The Internet of Things Brings New Wave of the Information Industry

Yingying Lei1 , Pingchuan Ma2 and Lili Zhao3

Institute of Policy and Management of Chinese Academy of Science, Beijing, China

Summary

Since the America brought up the concept of 'the Smart Planet', there has been more and more attention put on the Internet of Things (IOT). In the present work, we introduce the origin and background of the IOT. At the same time, it expounds the principal and technologies of IOT and analyzes its enormous market potential in the Green application, pointing out that IOT is another technical revolution in the global information industry of science and technology after the Internet. Especially in the background of the global financial crisis, IOT will become the new economic growth pole and bring new impetus for economic growth.

Key words:
Smart Planet, Internet of Things, Technical Revolution, Economic growth point

1. The Origin and Background of Internet of Things

Last century, information technology has promoted the progress and development of human society enormously. The emergence of the computers, Internet and mobile communication network has set off a giant wave of the information industry. In the background of another round of the global financial crisis, the growth of the global economy requires new powers. The most effective way is to rely on scientific and technological innovation to create new economic growth point and innovative development model, carrying on the re-balance through technological innovation. The innovation fusion of the "Internet of Things" and "Internet" is just on the right time, proposing innovation ideas for us to create a newer, smaller and smoother world. IOT depends on the development of new generation information technology, such as radio frequency identification technology, sensor technology, nanotechnology, intelligence embedded technology and so on, with the conception extending and unceasingly thorough. It can be more thorough instrumented, more extensive interconnected and more in-depth intelligent. Besides, it also can enable people to manage their production and life by a more refined and dynamic way, improve resource utilization and productivity levels, and also improve the relationship between man and nature. It is not hard to predict that IOT will trigger another wave of the information industry.

The IOT was first proposed for people's new requirements for the supply chain in the background of globalization. A variety of materials and products circulate worldwide, inevitably causing keen competition between chains. The pursuit of zero inventory of materials and products makes the first EPC-based architecture of IOT come into being. The phrase "Internet of Things" was coined some 10 years ago by the founders of the original MIT Auto-ID Center, with special mention to Kevin Ashton in 1999 [1] and David L. Brock in 2001 [2]. When the EPC (Electronic Product Code) Executive Symposium took place in Chicago September 2003, the Auto-ID Center launched the EPC Network – an open technology infrastructure allowing computers to automatically identify man-made objects and track them as they flow from the plant to distribution centre to store shelves. The Symposium, supported then by more than 90 major companies from around the world – representing food, consumer goods, retail, transportation and pharmaceuticals industries, among others – highlighted RFID deemed to become a key enabling technology for economic growth in the next fifty years. On November 17, 2005, at World Summit on the Information Society held in Tunisia, the International Telecommunication Union had issued "the ITU Internet reports 2005: Internet of Things ", formally proposed the concept of IOT [3], and pointed out that the omnipresent "Internet of things" communication era is approaching, thus all the objects in the world can take the initiative to exchange data via the Internet. At the beginning of 2009, IBM Corporation also incorporated the concept of IOT, proposed "the Smart Planet" strategy [4], the meaning of which is "Internet + Internet of Things = the Smart Planet". It integrated the IOT with the supercomputer and cloud computing, and pointed out the mission of the IT industry in the next stage is to make full use of next-generation IT technologies among every walk of life, which is embedded sensors and equipment to the power grid, railways, bridges, tunnels, roads, buildings, water systems, large dams, oil and gas pipelines and other objects, and then everything is generally connected to form a so-called "Internet of Things."

