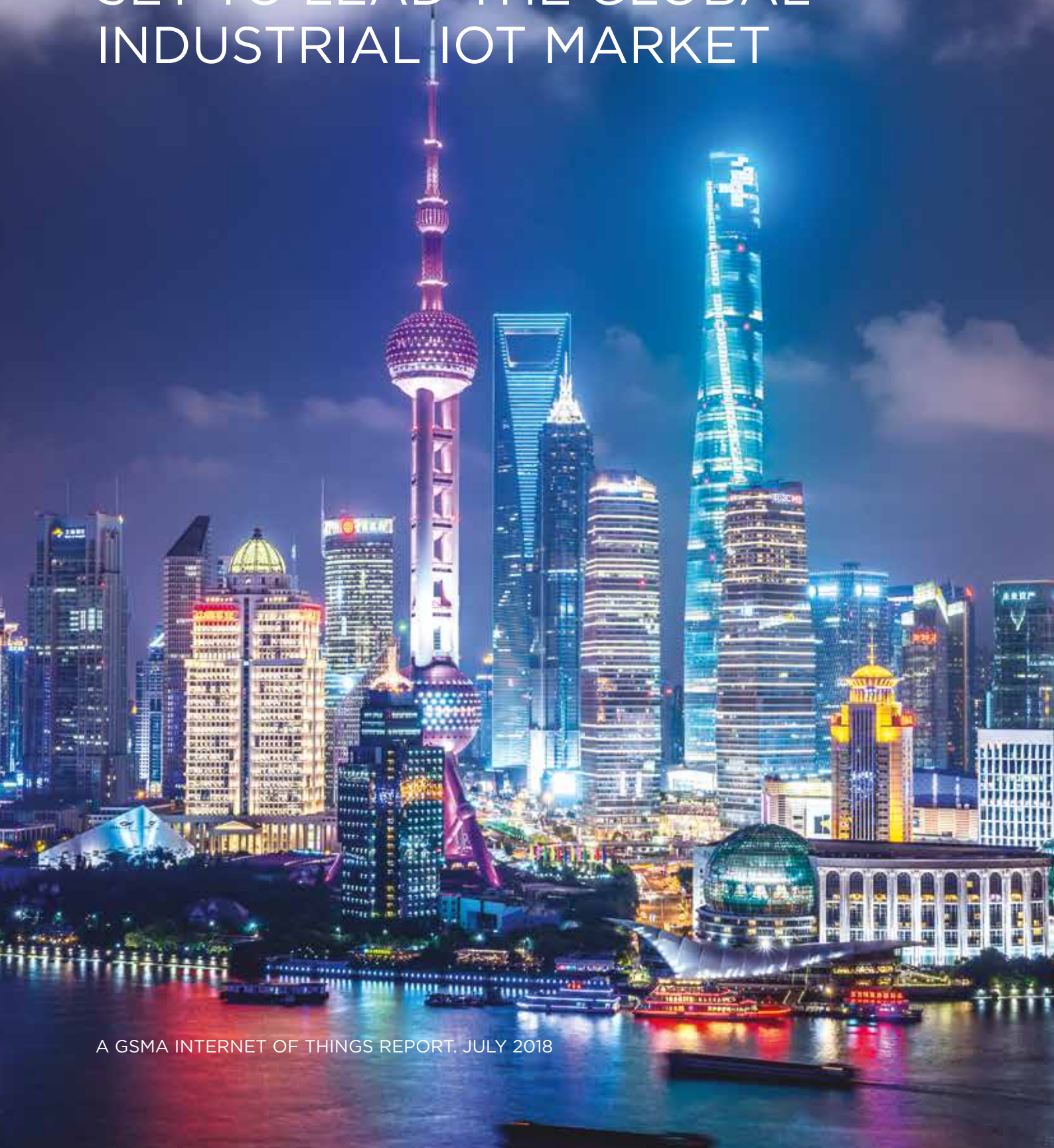




HOW GREATER CHINA IS SET TO LEAD THE GLOBAL INDUSTRIAL IOT MARKET



A GSMA INTERNET OF THINGS REPORT. JULY 2018



FOREWORD

The Fourth Industrial Revolution describes a dramatic step change in all of our lives. The confluence of high internet speeds, big data, the Internet of Things (IoT), analytics and artificial intelligence (AI) will fundamentally alter the way we live and work, intelligently connecting virtually every device, making our cities smarter and our lives easier and more productive.

Central to this will be the Industrial Internet of Things (IIoT), which will help to increase productivity by streamlining and automating manufacturing processes via internet connectivity. Overlaid with AI, cloud computing and advanced analytics, factories can monitor and interpret data from production lines and complex machinery in real time to anticipate faults, manage infrastructure and mitigate risk. The captured data will, in turn, drive efficiencies, optimise productivity and decrease costs in many important economic sectors beyond manufacturing such as resources, energy and telecoms.

Backed by positive and proactive government support, China is betting big on the IIoT and, as one of the world's largest economies, is poised to not only become the world's leader in deploying solutions but benefit from enormous economies of scale. As the producer, supplier and end user of many of the world's IoT-related sensors and devices, China is in the early stages of this latest industrial transformation. Intelligent production processes, collaborative manufacturing and cloud manufacturing platforms will enable interconnectivity and collaboration across the entire value chain. Location tracking will allow suppliers and manufacturers to monitor the location of critical materials throughout the manufacturing cycle, pinpointing and resolving issues before they occur. China, as elsewhere, is also making advances in the area of AI which, with machine learning, will help factories and businesses manage complex processes and drive innovation.

China's mobile operators will play a fundamental role in all of these developments by providing secure, reliable and intelligent connectivity to businesses and enterprises across the country. They are integral to the development of the IIoT and an invaluable and strategic partner for cities, governments and other organisations. The GSMA's Internet of Things Programme is working closely with all operators as well as other vendors in the ecosystem to support and help accelerate the delivery of compelling and secure IoT solutions including Low Power Wide Area networks, such as NB-IoT and LTE-M, which are helping to usher in innovative new services across the country.

Through intelligent connectivity, China is creating a better future for its citizens and businesses and providing an example for the rest of the world to follow.



Foreword by Mats Granryd
Director General,
GSMA

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INTRODUCTION

The Industrial Internet - the convergence of industrial systems with Internet-based technology, such as cloud computing and advanced analytics - is now developing apace. Large numbers of connected sensors can monitor the performance of complex physical machinery in real-time. The analysis of the resulting data can be used to optimize production and perform predictive maintenance, increasing efficiency and generating insights that can be used to develop new processes. This concept is known as the Industrial Internet of Things (IIoT).

The data captured by the Industrial IoT can also be used for machine learning to develop artificial intelligence (AI) systems - a field that is developing rapidly in China and elsewhere.

