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Internet of Things (IOT) Development for the Promotion of Information Economy

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1. Executive Summary

1.1 Background

The IOT (Internet of Things) represents a vision in which the Internet extends into the real world embracing everyday objects. With the rapid development of ICT, the digital and physical worlds are in deep convergence, the development of IOT is opening up huge opportunities for both economic growth and social progress. According to IDC, the Internet of things and its surrounding technology ecosystem is expected to be an $8.9 trillion market in 2020.

As an emerging industry, the technical, industrial and application foundation of the IOT has grown exponentially and suggests a huge potential for further growth in the Asia-Pacific region. As the size of the information economy expands, many APEC member economies have upgraded IOT as one of the most important priorities in their innovation strategies.

The 21st APEC Economic Leaders' Meeting declared, “We aspire to achieve a seamlessly and comprehensively connected and integrated Asia Pacific.” The 2013 APEC Ministerial Meeting also declared, “We shared the view that seamless physical, institutional, and people-to-people connectivity are critical prerequisites to achieve the Bogor Goals and attain the APEC community vision.” The 22nd APEC Economic Leaders’ Meeting’s declaration included a vision “To implement the APEC Accord on Promoting Innovative Development, Economic Reform and Growth”. In addition, “[t]o implement the APEC Connectivity Blueprint and achieve the overarching goal of strengthening physical, institutional and people-to-people connectivity by taking agreed actions and meeting agreed targets by 2025, with the objective of achieving a seamless and comprehensively connected and integrated Asia-Pacific.”

The Workshop on *Internet of Things (IOT) Development for the Promotion of Information Economy* was proposed at the 49th Meeting of the Telecommunications and Information Working Group (TEL49) by the People’s Republic of China and approved by the TEL as an ICT Development Steering Group (DSG) project. The sponsoring economies included Brunei Darussalam, Hong Kong, China, Japan, Malaysia, Singapore, Chinese Taipei, and The United States.

Through this workshop, policy makers, regulators, private sector

stakeholders and academia both from developed economies and developing economies shared their experiences on IOT Development for the Promotion of Information Economy.

This study report is one part of the project of Workshop on IOT Development for the Promotion of Information Economy.

1.2 Objectives

The main objectives of the project are as follows:

- To provide a platform for APEC members to discuss issues related to policies and strategies on promoting the development of IOT and its integration with traditional industry to reform and upgrade the economic structure including favourable regulatory policies, technological innovation and standardisation and applications development, etc.

- To analyse the status of IOT development and the important role it plays in promoting information economy in APEC economies, the main problems and challenges the economies face in promoting IOT for information economy development.

- To develop recommendations for developing economies, to promote technology and policy capacity building in developing economies in a view to bridge the digital divide and achieve promote both developmental and social benefits in the region.

1.3 Methods

- Gather and process information and perform analysis on the status and the trend of “IOT Development for the Promotion of Information Economy” in the APEC region;

- By the study on the information and studies on IOT Development for the Promotion of Information Economy, develop a speech material for the workshop;

- In coordination with Project Overseer, participate in the workshop to report on the report undertaken and the key findings;

- As reference of the materials provided from the speeches and discussion in the workshop, formulate the final version study report;

- Submit a study report to TEL, provide an electronic copy to the APEC Secretariat, and identify other channels for dissemination of report.

1.4 Glossary

Internet of Things (IOT): IOT is the network of physical objects or "things" embedded with electronics, software, sensors, and network connectivity, which enables these objects to collect and exchange data. The IOT allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration between the physical world and computer-based systems, and resulting in improved efficiency, accuracy and economic benefit.

Information Economy: Information Economy is an economy with an increased emphasis on informational activities and information industry.

Big Data： Big data is a broad term for data sets so large or complex that traditional data processing applications are inadequate. Challenges include analysis, capture, data curation, search, sharing, storage, transfer, visualisation, and information privacy. The term often refers simply to the use of predictive analytics or other certain advanced methods to extract value from data, and seldom to a particular size of data set. Accuracy in big data may lead to more confident decision making.

Smart City： A smart city uses digital technologies or information and communication technologies (ICT) to enhance quality and performance of urban services, to reduce costs and resource consumption, and to engage more effectively and actively with its citizens. Sectors that have been developing smart city technology include government services, transport and traffic management, energy, health care, water and waste.

1.5 Executive summary

- The development of IOT infrastructure will promote the connectivity of physical ICT infrastructure directly. Innovative IOT applications will profoundly affect all aspects of social production, consumption and operation, which will significantly contribute to the institutional and people-to-people connectivity both in urban and rural area from many aspects.

- Wearable, healthcare, connected car, manufacturing and smart city will develop rapidly and generate large amount market value in the next five years.

- As the size of the information economy expands, many APEC member economies has upgraded IOT to one of the most important priorities of their innovation strategies.

- Government should promote the IOT Infrastructure development. Data is at the heart of the IOT and it needs to be shared, connected, and analysed through a robust infrastructure.

- Governments need to play a role in the development of IOT, not just to enact and execute on strong policies to foster innovation but also to strengthen the regional cooperation, such as establish the sustainable and cohesive policy frameworks that mandate cross-border collaboration for all policy, economic and social initiatives.

2. The Development of IOT

2.1 IOT Service Definition

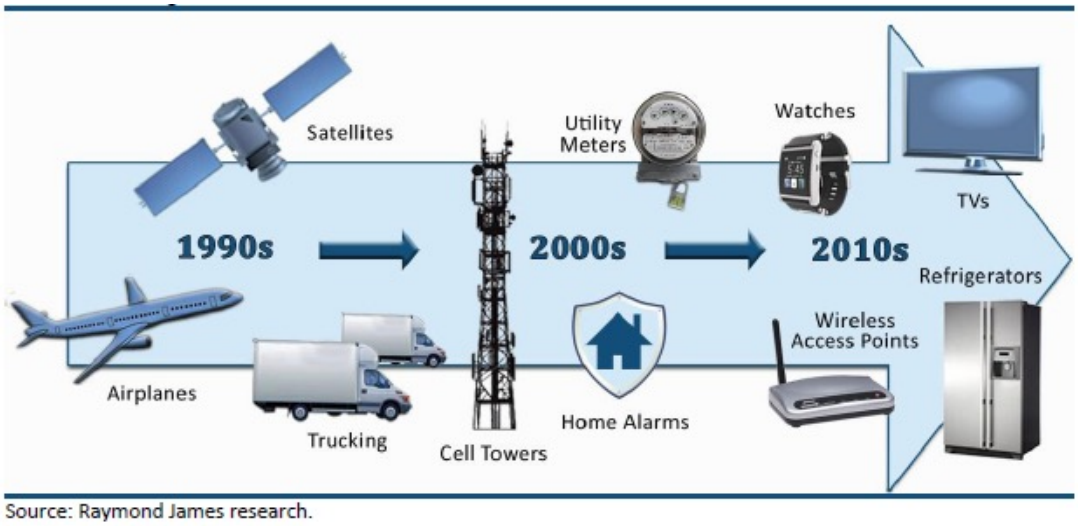
IOT is not an emerging industry or a vision, which can be traced back to late of 1990s. Connected "things" have provided benefits to enterprises and consumers for years, such as automated teller machines (ATMs), airline check-in machines and card-operated door locks. The concept of IOT expanded in the past two decades. At present, the IOT is the network of physical objects that can independently share data, instructions and decisions through intelligent networks.

"The IOT is the network of dedicated physical objects (things) that contain embedded technology to sense or interact with their internal state or external environment."[1]

"The Internet of Things is the combination of sensors, actuators, distributed computing power, wireless communication on the hardware side and applications and big data/analytics on the software side."[2]

[1] The Internet of Things and Related Definitions, Gartner, 2014
[2] The 'Internet of Things' is Now, Morgan Stanley, 2014

Fig. 1 The history of the commercial IOT products & services



Source: Raymond James research.

Machine-to-Machine (M2M) is one concept often related or synonymous with IOT. Strictly speaking, M2M is a kind of service from telecommunication carriers and IOT is a bigger concept that will impact not only the IT industry but also every industry. M2M is the most mature market of the IOT industry at present.

M2M communication services refer to connectivity services that link IOT "things" to central or back-and systems, without human input.[3]

M2M refers to SIM connections that enable mobile data transmission between machines，it does not count SIMs used in computing devices in consumer electronics such as smartphones, dongles, tablets, e-readers, routers or hotspots.[4]

2.2 The Drivers of IOT

IOT is the third wave in the development of Internet-based information systems. The first wave was the Internet wave in 1990s', which connected 1 billion users. The second wave was the Mobile Internet wave in 2000s which connected another 2 billion users and is growing fast. As the third wave, the IOT is predicted to connect 50 billion 'objects' to the Internet by 2020, ranging from bracelets, clothing, appliances, cars, offices, schools, houses and even cities. The convergence of connecting people, things, data and processes is already transforming our internal and external facing lives and everything in between.

[3] The Internet of Things and Related Definitions, Gartner, 2014
[4] From concept to delivery: the M2M market today, GSMA, 2014

With its huge influence, governments have placed IOT as a critical strategic level industry, relative to international organisations and private sectors.

- In 2005, the UN's International Telecommunications Union (ITU) published its first report on the IOT.

- In 2008, the EU held the first European IOT Conference.

- In 2008, U.S. National Intelligence Council listed the Internet of Things as one of the 6 'Disruptive Civil Technologies' with potential impact on US interests out to 2025.

- In 2009, Chinese Premier Wen Jiabao proclaimed the IOT a key industry for China and announced plans to make major investments in it.

- In 2011, the IPV6 protocol was launched, allowing for 2128 (approximately 340 undecillion or 340,282,366,920,938,463,463,374,607,431,768,211,456) unique addresses or as Steven Leibson, Director of Strategic Planning at Xilinx puts it, "we could assign an IPV6 address to every atom in every human on the earth."

- In 2011, the IOT-GSI Global Standards Initiative was created. It promoted a unified approach for development of technical standards enabling the Internet of Things on a global scale. Acquisitions, VC investment and government/corporate spending in the IOT space is rising dramatically.

- In 2014, AT&T, Cisco, GE, IBM and Intel announced the formation of the Industrial Internet Consortium (IIC), an open membership group focused on breaking down the barriers of technology silos to support better access to big data with improved integration of the physical and digital world.

- In 2015, IBM announced the creation of a new Internet of Things unit and an investment of $3 billion over four years to build it. At the core, IBM's new cloud-based platform aims to help businesses learn more about their industries based on the data coming through, whether it is through weather sensors, smartphones, appliances, cars and planes. It plans to then take that data and help eventually cut down on crime and power outages, minimize risk for firefighters and monitor water conditions.