2. Principle and Technologies of Internet of Things

2.1 Principle

Internet of Things [5] is the network that connects everything with internet, through various types of information sensor devices, such as radio frequency automatic identification (RFID), microwave sensor, global positioning system and laser scanner, in term of conventional agreement, to give information exchange and communication, and its final aim is to achieve intelligent identification, location tracking, monitoring and management. Internet of Things is based on computer internet, utilizing RFID, wireless radio frequency technology, database technology and middleware technology to create an "Internet of Things" composed of many networking reader and moving labels that covers every thing in the world, as shown in Fig. 1 and Fig. 2. In this network, the system can identify, location track, monitor and manage objects automatically and real-timely, and trigger relevant things, without human intervention.
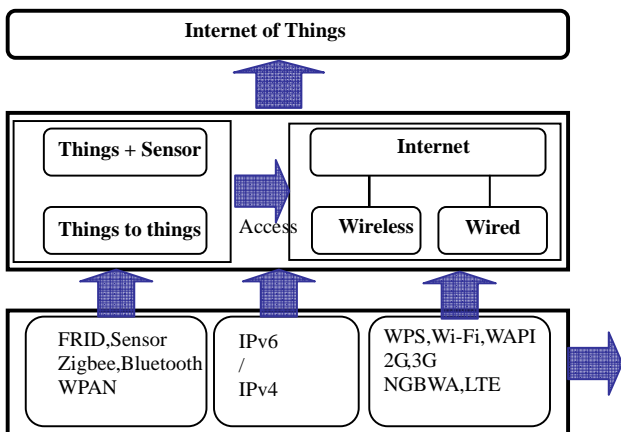

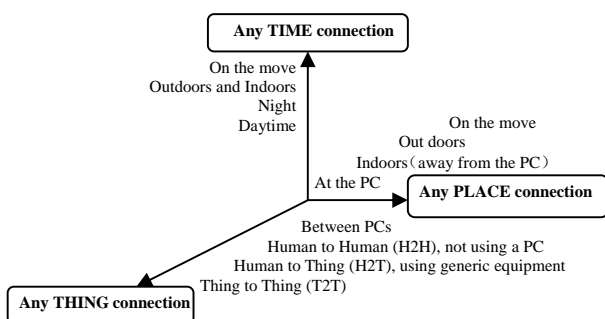Fig. 1 The structure of Internet of Things

Fig. 2 A new dimension of information and communication technologies

Internet of Things breaks traditional thinking mode, connects physical infrastructure with IT infrastructure, and lets all the things connect with the network. A new dimension has been added to the world of information and communication technologies: from anytime, any place connectivity for anyone, we will now have connectivity for anything. It makes us step into future "Ubiquitous Society" from "Electronic Society" of mobile transceivers and internet.

M2M for Internet of Things is the same as LAN for Internet. As different parts of body have different functions, different M2M systems will be responsible for different functions. It finally consists with the intelligent society system, through the collaboration of central processing units. M2M [6] is the abbreviation of "Machine to Machine", but it also can be explained as "Machine to Man", "Mobile to Mobile" or "Grand Integration of Machine to Server". It means combining various machines together: Machine communicates with Machines, Machine controls communication, Human communicates with Machines and Mobile communicates with Network. Machines, devices, application processes and background information systems can share information through M2M. It provides devices with ways to set up wireless connection and transmit data between systems, remote devices or individuals real-timely. The operator also can share information and achieve better perception. M2M technology is the sum of data collection, GPS, remote monitor, telecommunication and information technology. As an ecological system of computers, network, devices, sensor and human, it integrates the real-time states of information technology system and non-IT devices. That can make the business process automation and create value-added services.

M2M technology is the general name of the technologies that can enhance the communication and networking power of the machines. The goal is to provide networking and communication skills to all the devices, and the core idea is Network Everything. Communication between people is mostly realized by machines, such as, by mobile, telephone, computer and fax machine. Another kind of technology is especially for the establishment of communication between machines, for example, intelligent instruments with RS -232 and GPIB communication interface have larger capability to communicate with computers or other instruments. With the development of science and technology, more and more devices have the ability of communication and networking. Network Everything gradually comes true.

2.2 Technologies

ITU reported that Internet of Things has four key application technologies: RFID, sensor technologies, smart

things, nanotechnology and miniaturization. In these days, it also includes traditional barcode technology, Electronic Product Code (EPC) technology, wireless data communication, database technology and middleware technology. Internet of Things covers many areas, such as object identification, system architecture, communication and networking, security and privacy, service discovery and search, software and hardware, energy retrieving and storing, device miniaturization and standardization.

RFID [7] is also called electronic label technology. The labels are stored with information of specification and interoperability. Firstly, the labels are collected to the central information system through wireless communication network. Then, to identify objects and share, interconnect information computer internet through computer network. At last, because information can be change and share by open network, it can achieve transparent management of objects and tracking management of each chain so as to avoid mistake and raise productivity. Because RFID can implement "the Right to Know" of the supply chain management, its application prospect in the field of logistics is very good. RFID is a new kind of identification technology that can replace barcode. And by, traditional barcode have been replaced by RFID in some industries and areas all over the world.

