



# MOBILE INTERNET OF THINGS CASE STUDY

## GREATER CHINA

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MARCH 2018



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## GSMA Internet of Things Programme

The GSMA Internet of Things programme is an initiative to help operators add value and accelerate the delivery of new connected devices and services in the IoT. This is to be achieved by industry collaboration, appropriate regulation, optimising networks as well as developing key enablers to support the growth of the IoT in the longer term.

Our vision is to enable the IoT, a world in which consumers and businesses enjoy rich new services, connected by an intelligent and secure mobile network.

For more information, visit the programme's website at [www.gsma.com/IoT](http://www.gsma.com/IoT)

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# PREFACE

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Mobile IoT technology has been widely deployed in cities in the Greater China region. There are a number of successful cases showing not only the benefits of using standard cellular IoT networks, such as NB-IoT technology, but also how mobile operators can provide management and analytic solutions in the value chain as well as the importance of partnerships with local government bodies, utilities, enterprises, service providers and solution providers.

This GSMA Mobile Internet of Things Greater China region case study summarizes a number of representative cases, from smart metering to the sharing economy to smart cities using mobile IoT technologies.

Sincerely thanks for all contributors to this report, including China Mobile, China Telecom, Chunghwa Telecom, Huawei and ZTE, etc. Together with GSMA, our aim is to promote and accelerate mobile IoT end-to-end deployment with the wider ecosystem from the Greater China region towards the worldwide market.

# CASE STUDY 1

## CHINA MOBILE

### ELECTRIC SMART METERING

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#### INTRODUCTION

Smart meters have been deployed by many utilities around the world, and with the technology available to smart meter manufacturers and utilities improving rapidly over the past few years, there is always an opportunity to refresh implementations or add new, more efficient technology to a rollout.

China Mobile Automated Meter Reading (AMR) service for electric utilities consists of an NB-IoT connected smart meter and the cloud based OneNET management and application development platform, all supplied by China Mobile, and which can be deployed in utilities, industrial parks and intelligent buildings. The solution optimises the meter reading process and enables accurate billing for electricity consumption, which has been an issue in some Chinese markets.

#### NB-IoT ELECTRIC SMART METER DEPLOYMENT

China Mobile has developed NB-IoT smart metering and partnered with the State Grid Electric Power Research Institute and Provincial Metrology Institute to deploy and test the NB-IoT connected smart meters in the field. 200 NB-IoT smart meters have been deployed by China Mobile in a number of cities in cooperation with State Grid Corporation of China (CEPRI) in Yingtan, Wuxi, Zhuhai, Chengdu, Chongqing and Beijing.

The China Mobile AMR service today, using 2G or 4G network, is able to collect real-time voltage, current, power consumption and other information from the meters. Through big data analysis, the actual electricity consumption of each device can be assessed, allowing an effective electricity supply

strategy to be developed across an area.

These 200 NB-IoT enabled smart meters are designed to offer the same functionality. Additionally, device management is also conducted through the OneNET platform, so data and commands can be sent to and from the smart meters at any time.

Coverage is very important to connect smart electricity meters wherever they can be installed. Meters are typically installed in locations that are hard to reach, such as in basements or inside cupboards and cabinets. Therefore, network coverage is critical to ensure that every smart meter can be connected to the management platform. NB-IoT offers enhanced network coverage, allowing more smart meters to be connected.

## BENEFITS TO THE CITY

NB-IoT has delivered some significant benefits to the cities and utilities that are piloting the NB-IoT AMR service from China Mobile.

**Simplification** - compared to the existing meter reading services available to Chinese utilities, the NB-IoT Smart Meters are much simpler to install and operate. This in turn lowers costs as maintenance demands and manual meter reads are no longer required. NB-IoT support for frequent data transmissions also means that real-time data is available to the cities and utilities for fast data analysis. Issues such as power outages can be quickly identified.

**Network Coverage** - NB-IoT is designed to offer enhanced coverage over existing mobile networks. This means that it is suitable for connected meters in hard to reach locations, such as in buildings or in meter cabinets, where other networks may not be able to provide coverage. Additionally, as NB-IoT is based on existing mobile networks, coverage is available across the whole existing network.

**Deployment** - as NB-IoT coverage is already in place, there are no restrictions on how the smart meters are rolled out. This means that coverage planning is not required, which makes rollout planning more straightforward. Smart meters can be installed in residential properties at the convenience of the residents, as opposed to a rollout confined by network coverage constraints.

**Data Security** - NB-IoT is designed to be secure. It operates in licensed spectrum meaning that interference from other networks is avoided and quality of service can be assured. Based on 4G networks, NB-IoT shares the same characteristics, offering secure, encrypted communications to smart meters and other IoT devices.

## OUTCOMES & LESSONS LEARNED

All deployed 200 NB-IoT powered smart meters have been able to connect successfully to the NB-IoT network in their deployment locations and transmit data and commands, connect to the AMR cloud platform and provide insight of real-time energy consumption.

A variety of test scenarios have been tested as part of the pilot, including meter reading, device management, report generation and displaying installation locations. All of

these test scenarios have been completed successfully on all installed NB-IoT smart meters, showing that NB-IoT is a technology fit for smart meter operations in the future.

The improved coverage offered by NB-IoT has been crucial in ensuring that every meter has been able to connect across a wide range of locations - indoors, outdoors and in basements across different city topography. This means that installation location does not have to be compromised in order to

obtain network coverage, which makes rollout planning easier, and also means meters can be hidden away from view where required.

NB-IoT, as a globally standardised technology, has proven to offer several advantages over other networks that have been used for smart metering. For China Mobile, this means that the platform architecture is simplified as it does not have to support proprietary

protocols, the network infrastructure is simpler to update and manage, and the hardware costs for the smart meter are lower with a wider variety of suppliers to choose from. This means that cost savings are available, which when spread over a large scale smart metering deployment, which may expand to millions of devices in the future, there are real cost savings and taking advantage of economies of scale.

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## CONCLUSION

It has proven that NB-IoT technology is a very good fit to the demands of China Mobile's AMR solution and wider smart metering connectivity. It offers a high quality of service, essential for operation of critical national infrastructure such as smart meters and grids, wider network coverage to connect

more meters in hard to reach locations, and simplifies device management and integration into cloud management platforms. After the success of this pilot, China Mobile will be investigating more widespread rollouts of their NB-IoT connected smart meters to bring these benefits to electricity networks across China.

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## CASE STUDY 2

# CHINA TELECOM AND SHENZHEN GAS SMART GAS METERING

### INTRODUCTION

China's current 5 Year Planning aims to increase the usage of natural gas as a primary energy source from 5.9% in 2015 to 10% in 2020. This means a significant investment in gas infrastructure, with 40,000km of new pipeline installed, and gas connections available to 470m people.

Existing smart gas meters are helping solve some of the challenges that they face in this expansion, however, many problems remain unsolved. The meter success rate is low, data transmissions are so far unstable and power consumption is too high. Many gas meters are installed in a variety of hard to reach locations, such as indoors and underground, meaning that existing communications networks have struggled to maintain connectivity with all meters.

Against this background, Shenzhen Gas, China Telecom, Huawei and Goldcard have jointly trialled NB-IoT gas meters to try and solve some of the challenges that the industry faces with today smart gas meters.