Just as with technological revolutions of the past, the IOT creates a revolutionary and global information economy that can benefit governments, businesses and individuals. There are five driver factors:

1. **The popular of connectivity.** Fixed and wireless broadband technologies are very popular today - broadband access speeds have improved and the cost of services and devices have declined. Enterprises and the consumers have the payment capacity to connect machines and devices into the Internet.

2. **The matured embedded technology.** The costs of sensors are now economically viable for most situations, and the costs will continue fall.

3. **The huge smart devices market.** Smart devices are so popular and many people have more than one device. Customers can now directly control Internet refrigerators, medical equipment, industrial robots, sensors on machines remotely with their mobile phones.

4. **The Matured mobile internet ecosystem.** Enterprises can develop applications easily for many industries (including industry，agriculture, health care), control and gather data from devices and machines, help the information running and monitored through the entire value chain.

5. **The development of cloud-based infrastructure and big data.** Cloud computing and data analytics have paved the way for businesses to gain access to nearly unlimited amounts of data and analyse the data to get useful information.

2.3 The Ecosystem

The IOT can be depicted in a five-layered model, comprising devices, connectivity, applications, platforms, and analytics.

1. **Devices:** In this layer, the use of modules and devices with sensors, RFID tags and microcontrollers to obtain the object information anywhere.

2. **Connectivity:** Devices can be connected directly to the network, or indirectly through another similar device (mesh) or a gateway with wireless broadband (Wi-Fi/Cellular), fixed broadband, Bluetooth, Zigbee, and all other kinds of communication technologies.

3. **Platforms:** Devices and connectivity requires a platform to provide a service. Platforms provide the devices, manage and control them.

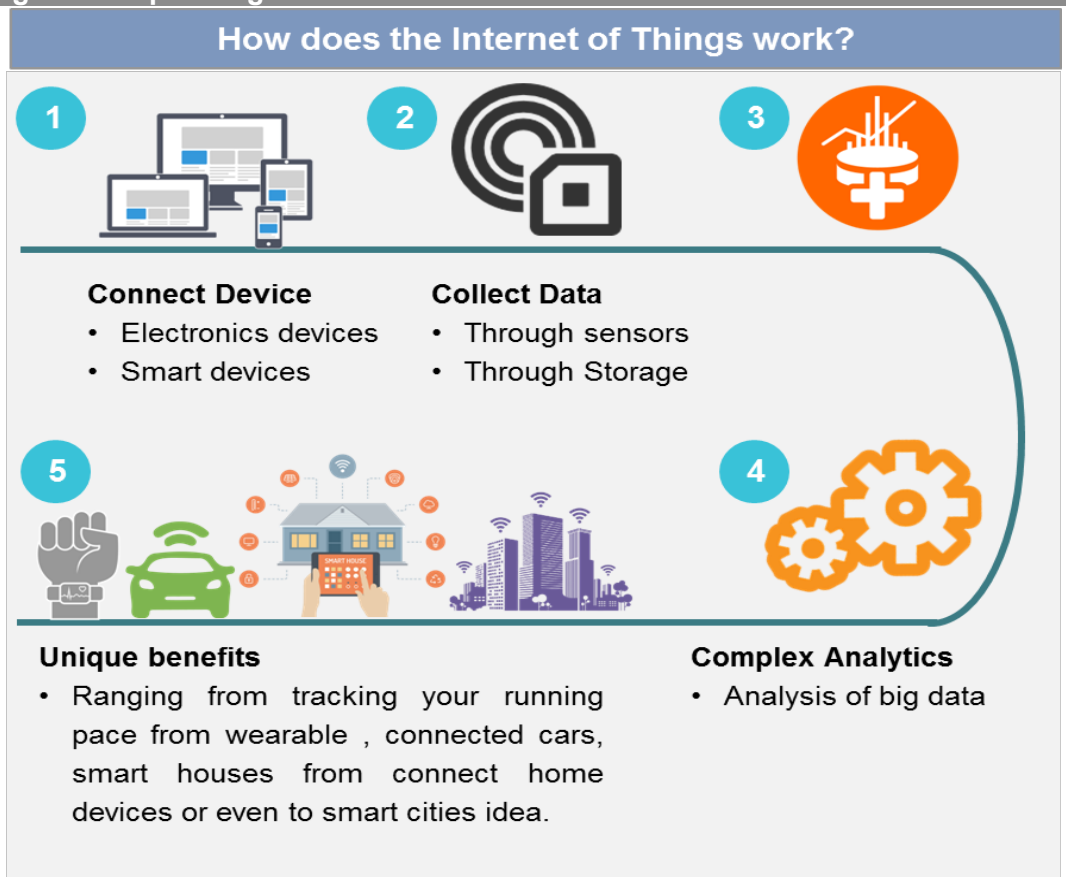
4. **Applications:** Applications define the use case of the device and include all the necessary functions required to make use of the device for the intended purpose including the hardware and software architectures. IOT

application stores are emerging with applicability to specific industry verticals, with the health wearable devices being a recent example.

5. **Analytics:** IOT devices can bring huge volume of data. This data includes all kinds of information about person, environment, machines, production, etc. The IOT service provider needs to analyse the mass data and use the results to make forecast， diagnose problems，decisions，and optimize resources in industries such as manufacturing, transportation and healthcare.

The IOT ecosystem is expected to create economic value of $1.9 trillion.

Fig. 2 The operating mechanism of IOT

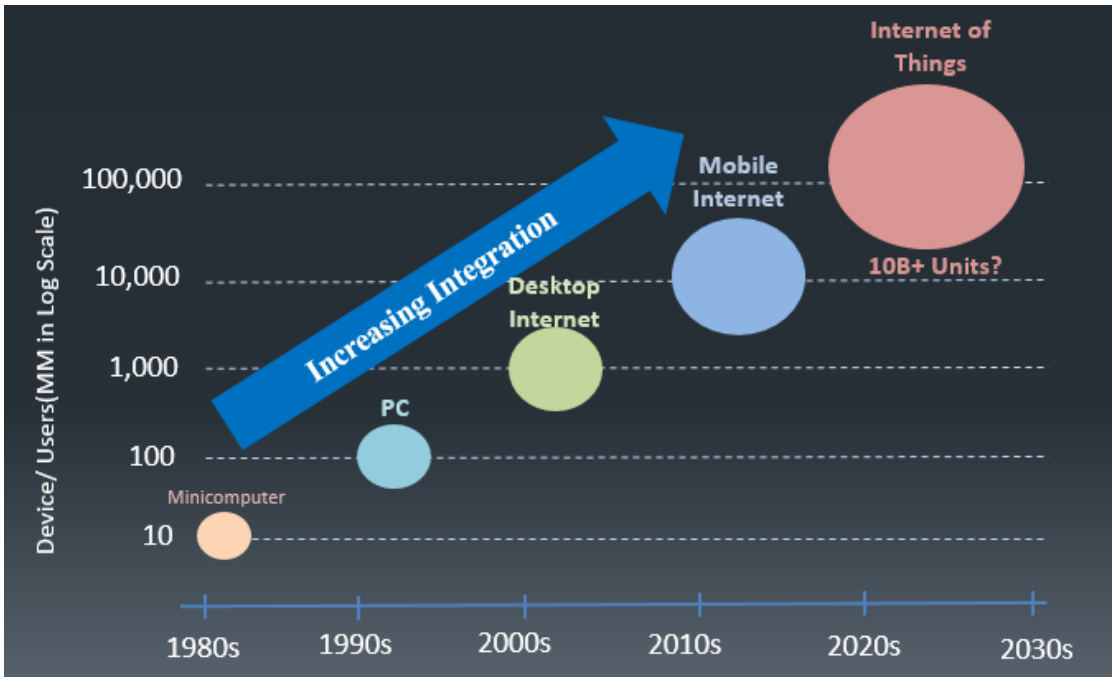


Source: TIME Consulting

2.4 The Market of IOT

According to Morgan Stanley, each new computing cycle typically generates around 10 times the installed base of the previous cycle. The handset market was the first billion level market for semiconductors. The IOT is posed to become the first computing market to reach 10 billion level.

Fig. 3 Each new computing cycle typically generates around 10x the installed base of the previous cycle



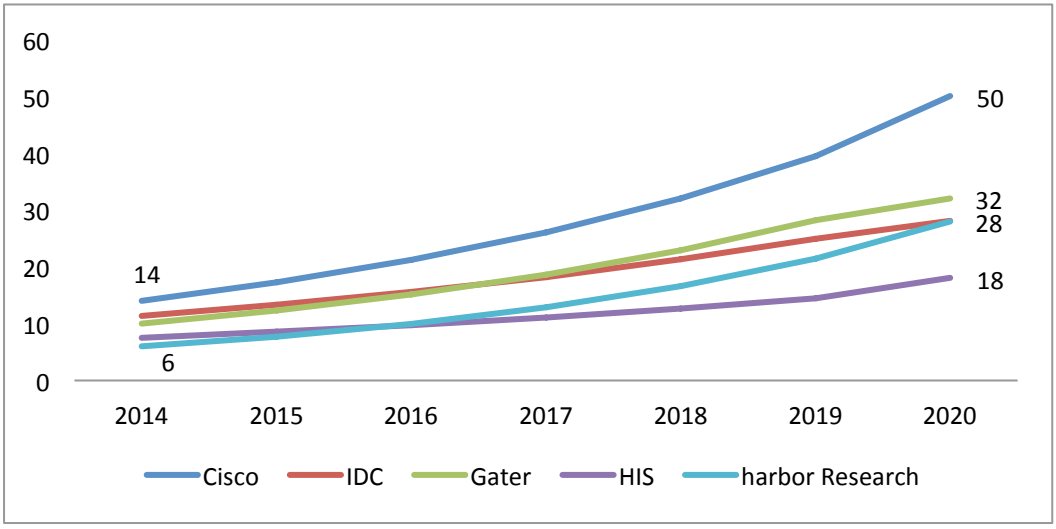
Source: Silicon Labs. Thomson Reuters, Morgan Stanley.

During our study, we summarised many of the major IOT devices market forecasts from Cisco, IDC, Gartner, HIS and Harbor Research. According to these statistics, the number of the IOT connected devices, which do not include smartphones, tablets, and computers, is approximately between 6 and 14 billion on 2014, and expected to be roughly 18 billion to 50 billion on 2020.

There are two main reasons for the differing predictions from these companies we surveyed. First, the differing roles played by these companies in the IOT ecosystem. Cisco is an IT company and the others are consulting companies. Second, the companies used different methodologies to evaluate the market.

