NB-IOT

-Enabling New Business Opportunities

BUILDING A BETTER CONNECTED WORLD

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Executive Summary

The LPWA market has existed for about 10 years; it's not a new thing. The current technologies (solutions) supporting this market are fragmented and non-standardized, therefore there are shortcomings like poor reliability, poor security, high operational and maintenance costs. Furthermore, the new overlay network deployment is complex.

NB-IOT overcomes the above defects, with all the advantages like wide area ubiquitous coverage, fast upgrade of existing network, low-power consumption guaranteeing 10 year battery life, high coupling, low cost terminal, plug and play, high reliability and high carrier-class network security, unified business platform management. Initial network investment may be quite substantial and superimposed costs are very little. NB-IOT perfectly matches LPWA market requirements, enabling operators to enter this new field.

NB-IOT enables operators to operate traditional businesses such as Smart Metering, Tracking, by virtue of ultra-low-cost ($ 5) modules and super connectivity (50K / Cell), also opens up more industry opportunities, for example, Smart City, eHealth.

NB-IOT makes it possible for more things to be connected, but also managing the commercial value of the resulting Big Data is a big task, operators can carry out cooperation with related industries, in addition to selling connections, they can also sell data.

1. Emerging Market for Low Power Services and Applications

1.1 IoT development & Growing Demand for LPWA

The Internet of Things – IoT – has moved from fiction to reality. By 2020, there will be over 14 billion network-enabled devices, according to the International Energy Agency. This compares to approximately 3.2 billion people using the internet. IoT dramatically widens the internet's scope from people-operated computers towards autonomous smart devices. Often, these devices are connected to the internet for remote diagnostics & control, leading to cost savings. In addition, innovative IoT hardware & services can generate new revenues – for example, connected glasses used for industrial applications, more efficient logistics serving new market segments, or industrial appliances sold in a per-usage business model. In many cases, business users & private users can control their IoT application through existing smartphones and tablets, through mobile applications that interact with web servers which the connected objects connect to.

Many mobile operators have set up dedicated IoT/M2M business units in order to serve the growing number of companies looking to embrace the business benefits that mobile IoT brings. Larger operators have even made acquisitions so that they can serve a wider part of the value chain and capture revenues beyond pure connectivity. As the market grows, it is becoming obvious that there are many mobile IoT use cases for which existing cellular networks are not suitable.

The reasons are simple: Coverage, battery life and device cost. First, coverage: Existing cellular networks already offer very good area coverage in mature markets. However, many potential "connected objects" are located in vast remote areas, far away from the next cellular base station. If there is coverage, it is often weak which requires the device transmitter to operate at high power, draining the battery. In addition, cellular networks are not optimized for applications that occasionally transmit small amounts of data. A battery life of several years combined with an inexpensive device cannot be realized on existing cellular standards, as they do not support the required power saving mechanisms.

The third aspect is device cost: Mobile devices working on GSM, 3G and LTE are designed for a variety of services, including mobile voice, messaging and high-speed data transmission. However, NB-IoT applications do not utilize any of this; they just require low-speed but reliable data transfer, and an appropriate level of reliability. Therefore, using cellular devices for NB-IoT applications means using devices that are too expensive for the application. Many of the NB-IoT use cases require a low device price, not just in order to have a positive business case for the service operation, but also due to practical aspects such as ease of installation or risk of theft.

In summary, there are strong market trends pointing at growing demand for NB-IoT applications, while the networks that can efficiently serve such applications are not in place yet. This whitepaper examines trends in the market for NB-IoT applications and discusses technology options that operators can choose from in order to enter this new business.

1.2 NB-IoT Use Cases & Market Potential

The strong growth in the NB-IoT market has motivated many analyst firms to create forecasts showing the expected numbers of connections as well as the revenue potential. Generally, the global IoT market is expected to be worth trillions of dollars by 2020. The NB-IoT market is a subset of this, and it is important for operators to understand the revenue potential in the countries they operate in.

Before looking into specific countries, we need to identify the industries or verticals where NB-IoT can add value. Figure 1 below shows nine industries where we see major market potential for NB-IoT services:

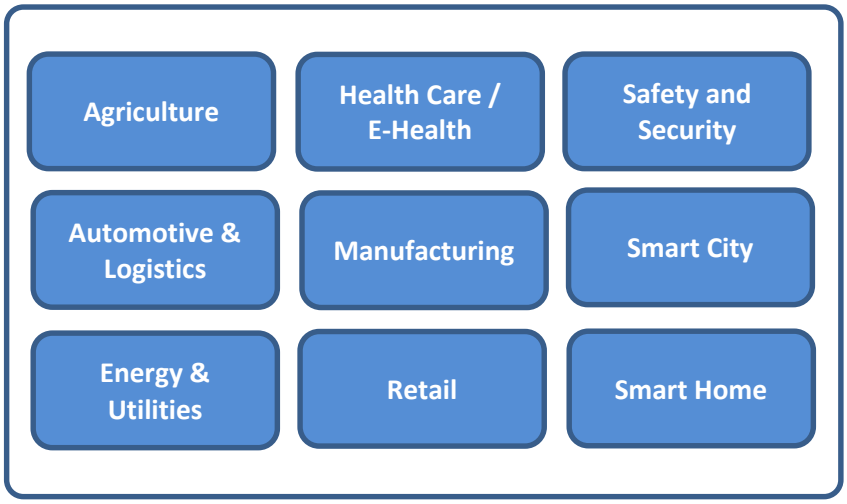

Figure 1: Target Industries for NB-IoT Services

Huawei's business case analytics is designed to evaluate the NB-IoT business for specific industries, countries or regions. Based on our deep country-specific research which includes social and demographic data evaluation, we have modeled how the adoption rates for different NB-IoT applications will develop during the next five years.