### NB-IoT GAS METER DEPLOYMENT

In March 2017, a number of smart gas meters manufactured by Goldcard were deployed in partnership with Shenzhen Gas, China Telecom and Huawei for trial of NB-IoT communications in a range of different scenarios and locations using 800MHz spectrum.

By using NB-IoT, Shenzhen Gas, China Telecom, Goldcard and Huawei are able to take advantage of standardised data gathering and IoT platforms, where the whole end-to-end management of network operations can be conducted centrally by either the gas company or mobile operator.

As part of the trial, the partners have implemented a new framework for smart gas metering, which allows new applications to be rolled out on the network quickly. This is hosted on the eCloud jointly developed by China Telecom and Huawei, with a data structure specifically formulated for the Chinese gas industry. This means that gas suppliers and their partners across China can take advantage of these new technologies.

The partners wanted to test the successful completion of a number of different scenarios, including prepaid and post-paid billing and

payments, valve controls, various meter parameter changes, different communications configurations and data integrity protection. As such, the trial has been designed to test a number of different scenarios and ensure that gas meters can be connected even in difficult to reach locations, such as inside metal meter cabinets or inside large buildings.

The NB-IoT enabled gas meters were tested and measured against designed stringent gas industry performance requirements that in line with the expectation. These included a meter reading success rate of over 99%, ability to conduct meter readings on demand and successful reads even when the signal received by the meter is very weak.

## BENEFITS TO SHENZHEN GAS

In the gas market, NB-IoT enables stable, real-time data collection and control of smart gas meters to enable remote operations and new gas services. This in turn improves customer satisfaction and the efficiency of the gas industry processes as well as create new business opportunities for gas utilities.

**Cost Reduction** – for gas metering, NB-IoT can reduce costs of operations by allowing real-time data analysis and prompt troubleshooting, which decrease the operational costs and improves operation efficiency.

**Data security** – it is a key issue for the Chinese gas sector. End-to-end security management of the NB-IoT gas solution ensures data integrity. NB-IoT is only used by mobile network operators on licensed spectrum. This means that risk of interference is minimised and data security can be assured. As NB-IoT networks are based on existing mobile technology, they are easily deployed by mobile operators, and the enhanced coverage these networks offer ensures that all meters can be connected, removing the need to use multiple network types to obtain data.

**Power consumption** – the power of NB-IoT devices has been proven to last at least 10 years. This is due to optimised communications profiles and low-power

signal requirements. This means that meter maintenance costs can be minimised, as there is no need to visit meters and update components on a regular basis. Gas meters are also free to be located in any location along a pipeline; there is no need to locate gas meters close to power supplies or in specific areas to ensure network coverage. This gives the gas supplier a great deal of flexibility in how they rollout their gas smart meters, and the rollout programme can be optimised to ensure the lowest cost installation.

**Scale Deployment** – in terms of massive connectivity, NB-IoT allows for both large scale deployments and a unified platform to accommodate diverse IoT applications. This platform assures protocol compatibility between applications of different manufacturers thus simplifying their integration. This means that gas meters from numerous manufacturers are able to access the network in a common way, allowing gas suppliers to interconnect networks using different gas meters.

## OUTCOMES & LESSONS LEARNED

The results of the Shenzhen Gas trial with China Telecom, Huawei and Goldcard were as follows:

- NB-IoT has significant coverage advantages over other networks (up to 20dB over GPRS networks).
- The power consumption of NB-IoT is much lower than that of GPRS.
- The coverage delivered in field tests was good with an average uplink rate of 13 kbps and an average downlink rate of 7.8 kbps, which is sufficient for meter reading.
- Meter services were successfully completed on the meter head-end service platform, including user registration, tariff adjustment, pre-payment data, remote valve control, remote meter reading and remote parameter configuration, all of which meet the test case requirements.
- The meter reading success rate was 100% in standard operations.
- By comparing the actual readings on gas meters with the data collected by the system, the meter reading accuracy was also 100%.

The outcomes of the trial were very positive, with NB-IoT showing that was capable of meeting all of Shenzhen Gas' stringent requirements, and connected all meters that were deployed.

In addition to the physical trial, a larger scale scenario was also conducted virtually. This trial was designed to simulate communications to 3 million meters within a 200 minute window. Various commands were simulated, including registration, meter readings, payments and valve control.

The results of this trial were also very positive, with NB-IoT demonstrating that the average response time was 640ms, with data collected from every device within 60 seconds of first communication, averaging 30 seconds across all 3 million meters. NB-IoT proved that it is suitable for use in smart gas meters, even at this large scale, and is clearly a good option for connecting large fleets of smart gas meters in the future.



## CONCLUSION

Shenzhen Gas NB-IoT trial with China Telecom, Huawei and Goldcard has proven to be a success, with all gas meters in all locations connected and communicating. NB-IoT has met the Chinese gas industry's requirements, with secure, high availability communications assured. NB-IoT can collect data and control all of the required parameters on a smart gas meter and will in future allow gas suppliers to offer new innovative services directly to their customers.

The trial has also proven that mobile operators are good partners for gas suppliers looking to deploy smart gas meters, as the IoT platforms and services that they are able to offer are a strong fit for industry needs. NB-IoT is a good choice for Chinese gas suppliers, and able to meet the 2020 objectives through scalability, security and functionality.

### NOTE

This China Telecom and Shenzhen Gas Smart Gas Metering Case Study is based on the “NB-IoT Smart Gas Solution white paper” that was published in September 2017 as a joint effort from Shenzhen Gas, China Telecom, Goldcard and Huawei. The white paper can be accessed at <http://www.huawei.com/en/news/2017/9/NB-IoT-Smart-Gas-Solution-WhitePaper>

# CASE STUDY 3

## CHINA TELECOM AND OFO SHARED BICYCLE

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### INTRODUCTION

Ofo bikes was founded in China in 2014 and currently operates over 10 million dockless hire bikes in over 180 cities around the world. In China, Ofo operates in all major cities including Beijing, Shanghai and Guangzhou. They have partners with China Telecom to improve their operations and make their hire bikes easier to use and lower the cost of managing them.

Ofo promotes the sharing economy, with their bicycles available to be hired at any time by any user who has installed the Ofo app. As such, Ofo needs to deploy network technologies which are simple to implement, offer a good quality of service, and do not affect the users experience of hiring or using Ofo bikes.

Ofo has to date been using a GPRS modem in their bikes to allow for the bicycles' locks to be opened when a user requests to use them via the app. This has created a few issues for Ofo, such as having to adapt their bikes to recharge the modem's battery whilst the user cycles, forcing users to have to wait up to 25 seconds for the lock to open, and lack of coverage leading to failure to open the locks, all of which adds cost and complexity to their operation.

### NB-IoT DOCKLESS BICYCLE DEPLOYMENT

Ofo has signed an agreement with China Telecom and Huawei to implement NB-IoT in their dockless hire bikes to solve some of the issues that they have been experiencing and improve the user experience. China Telecom is providing the NB-IoT network and Huawei are providing the NB-IoT chips and platform.