Notwithstanding, all these companies agree that there will be a massive increase of Internet connected devices in the next five years. The expected growth rates are well beyond those of most other industries that are being forecasted (Annual growth rates ranging from 14% to 29%). For every person living on earth, there will be at least two, maybe even six connected “things” by 2020.

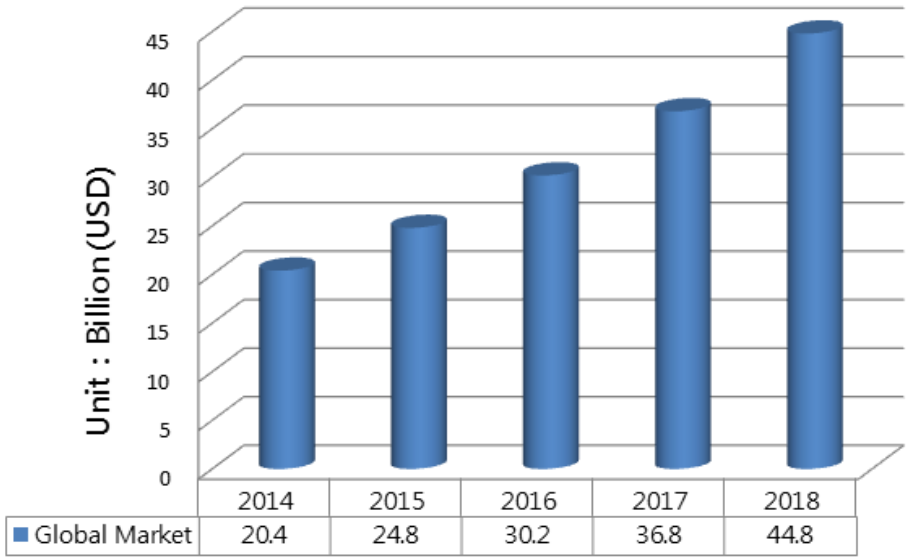
Fig. 4 Global Internet-Connected devices forecast by 2020 (in Billion)



Source: Cisco (2013), IDC (2014), Gartner (2013), HIS (2014), Harbor Research (2014)

According to Ovum, the global IOT market scale will be 44.8 billion dollars in 2018. The Asia-Pacific region will be the largest market, reaching $15 billion in 2018, with the highest Compound Annual Growth Rate (CAGR) growth rate (26.3% from 2014 to 2020).

Fig. 5 Global market forecast

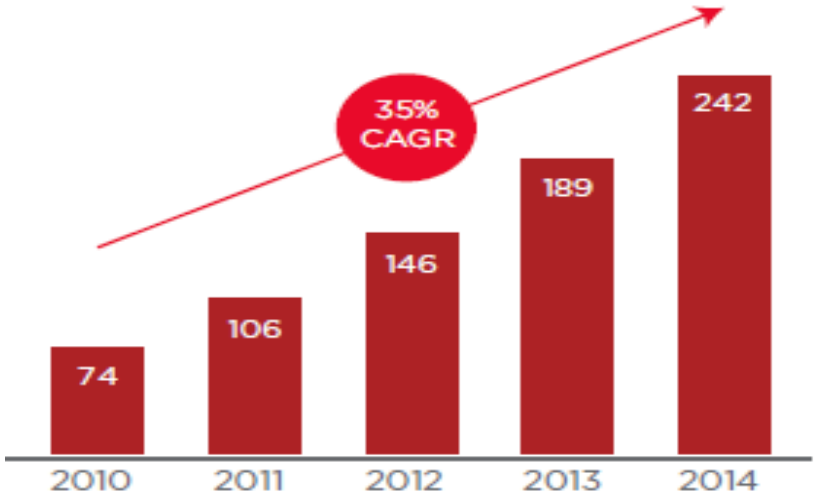


Area	2014	2018	CAGR
1.Asia-Pacific	5,909	15,056	26.3%
2.North America	5,650	11,040	18.2%
3.Western Europe	5,313	10,381	18.2%
4.South and Central America	1,460	3,392	23.5%
5.Eastern Europe	931	2,162	23.5%
6.Middle East	843	1,949	23.3%
7.Africa	323	820	26.2%
Total	20,430	44,800	21.7%

Source: Ovum (2013)

At present, M2M is the most mature market of IOT, and the market is growing very fast. According to the GSMA report, "How China is set for global M2M leadership", there had been 242 million M2M connections globally by the end of 2014, the CAGR during 2010 to 2014 is 35%.[5]

Fig. 6 Global M2M connections (million)



Source: GSMA Intelligence

3. The Promotion of IOT for the Information Economy

3.1 The Impact of IOT for the Information Economy

The development of IOT infrastructure will promote the connectivity of physical ICT infrastructure directly. Innovative IOT applications will profoundly affect all aspects of social production, consumption and operation, which will significantly contribute to the institutional and people-to-people connectivity both in urban and rural area in many aspects:

1. **Improve efficiency:** Sensors can now be directly connected and integrated into enterprise systems. The valuable data in real time can be used to estimate, analyse and inform decision-making processes to improve on the production process, adjust its development and production cycles and responsiveness according to the demands.

[5] How China is set for global M2M leadership, GSMA, 2014

2. **Cost reduction and saving energy:** Smart Grid GB estimates that a £19 billion of savings might be achieved in the energy sector by upgrading the UK's network to a 'smart grid[6].

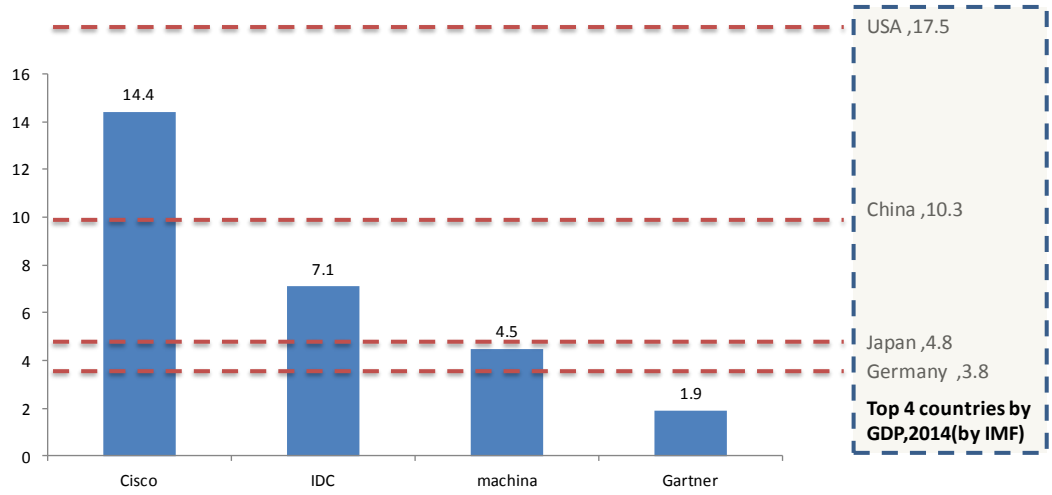
3. **Avoid loss and accident:** More robust safety measures in autonomous vehicles and smart transport infrastructure could reduce the £34.3 billion annual cost for traffic incidents[7]

4. **Promote consumption:** IOT applied in smart devices, TV set and vehicles will bring out new and upgraded products, including wearables, connected car and smart TV.

5. **Create new business opportunities:** The real value of IOT lies in the production, capture and analysis of real time data, and the possibility of using this data for social good. This is promoting business innovation, such as IOT data analysis. Many new start-up companies are emerging, creating new business models and generating employment for the society.

IOT will have a massive economic impact in the future. Cisco, IDC, Gartner, and Machina have published forecasts of the "value" of the Internet of Things for the global economy, projecting that it will reach between $1.9 to $14.4 trillion in 2020. Notwithstanding the disparity given the differing definitions of "value", these companies agree that IOT will have a massive economic impact. In both Cisco's and IDC's scenarios, the global value of IOT would surpass the GDP of Japan today in less than 5 years.

Fig.7 Industry projections for Global Economic Value of the Internet of Things in 2020 ($trillions)



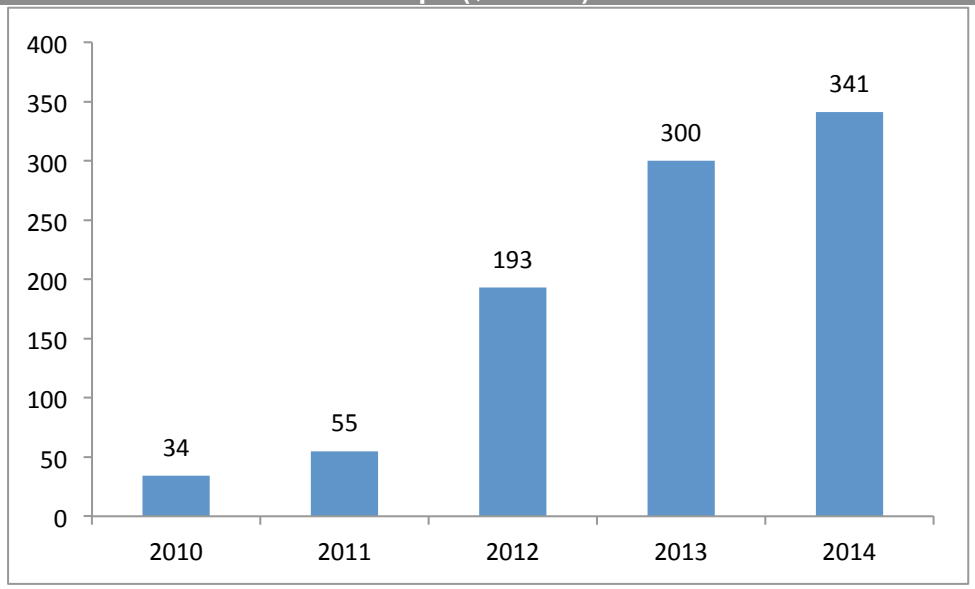
Source: IMF

[6]'GB Smart Grid: a race worth winning?: a report on the economic benefits of smart grid', Ernst and Young, 2012

[7] Smart Cars and the IOT', ABI Research, 2014

The capital market has also seized the opportunity of IOT. According to Business Intelligence (BI), $341 million was invested on IOT start-up firms in 2014, and it was 10 times as much as in 2010.