Our forecasts are based on use cases; distinct NB-IoT applications that will often be deployed in more than one industry. The model currently includes over fifty use cases, covering many service categories such as:

- Smart metering (electricity, gas and water)
- Facility management services
- Intruder alarms & fire alarms for homes & commercial properties
- Connected personal appliances measuring health parameters
- Tracking of persons, animals or objects

- Smart city infrastructure such as street lamps or dustbins
- Connected industrial appliances such as welding machines or air compressors.

Figure 2 below shows as one output example of five-year revenue forecast (connectivity only) by Huawei for Germany divided by nine industries:

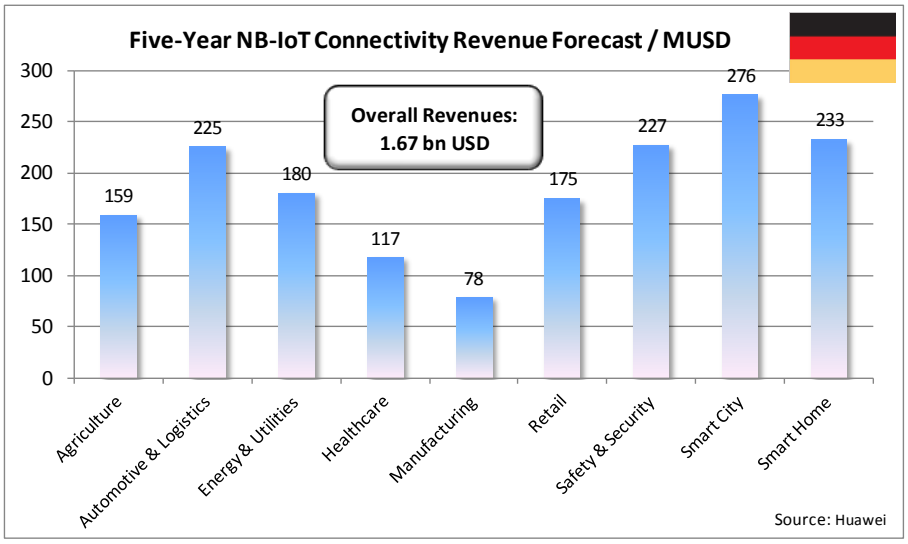

Figure 2: Five-year NB-IoT revenue forecast for Germany

The overall sum of 1.67 billion USD for five years equals a per-year NB-IoT revenue of 334 million USD. This would equal to a revenue uplift of 2.2% for the existing German operators thanks to the launch of NB-IoT services. This show, just as starting point, that already with conservative assumptions, NB-IoT is a promising new business area which operators should invest into now, if they do not want other players to capture this attractive market.

2 Emerging Low Power Technologies

2.1 Introduction to NB-IOT (Best Solution For LPWA)

As mentioned earlier services that leverage low power wide area networks mainly require deep / wide coverage, low power consumption and massive connections. There are several inherent characteristics of the NB-IOT technology that makes it the best for LPWA deployment.

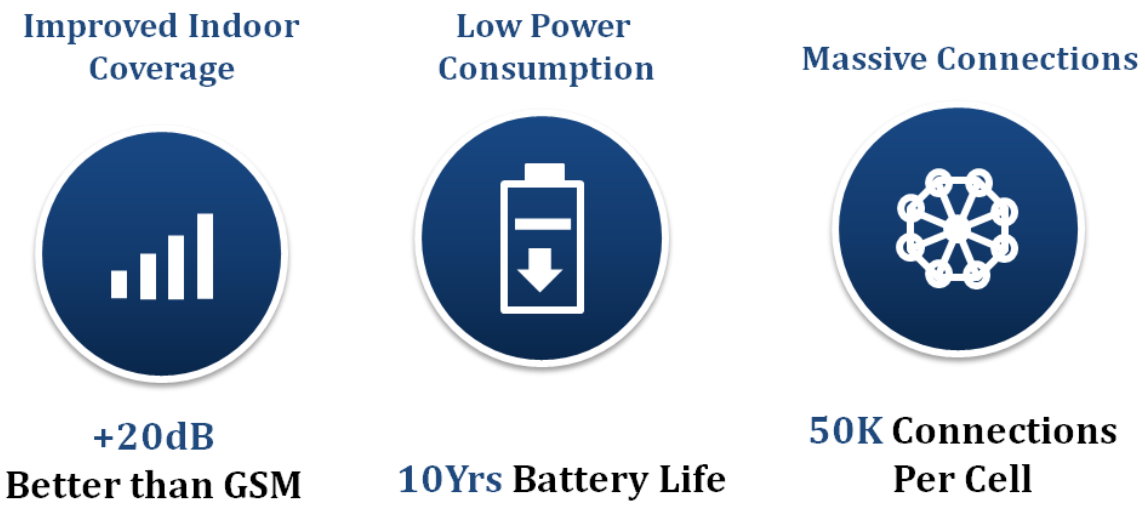

Figure 3: Inherent capabilities of NB-IOT

Moreover low power consumption is a prerequisite for almost 80% of all LPWA use cases, ranging from applications like smart meter, smart parking, and wearables to smart grid. Additionally, with the availability of massive connections it is possible to make everything around us smart.