The aim of this agreement is to demonstrate that NB-IoT is a beneficial technology for Ofo bikes. This is demonstrated by showing that NB-IoT makes it easier for users to find a hire

bike through the Ofo app, the time taken to unlock the bike and lock it again at the end of the hire period is significantly reduced, coverage is improved so that no failure of bicycle unlocking occurs, and finally it proves that Ofo is able to bill the customer accurately with the usage information that they receive from the NB-IoT connection in the bicycle.

## BENEFITS TO OFO

NB-IoT has delivered some significant benefits to Ofo bicycles compared to their existing 2G communications solution.

**Battery life** – NB-IoT is designed for power optimisation, meaning that it can operate from battery power and maximise battery life span for up to 10 years. The current 2G solution has to be charged by a charging unit built into each bicycle and operated as the user pushes the pedals around. This adds cost to each bicycle that Ofo produces.

**Coverage** – NB-IoT is based on LTE, but is designed to offer improved coverage of up to -20dB over existing LTE networks. This means that bikes which currently do not receive coverage are likely to be able to connect to the network with NB-IoT, even if the bicycles

are located indoors or in underground parking garages.

**Scalability** – NB-IoT is based on LTE, and is designed purely for IoT connectivity. It is therefore well suited to Ofo's requirements as it can scale to connect millions of bicycles in a city, and offer enough bandwidth to successfully operate each bicycle individually. Users of the Ofo app should see no degradation of service no matter how many users or bikes Ofo deployed in a city.

## OUTCOMES

The initial deployment of NB-IoT connected Ofo bikes has been a success, and has significantly improved the experience for Ofo and their users.

The NB-IoT connection significantly shortens the time delay for opening and securing the smart lock on the bicycle. Compared to the GPRS lock, NB-IoT has improved the time delay from the previous 25 seconds to 5 seconds or less. This means that Ofo users can more quickly get onto their bikes and head off to their destinations.

The new NB-IoT modem batteries have shown that they do not need regular recharges or replacements. The new system has shown battery life of more than 2 years without any recharging needed, reducing both the cost of operation and maintenance of the bicycles.

Improved coverage available from the China Telecom NB-IoT network means that the Ofo bikes are able to connect and run smoothly in all areas of the city, and Ofo can actually now deploy their bikes into areas that they previously would have been unable to offer a service in.

## CONCLUSION

This NB-IoT deployment for Ofo from China Telecom and Huawei has shown that there are significant benefits for Ofo. They are able to both improve the customer experience and reduce their operational and maintenance costs. NB-IoT is a clear contender to connect the many millions of dockless hire bikes that Ofo is deploying around the world. Its global footprint means that Ofo can build a single version of their bicycle which will be able to connect to a local NB-IoT network anywhere that they want to operate.

NB-IoT gives Ofo the opportunity to focus on improving their service and offering new, innovate services to their users that are powered by NB-IoT.



# CASE STUDY 4

## CHUNGHWA TELECOM SMART PARKING

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### INTRODUCTION

Parking in Taipei is at a premium, with strict parking controls that are enforced by the city with heavy fines for illegal parking. In this environment, it is common for residents to rent out their personal parking spaces to commuters and visitors through apps from a number of different providers. To ensure that only authorised vehicles park in these spaces, Chunghwa Telecom has developed an NB-IoT powered smart lock that can be used to prevent unauthorised parking. The lock is bolted to the floor and can be raised or lowered remotely.

Chunghwa Telecom is aiming to create a new market with the smart lock, as limited parking resources across Taipei can be utilised more effectively to meet growing demands for parking with the use of this technology.

### NB-IoT DEPLOYMENT

Chunghwa Telecom is working in partnership with USPACE, a shared parking space provider, to supply the smart locks. Lock users can rent out their parking space, and allow immediate access to the space via the app. Drivers wishing to park can see the location and availability of all parking spaces using the system, and when a space is selected and paid for, the lock is lowered via its NB-IoT connection. USPACE provides the lock and app to its customers, and Chunghwa Telecom provides the NB-IoT network to connect the locks. Bluetooth Low Energy is also installed in the locks to enable short range communications.

In addition to the NB-IoT network, Chunghwa Telecom provides the IoT management platform for the service and big data analysis to further improve the service.



## BENEFITS TO USPACE

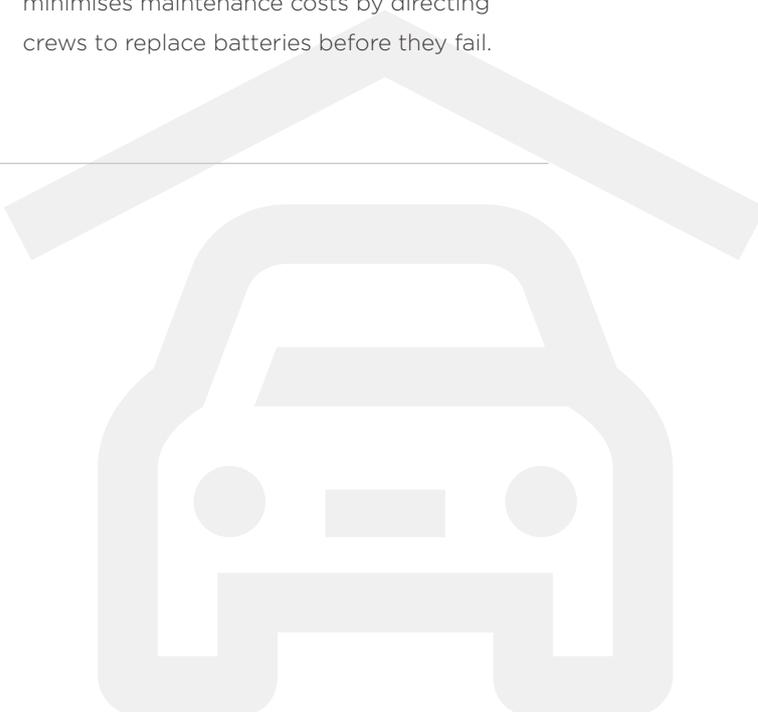
NB-IoT has delivered some significant benefits to USPACE and their customers in launching this new service.

**Simplicity** - The NB-IoT connected smart lock is simple to use and does not require training by either the parking space owner or user to understand. All actions are intuitive and quick to respond. NB-IoT offers a low latency for message delivery, meaning that the smart locks can be raised and lowered as needed - if a driver arrives at a space that they have reserved and paid for, the lock can be quickly lowered to prevent congestion and frustration.

**Cost reduction** - As the smart parking locks are distributed across a wide area, NB-IoT offers considerable cost reductions over other communications mechanisms. NB-IoT uses the existing mobile network and allows for fully centralised device management across distributed parking areas, meaning that the process of managing the locks is simple and low cost. The status of each lock can be monitored and controlled remotely, which removes the need for manual maintenance and control.

**Data analysis** - Advanced data analysis can be conducted using both real-time data from the NB-IoT network and historic data to spot trends in behaviour. NB-IoT allows an overview of the status of all locks connected to the network. User behaviour such as location of spaces and time they are available can provide additional insight such as when spaces are likely to be available, and where the most popular locations are in order to adjust parking rates.

**Enhanced battery life** - NB-IoT is designed to be power efficient, and can run from battery power for up to 10 years, dependent on usage profile. The smart parking service is able to collect battery status from each lock to monitor power consumption and create an alert when a battery needs to be replaced to ensure a continuous service, which additionally minimises maintenance costs by directing crews to replace batteries before they fail.



