Chapter 2
Global Development Trend

2.1 Policies and Measures of Major Countries

In recent years, the Industrial Internet has gradually become an important tool whereby countries in the world promote digital, network-based and intelligent development of manufacturing. Governments have been energetically pushing forward the development of the Industrial Internet at home through strategic guidance, financial support, creation of a more favorable environment and other means, thus occupying commanding heights of the wider-range and deeper-level technology revolution and industrial transformation [7].

In the U.S., the development of the Industrial Internet is to a large extent spontaneously driven by the industrial circle itself, though the government still plays a key role. Firstly, the U.S. has strengthened strategic guidance. On October 5, 2018, the National Science and Technology Council released the "Strategy for American Leadership in Advanced Manufacturing" as an update of the National Strategic Plan for Advanced Manufacturing, which strategy underscores the need to actively promote digital and intelligent development of manufacturing. In February 2019, the White House released its plan for future industrial development, which proposes to increase investment in advanced manufacturing-related key areas by revising existing laws and other means. Secondly, the U.S. guarantees financial support. The National Science Foundation (NSF) has launched the Cyber-Physical Systems (CPS) program since 2006, and CPS is one of the important technologies underlying the development of the Industrial Internet. In 2019, the Networking and Information Technology Research and Development (NITRD) offered an accumulated fund of USD 139 million to support the R&D and transformation of the CPS technology. Thirdly, the U.S. is committed to cultivating actors of innovation. In 2014, the United States Department of Defense led the establishment of the Digital Manufacturing and Design Innovation Institute (DMDII), whose core members include corporate giants such as GE, Lockheed Martin, Rolls-Royce and Siemens. Focusing on four major areas, namely advanced manufacturing, intelligent machine,

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advanced analysis and cyber-physical security, DMDII is engaged in the R&D of technologies, validation of standards and training of personnel with respect to the Industrial Internet, and use of Industrial Internet-related technologies to reduce production and time costs in the design and manufacturing of complicated products by relevant enterprises. In February 2018, DMDII released the Strategic Investment Plan 2018, guiding investments mainly to areas such as design, future factory, supply chain and cyber security in 2018, with all tasks and objectives covering core elements including network, data and security. The construction of the DMDII has spread and lowered risks facing enterprises in their deployment and implementation of Industrial Internet solutions and can help enterprises stride over the "valley of death". Meanwhile, DMDII is integrated with regional economic clusters, creating and drawing closer partnerships between enterprises in the region and pushing for regional cluster development [8, 9]. In February 2019, the United States Department of Defense invested USD ten million to support DMDII's transformation into an independent organization mainly studying technologies and products regarding Internet connection.

In Germany, both federal and local governments are accelerating the implementation of the Industry 4.0 Strategy by taking multiple measures in respect of policy, financial, personnel and others at the same time. Firstly, they have perfected the top-level design. In order to fully tap the potentials of information technology (IT) in promoting industrial development and seize opportunities brought by the new industrial revolution as early as possible. The German government has issued a series of policies and measures to support and guide the development of Industry 4.0, successively facilitated improvements in institutions related to Industry 4.0 in 2012, 2014 and 2016, and released series strategy and policy guides to ensure effective deployment and implementation of Industry 4.0, thus providing strong policy guarantee for continuous advancement and system construction of Industry 4.0. Secondly, they have enhanced financial support. German Ministry of Education and Research (Bundesministerium für Bildung und Forchung, BMBF) has allocated totally more than hundreds of millions of Euros to fund the Industry 4.0 program. German Federal Ministry of Economic Affairs and Energy (Bundesministerium für Wirtschaft und Energie, BMWi) plans to invest EUR 50 million to support the research in respect of Industry 4.0, including projects on legislation, IT security, future labor conditions and skills, and standardization. The German government mainly supports small and medium-sized enterprises (SMEs) in the development of the Industrial Internet. BMWi will invest EUR 56 million in building 10 (12 as planned) digital capital centers for SMEs under the initiative "© (SME) 4.0—Digital Production and Work Processes", so as to solve cost and security problems for SMEs in the process of digitalization and introduction of Industry 4.0 [10]. The High-Tech Strategy 2025 released by Germany in 2018 states that over EUR 15 billion will be invested to carry forward the development of seven key areas, including Industry 4.0. Thirdly, they have intensified organizational guarantee. Germany has established three application promotion platforms, such as Plattform Industrie 4.0, Labs Network Industrie 4.0 (LNI4.0) and Standardization Council Industrie 4.0, allowed full play to the role of the government, industries and

enterprises to create synergy, thus expediting the development of technologies, standards and industries in connection with Industry 4.0 [11].