In time, AI systems should be able to help people manage complex industrial facilities effectively and efficiently, with the system learning and refining its algorithms over time.

This paper explores the development of the Industrial IoT in Greater China, drawing on interviews with six mobile operators in the region. It identifies the key trends in this sector, the benefits seen by exponents of the Industrial IoT and the challenges they face, before drawing conclusions about how digital technologies will drive the next industrial revolution in East Asia.

OVERVIEW OF THE INDUSTRIAL IOT

According to GSMA Intelligence, the global Internet of Things (IoT) market will be worth \$1.1 trillion in revenue by 2025 as market value shifts from connectivity to applications, platforms and services. Players from a range of backgrounds – including telecoms, IT, device manufacturing and systems integration – are all vying to capture a portion of this opportunity.

Business applications account for about half of the overall IoT market. By 2020, total global expenditure on IoT is set to top US\$3 trillion, according to research firm Gartner, with cross-industry business applications accounting for US\$570 billion and vertical industry applications US\$910 billion, respectively. That represents compound annual growth rates of 30% and 8% from 2016.

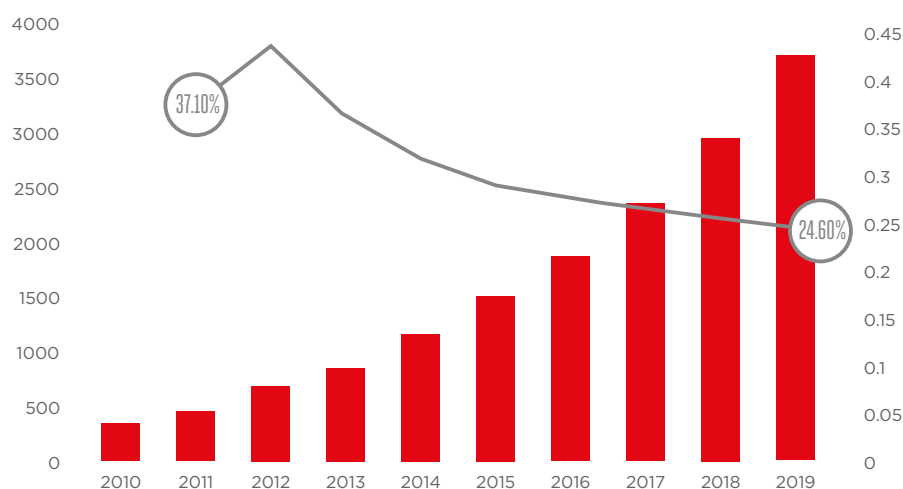
Greater China is both a huge market for the IoT and a major supplier of the component technologies. The workshop of the world, China is a leading producer of all kinds of goods, including much of the world's electronics. In fact, Greater China makes most of the sensors, microchips, and other components that are the fabric of the IoT. By 2020, there will be 200 billion IoT connected components and devices globally, of which 95 percent will be manufactured in China, according to Axa Insurance¹.

At the same time, China is also producing start-ups, such as landing.ai (founded by Baidu's former chief AI scientist Andrew Ng), K2Data, and RootCloud, that could play a key role in the development of the Industrial Internet. The city of Wuxi, a hot spot for the IoT industry in China, runs an annual 10 million yuan (US\$1.5 million) competition for IoT innovations – a form of crowdsourcing that can drive innovation.

Many of the IoT components and services developed in Greater China are deployed locally. Indeed, China's manufacturing sector is a major customer for IoT solutions. The Industrial IoT promises to enable China's millions of factories and production plants to greatly increase their efficiency, lower costs and better manage their infrastructure.

Research firm IDC forecasts that the overall market for IoT kit of various forms in China will rise from US\$193 billion in 2017 to US\$361 billion in 2020. Within that, the Industrial IoT market in China is growing by about 25% per annum and is set to reach almost 300 billion yuan (US\$47 billion) in 2018, according to China's Ministry of Industry and Information Technology (see chart).

The Overall scale and growth forecast of China's IIoT in year 2010 to 2019 (100 million RMB)



Source: China's Ministry of Industry and Information Technology

¹ <https://www.axa.com/en/spotlight/story/internet-of-things-made-in-china>

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Case Study 1: China Telecom Utilises NB-IoT to Accelerate Manufacturing Processes

Hebei Wuwei Avionics Technology, a manufacturer of alloy parts and components, had struggled with a long production order cycle and were unable to deliver customer orders on time amongst a number of other issues. In July 2017, they signed an agreement with Yantai Hengyuan Intelligent Technology and China Telecom to launch a digital management transformation project utilising NB-IoT Low Power Wide Area (LPWA) networks that focused on promoting digital manufacturing collaboration within the enterprise. The aim was to shorten product manufacturing cycles, accelerate manufacturing speeds and reduce costs.

The project allowed Wuwei to collect and analyse real-time data from across the business and drive collaboration in design, manufacturing and the supply chain. It also helped them coordinate information between different teams such as R&D, design, technology, production and procurement which improved the accuracy and speed of their production as well as monitor and evaluate data helping them to pinpoint issues and mitigate risk. Delivery times were cut from 5-6 months to approximately 1-3 months and on-time delivery increased from 47% to 75%. NB-IoT networks were also able to capture data on staff working times, equipment down-times as well as generate manufacturing cost data helping to reduce the cost of products by 5%.

There are multiple potential applications of the Industrial IoT in China, including intelligent production processes, mass customization, cloud manufacturing platforms, collaborative manufacturing and collaborative innovation platforms, B2B industry e-commerce and intelligent product development tools. For example, industrial enterprises can build cloud platforms to enable greater interconnectivity both within the firms and along the entire industrial value chain.

Consultancy EY has identified five major benefits the Industrial IoT can bring to manufacturing²:

- A reduction in correction cycle time,
- The ability to anticipate failures in advance,
- The improvement of design through big data analysis,
- Financial savings through proactive monitoring and prevention as opposed to reactive repairing,

- A reduction in faulty products and recalls that can cause severe reputational damage to a brand.

These benefits can also apply to entire supply chains. By connecting factories to suppliers, all parties involved in the supply chain can track the interactions among them, the material flow, and the manufacturing cycle. Moreover, the Industrial IoT can enable location tracking, remote inventory monitoring and access to reports of parts and products moving in the supply chain. As real-time data can help pinpoint potential problems before they occur, companies can take corrective measures to ensure they will have the supplies they need. As a result, a company may reduce inventory and even capital requirements.

In a survey of Chinese manufacturers in 2016 by Deloitte³, 89% of the respondents agreed the Industrial IoT is critical to business success in the next five years. While 72% had started Industrial IoT applications in one form or another, only 46% had established clear-cut Industrial IoT strategies and plans.

