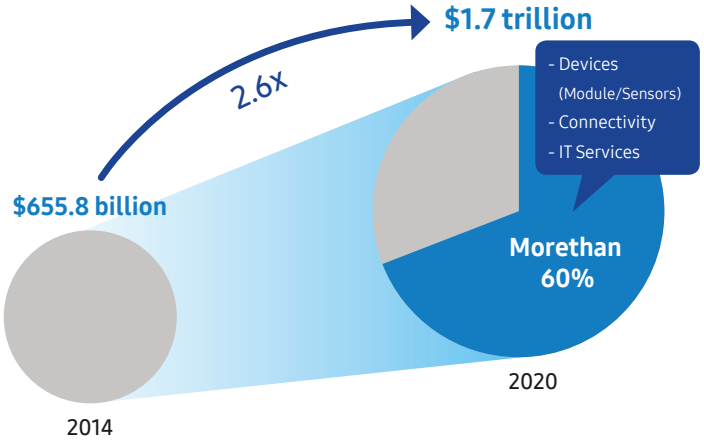
Internet of Things

Introducing innumerable opportunities

The Internet of Things (IoT) market is continuously growing as more and more devices are joined together. We are now witnessing an unprecedented increase of information, services, devices and people that are dynamically interconnected. The digital interactions are being harmonized into an ambient experience that rewrites the traditional definition of being connected.

Global IoT market trend and prospect

Even as our world today becomes increasingly connected, many industry experts testify to a bigger growth of IoT in the future. According to the International Data Corporation (IDC), the IoT market is expected to grow from $655.8 billion in 2014 to $1.7 trillion in 2020. More specifically, this vast market can be broken down to modules/sensors, connectivity, services and other technologies. More than two-thirds of the forecasted market share will be driven by the first three market segments with modules/sensors ranking first and connectivity coming in second.[1)] As such, technologies capable of connecting billions of devices together are more important than ever before

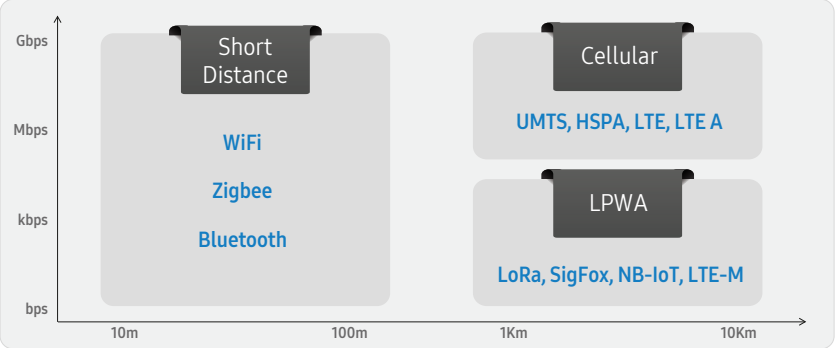


Communication technologies that empower the IoT world can be divided according to the distance across which devices need to communicate. Up to now, the majority of IoT business has been focused on short-range communication technologies such as WiFi, Zigbee and Bluetooth. These technologies can be utilized for stationary objects or at generally short distances at scales of tens of hundreds of meters. Smart homes, where stationary home appliances such as refrigerators, televisions and lighting systems are all situated close to each other, can be connected with such technologies. Smart offices, where printers, card readers and other devices can be connected, are also an ideal place to implement short-range connectivity.

However, the market is now requiring technologies for longer-range communications, particularly with the emergence of demand for connectivity between mobile objects or objects spread out across a wide area. These objects usually don't need to transmit high amounts of data and are often used to track the state of an object or its environment. Smart metering for electricity or gas, smart farming, such as checking the soil moisture levels, and smart tracking of freight are all excellent examples of such applications for IoT. All of these cases require a network where only small amounts of data will be transferred but spread across a wide area. Such networks are now referred to as Low Power Wide Area (LPWA) networks. Although not as developed as short-range IoT, there are already cases where long-range communication for IoT is being used and this trend will continue to grow exponentially. Operators are quickly realizing that this is a chance to develop a new source of revenue; LPWA network can be utilized by countless consumers as well as across virtually any industry imaginable.