To realize this, it's ideal to have about 50K devices per cell; this is possible assuming there are the household density per every sq m is 1500 with 40 devices in every household.

When we compare inherent capabilities of NB-IOT with other LPWA technologies like e-MTC, SigFox and Lora, NB-IOT offers better performance. Furthermore, when we look at all the technologies in terms of network investment, coverage scenario, uplink and downlink traffic and network reliability we realize that NB-IOT is the most suitable technology.

Additionally from a performance point of view, NB-IOT guarantees 20+dB coverage, ~1000x connections, ~10 years using only 200 KHz bandwidth whereas the other technologies like eMTC, SigFox offers far less in terms of performance.

NB-IOT has quite an extensive ecosystem mainly because of its support from many global top operators. Most importantly unlicensed solutions can't guarantee reliability and security.

2.2 The NB-IOT deployment scenarios

The recently 3GPP agreed technology for LPWA deployment NB-IOT will offer three deployment scenarios; these are, Guard Band, In Band and Stand Alone.

Standalone deployment is mainly utilizes new bandwidth where as guard band deployment is done using the bandwidth reserved in the guard band of the existing LTE network, In Band on the other hand makes use of the same resource block in the LTE carrier of the existing LTE network.

Figure 4: Three deployment scenarios of NB-IOT

In summary, it becomes clear that the Standalone and Guard band deployment options tend to offer the best performance in terms of improved indoor coverage, FDMA (GMSK) also offers about 20% power consumption saving and lower cost.

2.3 Low band, an excellent choice for fast deployment

Low band is quite known for its excellent performance in terms of coverage; furthermore leveraging the inherent characteristics of this frequency band in deploying NBIOT offers several benefits. It is widely known that several operators around the globe use the 900MHz frequency band for GSM voice deployments because of its extensive coverage capability. This is possible because such low frequency bands have excellent propagation characteristics and this generally improves the indoor penetration.

Deploying NB-IOT in frequency bands like 700MHz, 800MHz, and 900MHz is a great choice because they provide an already large and established ecosystem since quite a number of operators select them; it also offers benefits in terms of site number. There is quite a substantial number of commercial networks both UMTS and LTE that are currently running on the 900MHz frequency band. Analyst firms recently confirmed that there are about 14 LTE 900MHz commercial networks as at July 2015.

A few examples of such operators can be found in the Czech Republic and Sweden. There are other operators in South Korea with commercial LTE networks on the 800MHz frequency band. For mobile operators who are already running GSM 900MHz, it is possible to just upgrade, some operators might also be running on LTE 800MHz, there is a clear upgrade pathway to NB-IOT for such operators too.

3. Shaping the Business model

3.1 Value Chain and Partnerships

As shown in the NB-IoT business study for Germany, already connectivity is a valuable contributor to the operator's bottom line. Partnerships with IoT technology providers and alliances with chipset manufacturers are helping the operators to secure this part of the value chain as we see it today for some of the NB-IoT solutions, e.g. smart metering, smart parking and pet tracking. At the moment we see connectivity platforms already in the cloud in many markets where operators have deployed IoT services.

But there is more in than just connectivity. Operators have a chance to go further up the value chain by taken over more responsibilities than pure connectivity.

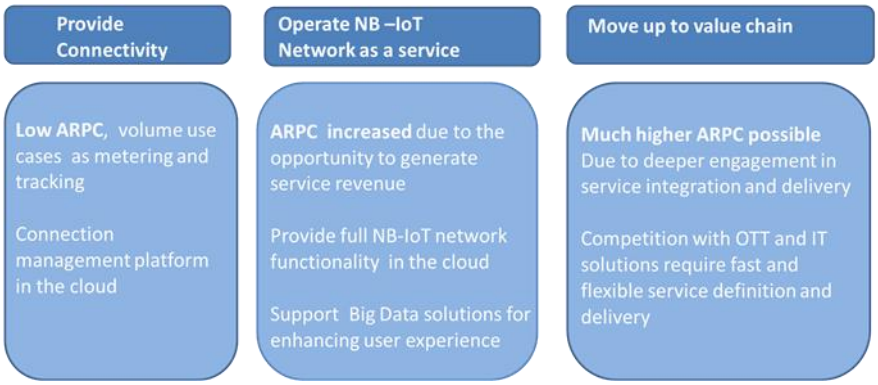

Figure 5 : Telco business models for NB-IoT along the value chain

Consequently the next step towards an integrated offer would be the incorporation of more functionality which points towards a setup, where the operators can offer the full NB –IoT Network as a service in the cloud to end to end service providers which are either private or governmental entities, according to the addressed industries or verticals .