EPC [8] is used as the only identification code for single product in the supply chain. EPC network proposed by EPCglobal is a shaped distributed networks framework. And EPC is a whole, complex, comprehensive system. It is a broader technology system formed by the internet and RFID technology, based on the worldwide uniform coding system. Its aim is to build global and open identification standard for each single product to make tracking and tracing single product in global range come true. Further more, it can improve the supply chain management level and reduce logistics cost. In EPC technology, product serial number is a string of number, as the representative of the manufacturer, product category and the only identification of a particular product. EPC is stored in the super high frequency radio frequency label to identify, dynamically track and position product. RFID electronic label, as the carrier of EPC, has a piece of silicon chips and an antenna, and transfer information through the Internet. When reading the label of EPC, it can connect with some dynamic data, such as the origin of the goods or date of production, etc. After RFID labels are added to every product, EPC system will continually gather a series of EPC in the production, transportation and sales process of product. When connecting to the management software, each EPC can tell us the features of the products. EPC network is mainly aimed at the logistics sector. Its purpose is to increase the visibility and control of supply chain, in order to gain more economic benefits for the logistics sector from RFID technology.

Sensor, as a kind of detecting device, can feel information being measured and detect the information. According to definite rules, the information change into electrical signal or other forms of information output to meet the demand of information transmitting, processing, storage, display, recording and control. Sensor is the principal link of automatic detection and automatic control. Using the electronic instruments is the same as the automatic device can replace the labor of human beings, in which the computer is analogous to the brain. But without five sense organs to perceive the information outside, the brain is not enough. Sensor is just the five sense organs of the central processing system. Sensors technology is a high technology developing rapidly in these days and has attracted people's eyes. It is also an important sign of the development of modern science and technology. Sensors technology, communication technology and computer technology are the three pillars of information industry.

The basic function of Wireless Sensor Network (WSN) is to connect a series of scattered sensor units through the wireless network self-organized. Then, they transmit and make a summary of the data gathered by every unit to carry out the physical or environmental monitoring in the scattered space. At last, analysis and handling will be done on the basis of the information. Because of the features of low cost, large scope, flexible layout and mobile support, WSN has been widely appreciated in many areas, such as industry monitoring, intelligent electric power, mining security, medical health and environment monitoring. At the same time, WSN is facing many technology challenges, for example, how to extend the working time of the nodes, how to increase the distance of communication, how to reach miniaturization and standardization. Meanwhile, market challenges are existed, such as seeking application area.

The intelligent technology required by Internet of Things (abbreviated as IOT) is regarded as intelligent analysis and control of massive information, which is defined as massive storage and immediate processing for a variety of information within IOT as well as instant feedback to all the components in domination of IOT with outcomes on basis of advanced software-engineering technology. For more details, intelligent technology emerges as a combination of approaches and means taking full advantage of intellectual analysis, aiming at accomplishing certain targets as expected. It is known that objects are supposed to be armed with anticipated intelligence to achieve active or passive interactions with subscribers in case of implantation of intelligent system into objects [9].

The technology of intelligent analysis and control mainly covers a multi-disciplinary field in which such subjects are included as the theory of artificial intelligence, interaction technology, intelligent analysis and control system etc. In

this way, objects under research are endowed with "intelligence" to imitate human-to-object and even object-to-object communications and conversations, having all the expected functions completed.

Nanotechnology studies the materials' properties and applications whose structure size range from 0.1 to 100 nm. The development of nanotechnology enables the objects down to ever smaller can connect to the Internet of Things for interaction and connection. At the same time, nanotechnology has prompted the electronic components needed by sensors and embedded chip become smaller and smaller, which makes the whole system smaller, faster, less power consumption and faster response.

In the fierce market competition, informatization will become a key factor for enterprises to gain competitive advantage. RFID, EPC, sensor technology, wireless network technology, smart things, nanotechnology and other technologies will prompt the Internet of Things lead to a significant change in the world. It will affect the production, distribution, consumption, distribution and other areas, and become a new economic growth point in the future.