After initially using the Industrial IoT to drive efficiency improvement, Chinese manufacturers are now turning their attention to the potential for revenue growth and risk management. Some 116 out of the 156 companies (74%) surveyed by Deloitte were seeking to improve the efficiency of their supply chains and reduce costs through Industrial IoT applications. Some 110 companies (70%) said they plan to use technologies, such as predictive maintenance, to improve operational efficiency and reduce downtime, while others hope to improve business agility and legal compliance.

Of course, the benefits of interconnectivity between machines, allowing for real-time transmission of information and big data insights, are not limited to manufacturing – these advantages can be a boon to the efficiency and productivity of many important economic sectors in China, including resources, energy and telecoms. Over the next 15 years, the IoT could cumulatively grow China's GDP by between US\$500 billion and US\$1.8 trillion, depending on the level of investment, according to consultancy Accenture⁴. Within that figure, the output of the manufacturing sector could increase between US\$196 billion and US\$736 billion, while the resources sector's output could rise between US\$48 billion and US \$189 billion.

Western firms see opportunities to serve the fast growing Chinese Industrial IoT market. For example, General Electric has opened a "digital foundry" in Shanghai to help Chinese companies develop and commercialize products for the Industrial Internet of Things. GE's new centre will promote Predix, its proprietary software for the industrial IoT, which is being used by China Eastern Airlines and China Telecom, while Huawei, a Chinese telecoms-equipment maker, is a partner, according to a report in the Economist⁵. Siemens, HP, Honeywell and Cisco are also among the western companies looking to play a role in the development of China's Industrial IoT.

² <https://consulting.ey.com/how-can-the-internet-of-things-benefit-manufacturers/>

³ <https://www2.deloitte.com/cn/en/pages/consumer-industrial-products/articles/from-interpretation-to-prediction.html>

⁴ <https://newsroom.accenture.com/news/internet-of-things-to-boost-chinas-economic-growth-by-us-1-8-trillion-by-2030-finds-accenture.htm>

⁵ <https://www.economist.com/news/business/21702487-china-aims-lead-world-connecting-factory-great-convergence>

THE ROLE OF CHINA'S GOVERNMENT

China's government is a major driving force behind the country's adoption of the Industrial IoT. In 2010, then Premier Wen Jiabao, announced that the IoT is critical to China's information and communication technology plans. This resulted in a national IoT centre being established in Shanghai.

In May 2015, the government outlined the Made in China 2025 strategy prioritising sectors boosting manufacturing innovation, including the IoT, smart appliances and high-end consumer electronics. Under the plan, these sectors will benefit from state funding in excess of 10 billion yuan (US\$1.5 billion), according to the Economic Information Daily, which is run by Xinhua. The strategy sets out a goal to transform China from "a manufacturing big house" to "a manufacturing super house" in the next 10 years.

The Chinese government is also promoting the development of the IoT in industrial control, financial services, healthcare and other major sectors of the economy, as well as manufacturing. Government officials are strategically providing funding to municipalities and economic development zones as part of official "smart city" pilot projects, which are looking to use IoT applications to address major urban issues, such as congestion and pollution.

Also in 2015, the government unveiled the Internet Plus Action Plan, which aims to integrate the Internet with traditional industries, and create a new engine for economic growth. It involves bringing together the mobile Internet, cloud computing, big data and the IoT with modern manufacturing, to encourage the development of e-commerce, industrial networks, and Internet banking and to help Internet companies increase their international presence.

The government is also seeking to bring faster and more affordable Internet connections to small and medium-sized enterprises (SMEs). By encouraging SMEs to upload their business systems to cloud platforms, the government is hoping to stimulate mass entrepreneurship and innovation. Public agencies are also seeking to beef up cyber-security: A report by the National Computer Network Emergency Response Technical Team/Coordination Centre of China highlighted security risks associated with IoT devices and networked industrial systems⁶.

More broadly, global leadership in the fast advancing field of artificial intelligence (AI) is a high priority for China's policymakers. In the summer of 2017, China's State Council issued a policy blueprint calling for the nation to become "the world's primary AI innovation centre" by 2030, by which time, it forecast, the

country's AI industry could be worth US\$150 billion⁷.

In October 2017, Chinese state media outlet, Xinhua, reported that China plans to take steps to accelerate the integration of information technology and the manufacturing sector and the development of industrial Internet, following a State Council executive meeting chaired by Premier Li Keqiang⁸.

Case Study 2: China Telecom Delivers Industrial IoT Platform to Upgrade Enterprises


Traditional manufacturing enterprises have faced a number of issues such as competition from emerging economies, rising costs and reduction in industrial workers. However, the task of upgrading and transforming these businesses was increasingly problematic. To solve these issues and help industrial enterprises meet the opportunities and challenges of the future, the Zhongshan Industrial IoT Open Platform was created. The platform is provided by China Telecom and provides a cloud infrastructure and computing platform which is also combined with a local government public service platform.

The aim of the project is to integrate IoT, cloud computing, big data and artificial intelligence technologies to build an integrated industrial IoT platform. This will help enterprises upgrade by providing low cost and quick delivery services to traditional manufacturing industries in Zhongshan. The platform enables companies to capture huge amounts of data in real-time via China Telecom's NB-IoT networks from sensors, barcodes, RFID and other areas and analyse it, providing instant insight across areas such as equipment detection, early warning and prediction, decision support and energy efficiency optimization. The platform also offers a complete real-time overview of the supply chain across different business segments such as R&D, production, sales, logistics and products. It also provides cloud application services and applications such as enterprise management, enterprise information and collaborative office.

⁶ <https://www.opengovasia.com/articles/7544-report-by-china-cert-highlights-cybersecurity-risks-associated-with-iot-devices-and-networked-industrial-systems>

⁷ <https://www.nytimes.com/2017/07/20/business/china-artificial-intelligence.html>

⁸ http://www.xinhuanet.com/english/2017-10/30/c_136715753.htm



THE ROLE OF MOBILE IOT AND THE GSMA

The mobile industry has developed a set of low cost connectivity technologies designed specifically to support the IoT and the IIoT. These Mobile IoT technologies use licensed spectrum to provide low power wide area (LPWA) connectivity, ideally suited for connecting devices that need to have long battery lives and are only transmitting small amounts of data. GSMA Intelligence forecasts there will be 1.8 billion Mobile IoT connections (out of a total of 3.1 billion cellular IoT connections) worldwide by 2025.

China is one of the main factors behind this growth; the country will record 860 million mobile IoT connections in 2025, associated with various industry vertical applications including smart metering, connected bikes and connected agriculture. GSMA Intelligence also estimates that there will be 13.8 billion industrial IoT connections by 2025 with 6.3 billion of these being in Asia Pacific and China accounting for 65% of these.