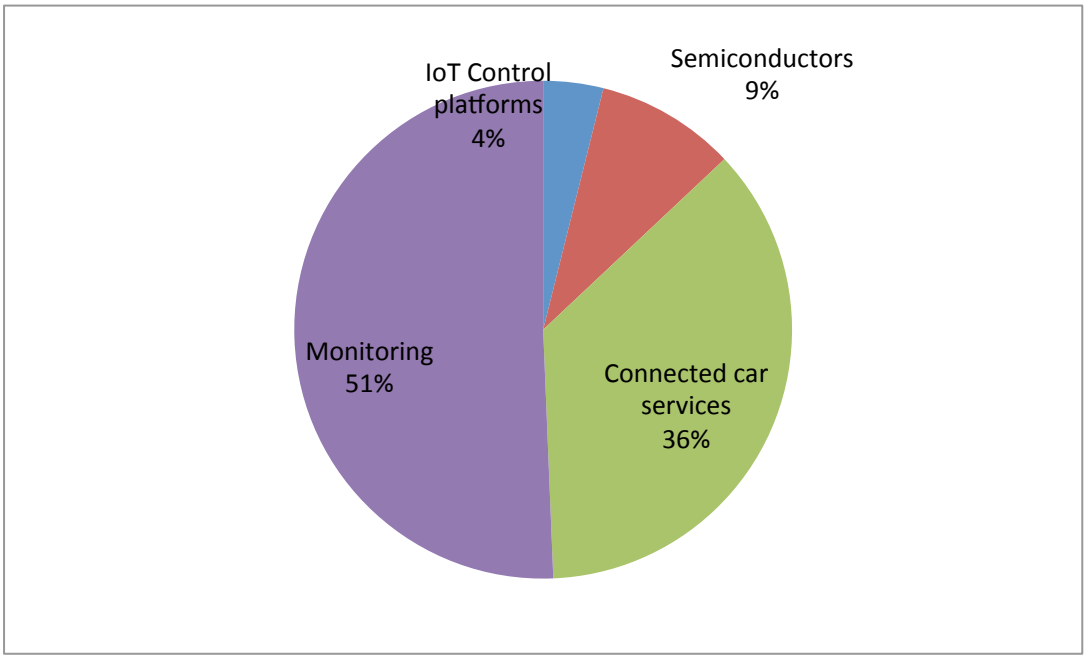
Fig.8 VC investment in IOT Start-ups ($million)



Source: BI, CrunchBase, Tech Crunch

There is an increased volume of mergers and acquisitions in IOT market. Total value of mergers and acquisitions in the IOT field is about $7.7 billion worldwide from January 2012 to November 2014.

Fig.8 IOT M&A activity January 2012-November 2014



Source: BI, Hampleton Partners

3.2 Applications in Vertical markets

IOT market comprise many vertical markets. The vertical markets can be summarised into three segments: consumer market, government market and enterprise market. Each segment has many sub-markets. The government market is specialised, because governments need to organise and promote, the applications in this market, and the market is often called a smart city.

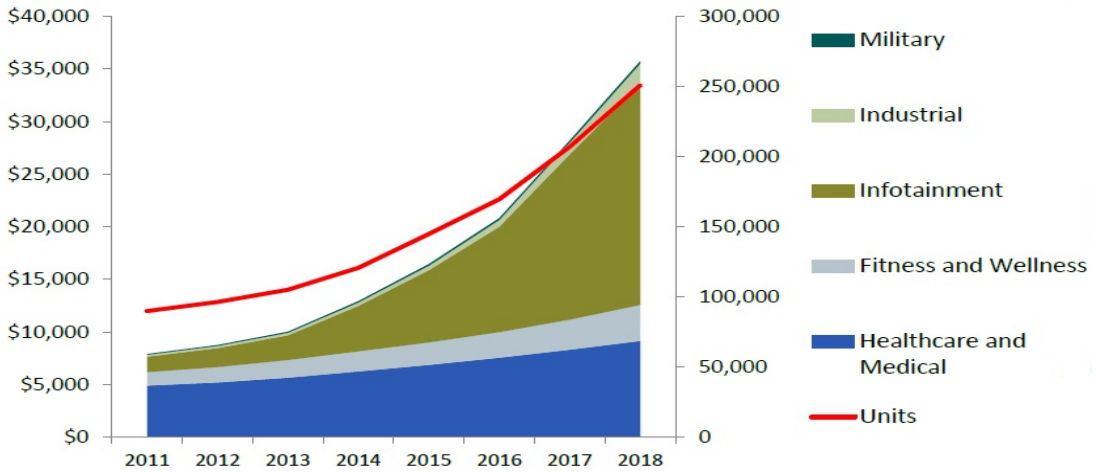
According to our study, wearable, healthcare, connected car, manufacturing and smart city will develop rapidly and generate huge market value in the next five years.

3.2.1 Wearable devices

Wearable devices have received lot of attention lately, and many vendors - including big names such as Google - are throwing their hats into the wearable market. A wearable device is an electronic device capable of storing and processing data that is incorporated into a person's clothing or personal accessories.

The most promising applications in wearable devices market are infotainment, fitness and healthcare. Because these applications can satisfy people's needs of life and are easily controlled with smart devices like smart phones. According to IHS, there will be 250 million wearable devices in 2018, most of them are applied in the three vertical markets. The service revenue will exceed $6 billion in 2018 inclusive of remote patient monitoring, support for gaming and enterprise applications, and military research.

Fig.9 World market for wearable devices and service($millions,000 units)



Source: IHS

There are all kinds of wearable devices in the market: smart glasses, smart clothing, smart watches, smart wristbands and so on. Other than the famous wearable devices like Google glasses, Apple watch, there are many other innovation products.

CardioNet, a company in USA, has developed an integrated technology and service - Mobile Cardiac Outpatient Telemetry™ (MCOT™) - which enables heartbeat-by-heartbeat, ECG monitoring, analysis and response, at home or away. CardioNet monitors patients 24 hours a day via a small sensor and monitor patients as they continue with their normal daily routines. As events occur, patient activity is transmitted automatically to the CardioNet Monitoring Centre for analysis and response.

Xiamen Yunduo Network Technology Co. Ltd, a start-up company in China, has designed a device to help parents locate their children via GPS on their smartphones. The accuracy can reach 5 meters in an open area. Parents can also determine a safe zone for the child. Once the child leaves this zone, the GPS tracker will alert the parents via an app. These GPS tracker shoes can also remember a child's whereabouts. When the child reaches a new area unrecognised by the tracker, it will send an alert immediately. Parents can also create a supervisor group and invite other friends or family members to look out for their children. Priced at US$48, these shoes are inspired by Marvel and Disney characters, and use a 370mAh polymer battery that can last for 32 hours on one charge.

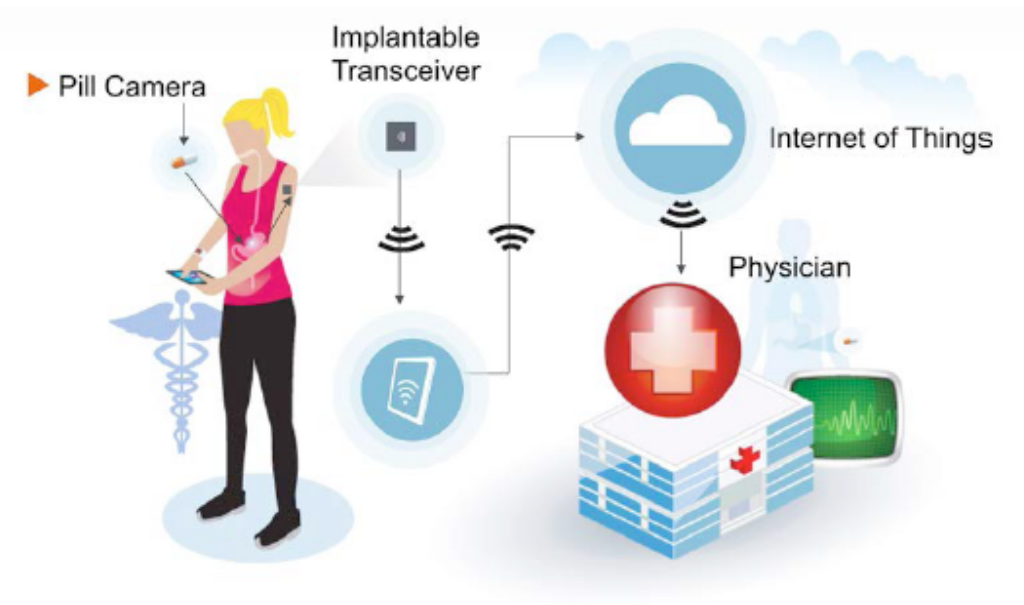
3.2.2 Healthcare

A number of connected devices have been developed to improve health care delivery. Over the past 10 to 15 years, health care providers have increasingly become connected through mobile computers, iPads, iPhones, Wi-Fi phones, and communications badges. A number of companies are now working on developing further connectivity to improve communication between health care givers and patients by using IOT technology. In addition, many applications in healthcare have been developed to reduce cost and improve patients experience.

Remote monitoring: There are people all over the world whose health may suffer because they do have ready access to effective health monitoring. Small, powerful wireless solutions connected through the IOT are now making it possible for monitoring. These solutions can be used to securely capture patient health data from a variety of sensors, apply complex algorithms to analyse the data and then share it through wireless connectivity with medical professionals who can make appropriate health recommendations. Utilising remote monitoring in patients with cardiac and chronic diseases is expected to

save $36 billion in the healthcare industry.

Fig.10 Remote Patient Monitoring



Source: Freescale

Home care: We see the IOT as an important tool for handling the greatest acceleration in home care demand to deal with aging population issues. An aging population is a big issue not only for developed economies, but also for developing economies like China. As more elderly require healthcare services at home and most of them live alone, IOT enables monitoring, alarm, remote advice and integrate all data in cloud-based solutions, which the patients, hospitals and insurance can access easily.