In Japan, multi-dimensional coordinated arrangements have been made to advance the Industrial Internet and social changes. Firstly, Japan has enhanced financial support. Japan increased investment in Industrial Internet-related areas, and put forward the "Connected Industries" initiative, which is intended to pool government funds to address weaknesses and bottlenecks in industrial development and guide stakeholders to actively take part in the development of the Industrial Internet industry. In June 2017, Japan adopted the basic policy for economic and fiscal operations of 2017 and a new strategy for economic growth titled "Future Investment Strategy", which identifies investment in human resources as the backbone and construction of the IoT and application of artificial intelligence (AI) as two priorities. The "Future Investment Strategy" makes it clear that Japan will support the development in five major fields, such as infrastructure, financial services and supply chain, through a variety of policies, and actively promote extensive application of the technological change represented by AI and the IoT in all sectors of production and life on the premise of addressing existing problems, so as to achieve the ultimate goal of "Society 5.0" [12]. Secondly, Japan has built an industrial ecosystem. The Japanese government encourages the establishment of industry alliances and similar organizations focusing on manufacturing, with a view to advancing the development of the Industrial Internet through industry-university-research-application cooperation. In June 2015, 23 Japanese enterprises initiated the Industrial Value Chain Initiative (IVI) alliance, aiming at establishing a mechanism that enables combination of the expertise of different enterprises by distinguishing areas of cooperation and competition, sharing enterprises' reference models and other means, and then attaining relevant policy goals. In October 2015, with the guidance from Japan's Ministry of Internal Affairs and Communications and Ministry of Economy, Trade and Industry (METI), a number of enterprises from home and abroad made up the "IoT Acceleration Consortium" [13], under which there is an IoT promotion laboratory that develops and promotes in society as early as possible advanced IoT projects, whilst helping matching and cooperation between solutions in different fields. Thirdly, Japan has propelled international cooperation. The Japanese government encourages and guides its industrial circle to actively participate in international cooperation, thus boosting the integration of its industries into the global industrial ecosystem. At the government level, Japan has been vigorously driving strategic alignment with Germany and France and has signed documents on cooperation with relevant countries in key areas. At the industry level, Japan encourages its industrial circle represented by the IVI to actively seek cooperation all over the world, thereby aggressively integrating the Japanese industrial circle into the global Industrial Internet ecosystem.

Beyond these, European countries such as the UK and France, and emerging economies like India have in succession identified the Industrial Internet as a national development strategy for promoting technology innovation, pushing forward intelligent industrial development and achieving integration and reengineering of industrial processes in the next 5 to 10 years, and carried out strategic deployment in advance [14].

2.2 Network

The application of new-type network technology has become a global hotspot. Time Sensitive Network (TSN), as a new technology to meet the demands of high-speed, highly-reliable and highly-real-time Internet connection in factories, has attracted high attentions of the industrial circle. In HANNOVER MESSE 2018, Siemens, Huawei and IIC released their TSN products, solutions and test beds. Edge computing is accelerating comprehensively. American open fog computing alliance Openfog has been merged with IIC to better drive deployment of edge computing in the industrial Internet; Edgecross Consortium, a major corporate organization of Japan, has sped up the deployment and development of edging computing technology and product; industrial enterprises such as GE and Siemens, and communication enterprises including Cisco, Microsoft and Amazon, have all released relevant products. Studies on the application of 5G in industrial field has been on the fast track, and Ericsson, Huawei and Vodafone, together with Bosch, Siemens and Yokogawa, have established the 5G alliance of industrial internet and automation (5G-ACIA), to move ahead with industrial application of 5G. The technology of software-defined network (SDN) has gone deep into industrial production scenarios gradually, and German Fraunhofer IZM and some German enterprises are working to give impetus to application of SDN in industry.