These new networks can support IoT solutions across a wide variety of applications, such as industrial asset tracking, safety monitoring or water and gas metering, providing extensive coverage in both cities and remote rural locations. The GSMA's Mobile IoT Initiative, which was created to help the industry deliver commercial LPWA solutions in licensed spectrum, is backed by 74 global mobile operators, device makers and chipset, module and infrastructure companies worldwide.

Mobile IoT is gaining momentum worldwide. To date, 29 mobile operators have launched 53 Mobile IoT networks using either Narrowband IoT (NB-IoT) or LTE-M technologies, both of which have been standardised by 3GPP. Mobile IoT technology has been widely deployed in cities in Greater China. The expanding Mobile IoT ecosystem also includes 36 IoT Labs and more than 1,000 organisations in the GSMA's Mobile IoT Innovators Community.

As well as supplying the connectivity, mobile operators can provide management, security and analytic solutions, often in partnerships with local governments, utilities, enterprises, manufacturers, service providers and solution providers.

Mobile IoT technologies, such as NB-IoT and LTE-M, will play a key role in the 5G networks of the future and, in particular, the development of 'massive IoT'. Massive IoT is one of three principle 5G use cases, alongside critical communications and enhanced broadband, which will enable smart cities, industrial automation and other applications involving large numbers of connected devices. Leading mobile operators, including AT&T, Deutsche Telekom, KDDI, Orange and Vodafone, are committed to deploying these networks as part of their future 5G massive IoT strategies.

KEY SECTORS FOR THE INDUSTRIAL IOT IN CHINA



Utilities/Energy

China is looking to clean up its enormous energy market, which has historically been heavily dependent on coal. President Xi Jinping's vision of building a green, robust and resilient economy was reaffirmed in the 13th Five-Year Plan (FYP), published in March 2016. The plan prioritizes building efficiency, requiring 50% of all new urban buildings to be "certified green buildings". An IFC report⁹ suggests that following through on these commitments would represent a US\$12.9 trillion investment.

China is already at the forefront of a global push to deploy smart grids that capture up-to-date information about the utilisation of energy and water infrastructure to improve efficiency and reduce waste. The information collected by connected energy and water meters can help consumers and businesses to reduce usage, while enabling utilities to better balance supply and demand, and identify leaks and faults. China became the world's largest market for smart grids by investment in 2013, according to consultancy McKinsey, which says about 310 million households were using smart meters, a penetration rate of more than 80 per cent, by 2015¹⁰. By the third quarter of 2017, China accounted for almost 70 per cent of tracked global installations, according to a research report by Navigant.

Mobile IoT connectivity provides a less expensive and less complex means of connecting utility meters than earlier technologies. By extending the battery life of smart meters, Mobile IoT connectivity can enable a utility to reduce maintenance significantly: Lengthening the service cycle from 2-3 years to 10-15 years would dramatically improve the utility's return on investment. As utility meters tend to communicate comparatively small payloads (100s of bytes, at maximum) of data, low bandwidth, power-efficient network technologies are particularly well suited to this application.

Employing Mobile IoT technologies enables an operator to connect meters using its existing cellular infrastructure, as well as taking advantage of cost-effective standardised device hardware. The technologies are also designed to support two-way communications, enabling time synchronization and firmware updates for digital water meters.

Case Study 3: China Mobile's NB-IoT Smart Meter Solution

China Mobile developed an NB-IoT smart metering solution and partnered with the State Grid Electric Power Research Institute to deploy 200 smart meters in Yingtian, Wuxi, Zhuhai, Chengdu, Chongqing and Beijing. Their existing solution used 2G or 4G networks to collect real-time voltage, current, power consumption and other information from the meters. Through big data analysis they could monitor the actual electricity consumption of each device, enabling them to deliver an effective electricity supply strategy across a particular area.

However, the introduction of NB-IoT networks offered enhanced network coverage, allowing more smart meters to be connected. They are also much simpler to install and operate which lowers costs for maintenance as manual meter readings are no longer required. Real-time data is also available to cities and utilities companies allowing them to analyse data more quickly. The enhanced network coverage with NB-IoT means the networks are 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. They are also designed to be secure because they operate in licensed spectrum.

China Mobile was able to benefit from the improved coverage offered by NB-IoT which has been crucial in ensuring that every meter has been able to connect across a wide range of locations – indoors, outdoors and in basements. It also offers a high quality of service, essential for the 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.

⁹ https://www.ifc.org/wps/wcm/connect/51183b2d-c82e-443e-bb9b-68d9572dd48d/3503-IFC-Climate_Investment_Opportunity-Report-Dec-FINAL.pdf?MOD=AJPERES

¹⁰ <https://www.mckinsey.com/featured-insights/china/digital-china-powering-the-economy-to-global-competitiveness>



Logistics

Online commerce is becoming increasingly popular with Chinese consumers, as the country's leading online retail giants, Alibaba's Taobao and JD.com, compete for more customers. But China's huge logistics industry needs to cut costs. In China, 11.1 trillion yuan (US\$1.7 trillion) was spent on logistics in 2015, accounting for 14.9 per cent of the country's GDP (gross domestic product), according to China's Ministry of Commerce. In the United States, logistics costs account for 6.5 per cent of GDP, while in Japan and Germany it stands at 3.5 per cent. China's logistics sector is struggling with rising land prices for building warehouses and management and labour costs.

In response, distributors are using wireless technologies to become increasingly automated and reduce the cost of transporting goods across the country. For example, Alibaba has constructed a massive 3,000 square metre warehouse in Huiyang, Guangdong Province that is fully operated by the IoT (Internet of Things) and large fleet of robot workers. Cainiao, a logistics subsidiary of Alibaba Group, offers either same-day or next-day deliveries to over 1,000 regions of China.

In 2017, Huawei, China Mobile and DHL Supply Chain began a joint project to develop an IoT system to upgrade logistics for an automobile factory. The companies are using NB-IoT to improve the efficiency of a manufacturing site in Liuzhou, in the Guangxi Zhuang Autonomous Region.

DHL and Huawei have integrated NB-IoT chipsets into vehicle detectors, enabling DHL's supply chain to identify available docks in real time. When a truck arrives, its driver checks in via an app on his mobile, receiving a queue number and an estimated waiting time. The yard management system then automatically screens the docks for their availability, providing each driver with real-time status updates visible via the app. As soon as a dock is free, the driver is notified to proceed accordingly. As a result, inbound trucks can be prioritized in line with the manufacturing site's needs and shipments are unloaded at the most appropriate dock. The system has halved the waiting time for drivers down to 20 minutes, significantly reducing the risks of manufacturing delays as materials arrive in time and resources are optimized appropriately.