Fig.11 Typical home care service

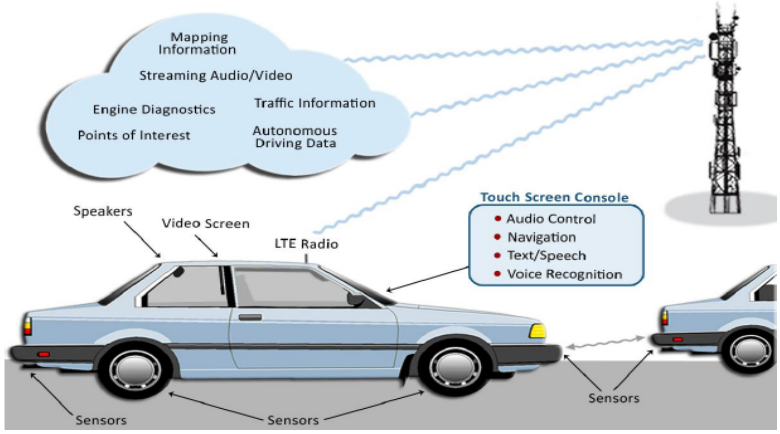
Source: Raymond James research

Improve care management: Healthcare industry data is characterised by its vast size, complexity, and distribution across a large and heterogeneous set of industry participants. This issue makes healthcare industry inefficient and increases costs. According to the US Center for Medicare & Medicaid Services (CMS) estimates, annual national health expenditures reached $2.9 trillion in 2013 and are projected to reach $5 trillion by 2022, of which 30%, or $786 billion is attributed to waste. The IOT can be combined with Big Data analytics to improve care management of patients with chronic diseases or target preventative actions when early signs of a disease episode are detected. For example, sensors in medical devices attached to patients can capture vital signs and other data and wirelessly transmit it to centralized repositories, which consolidate patient health information. Big Data analytical algorithms could then monitor patient health in real-time and trigger interventions by a patient's care management team. The use of 'smart' interconnected devices and automated Big Data algorithms would not only reduce costs from avoidable patient health emergencies and associated hospital admissions, but also improve the operational efficiency of hospitals and clinics by reducing the amount of manual oversight involved in patient monitoring.[8]

3.2.3 Connected car

Connected car is not new, telematics services have been on market for years. Telematics services including automatic crash notification, stolen vehicle assistance, diagnostics, and navigation. With IOT and wireless (3/4G, Wi-Fi) technologies, there are new applications including remote downloading of mapping/traffic information, fuel saving, accident avoidance and streaming digital music and video, the connection can be extended to vehicle-to-vehicle and vehicle-to-roadside with sensors.

Fig.12 Information flows of the connected car

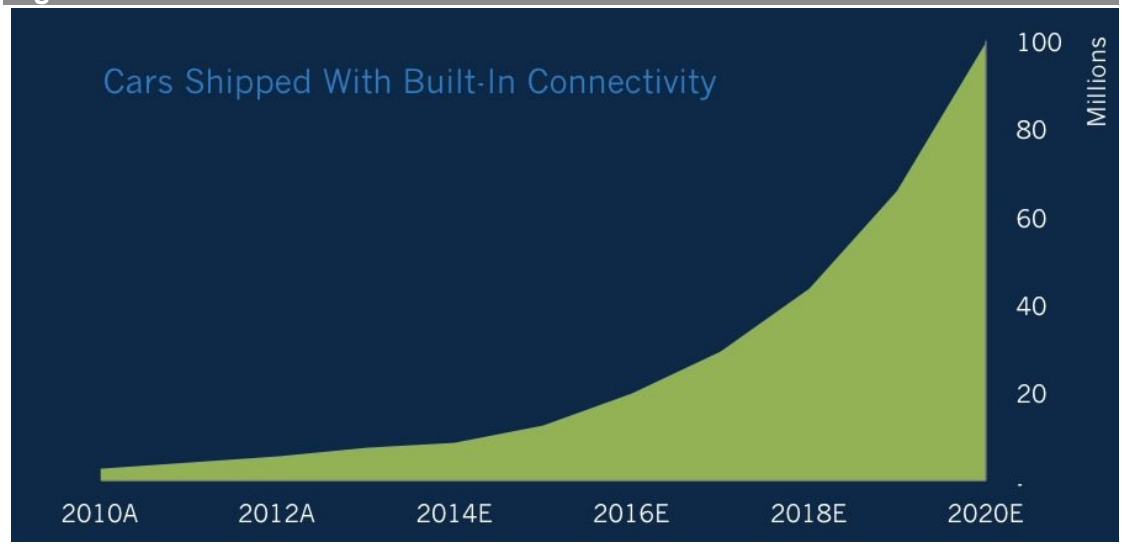


Source: Raymond James research

[8] The 'Internet of Things' Is Now, MORGAN S TANLEY, 2014

According to BI, there will be 100 million new cars will have their own internet connections by 2020. And major manufactures have entered this huge market, including Audi, BMW, Volvo, and Ford.

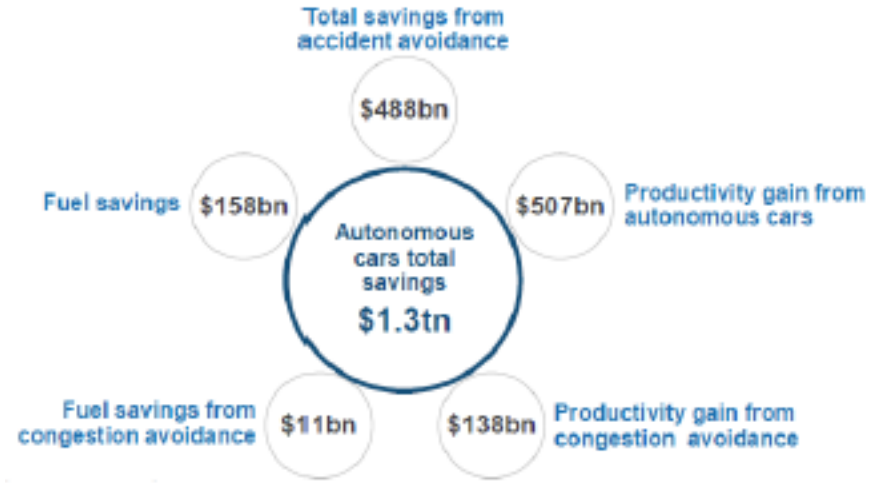
Fig.13 The forecast of connected cars



Source: BI

Connected car is not only a huge market but also make significant contribution to global GDP. Morgan Stanley Research believes the US economy can save $1.3 trillion per year once autonomous cars become fully penetrated. To put that number in context, it represents 8% of US GDP. Extrapolating these savings to a global level by applying the ratio of US savings / US GDP to global GDP, Morgan Stanley Research estimates global savings from autonomous vehicles to be in the region of $5.6 trillion per year.

Fig.14 Potential US cost savings



Source: Company Data, Morgan Stanley Research

3.2.4 Manufacturing

"Smart Manufacturing" becomes the norm in a world where intelligent ICT-based machines, systems and networks are capable of independently exchanging and responding to information to manage industrial production processes. Smart Manufacturing will optimise plants and supply networks by starting to transform them into profit centres. Progressive businesses have already begun gathering information and manufacturing intelligence by investing in highly automated and IT-driven production. This manufacturing intelligence enables the factory floor to become a profitable innovation centre.

Early adopters foresee a smart manufacturing model flexible enough to respond to global consumer demand and bring to life innovations such as the electric-powered car or other game-changers. Flexible factories can be more quickly reprogrammed to provide faster time to market today and the next generation of mass customisation. Smart manufacturing marries information, technology and human ingenuity to bring about a rapid revolution in the development and application of manufacturing intelligence to every aspect of business. It will fundamentally change how products are invented, manufactured, shipped and sold. It will improve worker safety and protect the environment by making zero emissions, zero-incident manufacturing possible. It will also enable an interconnected, efficient global industrial ecosystem.

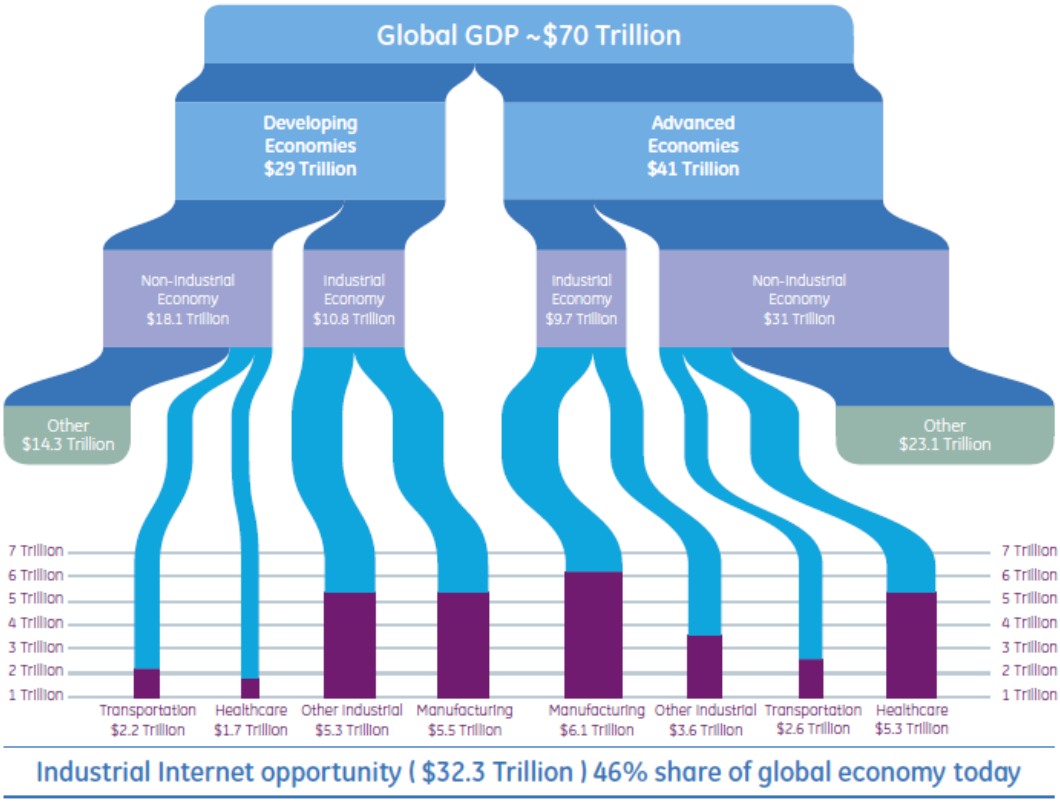
While manufacturers have been generating a large volume of data for years, companies have had limited ability to store, analyse and effectively use it. New big data processing tools are enabling real-time data stream analysis that can provide dramatic improvements in real time problem solving and cost avoidance. Big data and analytics underpin competitive capabilities such as forecasting, proactive maintenance and automation. A good example is a global food processor that makes 800 different kinds of flour. The company uses predictive tools and services to forecast pricing, capacity requirements, and customer demand. This allows the company to maximise revenues through improved margin decisions and to increase production capacity utilization by 5%.[9]

As GE predicted, when traditional industry is combined with the transportation and health services sectors, about 46 percent of the global economy or $32.3 trillion in global output can benefit from the Industrial Internet. As the global economy and industry grows, this number will grow as well. By 2025, we estimate that the share of the industrial sector (defined here broadly) will grow to approximately 50 percent of the global economy or $82

[9] The Cisco Connected Factory: Powering a Renaissance in Manufacturing, 2014

trillion of future global output in nominal dollars.[10]

Fig.15 Industrial Internet Potential GDP Share



Source: World Bank, 2011 and General Electric

3.2.5 Smart city

A smart city uses innovation and technologies to enhance performance and well-being, to reduce costs and resource consumption and to engage more effectively and actively with its citizens.