This will create for the operator the opportunity to lever its asset as security, billing and big data into that domain. Quality of service assurance and service level agreements are common in the telco space and could be leveraged into the NB-IoT Network as a service business model

Following this idea even more, operators themselves can enter the IoT business as an end to end service provider by adding customer management and system integration functionalities on top. The operator as e2e business owner can also outsource certain parts of the e2e domain to its partners, sharing effort and revenues, and to expand the operators own experience in the OTT domain. However competing in the OTT domain is not common to most of the today's operators and could be quite challenging.

3.2 Business Potential & Revenue model

The business is scalable and can be grown by demands by orienting the service introduction and go to market strategy on use cases which are profitable at a given point of time and contributing to the operator's bottom line allowing further business expansion. As the operator can reuse his existing sites, no specific investment in towers or acquisition of sites are needed.

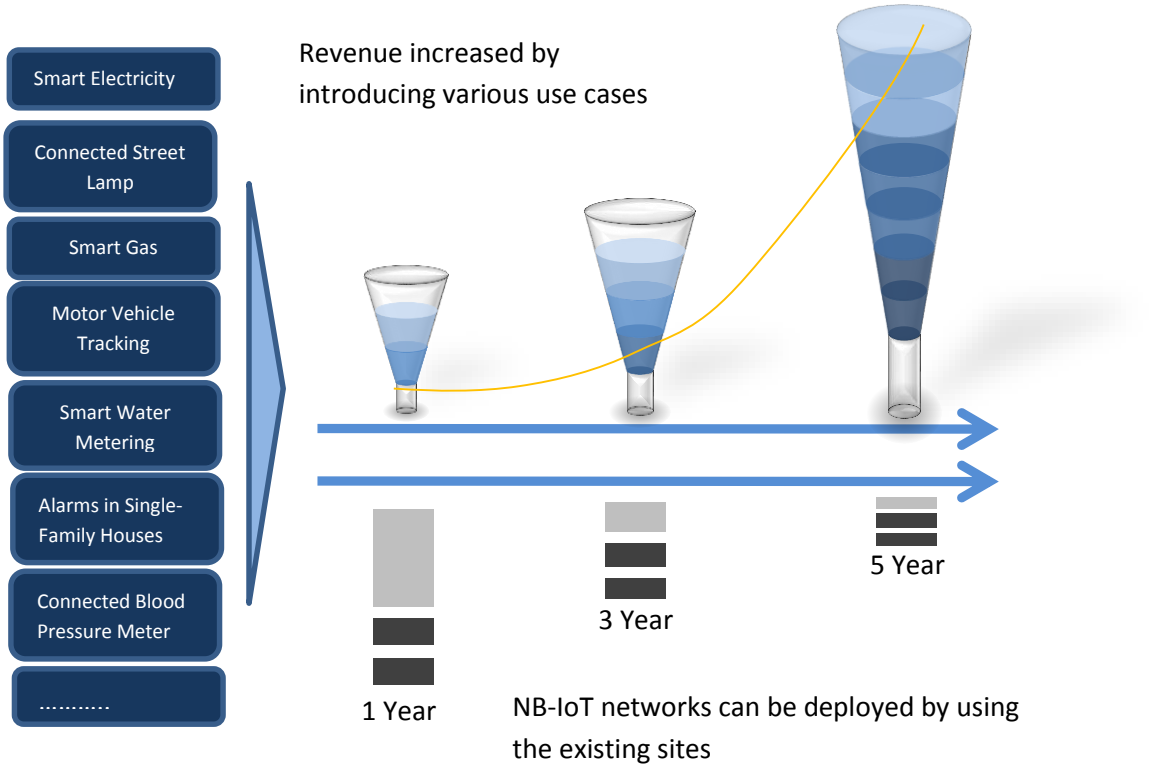

Figure 6 : NB-IoT "time to market" and number of primary use cases

The selection of use cases can be different per operator, country and region or per addressed market. Huawei's business modeling framework is able to address those challenges and advise on the right mix of investment, use case deployment and business model selection.

3.3 Summary

The opportunities for operators to enter business in NB-IoT domain are reflecting the huge potential of NB-IoT. Operators can choose from three basic setups according to their strategy per country or region:

- Connectivity: For the Internet of Things a reliable connectivity is required, but there are more business opportunities as just to engage in connectivity

- NB- IoT NW as a Service: Carrier grade solutions with security, billing, big data integration and QoS assurance allow the creation of new businesses and improvements to existing ones on a solid technological basis. NB-IoT Network as a service is supporting the global trends of network virtualization and cloud based service provision.

End to End service provision: Operators may choose to extend into the e2e service provider domain for specific IoT solutions, but this needs careful planning, technology and business partnerships with players in the industry, including outsourcing and revenue sharing models.

4 IOT Use Case

In this section, the various services and applications supported by LPWA has been classified under four categories; IOT Appliance, Personal, Public and Industry.