## OUTCOMES & LESSONS LEARNED

NB-IoT has proven that it is well suited connecting the USPACE smart locks across a wide area of Taipei, in a range of locations such as parking garages and off-street parking bays.

All smart locks deployed across the city have been able to successfully connect with the NB-IoT network, and communicate in real-time the status of the smart locks to the control centre. The data that has been successfully transmitted via NB-IoT includes lock open; lock closed; availability status; battery level; time and date; anomaly alert.

The smart locks can be controlled directly from the USPACE app, meaning that operation of the locks by the user is as straightforward as possible, with NB-IoT enabling a simple

process that allows the parking space owner or driver to lock and unlock spaces that they have previously reserved and paid for.

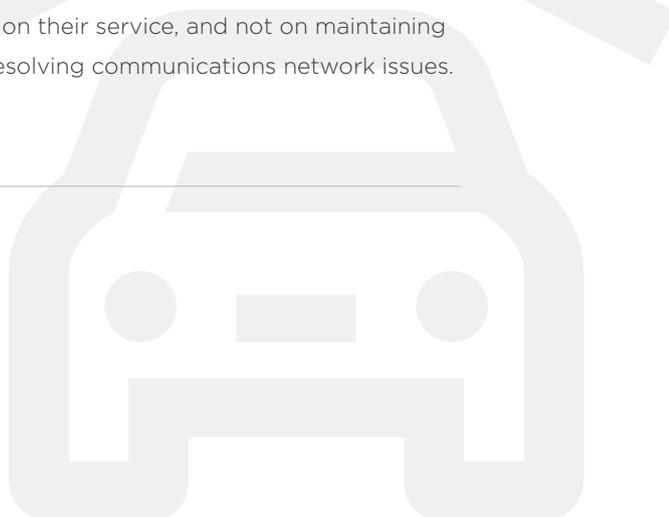
NB-IoT is designed to support a battery life of up to 10 years, depending on usage profile. The battery performance of the smart locks has resulted in reduced maintenance costs and better visibility of any issues with the smart locks that may require maintenance.

The smart lock has been proven in live operation by Chunghwa Telecom and USPACE, and now forms a part of their ongoing strategy, with the lock for sale to the public. The aim is to extend the parking service across the city and free up as many off-street parking spaces as possible through their monetisation.

## CONCLUSION

The Chunghwa Telecom and USPACE smart parking service is an advanced demonstration of the suitability of NB-IoT for smart city solutions. USPACE can offer a unique proposition into the Taiwanese market that has been enabled by NB-IoT, and the devices that have been deployed offer a long lifespan, minimal maintenance, and a high quality of service. NB-IoT coverage in place today

across Taipei means that Chunghwa Telecom and USPACE are able to expand their smart parking service quickly and open up many new parking spaces to commuters and visitors to the city. The reliability and high quality of NB-IoT communications allows partners to focus on their service, and not on maintaining and resolving communications network issues.



# CASE STUDY 5

## CHINA MOBILE SMART PARKING

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### INTRODUCTION

Smart Parking, powered by NB-IoT technology, is making it easier for drivers to find free parking spots. Cities can better manage their parking assets and maximise the revenue available to them as a result. Drivers searching for parking create congestion and pollution by circling and hunting for available parking. Smart Parking services are able to significantly ease these problems by guiding a driver directly to a parking space.

China Mobile, together with their partner DTMobile have initiated 2 separate smart parking pilots using NB-IoT connectivity, one in Yunnan and another in Southeast Guizhou. Based on LTE networks, NB-IoT is a good fit for smart parking as it has support for a long battery life and offers improved coverage which allows sensors to be placed in any location. NB-IoT use of licensed spectrum also ensures a high quality of service. The China Mobile smart parking solution consists of a number of smart parking modules such as parking bay detection, license plate recognition, mobile payments, parking guidance for drivers and an intelligent parking management system for the city.

### NB-IoT SMART PARKING DEPLOYMENT

China Mobile have implemented two separate NB-IoT Smart Parking systems. The first has involved installation of smart parking sensors across some of the 4000 spaces identified as part of the Yunnan Intelligent Parking project. The second, in Southeast Guizhou, involves a total of 6 sets of entrance and exit systems around the highlighted parking lot, combined with a parking management system connecting more than 300 parking bays.

These two implementations are designed to showcase the capabilities of NB-IoT for Smart Parking, and China Mobile's Intelligent Parking services. The parking system utilises sensors installed in each parking bay, which are able to detect when the space is occupied, and send the status via the NB-IoT network. Parking attendants and parking management are able to use a tablet device to monitor space occupancy. Using the sensors and NB-IoT network means that charging can commence

as soon as a space is occupied to ensure that accurate billing takes place. The system's operational status, the occupancy status of the parking bays, recorded charging details and other information are uploaded to the parking management platform, and data can then be sent down to outdoor information guidance screens in real time to inform car owners of remaining parking bays in each area.

China Mobile have invested heavily in their NB-IoT network, with their partner DTmobile who provide the NB-IoT network equipment. This means that coverage is extensive, allowing the sensors installed in the parking bays to be reliably connected to the network to ensure the service is available.

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## BENEFITS TO THE CITY

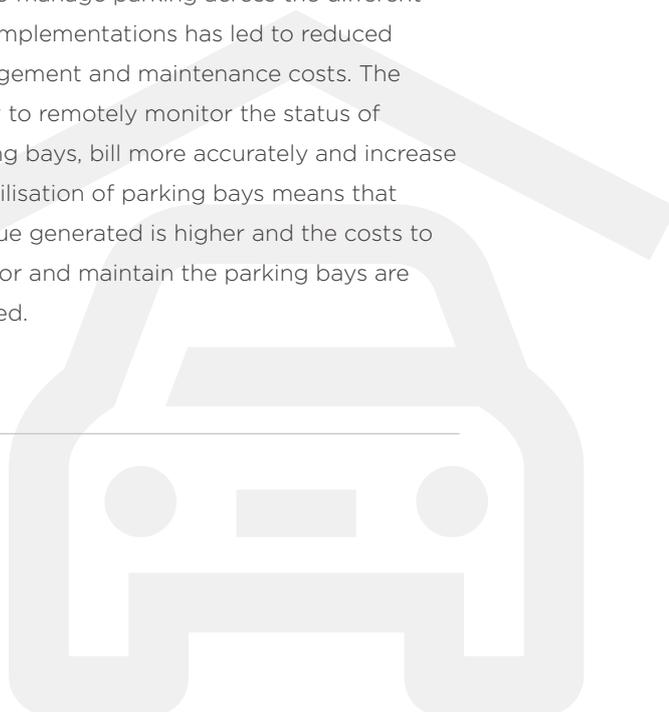
NB-IoT has delivered some significant benefits to the cities that are piloting the NB-IoT smart parking service from China Mobile.

**Coverage** – Improved coverage offered by NB-IoT over existing mobile networks means that China Mobile have been able to connect smart parking sensors in locations where coverage would of previously been harder to discover. Parking sensors are embedded into pavement of the parking bay, which is normally under a vehicle and often within a large parking garage. These are challenging conditions to obtain coverage, but NB-IoT has proven that it is able to connect sensors even in these challenging conditions.