Smart Cities

China has about 500 smart city pilot projects, more than any other country in the world, according to consultancy Deloitte. One of the most advanced is in the city of Hangzhou – home to more than 9 million people. Here the local government has collaborated with Alibaba and Foxconn to build the “City Brain”

project. The metropolis is run in part by an AI system that draws on behavioural data captured by apps to make real-time decisions and to work out optimal future scenarios for smoother commutes and safer streets. As a result, traffic congestion, road accidents, and crime are all down. As well as keeping the authorities informed, the City Brain can transmit data to citizens' mobile phones, informing them of upcoming road traffic or adverse weather conditions in real-time.

Mobile operators are heavily involved in the development of smart city solutions in Greater China. China Mobile Hong Kong (CMHK), for example, has signed a memorandum of understanding with property developer Sino Group to use CMHK's NB-IoT technology in the latter's residential and commercial properties to support smart home, smart shopping mall, and smart property management applications.

In Jiangsu Province, China Mobile and the Nanjing Street Lamp Management Bureau have deployed “smart street lamps”, which use NB-IoT to collect data on the volume of passing traffic and pedestrians and dim automatically when no one is around. They can also monitor weather conditions, such as haze and fog.

Case Study 4: China Mobile Rolls Out Smart Parking Solution

China Mobile instigated two smart parking pilots using NB-IoT connectivity in Yunnan and Southeast Guizhou. Smart parking is designed to make it easier for drivers to locate free parking spaces, minimising congestion and pollution by limiting the idle time and the need for drivers to hunt for available spaces. NB-IoT is a good fit for smart parking as it has support for long battery life and offers improved coverage which allows sensors to be placed in any locations. NB-IoT makes 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. The parking system utilises sensors installed in each parking bay, which are able to detect the space occupancy and send the status via NB-IoT networks. NB-IoT offers a number of benefits such as improved coverage, real-time communications and low power consumption.

NB-IoT modules are also designed to offer battery life of many years, meaning that the sensors can be installed in virtually any location and require very little maintenance. Additionally, by integrating mobile payments with the system, the amount of time it takes drivers to enter and exit car parks is much reduced by removing the need for them to queue to pay. This makes turnaround time shorter, resulting in a higher utilisation of the parking bays. China Mobile is planning to roll out the services throughout cities in China in the future.



CHALLENGES FOR THE INDUSTRIAL IOT IN CHINA

Although the Industrial IoT is growing rapidly, it continues to face a number of obstacles, such as security and privacy concerns, interoperability issues and skill shortages. A survey of Chinese manufacturers in 2016 by Deloitte¹¹ identified the following challenges for the Industrial IoT:

- **A lack of interoperability standards:** For 52% of the companies surveyed, a lack of interoperability standards is one of the major challenges in applying Industrial IoT technologies.
- **Ownership and security of data:** A total of 46% of the companies surveyed believe ownership and security of data are major challenges in applying Industrial IoT applications. The market has yet to agree on who owns the data, manufacturers or users of the equipment with which the data is collected.
- **Lack of relevant technical personnel:** A lack of qualified technical personnel is another major challenge for 42% of the companies surveyed. Given the variety of Industrial IoT applications and circumstances, new data sources, changes in system architecture data, as well as multi-structured data, today's manufacturing companies do not have adequate analytical capabilities.

Maintaining high levels of security is another significant challenge for the Industrial IoT: the increase in the number of connections broadens the attack landscape for would be hackers. This issue is covered further in the GSMA IoT Security Guidelines & Assessment.

A final challenge is fragmentation. Forrester Research says the sheer number and variety of IoT platforms in the market place are creating confusion, as well as choice. Telecoms operators, such as China Mobile, China Unicom and China Telecom; ICT firms, such as Alibaba and Huawei; software firms, such as SAP and PTC; and manufacturing firms, such as Foxconn and Haier, have collectively introduced dozens of platforms. Although these firms say that their platforms can cover multiple layers of the IoT stack, many still struggle to differentiate their capabilities and foster broader ecosystem collaboration, according to Forrester, which notes that big manufacturing firms also find it challenging to build and market IoT platforms.

¹¹ <https://www2.deloitte.com/cn/en/pages/consumer-industrial-products/articles/from-interpretation-to-prediction.html>

OPERATOR FOCUS – INTERVIEWS

This section profiles various mobile operators supporting the development of the Industrial IoT in Greater China, drawing on interviews with each operator.



Asia Pacific Telecom Group

Asia Pacific Telecom (APT) is planning to commercially launch NB-IoT and LTE-M services across Taiwan at the end of June 2018. Aimed primarily at the business market, APT's Mobile IoT services are designed to meet growing demand for low power wide area connectivity. "Coverage and battery life are the most important things," says Nicole Chen, Director & Head of the IoT business unit at APT, noting that customers are looking for a battery life of more than five years and transmissions even when the radio signal is as weak as -120 dB.

Although APT is also using other cellular technologies to support the IoT, Nicole Chen says NB-IoT is the best solution for most IoT devices. While noting low latency is very important for some IoT services, she believes NB-IoT and LTE-M can support most applications.

APT is aiming is to be serving 2 million IoT connections by the end of 2020. "2018 is the first Mobile IoT year in Taiwan, we found everybody is attentive to the global trend and is looking to join the ecosystem in this beginning stage," says Nicole Chen. "We think it will be exponential growth next year." APT anticipates the expansion of the IoT will further increase demand for data scientists and support the development of sophisticated AI. "The major business value of IoT is from AI," adds Nicole Chen.

However, APT says that module costs need to fall further, while security and interoperability issues also need to be resolved. "Interoperability is not easy for us and we need to ask for the vendors' support," says Nicole Chen. "A platform (such as a device management platform or an application enablement platform) is the way we try to solve some of the security issues."

APT sees four main markets for its IoT solutions:

1. Smart city solutions, such as smart metering, smart parking, air quality monitoring and disaster prevention.

2. Digital life solutions, such as home security and pet tracking.
3. Smart healthcare, such as monitoring the elderly.
4. Smart factories and industrial applications

APT anticipates the public sector will be among the early customers, harnessing Mobile IoT networks to enable smart metering and smart lighting. The operator also sees mobile connectivity being used to monitor the levels of pollutants in the air, as well as to monitor water levels in gutters, so as to provide an early warning system for flooding.

APT says it is collaborating with multiple local governments in Taiwan to deploy end-to-end IoT solutions co-developed with solution providers, mainly focus on smart metering, smart parking, and air quality monitoring. "We are going to develop an open platform based on cooperation with platform companies," says Nicole Chen. "In each vertical integration, we work with a different industry partner to jointly design and develop the IoT service and solution."

She attributes Greater China's leadership in the IoT to the size of the population, innovation, rapid adoption of new technology, and a willingness to invest, suggesting other regions would also benefit from strong government support and a clear vision.