The technology of identifier resolution is still in its early days and the application keeps deepening. Currently, there are various identifier coding and resolution technologies in the world, which can be classified into two routes for technical development. One is the technical improvement route, which mainly relies on the current Internet domain name system for improvement; the other is the technical change route, with the Handle identifier resolution system invented by Dr. Robert Kahn, father of Internet, as one of the typical solutions. In the future, new technical solutions may appear. In some countries, the industrial Internet identifier resolution system has realized initial application in the manufacturing industry, and smart factories based on the identifier resolution technology have come into being. In view of relevant deployment and application effects in the U.S. and France, there exist some critical problems to be solved in terms of industrial application of the identifier resolution system, of which, some problems are beyond common system design, including those of safety, elastic system, integratability, interoperability, combinability, data management and intelligent system, and the combination with cutting-edge technologies of AI, blockchain and big data has become the significant direction to address such problems. Due to the diversity of industrial application requirements, there are some uncertainties in the direction of the future technical standards for identifier, and the final result of which kind of technical standard will win out or that multiple technical standards will co-exist is still to be tested by the practice.

2.3 Platform

Industrial Internet platforms focus on service capacity requirements and continue to strengthen their key technologies. In the first place, edge technologies and platforms have completed integrated application, facilitating integration of cutting-edge technologies such as big data and AI into terminal devices. For instance, Microsoft has completed the transition of its business logic to edge devices with the aid of the edge platform Azure IoT Edge [15]. Secondly, new network technologies assist these platforms with wider-range and cheaper device interconnection. For example, in order to meet lower power consumption and other demands, Cisco has introduced the Jasper Control Center, which can support the narrow band Internet of Things (NB-IoT) to realize automation and real-time data analysis in case of mass devices. Thirdly, these platforms focus on data analysis and the application of digital twin modeling to consolidate the foundation of intelligent application in an all-round manner. For example, Parametric Technology Corporation (PTC) has successfully imported and integrated external data analysis tools by using Analytics Manager in the ThingWorx platform. Siemens has integrated product data in the MindSphere platform and built digital twins through big data to optimize product design. Fourthly, the platforms have accelerated the layout for the low-code development technology to lower the threshold and time cost for platform application innovation. An example is that Siemens has introduced the low-code development technology owned by Medix, which has been acquired by Siemens, into the MindSphere platform, so as to comprehensively shorten the cycle of innovations in industrial APPs [16].

Industry magnates have all quickened their arrangements for Industrial Internet platforms. First of all, they attach an increasing importance to platform-related services [17]. With digital industries as one of its core businesses, relevant revenues of Siemens registered over EUR 14 billion in 2017. ABB has advanced the transformation of industrial digital solutions in the four leading businesses based on its Ability platform. Secondly, they continue to increase platform-related inputs. By summarizing experience in application, Siemens has upgraded its MindSphere platform to Version 3.0, further improving platform functions and performance [18]. Emerson Electric has improved the service capacity of its platform in the field of pneumatics by acquiring the Germany-based company Aventics. Finally, they have been facilitating the application and deployment of platforms in different industries. Microsoft's Azure IoT platform has unveiled industrial solutions such as connected factory and predictive maintenance, and on this basis, worked with the UK-based company Rolls-Royce for joint research and development of a remote operation and maintenance system for aircraft engines. Through the deployment of more than 480,000 installation sites worldwide, Schneider Electric's EcoStruxure platform has gathered more than 20,000 developers and system integrators in its ecosystem, and managed over 1.6 million pieces of assets [19].