3. IOT is the New Growth Pole of the Global Green Development

3.1 New Growth Pole of the Global Economy

The appearance of economic growth fundamentally relies on technological advancement and breakthrough. New technologies can not only stimulate consumption, promote investment and, more importantly, are able to bring innovation of industry structure and development mode, and then lead towards a new round of sustainable growth. The same is true of IOT technology, which will play an important role in the areas of commercial, logistics and retail industries, so as to facilitate the circulation and monitoring of the goods. It not only brings convenience to our lives and productions, but also brings huge economic benefits and becomes a new economic growth points. The IOT has enormous pulling effect as the Internet industry did before. The formation and development of IOT contains bright prospect of the industry opportunity. Construction of a grand IOT has a dual effect, which stimulates new investment and improves the efficiency of economic operation.

The IOT on the one hand can improve economic efficiency and greatly reduce cost, on the other hand, from the economic perspective, as a wave of information industry after the computer, Internet and mobile communication, it can provide technology dynamic force for global economic recovery. The IT industry overlord "big blue"-IBM has

been leading the technology trends, such as e-Business, Cloud Computing and Smart Planet. Internet has also not widely been used in China since 2002, but at the first IBM Forum in the same year, "electronic commerce" was introduced to the domestic IT sector as a forward-looking concept. Today just online shopping of e-commerce transactions reaches higher than 100 billion, and Taobao occupies eighty percent market share. E-commerce is creating a miracle of the Internet economy. However, with the development of society and people's improving demand, Taobao is also facing technical bottlenecks in the merchandise management, logistics and trading links. The IOT will be able to promote the circulation of commodities mutual linkage in all sectors, and is expected to be the engine of economic growth in the era after the financial crisis. In the long run, it will lead to a new economic form.

In the worldwide, many countries and enterprises standing in the forefront of technology have smelled the economic wave and technological revolution triggered by "Internet of Things". With a view to the market active, they began to research on new technology application and setting standard. United States President Obama pointed out that "IOT" is the key strategy in economic revitalization and advantage establishment, and the U.S. will invest eleven billion dollars for research and construction of Smart Grid. China is accelerating to invest and construct the "Sensing China" Research Center. Europe commercial and information industry persons in EU Brussels, the headquarter of Europe Union, have widely discussed the IOT. IBM has brought up the concept of "Smart Plant" based on emerging Internet and IOT. Information industry leaders, such as GE, IBM, Siemens, Google, and Intel, have invested on intelligent grid business too. RFID products and integration services revenue increased year by year in the worldwide, as shown in Fig. 3 and Fig. 4.
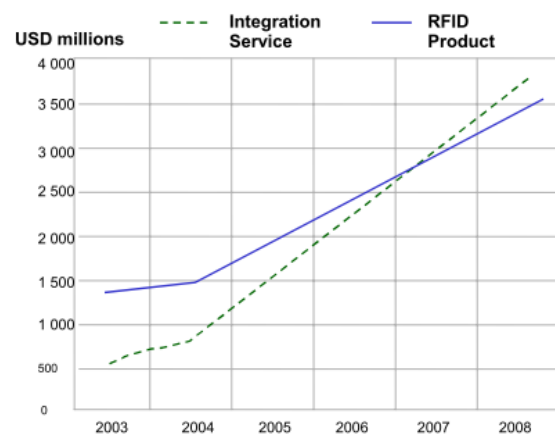

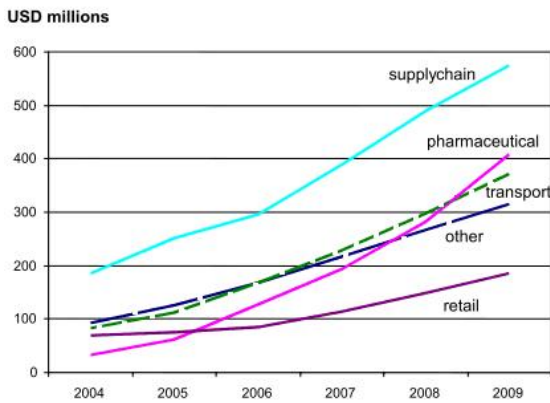Fig. 3 RFID products and integration services revenue [10]

Fig. 4 Total western European RFID revenue by sector

Fig. 6 Worldwide Robotics Market Growth (unit: $US billions)