**Low power consumption** – NB-IoT is designed to use small amounts of power and to be battery powered in many scenarios. This is an important attribute for smart parking sensors, as it is unlikely that they will access to mains

power and so must be battery powered. NB-IoT modules are designed to offer a battery life of many years, meaning that the sensors can be installed without regard to location of power supplies and will need very little maintenance in the years ahead.

**Low cost** – NB-IoT has created a simpler way to manage parking across the different pilot implementations has led to reduced management and maintenance costs. The ability to remotely monitor the status of parking bays, bill more accurately and increase the utilisation of parking bays means that revenue generated is higher and the costs to monitor and maintain the parking bays are lowered.



## OUTCOMES & LESSONS LEARNED

China Mobile's NB-IoT powered smart parking solution has proven to be a success, with many parking bays now connected to the China Mobile management system and local attendant's tablet devices.

The system has helped resolve some of the issues that the two cities had with their parking provision. Previously, parking spaces were harder to find, but now drivers can find available parking much more easily through reliable, up-to-date data on parking availability at the two locations managed by China Mobile. Parking disputes can be more easily managed as a reliable data source is available for the parking management team to investigate reported discrepancies. Congestion and pollution has been reduced by creating a more efficient parking service.

Additionally, by integrating mobile payments with the system, the amount of time it takes drivers to enter and exit car parks has been much reduced by removing the need for them to queue to pay. This in turn frees up spaces faster, resulting in higher utilisation of the parking bays.

NB-IoT offers a number of benefits to enable a smart parking solution – improved coverage, real-time communications and low power consumption – are all beneficial to ensuring that a smart parking service is easy to install, simple to maintain, and able to transmit the data required to enable fast turnaround of parking spaces. Additionally, NB-IoT is based on LTE networks, and uses the same licenced spectrum. This means the network is secure, a wide variety of ecosystem partners are active, and a high quality of service can be achieved.

The pilots deployed in the two locations have shown China Mobile that NB-IoT is a clear contender to connect large numbers of parking sensors in the future. The use of a standardised technology means that China Mobile are able to work with a range of partners from local industries in order to bring new products and services to the market.

## CONCLUSION

NB-IoT has proven that it offers significant benefits to China Mobile in their rollout of their Intelligent Parking service across China. It is more energy efficient, offers better coverage and makes the service more straightforward to install and manage. In the future, NB-IoT will become much more widespread by powering

all sorts of services and sensors throughout the city. As such, China Mobile will be able to rollout large scale volumes of connections throughout the city, offering a better customer experience and enabling a new range of services for the intelligent city.



# CASE STUDY 6

## CHINA MOBILE SMART LIGHTING

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### INTRODUCTION

LED street-lighting is transforming the urban environment and making maintenance and control of streetlight more straightforward. In the past, sodium lamps have been expensive to install and maintain, requiring manual inspection and manual controls. Across China, these traditional lighting methods are being replaced by intelligent LED lighting. LED lighting is easier to control and cheaper to operate, and by connecting the lamps to a control centre, dynamic control can be achieved, removing the need for manual inspections and interventions.

China Mobile has a 2G/GPRS powered smart street lighting service already available. This has been deployed in a number of cities including the city of Longnan, the city of Bahzou and the Wudang district of the city of Guizhou. China Mobile solution can integrate various kinds of sensor into the connected street lamp, including environmental, traffic and security monitoring, making full use of the connectivity nodes.

### NB-IoT STREET LIGHTING DEPLOYMENT

China Mobile has begun to research and deploy NB-IoT variants of their connected street light service to monitor the performance compared to GPRS and understand how network coverage, power consumption and network performance is compared to the existing 2G solution.

280 NB-IoT controlled intelligent streetlamps have been installed by China Mobile in a pre-commercial trial to monitor their performance. 50 streetlamps have been deployed in the Yongchuan district of Chongqing City, 120 in Xijiang Province, and 100 in Xiong

China Mobile has signed a cooperation agreement with the Yangzhou Gaoyou government to partner with the local streetlamp manufacturing alliance situated in the Yangzhou hi-tech zone in order to develop the connected streetlights and NB-IoT module.

The China Mobile system can connect either lamps individual or via a controller for loop control over several light poles. This connects each lamp to the cloud management platform, where all actions can be completed remotely. In the complex environment of the city, the NB-IoT network coverage is very good, meaning communications reliability will be high.

## BENEFITS TO THE CITY

NB-IoT has delivered some significant benefits to the cities that are piloting the NB-IoT street lighting service from China Mobile.

**Cost reduction** – A quicker, simpler way to manage the streetlights across the different pilot implementations has led to reduced management and maintenance costs. The ability to remotely monitor the status of streetlights, change the lighting up time or lighting intensity means that energy bills are lower and the cost of manual inspections is much reduced.

**Sensor & Data integration** – The integration of sensors into the light pole to monitor environmental conditions or traffic is simple to achieve, as they are able to share the same connection and relay data to the same management platform. This means all the

sensor and lighting data can be seen in the same place. In addition, via API access, this data is accessible to China Mobile customers, so that they can integrate the data into their own platforms and provide their own unique services and analysis on their local environment.

**Energy saving** – One of the core benefits of LED bulbs is low energy consumption. NB-IoT is also optimised for energy consumption, and together that make a good fit. By building a connected streetlight that has minimal energy needs, the costs of running lights across a city can be significantly reduced.

## OUTCOMES & LESSONS LEARNED

The initial deployment of NB-IoT powered streetlights has been a success, with all streetlights connected successfully to the NB-IoT network in the cities in where they were deployed.

The NB-IoT coverage needed to connect the streetlights is equivalent or better to the existing 2G service provided by China Mobile, and all light poles are able to be connected. NB-IoT is designed to offer improved coverage over existing networks, and so is able to cover larger areas of the city, including indoor locations.

Response times to incidents and issues have been greatly improved. In one instance, when lighting from a whole area was lost due to power supply issue, the lighting service was able to be restored far more quickly than in the past, when each light would have had to be visited and restored manually.

In addition to real-time lighting control, multiple sensors can also be supported on light poles through the NB-IoT connection, with the available bandwidth proving suitable for transmitting all data and commands to and from the various sensors that have been installed. This means that the city is in a

position to expand their intelligent city services and begin getting a fuller picture of the status of various locations as needed.

The pilots deployed in various locations have taught China Mobile that NB-IoT is a clear contender to connect large numbers of streetlights and sensors in the future. The use of a standardised technology means that China Mobile is able to work with a range of partners from local industries in order to bring new products and services to the market.

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## CONCLUSION

NB-IoT has proven to be a very capable upgrade to the existing 2G connectivity provided by China Mobile for their street lighting service. It is more energy efficient, offers better coverage and is straightforward to install and manage. In the future, NB-IoT will become much more widespread for powering

streetlights and other sensors throughout the city. China Mobile will be able to rollout large scale volumes of connections throughout the city, offering a better customer experience and enabling a new range of services for the intelligent city.