Start-ups are becoming a new force driving platform development. On the one hand, more and more technological innovation-based enterprises begin to dabble

in the field of Industrial Internet platforms. For instance, the U.S.-based Sight Machine has continuously accumulated knowledge on product quality control and production line process management in its platform to serve business expansion. On the other hand, the capital market is increasingly leaning to platform start-ups with outstanding performance. Since its establishment, Uptake, a U.S.-based company, has financed more than USD 250 million in total, with an estimated market value of up to USD 2.3 billion [20].

Cross-industry cooperation focusing on Industrial Internet platforms is active and the ecological development of platforms is increasingly deepening. Firstly, different platform enterprises cooperate to complement each other, thus bringing down their R&D costs. For example, GE and Siemens, respectively, have entered into cooperation with Microsoft and AliCloud in renting low-cost cloud infrastructure resources, not only relieving their input pressure, but also improving underlying performance. Secondly, cross-industry cooperation can help accumulate specialized knowledge and then improve the supply of platform solutions. For example, Schneider's EcoStruxure platform has maintained deep cooperation with industrial system integrators to acquire knowledge in various industries and form industrial APPs and solutions oriented towards different scenarios. Thirdly, through capital cooperation, industries make concerted efforts to push the development of platforms. For example, Rockwell and PTC join hands through a USD one billion equity investment to improve their competitiveness in the field of platforms in all aspects through business complementation.

Moreover, a platform-oriented ecological cooperation mechanism is taking shape at a quick pace: Siemens is building the "MindSphere World" together with various enterprises to improve platforms' ecosystem construction and promotion capabilities [21].

2.4 Security

There has been a lot of practical exploration into Industrial Internet security, covering five areas such as device security, control security, cyber security, platform security and data security. In terms of device security, in order for strong identity authentication of Industrial Internet devices, currently measures such as reinforcing operating systems and issuing certificates have been taken, ensuring authentic and trustworthy device identities at the chip level. Typical examples include two solutions to device security, namely Symantec's Critical System Protection and Symantec Device Certificate Service, which have issued over one billion security certificates to connected devices worldwide, covering a wide range of fields such as intelligent instrument, cable box and modem. In terms of control security, given the uniqueness of the control systems in the Industrial Internet, auditing of industrial control system behaviors is subject to specific requirements. The deployment is made in a way that control systems in the Industrial Internet are audited through mirroring monitoring while ensuring that monitoring network cards cannot actively

send out data packages. In terms of cyber security, the strategy of overall cyber security defense in depth has been adopted to strengthen the security defense of Industrial Internet networks in all dimensions. In terms of platform security, on the basis of the actual conditions of platform architectures, a combination of hardware reinforcement, boundary isolation, security audit, access control, behavior control, risk tracking and other technologies has been used to accelerate the improvement of the security protection capacity of Industrial Internet platforms, with a view to improving the overall capacity. In terms of data security, full life cycle of data has been covered and data encryption and data security audit have been made full use of to guarantee data security.

For example, Siemens has established a strategic partnership with the U.S.-based company Identify3D (ID3D) to comprehensively improve data security clearance and encryption and fully ensure data integrity in all links and processes throughout the value chain through end-to-end data security solutions [22].

The market size of global Industrial Internet security products is growing year by year and the industrial pattern is gradually improving. Industrial security protection products mainly include industrial firewalls, intrusion detection and protection systems, and industrial security gateways; industrial security management products focus on access control and terminal security management; industrial security compliance products, such as security baseline management, security testing and evaluation and other tools, remain a blank in the market. From the market application perspective, Industrial Internet security products are highly appreciated in energy, power, petrochemical and other industries, which are the main fields where industrial security products are seen for the time being. Industrial magnates and traditional IT security giants seek to cover a wider range of industrial security solutions by acquisitions or business expansion, so as to dominate the industrial security market, and leverage their own influence to further expand market share and scope of business. Typical examples include Continental AG has acquired Argus, an Israel-based automotive cyber security company, to seek intelligent and safe driving services and solution; Harman International Industries has acquired TowerSec, a Michigan-based automotive cyber security company, to further guarantee the safety of its automotive products [23].