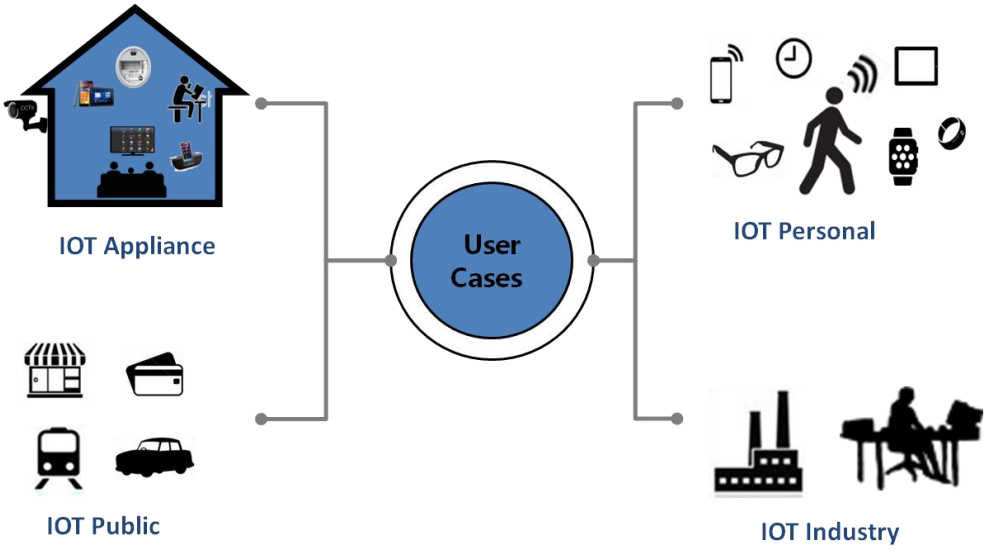

Figure 7: Four use case categories for NB-IOT

4.1 IOT Public

As the name suggests, IOT public focuses on LPWA applications that serves the general public; below are a few examples.

i. Smart metering

Smart metering helps saves manpower by remotely collecting electricity, water and gas meter data over the cellular network. This is gaining quite an amount of momentum with most of the top European MNOs taking an interest in this topic mainly due to the market opportunity it presents. Smart metering will consequently help cut down cost generated from manual meter reading and

changing of meter batteries, which seems to be the two major cost drivers for conventional metering. Smart metering includes smart meters for water, gas and electricity.

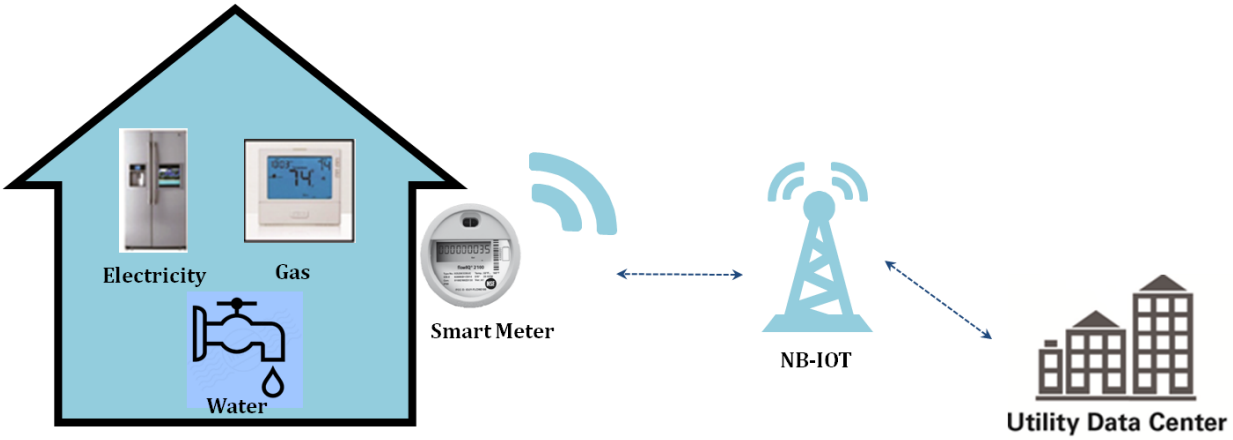

Figure 8: Smart metering use case

ii. Alarms & Event Detectors

Security has always been a very important aspect of human living , people at all times want to be guaranteed of home safety. Alarms and event detection will help to rapidly inform that user about a detected home intrusion. This system will not only offer inteligent protection from intrusion but will also offer intelligence for detected events that can lead to a fire outbreak like a sudden increase in home temperature or smoke. Alarms and events detectors will make use of sensors placed devices in ideal locations in the home that constantly communicates with the LPWA network, this use case will make use of a very low data throughput and battery life of the devices will be ultra critical.

Figure 9: Alarm & Event Detectors

iii. Smart garbage bins

Garbage bins in city are not built by demand, and most of time the collecting trucks routes and schedule are fixed which is not optimal for a smooth collection. Smart garbage cans can signal to the waste management agent when the garbage can is full and in need of service, the best collection route will be calculated and delivered to the drivers. Historical collection data can provide optimized routes and guide on the right-size garbage can for each location. Charging for this service can be done on sensor amount or on monthly fee basis.

Figure 10: Smart garbage bin

4.2 IOT INDUSTRY

IOT Industry mainly delivers low power wide area applications that help to improve general enterprise and industrial efficiency; here are a few examples;

iv. **Logistics tracking**

Large volumes of sensor data sent from tracking devices on shipping containers are aggregated and taken into an analysis to ensure that real time tracking of the location of shipments can be made possible. Alerts and optimized service recommendations are sent to technicians on their iPads, so that they can take preemptive actions in -real time. Charging model for this application can be done on a monthly payment or postpaid basis.