China Mobile

China Mobile serves more IoT connections than any other operator in the world. At the end of 2017, it reported 229 million IoT connections, up from 103 million at the end of 2016. By December 2017, China Mobile had launched NB-IoT in 346 cities, offering end-to-end commercial services. Moreover, the operator's OneNET IoT platform, which provides an array of IoT services, has 6,500 enterprise customers and has provided capacity building services to 56,000 developers.

Zhenyu He, OneNET Industrial IoT Product Manager, says the pace of the development of the Industrial IoT in China is being governed by government policy, global industrial competition, the rapid development of connected intelligence technology, particularly NB-IoT, 5G, big data, artificial intelligence and blockchain, and the availability of capital. "Chinese enterprises, in the face of global industrial competition, gradually understand more clearly their own positioning," he says. "Most industrial enterprises believe that the development of Industrial IoT is best to improve production efficiency and quality, reduce costs and maintain product competitiveness."

He explains there are essentially four business drivers behind the development of the Industrial IoT in China:

1. Enterprise-led personalised customisation: Enterprises use the IoT to enable user customisation and participation in the design of a product and service.
2. Enterprise-led intelligent production: Enterprises use an intelligent factory to increase income, reduce cost, increase efficiency and quality.
3. Government-led network collaboration: the government realises the real time supervision and monitoring, the enterprise realises the supply chain upstream and downstream coordination.
4. Enterprise-led service extension: the enterprise achieves income growth through post-sales services, and through product operation analysis to create a closed loop and lower the cost.

China Mobile is looking to make it easier for the country's businesses to harness the Industrial IoT by providing management platforms, security solutions and broader network coverage. "Industrial enterprises, especially small and medium sized industrial enterprises, lack the ability to build their own industrial network," says Zhenyu He. "China Mobile provides the OneNET industrial Internet platform and corresponding industrial applications to help small and medium-sized enterprises upgrade to the industrial Internet. At the same time, OneNET's Partner Certification Program works with partners to enrich industrial network terminals and application products, and ensure industrial field integration."

With respect to network security and coverage, China Mobile is tailoring its networks to the industrial production environment, so that they meet industrial safety standards, as well as providing SD-WAN gateway products, enterprise APN (access point name) and other solutions to secure the transmission of data. "Network coverage, especially the latest commercial NB-IoT network coverage, is still poor in some industrial plants areas," Zhenyu He adds. "China Mobile will speed up network deployment according to the needs of enterprises. For some industrial enterprises, China Mobile can also provide 5G pilot trials."

In its 2017 Annual Report, China Mobile says it has taken the lead in drawing up the Industrial Standards for universal IoT modules, facilitating the development and deployment of IoT applications. Moreover, Ericsson and China Mobile are jointly building an Industry IoT Cooperation Centre to plan for and develop IoT connectivity and IoT ecosystem solutions in areas such as manufacturing, industry, health, and intelligent transportation. Built on China Mobile's Co-Space and Ericsson Garage, the CMCC-Ericsson Garage aims to jointly develop new technologies and applications.

China Mobile also intends to provide LTE-M connectivity, once it has a license from the government. It sees LTE-M supporting a range of IoT services, including consumer propositions, such as connecting wearable devices and trackers for bicycles and consumers.



China Telecom

In May 2017, China Telecom launched a NB-IoT network comprising almost 300,000 base stations in 31 provinces across China. The operator is using the 800MHz frequency band, ensuring the network provides wide geographic coverage and can penetrate deep inside buildings.

China Telecom is looking to NB-IoT to drive a massive expansion in the IoT, which it regards as a major growth engine for the industry. In China, hundreds of thousands of devices have already been connected using NB-IoT and China Telecom expects that figure to rise rapidly. It also has plans to deploy LTE-M as part of a "premium IoT network".

The leading adopters of the Industrial IoT in China are the construction machinery, automotive and electronic information sectors, according to Donny Zhang, Industrial Internet Expert at China Telecom. Many industrial manufacturers are seeking to use the IoT to transform themselves into service companies.

To help the Mobile IoT value chain mature, China Telecom has published a white paper specifying its requirements for NB-IoT modules, as well as subsidising the production of modules. As a result, China Telecom says that 34 models of NB-IoT modules from 30 different suppliers are now being mass produced. By October 2017, China Telecom had purchased 500,000 NB-IoT modules, and reduced the price of each NB-IoT module to US\$5 – very close to the price of GSM modules.



The operator is exploring Mobile IoT applications in a range of different economic sectors, including smart cities, white goods and the “Internet of livestock”. China Telecom sees particularly strong demand from water companies for smart metering, pipe network monitoring and water quality monitoring services, which helps them to manage their infrastructure and upgrade their services, while reducing operating costs.

China Telecom charges a fee of about 20 yuan (about US\$3) per year per NB-IoT connection, reflecting the low traffic levels and large numbers of connections. The operator says this proposition has been well received by customers.

China Telecom has also partnered with Ericsson to develop the China Telecom IoT Open Platform – a global connection management platform to support China’s “One Belt One Road” international trade strategy. The platform is designed to enable enterprises to deploy, control and scale the management of IoT devices, while integrating their business processes with the managed connectivity service offered by China Telecom to create highly reliable IoT solutions.

Moreover, Paris-based Orange Business Services and China Telecom have agreed to offer enterprises access to each other’s IoT networks. The two operators said multinationals will be able to deploy IoT and M2M services across Asia, Europe and Africa thanks to an extension of an existing strategic partnership.



China Unicom

China Unicom, which generated IoT revenue of 1.41 billion yuan (US\$220 million) in 2017, is rolling out NB-IoT services across China. For instance, in Shanghai, Guangzhou, Shenzhen and Fuzhou. In Shanghai alone, Unicom has upgraded 2,700 base stations to support this low power wide area technology, providing coverage across the whole city.

Unicom’s customers are using NB-IoT in factories to monitor equipment on production lines, collect readings from energy and water metres, track the availability of parking spaces, control street lighting and monitor sensors inside buildings.

Dr. Xueqin Jia, the IoT expert of China Unicom network technology research institute stresses the importance of using digital technologies to strengthen the manufacturing and industrial sectors. “The real economy, with manufacturing as the core, is essential to realising the sustainable development of the economy,” says Dr. Jia. Unicom believes the Industrial IoT is critical to the development of smart manufacturing, as it can help eliminate information asymmetry in the value chain and help enterprises improve production efficiency, reduce costs and improve competitiveness.

Dr. Jia identifies the electric vehicle industry, the steel industry and the energy industry as three sectors with strong demand for Industrial IoT solutions. “New energy vehicle industry demand for Industrial IoT is growing, from the production of auto parts to assembly and monitoring of driving and the diagnosis of faults,” Dr. Jia says.

In this sector, both network coverage and security are key considerations. “A factory has a lot of occlusion, and the car conditions appear to be uncertain on the road, which requires good network coverage,” says Dr. Jia. “The safety of the car is related to the life of the passengers. In the context of equipment interconnection, the need to protect equipment from malicious attacks, and to prevent human error and equipment failure, requires network security protection.”