# CASE STUDY 7

## CHINA TELECOM AND SHENZHEN WATER GROUP WATER MANAGEMENT

### INTRODUCTION

Water supply in the city of Shenzhen has always been problematic, with many issues affecting the quality of water supply available to the residents and businesses of Shenzhen. Many issues have significantly affected the ability of the Shenzhen water company to provide a good quality of service. Issues such as water leakage caused by the poor management of water infrastructure and disputes caused by inaccuracy of water meters directly affect the satisfaction of consumers with Shenzhen Water Group. Additionally, the cost of water in Shenzhen is increased by the cost of serving the existing water meter fleet with manual labour, and also additional water charges added to water supplies in multi-dwelling blocks by the building owner.

China Telecom has partnered with the Shenzhen Water Group, Huawei and Ningbo Water Meter Company to jointly promote a new IoT water management platform, based around the deployment of NB-IoT powered water meters across Shenzhen.

### NB-IoT DEPLOYMENT

China Telecom is leading the deployment of this NB-IoT trial, having signed a collaboration agreement with the other partners. China Telecom is responsible for the NB-IoT network planning and deployment, as well as the use of their IoT platform. Shenzhen water has built the requirements for the pilot, as well as identified an appropriate location for the deployment. Huawei is providing the NB-IoT chipsets and network equipment, and Ningbo water meter is responsible for the development and manufacture of the NB-IoT equipped water meters.

The aim of the NB-IoT trial is to demonstrate that NB-IoT is a good solution for smart water meters. As part of the trial, the wide coverage areas and low power attributes of NB-IoT have been tested. China Telecom's NB-IoT network is designed to offer strong signal penetration, so that water meters, even when installed underground or in basements, are still able to connect to the NB-IoT network.

## BENEFITS TO SHENZHEN WATER

NB-IoT will deliver some significant benefits to Shenzhen Water Group, including:

**Reliability of transmission** – as NB-IoT is based upon 4G LTE networks, it shares high quality attributes associated with the technology. This means that messages can be sent and received reliably and regularly, that the network is stable, and that it is standardised globally. All of this gives Shenzhen Water group the confidence to rollout NB-IoT water meters without the need for additional backups and infrastructure needed for outage scenarios.

**Signal penetration** – NB-IoT is designed for improved coverage over existing networks, with up to a 20dB gain. This means that water meters in hard to reach locations such as indoors or underground are much more likely to be able to connect to the NB-IoT network

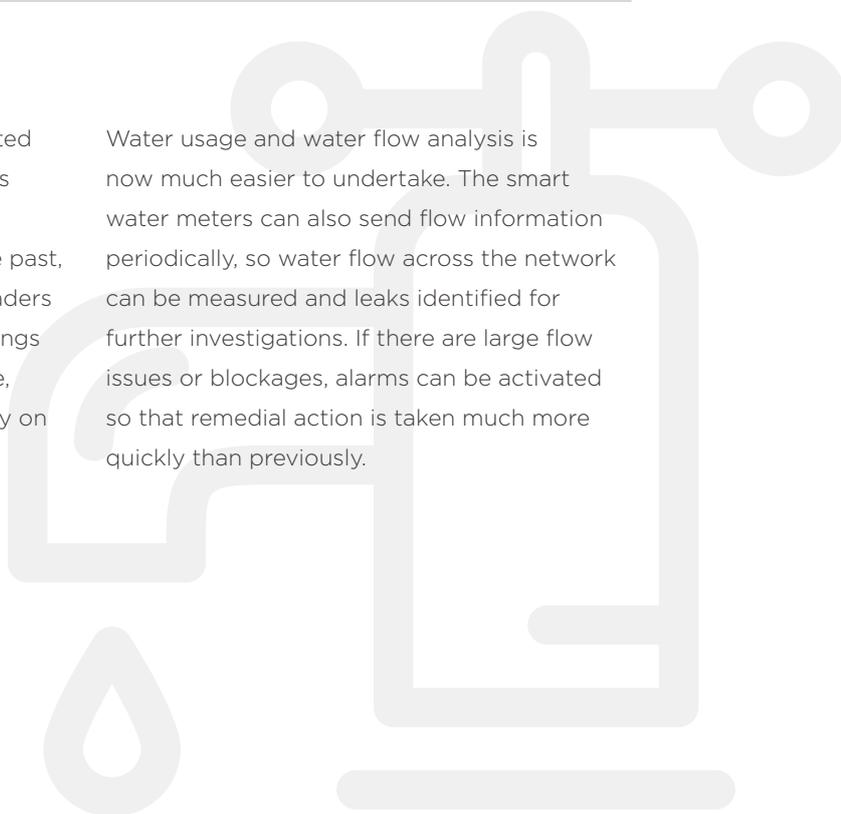
than other networks. Planning for water meter installation is thus more straightforward as network coverage is better, and meters can be located in convenient locations for the water company, rather than having to comprise to gain network coverage.

**Open data formats** – as NB-IoT offers enough bandwidth to support many data formats and protocols, the Shenzhen Water Group can use open data formats to ensure that data integration with the Chain Telecom platform is as seamless as possible. Using agreed data formats also means that other data sources can be combined to create big data analysis, so water consumption can be compared to weather conditions for example.

## OUTCOMES

The initial deployment of NB-IoT connected water meters has been a success, and has significantly improved the experience for Shenzhen Water Group customers. In the past, customers would have to allow meter readers into their properties, but now these readings can all be taken remotely and in real-time, without the water company having to rely on its customers granting them access.

Water usage and water flow analysis is now much easier to undertake. The smart water meters can also send flow information periodically, so water flow across the network can be measured and leaks identified for further investigations. If there are large flow issues or blockages, alarms can be activated so that remedial action is taken much more quickly than previously.



## CONCLUSION

The NB-IoT smart water meter deployment from Chain Telecom in partnership with Shenzhen Water Group, Huawei and Ningbo water Meter Company has been a success. The trial has demonstrated that NB-IoT connected water meters offer a resilient, good quality and low cost method for providing connected water meters and other infrastructure across the city of Shenzhen. As the NB-IoT connected water meters roll out further across the city, the benefits to Shenzhen Water Group will multiply as better visibility is gained into water consumption and water flow across a wider area. This in turn will simplify the maintenance processes that the group has in place, making them more efficient and cost effective.

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# CASE STUDY 8

## CHINA TELECOM CONNECTED COW

TECHNOLOGY MAKES PRECISE COW OESTRUS PREDICTION POSSIBLE

### INTRODUCTION

In China, most dairy farms rely on manual observation to find oestrus, which is time and labour consuming (often at midnight) with high rate of omission. Such practice makes it difficult to raise **reproduction** rate and milk **output**. Therefore, oestrus detection is a key link with direct influence on the profits of dairy farms.

For instance, the milk output of one cow is 11.8 tons each year in Israel, while it is only 2.5 tons in China, much lower than that of developed nations. The low detection rate of oestrus is a critical reason. Internet of cows (IoC) is just a right solution for this problem.