LPWA & Cellular IoT Networks

There are several different technologies that an operator can choose to deploy LPWA networks. An operator may consider either an evolved version of the current LTE cellular network such as LTE-M and Narrow Band-IoT (NB-IoT) or new IoT technologies such as LoRa and SIGFOX.



LPWA technologies all share certain traits that make them uniquely suitable for long-distance and low-power communication. Devices typically have a long battery life with usually over 10 years of operation possible depending on traffic and coverage needs. People are used to charging the batteries of their smartphones or tablets on a daily basis. However, this is impossible to do for most cellular IoT devices; they are often deployed to areas with no available power or in hard-to-reach locations as in the case of gas/electricity/water metering, agricultural monitoring or transportation tracking. If these devices had only a short lifespan such as today's consumer LTE devices, people would need to change the batteries of millions of devices on a regular basis – an unnecessarily costly and time-consuming job.

Because devices are spread out in such a wide area and devices can be situated in hard-to-reachh places such as basements or inside elevators, an enhanced coverage is necessary. Many of the deployed objects may also be moving and therefore broad coverage will also be needed to ensure uninterrupted coverage. At the same time, devices only need to send small amounts of data e.g. kilobytes at a time) to relay information about a certain object and heavier data, such as images or videos, is rarely involved. Therefore, these LPWA technologies only need a very small amount of bandwidth and can be deployed efficiently.

The cost of the devices themselves is now undergoing a significant decrease. Billions of devices are expected to be deployed in our connected future, and it would be virtually impossible to construct an IoT network with expensive devices. In order for mass deployment to become a reality, the total cost of ownership (TCO) should be very low.

Similar to LTE, LPWA technologies can be deployed in either licensed or unlicensed spectrum. LoRa and SiGFOX are great examples of LPWA technologies that use unlicensed spectrum. These technologies are developed for the sole purpose of enabling Machine Type Communication (MTC) and can connect sensors with ultra-low data transfer requirements. These technologies are available today and are already in use in many countries, enabling services such as bicycle tracking.

Cellular IoT, evolved from LTE, includes technologies such as LTE-M and NB-IoT. Both technologies have been standardized with NB-IoT being an integral part of the recently finished 3GPP Release 13. They are designed to be operated within spectrum bands – either GSM or LTE. LTE-M is readily available today and is a mature solution for MTC. Although evolved from LTE, it serves as something of a middle ground between the traditional capabilities of LTE networks and the requirements of IoT devices, supporting slightly higher data rates than existing LPWA technologies. LTE-M supports FDD, TDD and half duplex (HD) modes and can be deployed in any LTE spectrum. It can also coexist with other LTE services within the same band and only requires a very narrow bandwidth between 1.08 and 1.4MHz, compared to the 5, 10 or 20MHz bandwidth of a normal LTE carrier.

Narrowband-IoT, or NB-IoT, is expected to be available in 2016 and is designed to more closely match the requirements of LPWA-type networks. Geographical coverage is extended over that of LTE-M while supported data rates are lower, allowing even longer battery life for devices and narrower spectrum requirements of 180 to 200 kHz. NB-IoT supports 3 modes of operation in terms of frequency; standalone, guard band, and in-band. The guard band mode, as the name suggests, utilizes the otherwise unused narrow resource block within an LTE carrier's guard band. The in-band mode utilizes resource blocks within a normal LTE carrier. The standalone mode operates in its own individual block of frequency and may be deployed either on an LTE band or as part of a formerly used GSM carrier.growth of IoT in the future. According to the International Data Corporation (IDC),

	LPWA (Low Power Wide Area)					
	Cellular IoT (3GPP Standard-based)				Non-Cellular IoT	
	LTE-M			NB-IoT (Rel.13)	LoRa	SigFox
	Cat 1 (Rel.8)	Cat 0 (Rel.12)	Cat M (Rel.12)			
Coverage*	Same asLTE coverage (Cat-M : Deeper Penetration)			+ 20dB than LTE (<22km)	<14km	<17km
Spectrum	LTE In-band Only			LTE In-band Guard band Standalone	Un-licensed Band	
Signal BW	20 MHz	1.4 MHz	108 MHz.	180 kHz	125 kHz	0.1 kHz
Data Rate	10Mbps	1Mbps	1Mbps	200kbps	10kbps	100bps
Battery Life	10years			10years	10years	

* Based on 800MHz, Sub-Urban

IoT Use Cases in Korea

As mentioned above, many operators, who are currently focusing on short-range IoT, will also start investing in the LPWA market as well. Korea represents a perfect example of this trend. Korea is already an advanced LTE country where mobile subscriptions have reached saturation levels. In 2015, individual mobile subscriptions increased by a mere 1.5%; however, the number of IoT subscriptions increased by 23.4% over the same period.[2] Against this backdrop, more mobile service providers appear to be focusing their e orts on IoT and seeing that the LPWA market as a driving force and new revenue source for expanding their business.