Unicom believes the Industrial IoT can also help the steel industry reduce pollution and over-production. “Industrial IoT will help improve productivity, reduce production costs, reduce energy consumption, and assist the steel industry to move from traditional manufacturing to intelligent manufacturing,” says Dr. Jia. “Against the backdrop of national environmental governance, the steel factory will potentially be relocated to remote suburbs, so ensuring good network coverage of steel mills in those remote areas becomes essential.”

The Industrial IoT also has the potential to improve the efficiency of coal mining and oil and gas extraction – a huge industry that is of crucial importance to China’s economy. “Even a 1% improvement in production efficiency will bring

huge positive impact to the industry,” says Dr. Jia, noting that the wide area coverage offered by NB-IoT and LTE-M can help to bring connectivity to remote oil wells in deserts, in the ocean, and in mountains.

However, there is a need for more engineers who understand both the ICT industry and the manufacturing sector. “At present, in the Industrial IoT industry, the ICT staff do not possess much knowledge about the industrial sector and the industry experts do not understand ICT, leading to the knowledge/talent gap,” notes Dr. Jia. “Therefore, it is urgent to train a big group with knowledge in both fields.”

Dr. Jia also sees the need for more standardisation of industrial processes. “There are over 100 kinds of standards such as fieldbus, industrial Ethernet and industrial wireless; whereas only 40 of these are commonly used,” Dr. Jia says. “They cannot even be integrated with the IT domain communication standards of interoperability.” Unifying industrial communication standards and making IT and operational technology (OT) interoperable would help with the implementation of the Industrial IoT, Dr. Jia adds. To address this issue, Unicom is taking a two-step approach. First, it performs simple data analytics and integration through the edge of the industrial gateway. Then it encourages industrial enterprises to adopt standardised industrial Ethernet, TSN delay sensitive network, NB-IoT, LTE-M, and other industrial equipment for data transmission.

Unicom is also developing so-called edge solutions to meet enterprises’ demand for real-time data and high levels of security. “The Industrial IoT can require low latency (down to a millisecond or even microsecond) and the traditional central cloud processing method cannot meet the demand of industrial applications,” says Dr. Jia. “In addition, industrial enterprises want the data to be stored locally and privately. Through the deployment of an edge gateway and edge cloud, the data is analysed, processed and stored near the user meeting the requirement for real time and secure data transmission.”

Case Study 5: China Telecom Introduces Internet of Cows Solution

Many dairy farms in China rely on manual observation to find out when a cow is fertile which can be a time consuming and labour intensive process and making it difficult to raise the reproduction rates of cows and milk output for dairy farms. Consequently, China’s milk production rates are far lower than other developed nations making this detection process critical to raising volumes. To solve this problem, China Telecom and Huawei introduced a project using NB-IoT networks with a dairy farm in Yinchuan City with over 50,000 cows.

Sensors were attached to the necks of individual calves which detect when they are fertile via a cloud detection system dubbed “Little Shepherd” alerting farm workers. The process was effective in helping to increase pregnancy rates, shorten pregnancy intervals, reduce cost and increase milk output. The NB-IoT network has wide area coverage and low power consumption making it ideal for services such as this. It can also be applied to similar areas such as beef farms and livestock raising associations.



Far EasTone

The first operator providing NB-IoT commercial services in Taiwan, Far EasTone (FET) began rolling out its NB-IoT network in November 2017. Having initially launched NB-IoT in the Greater Taipei area and the industrial zone of Taoyuan, FET plans to expand the number of NB-IoT base stations to 8,000 by the second quarter of 2018.

FET expects to be providing NB-IoT connectivity to 7,000 enterprises within three years of the commercial launch, generating over TWD1.2 billion (approximately US\$40 million) in revenue in 2020¹². FET has also forecast there will be three million NB-IoT connected devices in Taiwan by the end of 2019¹³.

"NB-IoT is designed to offer enhanced coverage over existing mobile networks and power saving features," says Herman Rao, Head of Network Technology Division. "It is suitable for widely deployed IoT devices and has been prioritised as our key IoT technology for roll-out." FET uses a low spectrum band (700MHz) to provide NB-IoT services across Taiwan, providing better coverage than Sigfox and LoRa (see table). "After activating NB-IoT on these existing L700 sites, the NB-IoT service can easily achieve island-wide coverage," says Rao. "It saves a lot of roll-out time and is more cost effective."

FET is using Ericsson's global IoT connectivity management solution to enable its customers to deploy, manage and scale IoT connected devices and applications. Ericsson says there are more than 60 partners in the ecosystem and full operational service is planned for the second quarter of 2018.

FET says its Mobile IoT solutions include asset tracking, smart parking, city lighting and healthcare management and analytic solutions. In particular, it is seeing demand from customers for:

- Smart parking solutions that allow owners to confirm the empty parking space address through the mobile app.
- Smart lighting solutions that enable the control of each street lamp, including control switch, brightness adjustment and schedule management.
- Smart alarm solutions that can provide information on a fire to the fire brigade
- Green energy management to monitor rural area solar panels and ensure the electricity generation.

"In Taiwan, we have numerous smart city strategies to drive the city and industry development and innovation," says Philip Tseng, Head of Enterprise and Carrier BU. "Smart metering services across electricity, gas and water will also be widely deployed." Tseng also sees demand for Industrial IoT solutions in the automotive and semiconductor manufacturing and security sectors. "We will fulfil customer's requirements and provide an end-to-end solution through network to device," adds Tseng.

FET sees the key challenges facing Industrial IoT solutions in Greater China as ensuring there is sufficient bandwidth available for the transmission of images and other large files, together with the need for low latency connectivity to support real-time updates for some applications. Maintaining high levels of security is also a challenge. Tseng says there is a risk of IoT device theft, as well as data breaches and attacks by hackers. Remote SIM provisioning, vibration sensors that can trigger an alarm if the device is disturbed and positioning and tracking systems can all help prevent device theft. Encryption can help to secure data, while mutual authentication systems and dedicated hardware keys can prevent hacking.

"From an IT architecture point of view, we need to leverage existing modules and functions and build an ecosystem to support the IoT business," concludes Tseng. "But with a dynamic market and ever changing technology, it requires all the teams to work together to address the changes."