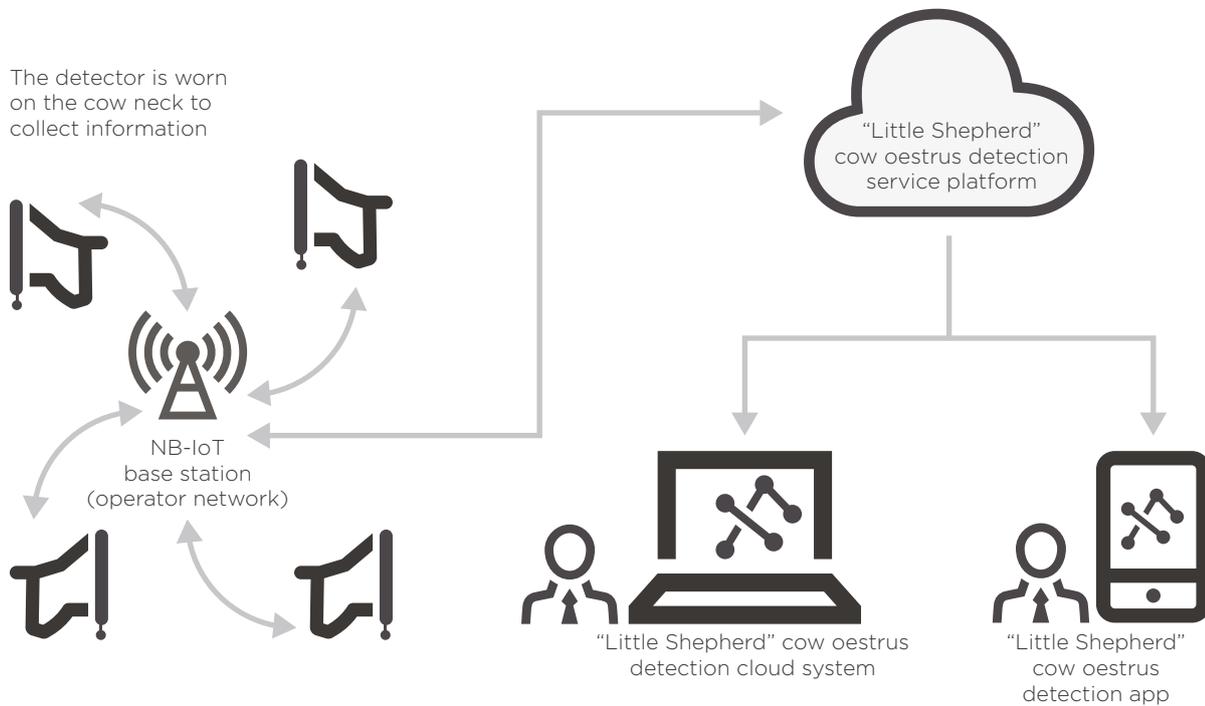
Internet of cows is a big innovation of China Telecom. China Telecom and Huawei have conducted cooperation in a dairy farm with over 50,000 cows in Yinchuan city. In addition to the revenue from milk, calves are also an important source of income. If the mating time is right in, more than 3000 calves can be born each year. The sensor on the neck of each cow can measure its body temperature to ensure its safety while detecting oestrus for timely mating.

### NB-IoT DEVICES DEPLOYMENT

Developed by China Telecom and Aotoso Information Technology, the “Little Shepherd” cow oestrus detection cloud system adopts NB-IoT communication and can bring millions of RMB for China Telecom each year. After the pilot run in Inner Mongolia Youran Farming,

Ningxia Helan Mountain Dairy, Heilongjiang Modern Farming Group, and Xinjiang Shihezi Xinyuan Farming in July, China Telecom and Ningxia Shangling Group have completed the first commercial order in August, 2017.





Architecture of “Little Shepherd” cow oestrus detection cloud system

## BENEFITS TO FARMS

The following results have been achieved after launching this NB-IoT solution:

**High detection rate** – the detection rate of the “Little Shepherd” system can reach up to 95%, which can effectively increase pregnancy rate, shorten pregnancy intervals, reduce cost, and increase milk output.

**Realization of comprehensive connection, wide coverage, and low energy consumption**

– with NB-IoT network communication, the “Little Shepherd” system can realize comprehensive connection with terminals up to 100,000 for a single system. In addition

to wide coverage, the batteries can last for more than 6 years. seen in the same place. In addition, via API access, this data is accessible to China Mobile customers, so that they can integrate the data into their own platforms and provide their own unique services and analysis on their local environment.

**Stable performance** – the NB-IoT technology supports 24h data storage, and can work at environmental temperatures of -30°C-45°C with IP65 protection grade.

## OUTCOMES & LESSONS LEARNED

Besides cows, the system can also be applied in beef farms, dairy enterprises, and livestock raising associations. According to China Telecom, the price of each set is 290 RMB, which is one third of the average market price and well received.

The data generated by the “Little Shepherd” also has reference value for food tracing and cold-chain transportation. China Telecom intends to obtain profits in terms of service fees based on the data value.

In terms of the business mode, “Cloud Cattle” has formed its own way of profits:

- Sell cattle raising data to banks.
- Collect service fees from B2B beef transactions and private beef transactions.
- At last, the APP has extended to the field of beef food processing, gaining revenue from sales of beef food.

To certain extent, what “Cloud Cattle” achieved, has outpaced China Telecom’s profit prospect in data from food tracing and cold chain transportation.

## CONCLUSION

China Telecom can gain millions of RMB by selling such connection and equipment through NB-IoT. The solution can additionally generate sales of sensors and bring about 2.5 million RMB in profits. The results also show that such IT and ICT solution can be applied in various industries. It is a huge potential market that, China Telecom has started from 50,000

cows, and now it has 1.2 million by the end of 2017. There are 150 million cows worldwide, it will be a huge market for the industry.

Oestrus prediction based on IoC is just a small step – “Our imagination is the only limitation for IoT”.



# CASE STUDY 9

## ZTE SHANGHAI WORLD EXPO SMART CITY PROJECT

### INTRODUCTION

The Shanghai World Expo Smart City project is planned in experimental free-trade zone located in Shanghai, China. It covers a total area of 9.93 square kilometres, and includes the Pudong, Yaohua and Qiantan areas, that addresses a population size in the order of ten million citizens.

The Shanghai World Expo Smart City project serves millions of citizens and tourists annually, letting them enjoy a smart life and work experience. As it grows, the project will provide an increasingly large number of public services to more and more Shanghai residents. This project is collaborating among China Telecom Shanghai, the Shanghai Government (Shanghai Pudong New Area Science and Technology and Economy Committee),<sup>1</sup> and ZTE. China Telecom Shanghai is the local operator, the Shanghai Government facilitates the usage of the area and helps promote the project towards enterprises and companies, and ZTE is the solution provider that provides the Internet of Things (IoT) platform and additional telecom equipment to enable the IoT applications and services in the project.

On the open IoT platform, ZTE newly introduces the emerging cloud computing technologies with Big Data analytic and Artificial Intelligence functionalities. The IoT platform enables quick and transparent connectivity of a broad range of terminals

using different protocols and technologies, such as NB-IoT, eMTC, 3G / 4G / 5G, and PON. The open interfaces allows the development and deployment of a broad suite of interoperable Smart City applications and solutions, with speed and agility.



<sup>1</sup> Reference : <http://www.kankanews.com/a/2017-07-07/0018062490.shtml>

## MOBILE IoT DEPLOYMENT

The NB-IoT mobile network technology has been deployed for different types of sensor and terminal connectivity. In addition, the core component of this project is the technology developed in the open IoT Platform.