Cutting-edge ICT systems and other modern innovations play an important role in the success of today's cities. ICT networks enable integration into global production chains, facilitate rapid information sharing and participatory communication, and decrease the traditional challenges of distance and time. A thriving, modern city leverages ICT and a smart and resilient infrastructure to facilitate and enhance its economic growth. It has significant impact on the efficiency and capacity of infrastructure and service delivery to citizens, their economic opportunity, and overall quality of life. Smart cities could therefore provide:

[10] Industrial Internet: Pushing the Boundaries of Minds and Machine, 2012

- Better and more convenient services for citizens;
- Better city governance;
- A better life environment;
- More modern industry, that is greener, and more people friendly;
- Smarter and more intelligent infrastructure; and
- A dynamic and innovative economy.

Gartner, Inc. estimates that 1.1 billion connected things will be used by smart cities in 2015 (see Table 1), rising to 9.7 billion by 2020. Smart homes and smart commercial buildings will represent 45 percent of total connected things in use in 2015, due to investment and service opportunity, and Gartner estimates that this will rise to 81 percent by 2020.

Residential citizens will lead the way by increasingly investing in smart-home solutions, with the number of connected things used in smart homes to surpass 1 billion units in 2017. Connected things include smart LED lighting, healthcare monitoring, smart locks and various sensors for things such as motion detection or carbon monoxide. Smart LED lighting will record the highest growth of IOT consumer applications, from 6 million units in 2015 to 570 million units by 2020. Light will move from being an illumination source to a communications carrier incorporating safety, health, pollution and personalised services.

In addition to residential IOT investments, there are a number of IOT deployments for on-street and off-street parking guidance, road traffic guidance and traffic flow metering. A quick win within transport is the reduction of traffic congestion. California and the U.K. are already implementing radio receivers or sensors embedded on a section of highway to diagnose traffic conditions in real time. Another successful use of IOT in the city is smart parking. The city of Los Angeles, for example, has implemented new parking meters, parking space vehicle sensors, real-time parking guidance and a full parking management system to influence demand during peak times.

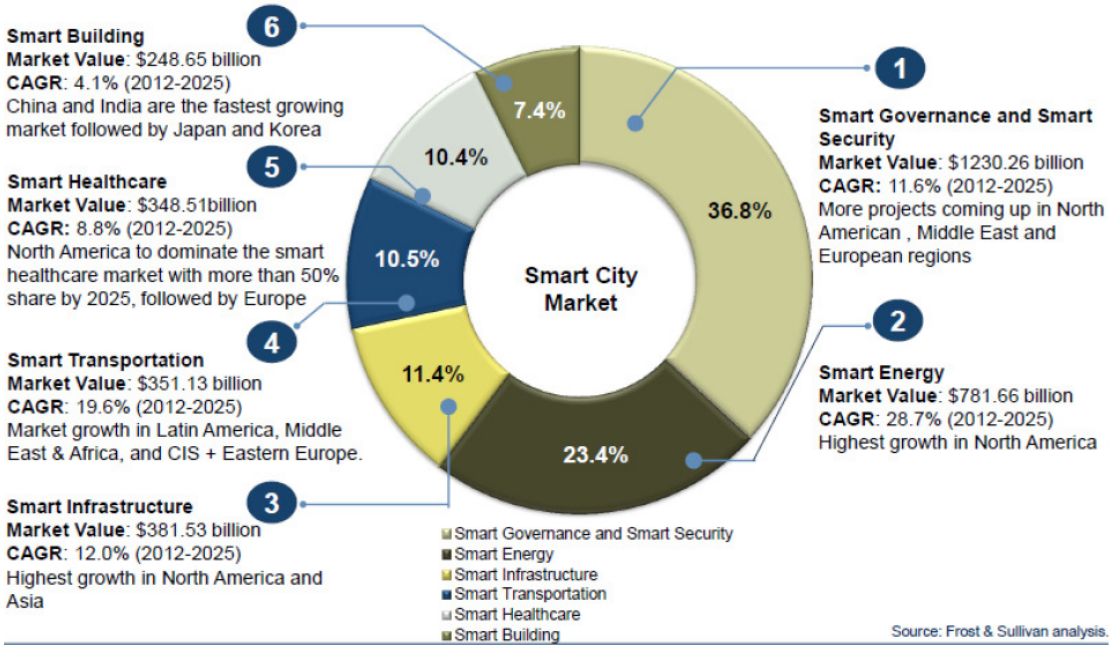
While investment in IOT hardware is fundamental for smart cities, the revenue opportunity is in the services and analytics sector. Gartner estimates that smart-home security and safety will represent the second-largest service market by revenue in 2017, and by 2020, the smart healthcare and fitness market would have grown to nearly $38 billion.

Table.1 Connected Things Installed Base Within Smart Cities (in Millions)

Smart City Subcategory	2015	2016	2017
Healthcare	9.7	15.0	23.4
Public Services	97.8	126.4	159.5
Smart Commercial Buildings	206.2	354.6	648.1
Smart Homes	294.2	586.1	1,067.0
Transport	237.2	298.9	371.0
Utilities	252.0	304.9	371.1
Others	10.2	18.4	33.9
Total	**1,107.3**	**1,704.2**	**2,674.0**

Source: Gartner (March 2015)

Fig.16 Global smart city market by segments, 2025



Source: Frost & Sullivan analysis

3.3 The trend of IOT

3.3.1 The trend of IOT ecosystem

With the rapid development of the IOT, the private sector within the IOT ecosystem gradually find their own roadmaps in the IOT services. Given the huge development potential of the IOT industry, there are opportunities for all kinds of companies to develop their business models and profitable markets.

- **Sensors/ Gateway vendors**

Many vendors set up industry alliances to compete on IOT standards. The chip providers attempt to dominate the market and seize the market share.

The Linux Foundation has announced the formation of the AllSeen Alliance, a new consortium dedicated to building and maintaining an open-source framework that lets devices of all shapes and sizes seamlessly communicate with each other. Qualcomm, LG, Panasonic, Haier, Silicon Image and TP-LINK are headlining the initiative, which also includes names as diverse as Cisco, Sears, and Wilocity. Qualcomm is the leader of the alliance because the entire AlleSeen Alliance is based on Qualcomm's technology.

The Open Interconnect Consortium (OIC) focuses on defining a common communications framework based on industry standard technologies to wirelessly connect and intelligently manage the flow of information among personal computing and emerging IOT devices, regardless of form factor, operating system or service provider. The member companies include Atmel Corporation, Broadcom Corporation, Dell, Intel Corporation, Samsung Electronics Co., Ltd., and Wind River. Member companies will contribute software and engineering resources to the development of a protocol specification, open source implementation, and a certification program, all with a view of accelerating the development of the IOT. The OIC specification will encompass a range of connectivity solutions, utilising existing and emerging wireless standards and designed to be compatible with a variety of operating systems. Leaders from a broad range of industry vertical segments – from smart home and office solutions to automotive and more – will participate in the program.

Samsung, Google-owned Nest Labs, and five other companies have collaborated to create Thread Group, which will focus on developing a new wireless-networking protocol for smart homes. Thread uses both the same frequency and radio chips as Zigbee, a standards-based wireless technology utilised by products like Phillips' customisable Hue LED light bulbs. It can connect more than 250 devices to a low-power, mesh network equipped with internet and cloud access. The new protocol is intended to address some of the issues present within the competition, including lack of interoperability, high power requirements, and hardware dependencies.

- **Smartphone vendors**

Smartphone is becoming the control Hub of IOT services. IT vendors have an advantage in terminal devices and provide development tools.

Apple has positioned itself to be the “home base” of the “Internet of things” by introducing CarPlay, HomeKit and HeathKit. With its iOS devices, Apple have become the centre of the Internet/Bluetooth connected “things”. Apple is providing the platform for all the IOT products to connect to or to be monitored by them: a platform for health, home, car and everything around customers.

Google Fit is a fitness-centred app that seeks to help users in effortlessly tracking physical activity released by Google. The Google Fit app uses sensors that are built into Android smartphones to automatically detect if the user is walking, running or biking. Users can also set specific fitness goals in Google Fit, progress of which can be monitored by the app and brought forward by the user's activities within each day. Users are also given the ability to connect fitness devices and apps to Google Fit. Such devices and apps include Withings, Strava, Noom Coach and Runkeeper.

Android Auto was announced on June 25, 2014, at Google I/O 2014, and released on March 19, 2015. The standard app offers drivers control over GPS mapping/navigation, music playback, SMS, telephony, and web search; both touchscreen and button-controlled head unit displays are supported, although hands-free operation through voice commands is emphasised to ensure safe driving. Compatible apps include Google Maps, Google Play Music, MLB at Bat, Spotify, Songza, Stitcher, iHeart Radio, and TuneIn.

Smartphone vendors also collect and analyse data from sensors, and provide services as a control Hub. Google’s move to acquire Nest Labs and Dropcam highlights the company’s strategic vision of leading the smart home automation market. By incorporating a market leading home security solution alongside Nest Lab’s existing thermostat and smoke detector products, Google is taking an important step toward offering an ecosystem of smart home products and applications.

The SmartThings acquisition by Samsung shows the company is creating a connected home platform that can still work seamlessly. Samsung “fully supports” SmartThing’s vision of a “totally open smart home platform that brings together third-party developers, device makers, and consumers.”

- **Network operators and vendors**

Network elements need to handle charging, subscription and massive support for small packages. Currently, 3G/4G communications technologies are dominant and LTE-M technologies are expected to be dominant in the future. While operators and vendors are reviewing their connectivity roadmaps

against the IOT requirements and the potential threats from new entrants and start-ups, LTE-M, an evolution of LTE optimised for IOT in 3GPP RAN has been released. First released in Rel. 12 in Q4 2014 with further optimization expected in Rel. 13 in Q1 2016. LTE-M is touted as a superior solution to satisfy the connectivity profiles and requirements for IOT since cellular IOT provides an easy software upgrade of existing networks while providing optimised device KPIs, battery life, coverage and cost.