	NB-IOT	SIGFOX	LORA
Standard	3GPP	Sigfox	LoRawan/LoRa Alliance
Fast construction	Leverage existing 4G Sites	New sites	New sites
Band	B28 700MHz Licensed Band (Win)	920-925MHz Unlicensed Band	920-925MHz Unlicensed Band
Coverage	Up to 100km (Win)	-50m	-15m
D/L Speed	-200kbps (Win)	-	-10kbps
U/L Speed	-180kbps (Win)	100kbps	-10kbps
Frequent Updates of Keys	Yes (Win)	No	No
Cryptographic Algorithms Support	Yes (Win)	No	No
Global Operator Reference	107 (Win)	51	83

¹² source: <http://www.taipeitimes.com/News/biz/archives/2017/11/29/2003683086>

¹³ source: <https://www.ericsson.com/en/press-releases/2018/2/ericsson-enables-far-eastone-to-drive-global-enterprise-iot-connectivity>

Taiwan Mobile

Having rolled out NB-IoT services, Taiwan Mobile is targeting five key markets: smart cities, smart metering, smart healthcare, connected cars and “smart life” applications for consumers. To serve these markets, the operator is developing solutions to connect LED street lights, parking lots, power meters, water meters, wearable devices measuring health metrics, in-vehicle control units, trackers and smart door locks.

“In Taiwan, smart city and smart metering solutions are in strong demand,” says Hermann Huang Deputy Director, IoT & Platform Service Division at Taiwan Mobile, pointing to the need to conserve energy as Taiwan moves away from nuclear power towards green energy. He also notes the importance of smart water metering as climate change and new semiconductor factories place greater pressure on fresh water supplies. “In the longer run, smart healthcare, smart life and connected cars will also generate strong demand,” he adds. “As the population ages and wants a better life style, IoT services can meet these demands.”

In the smart city sector, Taiwan Mobile says transportation automation, infrastructure monitoring and disaster detection are key applications for the Mobile IoT. “Some of these services need long battery life and long distance connectivity, so NB-IoT technology fits,” says Hermann Huang. “For other services that need lower latency or higher bandwidth, LTE or the future 5G will be used.”

In the smart city sector, demand for the Mobile IoT is being driven primarily by local governments seeking to become more efficient and by citizens seeking greater convenience, he adds. “For example, there are more and more private vehicles, but the parking lots are limited. So smart parking and navigation will be important, which needs more sensors, real-time data collection, predictive analytics and services.”

Taiwan Mobile has several different Industrial IoT propositions, ranging from a connectivity-only service to bundles of connectivity and cloud services, and entire end-to-end solutions, complete with systems integration. “We can provide the connectivity to governments, enterprises or system integrators,” explains Hermann Huang. “We can also bundle connectivity with IaaS (infrastructure-as-a-service) and PaaS (platform-as-a-service) and support governments, enterprises or system integrators with value added services. Another option is system integration in which we lead, deal and provide after-services for governments, enterprises or service providers. We will consolidate different suppliers to achieve the total solution.” He believes mobile operators need to play an active role in enabling the digital transformation of other enterprises, potentially providing data analytics and AI services, as well as connectivity.

For the Industrial IoT to realise its full potential in Greater



China, it will need to overcome challenges in three areas, says Hermann Huang. The first of these is the development of sustainable business models. “The industrial IoT businesses involves many participants in the ecosystem,” he notes. “When users will not pay more to adopt new technology, but every participant needs to invest in new components for the new services, how can the business work well and break even?” Ensuring personal data privacy also presents a challenge. “When a connected car will trace the drivers’ location or when a smart health solution will trace personal health data, the users may hesitate to adopt the new technology,” says Hermann Huang. The third challenge is ensuring security in a system with many interconnection points from the end device, the node, the network, the Internet and application servers to the user interface. “Every interconnection point may be targeted by hackers,” he adds. “Higher security needs more computing power or a longer processing time on devices or systems. But the IoT service need lower latency and lightweight devices. It is a big challenge.”

To overcome these challenges and help the Industrial IoT further in Greater China, Taiwan Mobile believes alliances between mobile operators, systems integrators, device vendors, platform vendors, governments, R&D institutions and related domain experts will be necessary. “Different industries may have different alliances,” notes Hermann Huang. “And different alliances may cooperate and compete each another.” Taiwan Mobile believes the government’s full support is also critical. “The government needs to set the goal and timeline, allocate budget, encourage initiatives and motivate service providers,” stresses Hermann Huang.

CONCLUSIONS

As well as benefitting from vast economies of scale, the Internet of Things (IoT) in Greater China is underpinned by strong government support at both a national and a local level. The mobile operators in the region are building out extensive solutions and services to meet the fast growing demand for the Industrial IoT and data streams it can deliver to China's millions of factories and production plants.

By employing large numbers of connected sensors, the Industrial IoT promises to transform the efficiency and effectiveness of industries and city services across East Asia, driving a fourth industrial revolution in which data analytics and artificial intelligence will play a central role. Mobile operators across Greater China are delivering the connectivity, and other capabilities, required to bring about this revolution. In particular, Mobile IoT technologies are helping to accelerate the development and the deployment of the Industrial IoT in East Asia.

However, the pace of development will be determined in part by the extent to which the ecosystem works collaboratively and employs interoperability between different systems and different companies in a supply chain. Another key challenge

is keeping the Industrial IoT secure, which may require the use of new security technologies, specifically designed for IoT or components targeting cyber security problems. Although mobile operators can play a central role in this respect, everyone in the IoT ecosystem needs to understand where their responsibilities begin and end, evaluating the potential risk at every juncture. Knowing the origin of a certain risk factor can help develop more secure solutions.

Although efforts to lay out Greater China's Industrial IoT are still embryonic, the sector is growing faster than that of consumer IoT applications, with smart cities and utilities among the early adopters. For the moment, the big winners in the Industrial IoT are component manufacturers and system integrators. But, as the industry grows, demand for services will increase and network operators and service platform providers will see their revenues increase.

By dramatically boosting efficiency and opening up new sources of revenue, the Industrial IoT can create new value for businesses and the societies they serve. Greater China is on course to be one of the first regions in the world to realise these benefits.





The GSMA represents the interests of mobile operators worldwide, uniting nearly 800 operators with almost 300 companies in the broader mobile ecosystem, including handset and device makers, software companies, equipment providers and internet companies, as well as organisations in adjacent industry sectors. The GSMA also produces industry-leading events such as Mobile World Congress, Mobile World Congress Shanghai, Mobile World Congress Americas and the Mobile 360 Series of conferences.

For more information, please visit the GSMA corporate website at www.gsma.com

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GSMA Greater China

The GSMA Greater China Region was created in October 2016. We focus on the promotion and execution of GSMA global programmes, advocacy initiatives, and working groups in the Greater China region. We bring together industry consensus, increase global impact of our partners, and work closely with operators and members in the wider ecosystem through our international events and platforms including Mobile World Congress, Mobile World Congress - Shanghai, Mobile World Congress - Americas and GSMA Intelligence to empower sustainable development of the mobile industry in Greater China.

For any further inquiry, please contact with chinamarketing@gsma.com.

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