Note: The chart excludes simple electronic toys

With the extremely rich meaning, the IOT potential market is based not only on the RFID Technology, but also includes many other advanced technologies, such as sensor networks, robot or even nanotechnology, which can convert labor-intensive work to high-tech and productive work. All of these can bring us the ubiquitous communication environment and help to open up the broader market. Wireless Sensor Networks applications in Industry, Power, Oil and Gas, Hydraulic and other fields maintain a clear upward trend from the year 2005. Its total number of applications is expected to grow up to 100 times within five years, as shown in Fig. 5. The world robot market will have a fast development in the next 15 years, which is expected to exceed 6.6 billion dollar market value (see Fig. 6).With the broad development prospect of IOT, it is expected to realize the economic recovery as soon as possible through the development of long-term competitive economy plans, and create significant employment opportunities.
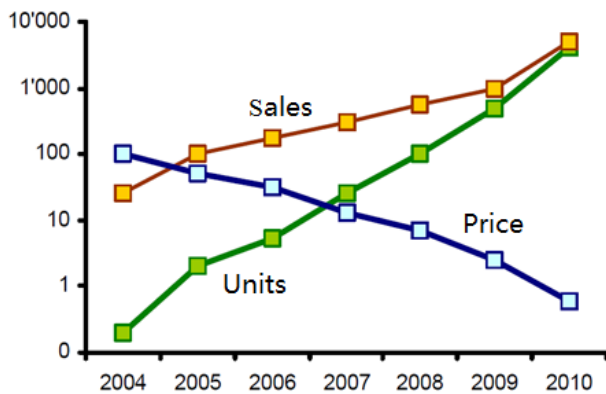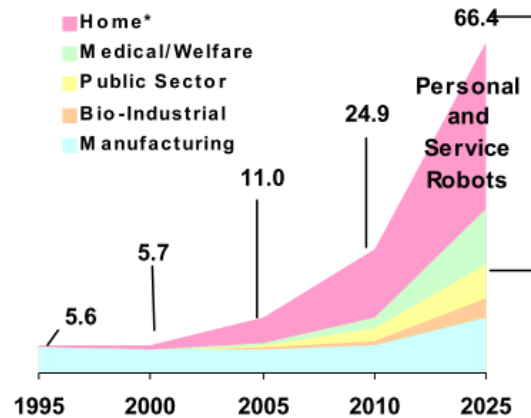
3.2 New power of the global green development

Green development has become the main trend of global development. The corresponding "green trend", which relies on green technology revolution and implies the changes in the patterns of economic development, endows with new meanings and expectations to the "green economy" in the context of the international financial crisis. Otherwise, IOT has been integrated into the trend of green economy, which not only aims at boosting the economy, but also does its best to achieve environmental sustainability. It develops new channel to intelligent construction such as smart grid, smart driving systems and intelligent medical, promotes the green development and helps people fully enjoy economic and environmental benefits.

The application of the IOT in supply chain can solve the problem of high logistics cost and long stocking time which incurred by transportation, inefficient storage and distribution systems. Therefore, it can stimulate domestic trade, stimulate domestic trade, improve the competitiveness of enterprises and promote sustainable development in economy. Furthermore, it can fully utilize the resources, ensure sustainable development in environment and improve the relation between cost, quality, service and time. The customer-focused supply chain can make it visible, satisfy the increasing requirements of customers, provide precise relations between supply and demand, and even avoid the risk of the chain.

The application of IOT in the field of energy is conducive to construct "smart grid". Through the sensor, Smart Grid links various devices and assets together, and then a customer-service bus comes into being, which can supply

Fig. 5 Adoption of wireless sensor networks （unit: times）

information integration analysis in order to reduce cost, increase efficiency, improve the reliability of power network as a whole, and optimize operation and management. With the help of the IOT, the power companies can read the user's electricity meters, while the users can see power supply and demand of the entire city at the same time. So in the function, data reading will be more real-time, high-speed and bi-directional. This will brings great change in energy use and make it more stable in electricity demand. As the power company can probably describe the power demand levels of all consumers each day, so they do not need a lot of backup power plants to meet peak demand.