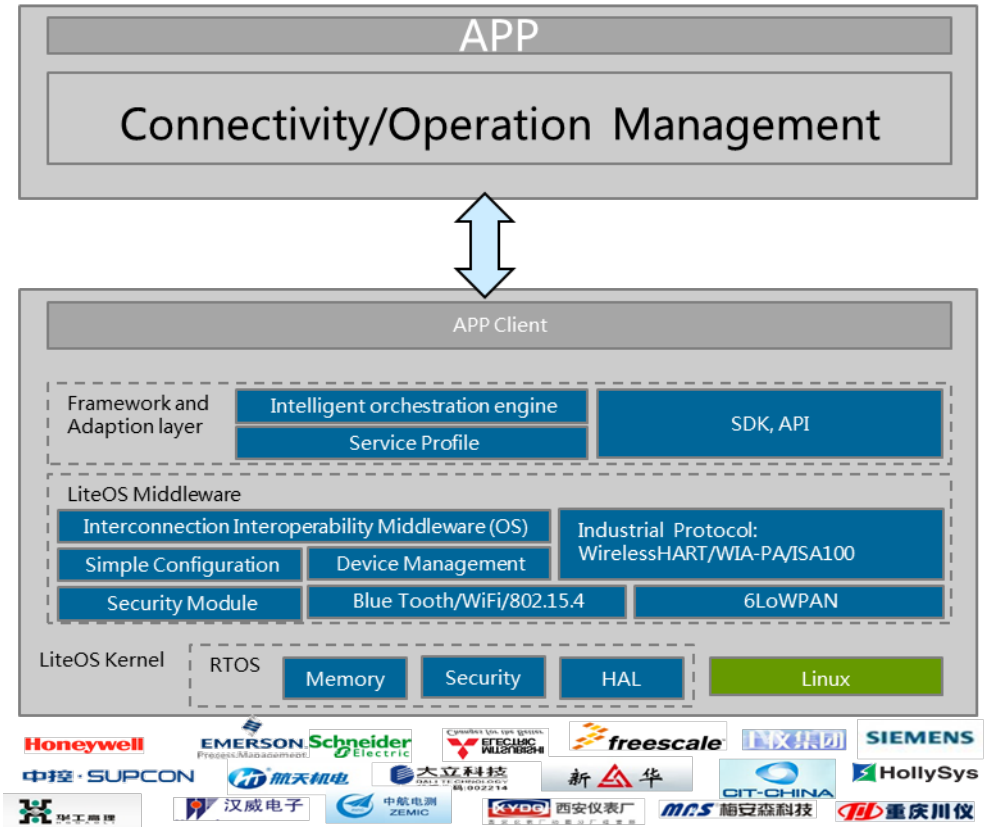
Besides network ability development, telecom providers also actively participate in engaging with proper terminal device vendors, in order to develop an IOT platform.

China Mobile has launched OneNet device cloud platform targeting Chinese enterprise users. The OneNet device cloud platform is a cloud service and information handling platform connecting terminals and applications. It provides Internet of Things enterprises with multiple protocols and access support and it can realize connection between smart devices and applications. In addition, it provides professional PaaS cloud services, targeting product prototyping, commercial use, and daily management.

AT&T Mobility is teaming with Ericsson, Amdocs, Jasper Wireless, Synchronoss and others to create the AT&T Drive, a mobile platform for developing LTE connected car services. In addition, the company and its partners are launching a 5,000-square foot facility to fine-tune those apps and services.

Huawei Technologies is targeting smart homes, cars, wearables and more with its own operating system, LiteOS for the international market. LiteOS can streamline the whole process. The LiteOS software can be as small as 10 kilobytes in size, and is designed to run on minimal power, making it suitable for a wide range of hardware, including microcontrollers and ARM Cortex embedded processors. Hardware running LiteOs can be controlled remotely or collect data. In addition, the operating system can be installed on devices already running Google's Android OS, and it can connect with other third-party devices. Chinese Internet players such as Baidu, Tencent and Alibaba are also moving into the Internet of Things space with their own software platforms, and Google's Android remains popular for mobile device development.

Fig.17 LiteOS Simplify Sensor Device Development



Source: Huawei

- **Big data companies and IT vendors**

Big data companies and IT vendors are using the information to create value and improve products.

IBM's 'smarter cities' initiative pushes the digitisation of a city's systems, turning the workings of those systems into measurable data points. Rio de Janeiro, in Brazil, has become one of the first cities in the world to gain 'smart city' status with the establishment of a centralised command centre that integrates more than 30 city agencies. The command centre helps the city improve emergency response co-ordination, manage increased traffic, and predict and counteract natural disasters.

Nest stores the data collected to understand how consumers need change over time. This way, Nest can best keep the consumers comfortable when they are home and conserve when they are not. For example, over time consumers can learn how their homes adjust to the change in and adjust the temperature and heating/cooling cycles accordingly.

3.3.2 The opportunities of IOT

Just as with tech revolutions of the past, the IOT creates a revolutionary and global information economy that can benefit governments, businesses and individuals. The opportunities of IOT industry are as follows:

- **Product development:** Better data will improve products and build relevance with customers. Businesses will have greater insights into how their products are being used, and this will influence the design and product development process.

- **Strengthen customer relationships:** Companies will have a deeper understanding of their customers, and this understanding will be more actionable than ever before. Actionable results regarding a consumer base will propel companies to build better and deeper relationships with their customers and thereby helping to extend the longevity of these relationships.

- **Increased demand for innovative products:** Internet connected products will spur demand for innovation across industries. Companies positioning themselves well for IOT will be at the forefront for this increased demand for innovative, smart and connected products and environments. What Apple did for the mobile phone will take place with other product categories, and companies realising the demand for IOT innovation will gain tremendous favour with consumers and B2B buyers.

- **Smarter, more relevant advertising:** Products will be internet connected. Constant network accessibility will transform the consumer, B2B buyer, the manufacturer and the marketer. Advertisers will be able to tap into the interests of buyers just as manufacturers will do and create more relevant experiences–helping to attract and convert potential buyers.

- **More companies will become tech/software companies:** The internet of things will create more demand for software and the data produced by IOT and connected products. As more companies become tech or software focused new marketing or revenue opportunities will emerge.

3.3.3 The Challenges of IOT

But challenges remain:

- IOT requires a new kind of 'trusted collaboration' as a globally unified and scalable network architecture is required across all developed and developing economies.

- IOT data will be often noisy, unstructured and real-time requiring a sustainable decentralised data ecosystem to store and analyse the vast amount of data.

- IOT infrastructure needs power. Without a large and collaborative investment in energy research, the IOT movement will stall.

- IOT puts many more doors on the networks that need to be securely locked and monitored.

- New economic, social and political understanding of IOT fundamentals is required. Those ahead of the curve will have a major advantage.

4. Policy Reference for IOT Development

4.1 Establishing specific plans and policies

As the size of the information economy expands, many APEC member economies has upgraded IOT to one of the most important priorities of their innovation strategies.

For example, China has unveiled "Internet Plus" action plan, aiming to integrate the Internet with traditional industries, and fuel economic growth. The Internet Plus concept was first presented by Premier Li Keqiang in March 2015. The action plan will integrate mobile Internet, cloud computing, big data and the Internet of Things with modern manufacturing, encourage the healthy development of e-commerce, industrial networks, and Internet banking, and help Internet companies increase their international presence.

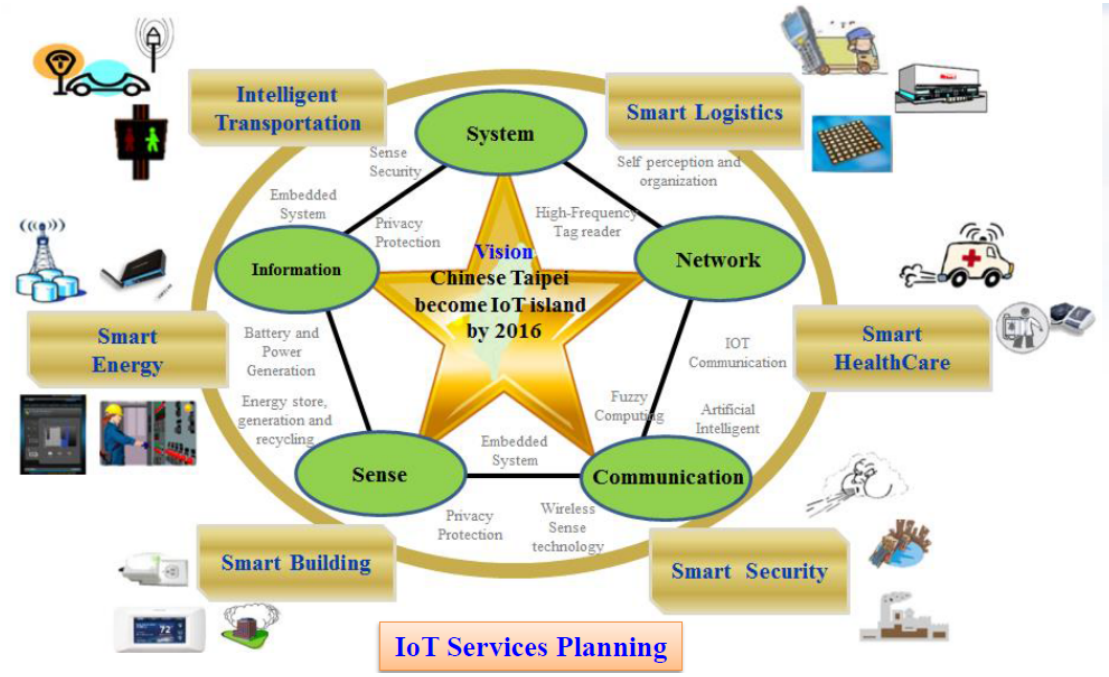
According to the action plan, China will push forward the integration of the Internet and traditional industries, fuelling its expansion from consumption industries to manufacturing. The action plan maps development targets and supportive measures for key sectors, which the government hopes can establish new industrial modes, including mass entrepreneurship and

innovation, manufacturing, agriculture, energy, finance, public services, logistics, e-commerce, traffic, biology and artificial intelligence.

The government aims to further deepen the integration of the Internet with the economic and social sectors, making new industrial modes a main driving force of growth by 2018. By 2025, Internet Plus will become a new economic model and an important driving force for economic and social innovation and development.

According to the Korea Ministry of Science, ICT, and Future Planning and the Ministry of Trade, Industry, and Energy, the government's goal is to foster an Internet of Things (IOT) and smart car business that will be worth 100 billion won ($90 million) by 2024. In 2015, the government will provide 1 trillion won in funding for various IT-related industries, including 77.2 billion won ($70 million) for IOT; 28.2 billion won ($25.5 million) for smart cars; 70 billion won ($63 million) for intelligence robots; 98.3 billion won ($89 million) for smart wearables; 77.1 billion won ($70 million) on its 5G networks; and 60.8 billion won ($55 million) on intelligence semiconductors. The government additionally plans to foster experts in each area, with small and mid-sized firms developing the technology themselves, and conglomerates working to commercialise them.

