



Gartner®



AIB^{AIoT} Business
antage

2021 Global AI+IoT Developers Ecosystem White Paper



Co-production

Welcome

In 2021, with the increasingly obvious trend of open platform in AI+IoT industry, developers have become the key driving force for the development of this industry. The more a platform supported by developers, the more chances it has got to achieve the win-win situation in the industry, popularize connection to all walks of life, and make IoT a common practice in families.

2021 Global AI+IoT Developers Ecosystem White Paper predicts that IoT, industrial internet and new infrastructure of B2B industry will be implemented on a large scale in 2021. As the ToC consumer market gradually went to saturation, technologies that would help the manufacturing, industry and vertical industries to reduce the cost and improve the efficiency would be more favored by enterprises and capital markets.

1.Current

- The origin, background, and development of AI+IoT.....02
- The analysis of the macro environment of AI+IoT industry.....04
- The analysis of global market for AI+IoT industry.....11
- AI+IoT industry chain and value analysis.....13
- The Status Quo and Trend of Investment and Financing of AI+IoT industry.....14

2.Practices

- Smart Hardware
(Five Major Categories: Home Appliances; Security; Health & Fitness; Lighting; Electrical).....19
- Smart AI+IoT Application Scenarios
(Smart Business; Smart City; Smart Home; Smart Industry).....58

3.Challenges

- Security of IoT Platform.....99
- At present, one of core challenges IoT industry has to face is the incompleteness of the standards.....103

4.Prospects

- Developer become the Key Role for the Industry to Take Off.....115
- Open platform the Main Driver of the Industry.....118
- Integration of Advanced New Technology and IoT 122
- Scale of IoT in ToB industry.....130
- Industrial Internet Drives Manufacturing Upgrading.....136
- New infrastructure will Accelerate AI+IoT Industry.....144

Preface

by Schneider Electric



Emmanuel Lagarrigue
-Chief Innovation Officer,
Schneider Electric

The world is becoming more digital, leading to disruptions in every sector of our economy. The global pandemic has profoundly shaken society and will continue to be a catalyst for change as we build the new normal. Digitization of everything has rapidly increased as companies look for solutions to ensure business continuity. Rapid acceleration of digitization brings new opportunities for growth for some, and challenges for those not able to pivot and adapt.

As industries digitize, the Internet of things (IoT), real-time information, and digital tools are breaking traditional silos, enabling remote operation of facilities and creating innovative and sustainable economic models. Artificial Intelligence technologies are enabling new solutions that can increase efficiency and sustainability as decisions are made in real-time. At Schneider Electric, we believe 'Life is On' and have a customer-first approach and obsession with innovation and sustainability. We are leveraging IoT to connect energy, automation, software, and analytics to fuel revolutionary innovations in efficiency, sustainability, reliability, and safety for our customers.

We also know we can't create all the solutions needed for a more sustainable and resilient future on our own. This is why we believe in building an eco-system of partners to co-innovate and scale bold ideas to meet customer needs. We also empower our over 650,000-strong partner ecosystem to expand our coverage.

It's clear that AI and IoT industry's development cannot be separated from a diverse developer ecosystem and a neutral and open development platform. Industries working together to build an interconnected development ecosystem strengthens the innovation generated. Strategic partnerships and alliances are essential to create and shape the future of IoT technology and smart living to ensure our buildings are efficient, sustainable and adaptable to new technologies. By working together and leveraging technology, we can develop the innovations needed to tackle the biggest problem we face collectively-fighting climate change, reducing inequality and creating a more sustainable world.

by Philips



Andy Ho
President of Philips Greater China,
Member of the Royal Philips
Executive Committee

Today, a world based on Internet of Things is at the horizon. From single smart device functionality to multi-categories devices interactions, from remote control in mobile to user value generation in data, users extract more from AIoT applications. Meanwhile, AIoT ecosystems turn more diversified. New collaboration models appear continuously across the spectrum as “closed” in one end and “open” in the other. Under various scenarios, richer vertical applications will be seen.

At Philips, a 130-year history health-tech company, we believe that care should be organized seamlessly around people's health journey, across consumers' healthy living at home, out-of-hospital and in healthcare settings – connecting people, data and technology. We believe that IoT is really about people not things.

The true added value of the AIoT lies not in any single device, but in integrated solutions: combinations of many systems, devices, software and services, configured and delivered in a way that address needs of our customers and consumers. IoT enables real-time data capturing and integration from various consumer and medical devices, translating those data into useful insights through AI. Our engagement and care can be very personalized, proactive, and preventative, across an entire journey.