Figure 11: Logistics tracking use case

v. **Asset tracking**

Asset tracking mainly deals with monitoring methods of physical assets made possible by a module on the asset broadcasting its location. Assets are usually tracked using GPS technology. This service is best leveraged in the logistics and transportation management industry, where through the use of sensors in modules sending information over the cellular network it is possible to gather and manage data relating to the current geographical location of assets. Asset tracking helps the owners of the assets to detect and preemtively react to unexpected events.

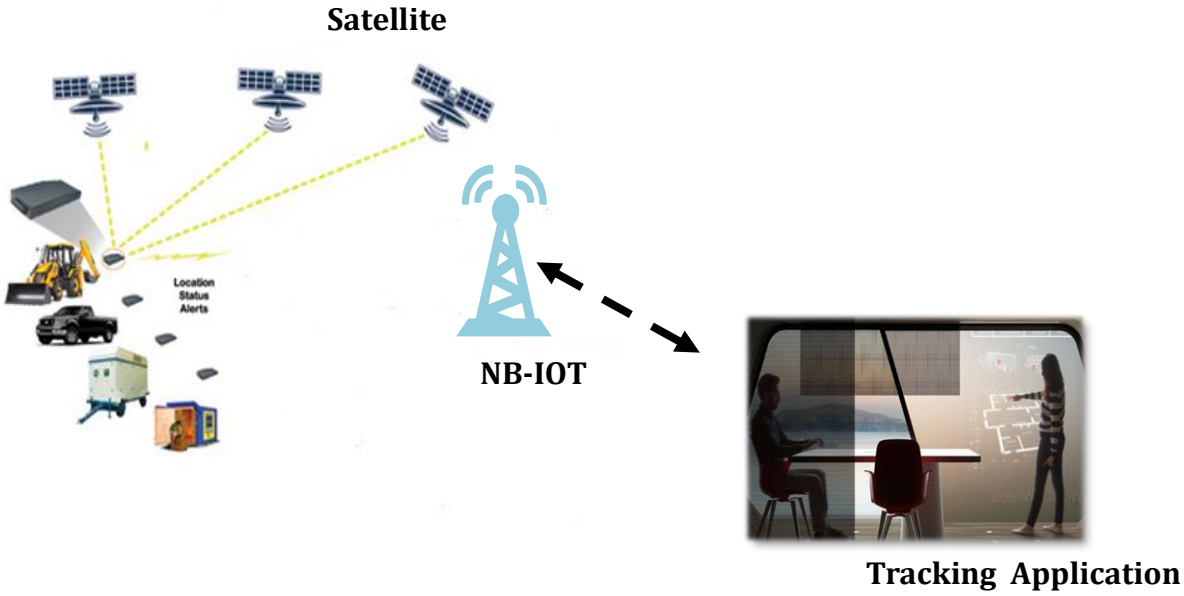

Figure 12: Asset tracking use case

vi. **Smart agriculture**

Farming industry is a sector with slim margins, and the way to survive in this industry is to optimize the general agriculture production including crops and livestock. Developing a sensor function to ensure the feeding of cattle has an optimized mix of nutritions to improve the yields from farming, and to reduce the waste of cattle feed. Installing sensors in the farming equipment that mix the cattle's feed, through sensors measurements the variation in the cattle diet can quickly be identified, assessed and corrected. Charging model for this application can be done on a monthly payment or postpaid basis.

Figure 13: Smart agriculture

4.3 IOT Appliance

Conventionally, smart home application are deployed on short range technologies like Z-Wave, Zigbee but a home gateway is needed. In the case, where the appliance is embedded with an NB-IOT chipset the benefits are surprising. For example, management becomes more efficient through improvements in big data analysis. IOT appliance mainly comprises of LPWA applications that aims to provide intelligence for the user through sensors and devices that are found in the local area. Below are a few examples;

Figure 14: IOT Appliance use cases

4.4 IOT Personal

IOT personal largely features LPWA applications that create a personal area network for the purposes of information exchange for the user. Below are a few examples;

vii. Wearables

Connected wearables in the past few years have taken center stage and increasingly becoming a lucrative industry as it is an application that mainly revolves around health, fitness and wellness. According to Cisco, there will be 177M connected wearables by 2018. Its market value is estimated at $250M in 2015 and is set to rise to $1.6B in 2022. A report released by Research&Markets and Berg Insight also estimated that global shipments of connected wearables in 2014 was 19 million and this figure is set to hit 168.2million by 2019 growing at a CAGR of 74.8%. Some of the few products that are making inroads in this industry are JawBone, GoPro & Nike just to name a few. While smartphone giants like Apple, Sony and Samsung are more linked to smartwatches.

Figure 15: Wearables use case

viii. **Smart bicycle**

For bike rental companies it is vital to keep track of where the bike is at the moment, especially if it gets stolen. A bike rental company in Holland has embedded an M2M SIM card into the bike's frame, and in this way the bike rental company can always find the bike. The M2M SIM is embedded into the bike in a non visible placeIf the bike is not returned to the rental company then the bike is positioned via the SIM. The rental cost for bikes can be reduced since the number of stolen bikes dramatically decrease. Stolen bikes can easily and quickly be located by the police via the SIM. Charging model can be done on a monthly payment or postpaid basis.