2.5 Application

In the advancement of the Industrial Internet, major developed countries have brought forward their own Industrial Internet strategies with different focuses in the light of respective actual national conditions. For example, the German Industry 4.0 strategy focuses on superimposing the new generation information technologies on existing industrial production devices to promote data integration and service sharing, and strengthen and upgrade hard manufacturing advantages with production and engineering technologies as its emphasis.

The U.S. Strategy for American Leadership in Advanced Manufacturing focuses on innovations in cutting-edge manufacturing technologies and the Industrial Internet, and stresses applying information technologies such as the Internet, big data and IoT to industries, thus transforming industrial production, products and services, promoting intelligent development of machinery equipment and changes in the business model, and maintaining intelligent data drive. Besides, both Germany and the U.S. have sped up the solicitation and promotion of pilot application programs to facilitate multi-industry coverage and multi-model construction, further expand their technological advantages.

Germany focuses on industrial production to advance the application of the Industrial Internet. Firstly, intelligent production of its *Plattform Industrie 4.0* gives impetus to the application of the Industrial Internet. Most projects have already completed verification through experiments and begin to be put into trial use and promoted, among which a few target production and management optimization. Secondly, automation and equipment enterprises lead the application of Industrial Internet projects. More than 12 industries have begun the application of the Industrial Internet, with the share of intelligent application by automation and equipment enterprises reaching 40%. Thirdly, the Industry 4.0 puts particular emphasis on integration of information and manufacturing technologies. The application of Industry 4.0 projects have popularized models such as quality management optimization, equipment failure prediction and production control integration. The well-known German manufacturer Siemens launched the MindSphere platform in 2016, based on which it provides the application of predictive maintenance, condition monitoring, energy data management and resource optimization. Currently, the MindSphere platform is used to monitor and test over 800,000 systems all over the world, including gas turbines, skyscrapers and traffic control centers. Siemens has developed a railway asset management scheme for the railway transportation industry, including functions applicable to all vehicles and infrastructure, such as remote monitoring, rapid diagnosis, failure prediction, which can be used to increase the availability and efficiency, reduce operational risks and costs, and improve the maintainability. Upon verification, the scheme has a Prescriptive maintenance validation availability of over 99%; delays have been reduced by 20% or more; GPS information has been applied to high-speed trains, enabling several hundred pieces of sensor data to be processed per second; and the time for complex troubleshooting has shortened by more than 20%. Bosch Group, as a global technology supplier, develops the IoT Suite and provides its customers with solutions and IoT applications.

Today, more than five million devices and machines have been widely interconnected via Bosch IoT Suite. Bosch has also tailored a solution for motor sports, which, by installing a wireless transmitter using 4G mobile technology in a car, can transmit data on the engine, location and speed to the receiver in the maintenance center, and enable almost real-time monitoring and analysis of car data based on Bosch IoT Suite.

The U.S. is pushing forward the application of the Industrial Internet on a larger scale. Firstly, a wide range of industries are covered, with a half being

manufacturing. IIC application cases cover industries such as manufacturing, transport, retail, healthcare and agriculture, and manufacturing enterprises account for a half of all these enterprises. Secondly, manufacturing instances focus on intelligent production. Most of the manufacturing application projects use the mode of intelligent production, and only a few are customized. Thirdly, U.S. IT enterprises are integrated into manufacturing in virtue of their technological advantages to expand the scope of business. The U.S. software giant Microsoft has been promoting the Azure platform in recent years and established a partnership with Shanghai Zhenhua Heavy Industries Co., Ltd. (ZPMC), under which its offers Microsoft cloud manufacturing IoT platform to connect devices, analyze real-time data and gather data into the global monitoring center, thus helping ZPMC shift from a traditional manufacturer to a new generation digitalized intelligent port service provider. ZPMC is developing integrated machine learning and other advanced analysis services and building solutions such as predictive equipment maintenance, remote monitoring, service and operation system, so as to improve its efficiency and security as well as customer satisfaction. Based on the GE Predix platform, Exelon, a nuclear power company, has achieved higher energy harvesting through data acquisition by edge devices and a precise wind energy prediction model, creating value of USD two million every year.