The application of IOT in traffic area can be effective in reducing traffic congestion. We have to get enough data to see pedestrians, vehicles, cargoes and goods mobile in the city and need the help of sensors in the vehicles and on the road to monitor and control traffic flow, so that we can get real-time traffic information to adjust the route and avoid congestion. We can also build automated highway to realize connection of vehicle to the network, and then guide vehicles to change routes or optimize vehicle travel. In the area of road tolling, it is more convenient and efficient to seamlessly detect, identify the vehicles, and charge fees with RFID technology and other advanced free-flow roadside systems. IOT not only improves the traffic situation, maximize traffic flow, greatly reduce the cost of urban management, increase operational efficiency, sharply decrease urban physical asset losses, but also significantly reduces carbon and pollutant emissions, noise pollution, energy consumptions, and improves the quality of our lives.

4. Conclusion

Reviewing the first two waves of information technology industrialization, the first was led by the computer, which caused the information process to obtain a qualitative leap; the second was led by the Internet and mobile networks, which made transmission of information get huge promotion. The IOT will start the third wave of industrialization under the development of the Internet-based information acquisition technology. In the "Internet of Things in 2020" report [14], EPOSS analyzes and predicts that in the future the IOT's development will experience four stages: RFID is widely used in logistics, retail and pharmaceutical field before 2010; realize the object-object interconnection from 2010 to 2015; objects enter half intellectualization from 2015 to 2020; objects come into the entire intellectualization after 2020. From the exchange of the virtual information to the interconnection between people, again back to perceive the real world objects, the information industries tide provides a powerful driving force for the development of

information acquisition, information transmission and information processing. As a new generation, regarding the strong demand for traction, IOT will bring a new transformation for the development of information industry, such as computers, mobile phones, networks and so on, causing economy to develop another piece of "the blue sea".

References

[1] "I could be wrong, but I'm fairly sure the phrase 'Internet of Things' started life as the title of a presentation I made at Procter & Gamble (P&G) in 1999", Kevin Ashton, RFID Journal, 22 June 2009.
[2] David L. Brock, MIT Auto-ID Center, MIT-AUTOID-WH-002, "The Electronic Product Code",January 2001.
[3] International Telecommunication Union. ITU Internet Reports 2005: The Internet of Things[R].2005: 2.
[4] Samuel J. Palmisano. "A Smarter Planet: The Next Leadership Agenda", http://www.ibm.com/ibm/ideasfromibm/us/smartplanet/200 81106/sjp _speech.shtml. Nov. 6, 2008.
[5] Wang JZ. From Internet to Internet of Things[J]. Communications World Weekly, 2009, (33): 12.
[6] Zhou HB, Hu HF, Shao XF. The Key Power in the Communication of Machine to Machine[J]. Manufacture Information Engineering of China, 2009, (11): 23.
[7] Liu LM, Qian H. FRID Brings up Internet of Things [J]. China Computer & Communication, 2004, (6): 16-17.
[8] Lee L, Zhu QF, Wang F. Research on middleware of EPC system[J]. Computer Engineering and Design, 2006, 27(18): 3360-3363.
[9] Liu HJ. Research on Key Technology for Internet of Things[J]. Computer Era, 2010, (7): 4~6.
[10] ITU, "Ubiquitous Network Societies: The Case of RFID", April 2005, at http://www.itu.int/ubiquitous.
[11] Juniper Research, 2005.
[12] ITU, adapted from Harbor Research, available at http://news.com.com.
[13] Japan Robotics Association, "Sizing and Seizing the Robotics Opportunity" at http://www.robonexus.com/roboticsmarket.htm.
[14] Commission of the European communities, Internet of Things in 2020, EPoSS, Brussels[EB/OL].(2008).[2010-05-12]. http://www.umic.pt/images/stories/publicacoes2/Internet-of-Things_in_2020_EC-EPoSS_Workshop_Report_2008_v3.p df.

Yingying Lei is currently a master student in Institute of Policy and Management of Chinese Academy of Science. Her major is management science and engineering. She received the Bachelors degree in University of Science and Technology of China in 2008.

Pingchuan Ma is currently a master student in Institute of Policy and Management of Chinese Academy of Science. Her major is management science and engineering. She received the Bachelors degree in Xi'an University of Science and Technology in 2009.

Lili Zhao is currently a master student in Institute of Policy and Management of Chinese Academy of Science. Her major is management science and engineering.