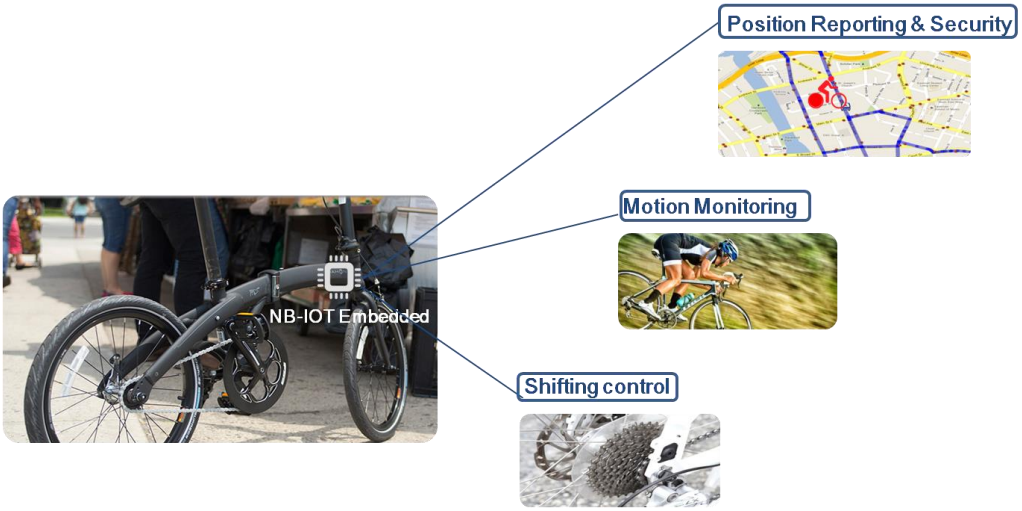

Figure 16: Smart bicycle

i. Kids monitoring use case

The world's population is aging, and senior people living alone at home need care in an easy and affordable way. Also parents have a great interest in being assured about their wellbeing and

activities. This use case provides realtime tracking of kids and the elderly. The information about their activities to the cloud. Real-time insights about the their status can be received on the users smartphone or other device.

Figure 17: Kids monitoring use case

5 Operator Reference Cases

5.1 Smart Parking

Parking can be a challenging issue, especially in urban areas where 30 % of all traffic congestion is caused by drivers circling around to find a parking space. Smart parking provides parking information to citizens in real time to enable better parking management. Huawei and a top operator are working on a smart parking project. Operator expects tens of millions of devices to be connected with this smart parking service. Another collaborator in this project is Neul, who provides the platform.

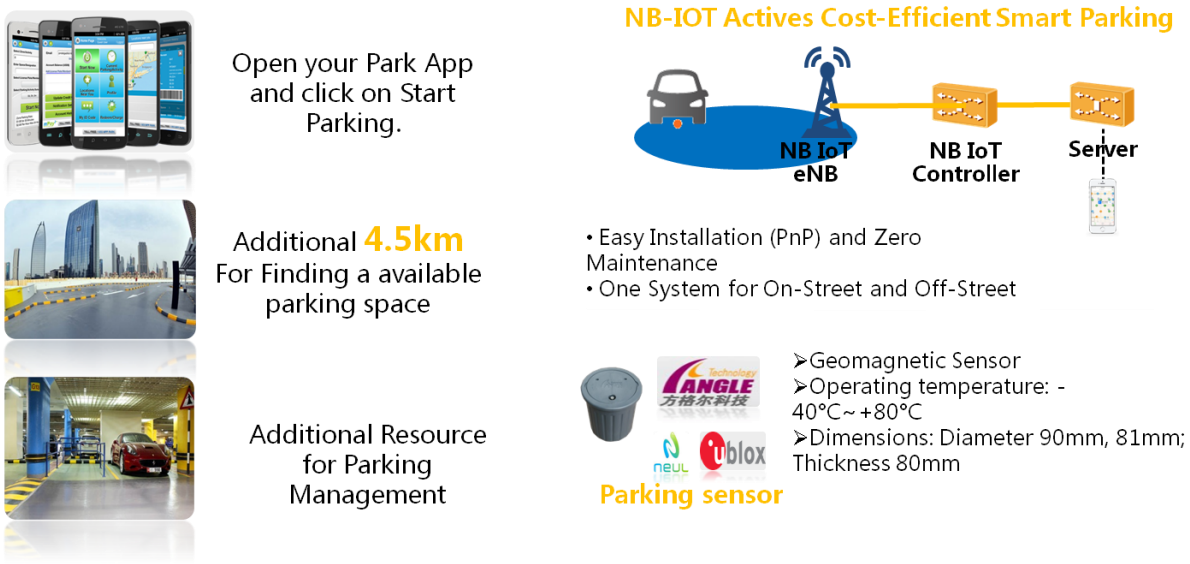

Figure 18: Smart Parking reference case

In this service, sensors that are placed under cars will communicate with the parking server through the cellular network to gain parking information. The operator and Huawei completed field trials for the smart parking project in July 2015 with Proof of Concepts already done. The commercialization of this project is expected in the second quarter of 2016.

5.2 Smart Metering

Smart metering as mentioned earlier enable the automated collection of utility meter data (Electricity, Water & Gas). Huawei and another operator are collaborating on an end to end smart metering solution. During Mobile World Congress 2015, Huawei and the operator unveiled this partnership on end to end smart metering project. Other players like Neul, Veolia, Kamstrup and Ublox are all collaborating efforts on this project that is planned to be launched in the first half of 2016.