01

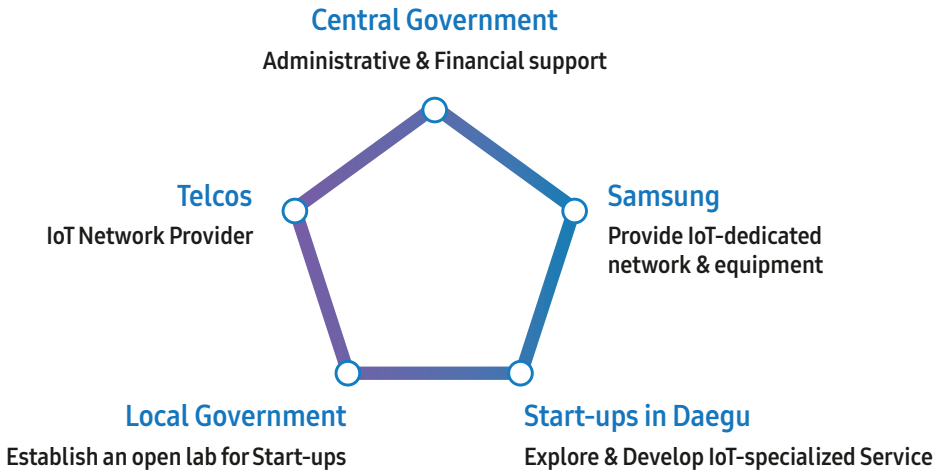
Transforming the city into an IoT hub[3]

The majority of today's IoT market consists of short-range communications and indoor environments, but the market is shifting its focus to long-range for both outdoor and indoor coverage. The Korean government, with one of the mobile carriers in Korea, has teamed up with Samsung to build an IoT city in Daegu, 300 kilometers southeast of Seoul and the nation's fourth-largest city. Daegu is to be designated as a regulation-free zone for information and communication technologies (ICT).

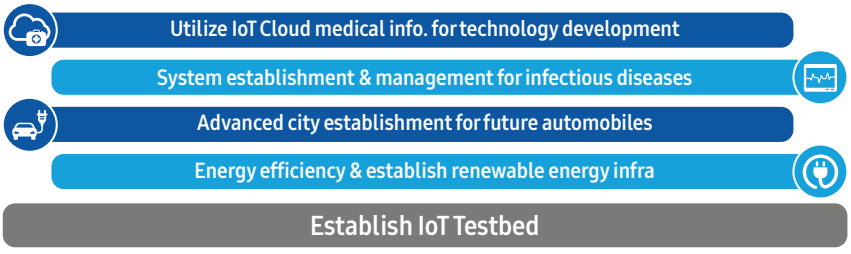
The government plans to install IoT infrastructure across the entire city, setting up IoT based infrastructure for renewable energy solutions, cloud platforms and big data analytics

for healthcare and medical services, as well as infrastructure for autonomous and electric vehicles. Samsung will provide its intellectual property on equipment and IoT-dedicated networks throughout the city, while the central government will ease regulations to facilitate IoT-related projects and secure budget, thus providing both administrative and financial support. And the Daegu municipal government will strengthen its support for IoT startup vendors and establish an open lab where IoT-specialized tech start-ups can verify their technologies and services.

Through the implementation of various solutions, including an IoT-dedicated network, standalone base stations and IoT applications, the Korean government plans to create a new business ecosystem by supporting ventures seeking to both enter the global market and play a key role in developing the nation's ICT industry. Golden opportunities are waiting to be tapped. Some of the major IoT applications in this testbed will include the following.