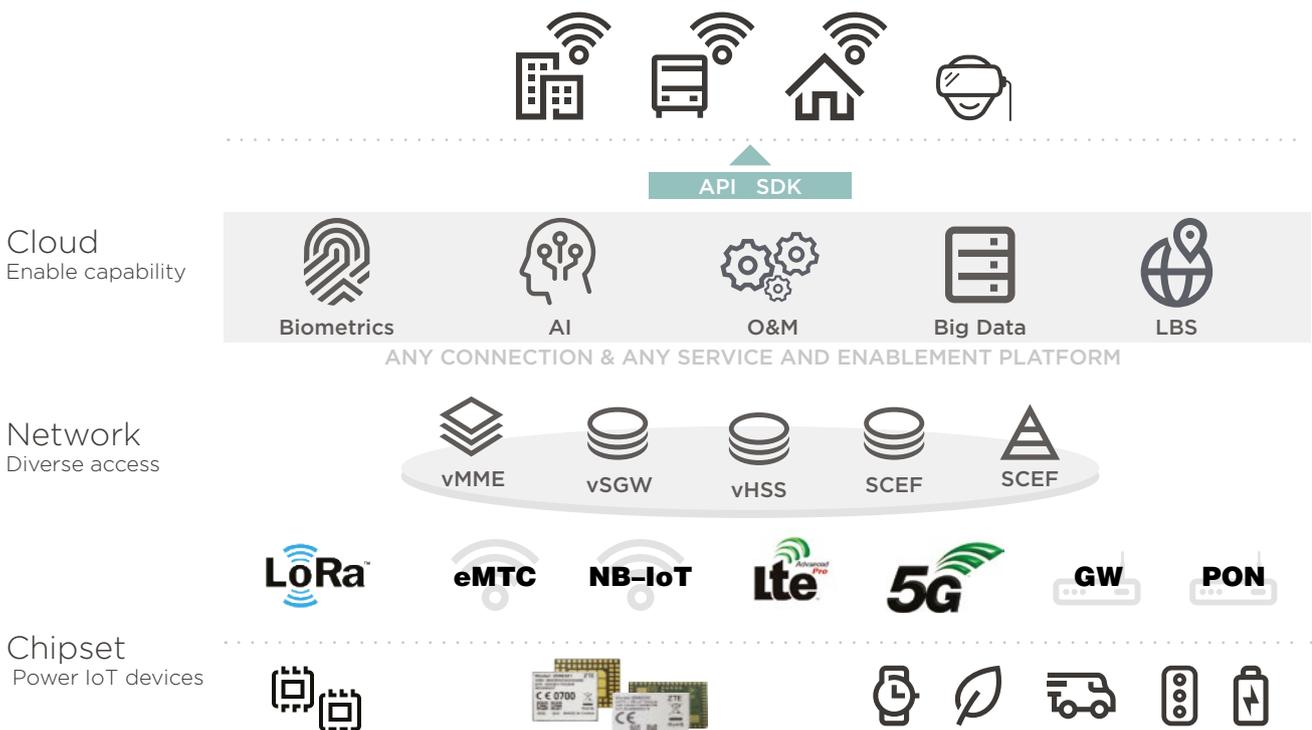
The IoT Platform provides an ICT (Information and Communications Technology) PaaS (Platform as a Service) functionality based on NFV (Network Function Virtualization). By providing unified IoT service components and APIs, it unifies different protocols and data formats. This enables a broad range of options for development partners effectively delivering standard and open information to all Smart City applications and citizens.

The IoT Platform is cloud-based architecture and hierarchical structure with independent access and service layers, which avoids coupling. This ensures further function evolution only impacting the corresponding

layer, and does not affect the implementation of other layers. Additionally, modules in the same layer also use loosely coupled interfaces. This ensures independence between modules, limiting the effects of system modifications and expansion.

The technical architecture of this IoT solution includes three layers – chipset, network and cloud platform as shown in the diagram below. In the cloud layer, it provides the network functionalities of biometrics, AI, big data analytic, location based service and O&M through open API and SDK for developers in application layer.

IoT Architecture Overview



## BENEFITS TO SHANGHAI WORLD EXPO SMART CITY PROJECT

NB-IoT and open platform have delivered some significant benefits to Shanghai World Expo smart city project, including:

**Wide coverage** – the NB-IoT technology provides 3GPP standardized low-power wireless connectivity with good coverage in underground and remote areas. This allows, for instance, cost-effective implementation of Smart Metering and Smart Parking in underground garages. This is crucial for the popularization and commercialization of emerging IoT applications.

**Real-time data** – With the advantage of NB-IoT technology, Shanghai government and other application users can obtain 7×24 data of parking positions, air quality, and street light status for the entire Expo area. This presents a continuous, clear and accurate view of the city's operational status. Additionally, this power-optimized technology makes the

lifespan of the smart IoT terminals as long as 8 to 10 years, which reduces manual intervention significantly.

**Rapid new application development** – with open platform and interface, the developers can easily build and develop new services and applications. In addition, the service and enablement functionalities and cloud layer, including AI, Big Data Analytic, Biometrics and Location-based Service, it provides core value-added functions and network transparent capability for the developers. It is greatly reducing the development effort and lead-time for new services and applications for the city. The application developers can focus in their domain expertise areas.

## OUTCOMES & LESSONS LEARNED

This project has met its first phase deployment objectives, for example, three IoT applications have been commercialized in this phase, including Smart Street Lighting, Smart Manhole Covers and Smart Air Quality Monitoring. Collected data allows visualization of the manhole covers' position, working status of the street lighting, PM 2.5 and CO2 density, and others.

One of the key successful factor of this project is the broad collaboration with government, telecom operator, and solution provider and application users in early stages. It is important to have early user engagement and requirements in the top-level design. Inputs from various enterprises and industry

stakeholders allow early definition and clarification of specific requirements before the first phase of the project starts, as well as designed for faster evolution to future phases. A good example of an early stakeholder would be a large enterprise needing Smart Building applications in their office buildings for better control, automation, safety and security.

In upcoming phase two, more IoT applications will be introduced, such as Smart Trash Cans, Smart Water Metering and Smart Water Quality Monitoring. Because of this project delivering a broad suite of high-end technologies and a friendly business environment, it will attract additional large and reputable companies joining in the future.

## CONCLUSION

The Shanghai World Expo Smart City project is an advanced showcase of the suitability of NB-IoT for smart city solutions, offering a long lifespan, minimal maintenance, and a high quality of service. NB-IoT coverage in expo area today is ready to expand from Smart Street Lighting, Smart Manhole Covers and Smart Air Quality Monitoring to other new applications for commuters and visitors to the city.

The ZTE IoT platform, based on an open architecture, effectively eliminates the problems of vertical applications, data silos, IoT service generation, and deployment difficulties. It helps improve the development efficiency and shorten the development cycles of Smart City applications. At the same

time, with its Big Data analytics and Artificial Intelligence capabilities, provides actionable and monetizable information, and help users on their decision-making. All these capabilities enable better and more comprehensive services to citizens and city stakeholders that enhance the speed of innovation of the industry.

Finally, the well-established collaboration among government, telecom operator, solution provider and application users in early stages of the project achieves successful deployment of smart city use cases from top-level user requirements, system design to effective and future-proof IoT application development.



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