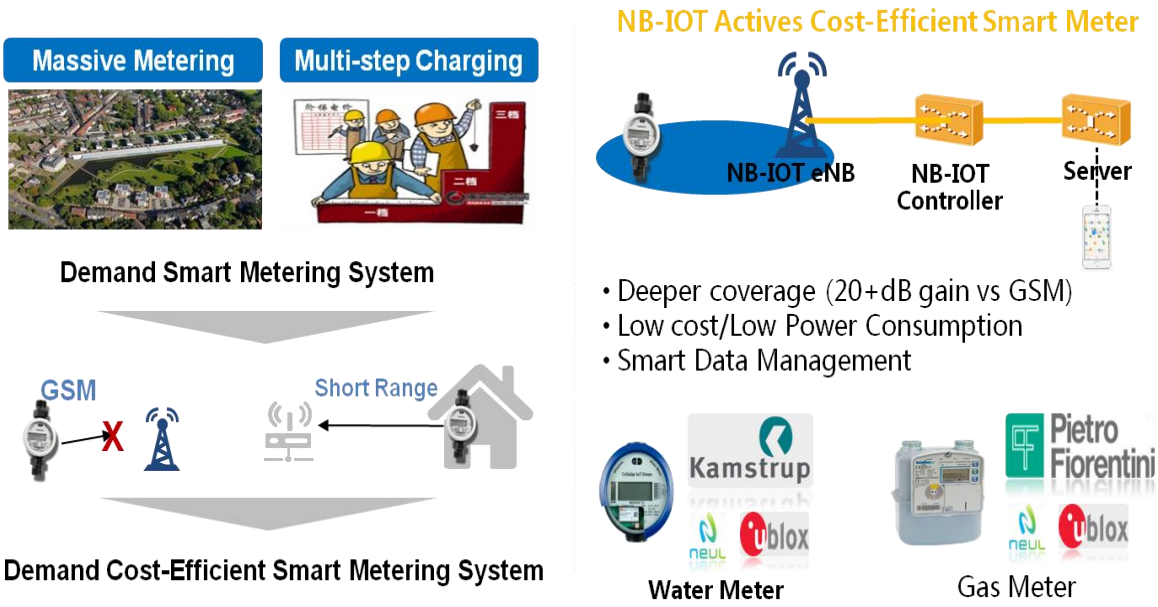

Figure 19: Smart metering reference case

Proof of Concept for the smart metering project have already been completed, Huawei and the operator are looking forward to conducting field trials in November 2015.Commercialization of the smart metering project is expected in the third quarter of 2016.

5.3 Pet Tracking

Humans and their pets share a good bond, unfortunately many users often face issues regarding lost or stolen pets. Pet tracking use case is one application that helps the user to keep track of its pets activities and most importantly location at all times. A small lightweight device placed around the neck of the pet embedded with an NB-IOT chipset helps to send tracking information to its user's device. This NB-IOT devices collects and sends location information leveraging GPS and Location Based Services and this can be done either periodically or in real time based on the users' preferences.

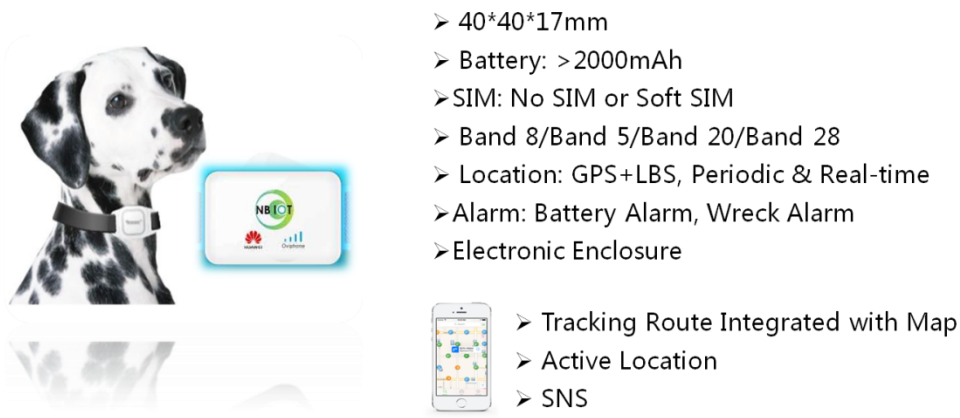

Figure 20: Pet tracking reference case

The user can then receive the information with a tracking route that is already integrated with the map. Furthermore, this device is embedded with several forms of alarms that can alert the user when the device battery is running low .Huawei is collaborating with other industry players and another operator on the pet tracking application.

6 Glossary

NBIOT- Narrow Band Internet of Things

PSD – Power Spectral Density

LPWA-Low Power Wide Area

GMSK – Gaussian Minimum Shift Keying

CAGR – Compound Annual Growth Rate

SC FDMA – Single Carrier Frequency Division Multiple Access

DL – Downlink

UL – Uplink

eHealth – Electronic Health

3GPP – Third Generation Partnership Project

TTM – Time to Market

dB – Decibel

GPRS – General Packet Radio Service

MNO – Mobile Network Operator

PoC – Proof of Concept

KHz – Kilohertz

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