- Utilizing IoT Cloud medical information to develop technologies: Based on global IoT cloud, develop and establish a medical information system, develop Artificially Intelligence (A.I) doctor for early detection of diseases
- System establishment and management for infectious diseases: Establish national system for efficiently manage infectious diseases; develop home monitoring system and medical equipment, develop real-time tracking of quarantine patients
- Establishing an advanced city for future automobiles: Establish charge infrastructure for electric cars.
- Energy efficiency & establish renewable energy infrastructure: Build solar energy a power plant for idle sites, parking lots and industrial complex. Replace 60,000 streetlights and security lights to LED.



02

Connecting industries and lives with LTE-M[5)]

In the near future, things around us, such as bicycles, parking lots, lights, and construction equipment will be connected and capable of automatically fulfilling our needs and providing important information and adjusting our behaviors or business processes.

One of the Korean fixed line telecommunications providers has announced that they will incorporate LTE-M into their network and support the Internet of Things (IoT). Moreover, the provider will explore several new specialized services such as bicycle anti-theft service, smart metering, smart blood box, smart lighting and more.

The telecommunications provider's latest initiative for the deployment of a commercialized nationwide IoT network is based on, and named after, the 3GPP's LTE-M standard and largely utilizes the existing LTE infrastructure, but aims to provide a lower data-rate at a lower transmission power without impacting existing cellular service. As such, it is an optimal choice for network operators to support the connectivity requirements for IoT since it o ers an easy software upgrade for existing networks while providing advanced device key performance indicators (KPIs), as well as improvements to device battery life and coverage while ensuring a low overall total cost.

Following the Korean government's lead, the mobile carrier plans to complete service testing for its network within the final quarter of this year, providing connectivity for 100,000 objects. The operator aims to increase the number of connected modules to 4 million by 2018. Such networks can lead to clear cost savings in our daily lives and can also be used to save lives. Moreover, the entire global economy will benefit from this standards based approach as it stimulates innovation, accelerates cost efficiency and guarantees interoperability.

Bicycle anti-theft service
Anti-theft alarm & real-time location tracking

Smart metering
Electricity metering, water & gas will be available, LPG tank deterioration, freshness & remaining amount of beer in a barrel

Smart blood box
Sample and blood location tracking, and real-time blood temperature check

Smart container/smart lock
IoT-base smart track/lock solution for home, warehouse and customers

Smart Vehicle
Platform to provide innovative connected-car service based on real-time control and data analysis

Smart heavy equipment
Solution for factory & industrial sites to prevent accident, efficient human resource management

Smart lighting
Turns on/off store signs, monitors stores using temperature/humidity/CO2 level/fire sensors

Industrial G/W and smart factory
Industrial device for collecting info. of different sensors attached to production facilities

03 IoT for Public Safety LTE

Korea is a forerunner in Public Safety LTE or PS-LTE, and the Korean government is strongly pushing the rollout of a nationwide PS-LTE network. The network will be rolled out in three phases, culminating in a nationwide PS-LTE service availability by 2017. The Korean government is planning to invest around 1.5 billion US dollars for the network, which includes the commercial pilot, deployment and operational costs.

Not stopping there, the government also plans to establish LTE-Railroad, the world's first LTE-based network to support railroad and subway operations and LTE-Maritime wireless communication networks. Busan, Korea's second largest city has already deployed a commercial LTE-Railroad network in 2015 and the government is planning to set up and install LTE-Railroad base stations throughout the country's entire rail network by 2025. LTE-Maritime will be a comprehensive safety system to assist the prevention of maritime accidents and will o er tailored safety measures. The three networks, PS-LTE, LTE-Railroad and LTE-Maritime will also provide interworking with each other in emergency situations.

In the near future, such networks will need to accommodate the Internet of Things as well. Sensors such as smoke alarms and motion detectors, security cameras, wearables for emergency workers and other such devices will all be connected to these networks. When sensors and other devices are connected to the IoT network, real-time monitoring is possible and in times of emergencies, swift actions can be taken.

Couclusion

IoT will define how we live our lives in the years to come. A world of interoperable and interconnected objects surrounding us will be a part of nearly every aspect of our lives, informing us of the surrounding environment and guiding our actions to help us make better decisions. Business opportunities related to IoT will be innumerable with both industries and consumers using billions of connected devices. While short-range IoT applications have taken the spotlight up to now, there are new and exciting pportunities opening in the LPWA market. Both unlicensed technologies such as LoRa and Sigfox and cellular IoT such as NB-IoT and LTE-M will be able to address the challenges of broad device connectivity and present new and critical means of revenue generation for operators.

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