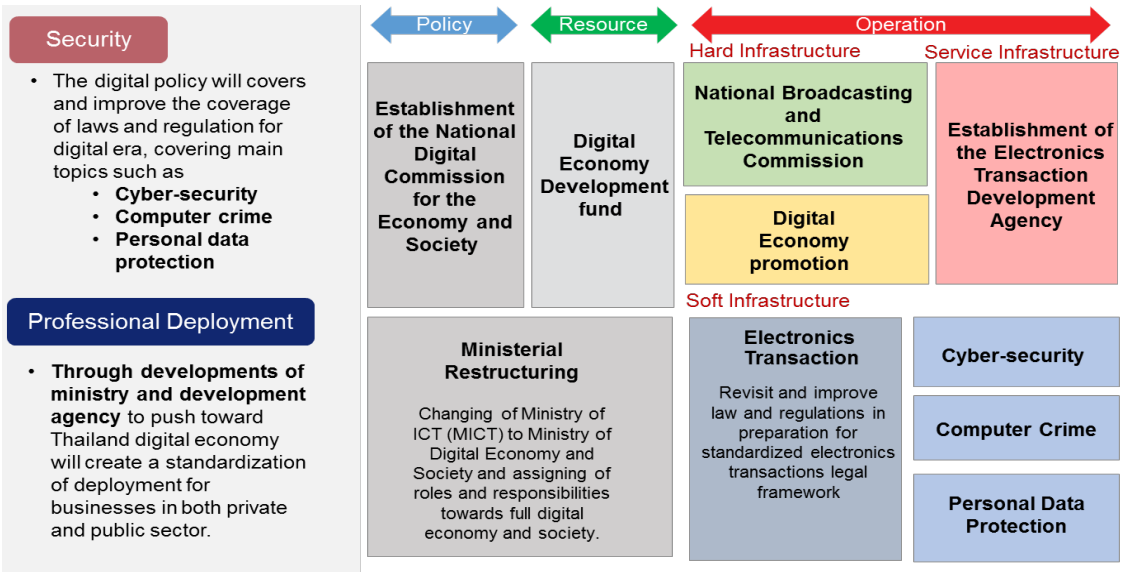
Chinese Taipei declared the vision is to become the IOT island by 2016 - 4G users would reach 10 million and a 90% coverage rate in 2016. 4G popularity will drive the rapid growth of IOT market. The actions include, first, developing leading technologies of multiple networks and service platform to help industry develop high-value products and solutions. Second, helping industry develop demonstrative fields of smart town and smart parks by means of advanced ICT and cross-field capabilities. Third, building industrial chain of smart life, and helping industry build successful cases and fight for international orders.



Source: Chunghwa Telecom Co., Ltd.

To drive IOT adoption, the Malaysian Ministry of Science, Technology and Innovation (MIMOS) launched the National Internet of Things Strategic Roadmap, which is expected to fund about US$2.49 billion to Malaysia's GNI by 2020. Other initiatives include Singapore's "Smart Nation", Bangkok's and Jakarta's Smart-City Programs, and the efforts of the private sector with Ericsson and ICT, among others. Thailand's draft digital economy policies covering legal, resource, and operation aspects will serve as a foundation towards security and deployment components.

Fig. 19 Developing Security and Deployment Components



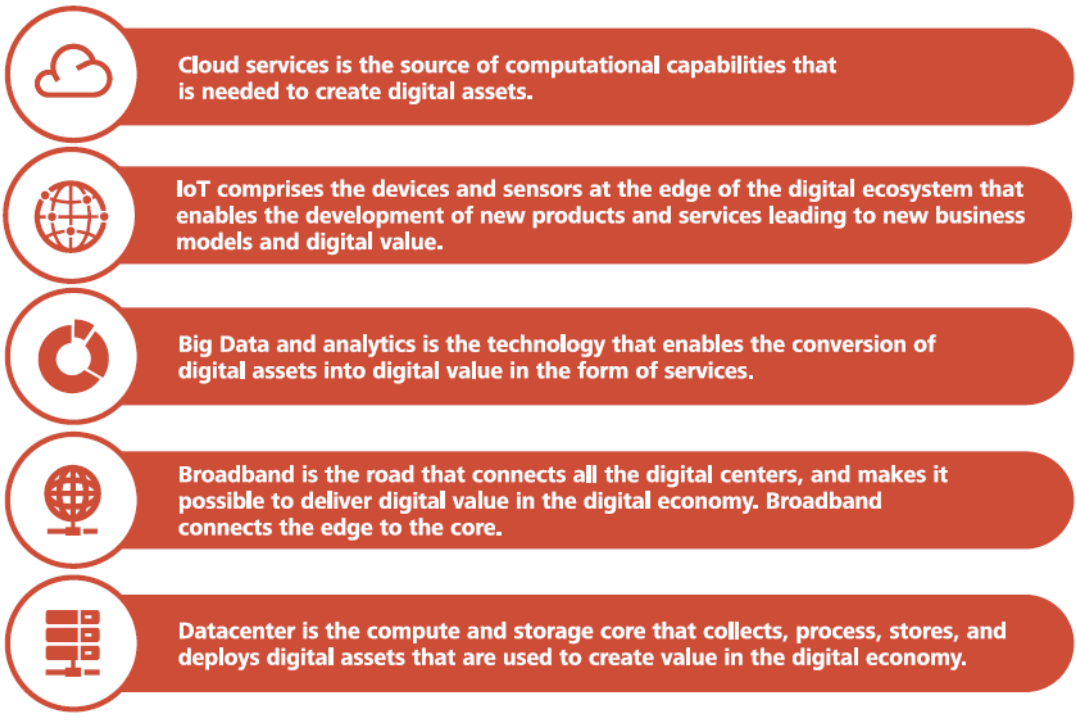
Source: TIME Consulting Co., Ltd.

4.2 Promoting the IOT Infrastructure

Critical to the long-term success of IOT is an investment in infrastructure and expanded bandwidth to build out wireless networks that will allow for communication between connected devices. However, the ways of promoting demand for IOT infrastructure vary among the economies with different level of technically literate.

The IOT infrastructure contains two (2) parts: CT infrastructure and IT infrastructure. The true power and influence of connectivity is truly vast in today's world, and can be seen and measured in five transformation enablers of cloud, the Internet of Things, Big Data, broadband, and data centre. These five areas are key transformation enablers to drive forward the digital economy. Any evaluation of the impact of connectivity on an economy's digital economy would need to consider the development progress of these five enablers as well.

Fig. 20 Five Transformation Enablers



Source: Huawei

The positive impact connectivity can have on any economy, socially and economically, is evident and correlates well with the dynamics around supply, demand, experience, and potential. According to Global Connectivity Index (GCI) calculated by Huawei, the United States finds itself fourth among its peers from a GDP per capita perspective. The United States scored "above

average" of its peers in all the connectivity categories and across all the horizontal attributes except one, that is, broadband. This is a result of lagging behind significantly in the proliferation of fibre to the home (FTTH), thereby reducing the availability of high-speed experience throughout its population. The next grouping of economies can be referred to as Followers. Unlike the leading economies, however, their performance does not exceed that of developing on average, the GCI score of the leading economies was 65% more than the average score of following economies and 130% more than the beginning economies. However, the average GCI score of following economies was 40% more than the average of beginning economies. Therefore, Follower economies as a group are closer to the Beginners than the Leaders, and this bears out with many of the performance scores.

The following suggestions are to help government and business leaders navigate the daunting march toward IOT development for the promotion of Information Economy:

ICT investment must begin at the core, without a robust infrastructure/foundation, anything built atop of it risks falling prey to low usage due to poor experience. Along with this investment should be directives to push IT budgets toward cloud-related projects and services. Data is at the heart of the IOT and it needs to be shared, connected, and analysed through a robust infrastructure.

Invest in IOT and Big Data. Every connection introduces new sources of data, and decisions will need to be made on that data. Generally, more data is a good thing, but only if something is done with it to create value, improve business, or to create innovative experiences. The leading companies are all moving to capitalise on IOT and Big Data — and there is still ample time to follow.

Improve experience to sustain demand. Experience can sometimes be in the body of the beholder, but when it comes to a digital economy, there are things that can happen that will not only disrupt one's experience, but also destroy business opportunities as well as technology adoption. Leading economies are moving fast to adopt technologies such as enterprise flash to improve the speed and agility of aging infrastructures. New flash-enabled systems excel at accelerating workloads, response times, and analytics on databases and data sets, structured or unstructured. There are plenty of other ways to improve experience, but ubiquitous broadband, real-time interactions, and speedy downloads are guaranteed to compel more use and more innovative solutions and applications.

4.3 Strengthen regional cooperation

The emerging Internet of things will affect many facets of lives, so we need to make sure that it is built in a structured, robust way. That entails cooperation between vendors, the creation of standards, and a certain amount of regulation.

We are already seeing organisations such as the Allseen Alliance emerge to enable cooperation across the private sector. But the focus of these groups is primarily on increasing and accelerating adoption of IOT. We believe this idea needs to expand beyond the business world and become a priority among governmental bodies that have more sway to implement the IOT initiatives that will have far reaching impact on both our business and personal lives.

Governments needs to play a role in the development of IOT, not just to enact and execute on strong policies to foster innovation but also to strengthen the regional cooperation, such as establish the sustainable and cohesive policy frameworks that mandate cross-border collaboration for all policy, economic and social initiatives.

For example, Europe and China have been very early adopters of the Internet of Things (IOT), although knowing that a complex endeavour like the IOT will probably take a decade for a wide scale adoption and market penetration. Besides valorising the economic potential of the IOT, the conviction for IOT stems also from the interest to address societal challenges, such as aging societies, environmental pollution and questions of sustainable resource management. In light of recent evolutions, the focus has also been adopted to consider topics like Smart Cities and 5G.

Since February 2011, under the coordination of DG CONNECT and MIIT-CAICT IOT experts from both regions met biannually for political and technical conversations, and improved coordination. The current focus of the cooperation is to concentrate on dedicated Large Scale Projects (LSP) on IOT application areas, such as Smart Agriculture and Food Safety, Smart Cities, e-Health, Autonomous Vehicles in connected environments, and water management. Furthermore, common standardisation interests and the participation in Chinese and European innovation support programs are under consideration to be reinforced.

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