The Global AIoT Developers Ecosystem White Paper analyzes the current situation and future direction of the AIoT industry from a macro perspective, and reveals the current challenges and the key to the development of the industry. In order to realize the interconnection of all things, rich and diverse developers, and an open and neutral platform are indispensable. We look forward to the publication of the White Paper to inject new vitality to the AIoT industry, and enrich vertical applications in different scenarios.



by Calex



Will Smits
Electro Cirkel B.V.
Managing Director

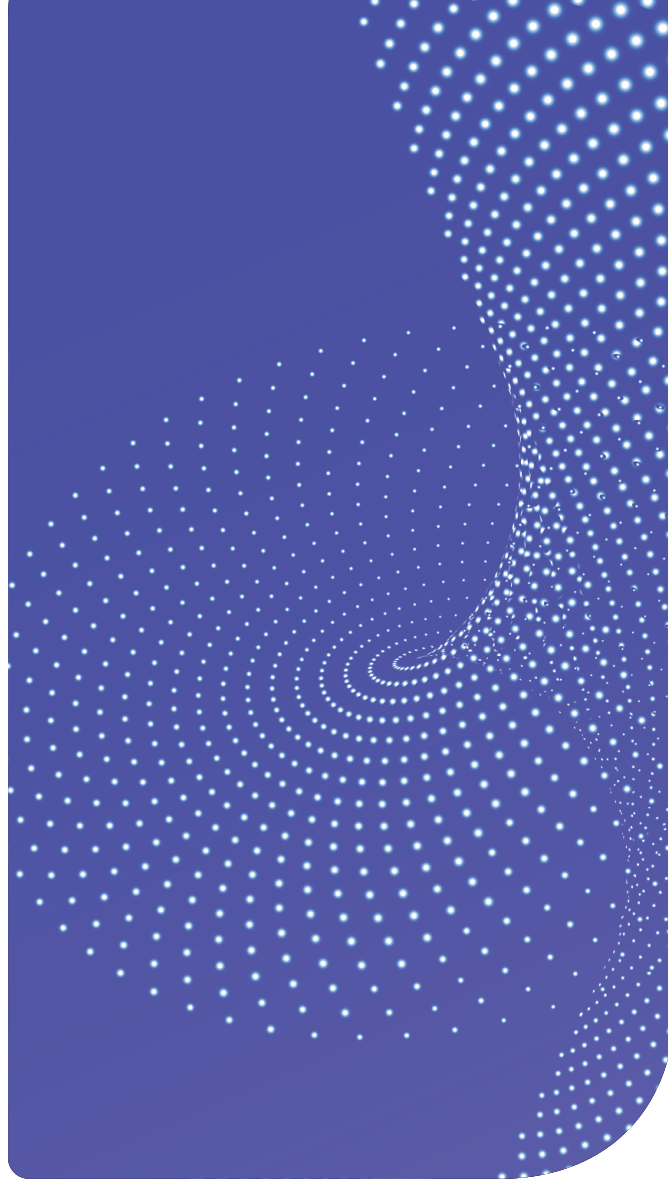
The surge of digitalization, which took place in the past decades, changed the global business landscape. The new environment pushes the traditional business model's transformation to feed the consumer experience's new requirements. Staying "smart" and "connected" have become the new rules of survival.

Lighting is an essential need in daily life. As an innovator of the lighting industry, Calex has been fortunate to follow the progress of the smart home market as a developer since its early days and has offered various products. With the introduction of the Tuya Platform, we found the ideal combination between the ease of use from a consumer point of view and the right price entry point, making smart products available for the mass market.

Technology develops itself as quickly as consumers can adapt. Most good corporations have now come to a stage where they have embraced an ecosystem and welcome its broad compatibility and functionality. No longer does a consumer have to worry about choosing the wrong platform or system as long as there is the cloud to cloud communication between the primary standards. One should think of Google and Amazon, where all the diverse platforms can come together, and the different protocols included in the platform like Wi-Fi, Bluetooth, Bluetooth Mesh, and Zigbee. Each protocol serves a different purpose with its unique features though it is no longer the basis of a consumer choice for a specific smart platform.

In the lighting industry, the discussion on the dimmability of bulbs when changing from incandescent to compact fluorescent to LED took almost five decades. We genuinely believe that the discussion about smart lighting will take less than one decade to come to the conclusion: smart will be the standard for a light source.

It is my privilege to be the preface writer of the 2021 Global AIoT Developers Ecosystem White Paper. The articles inside this white paper indicate the industry's potential trends and elucidate the possibilities of consumer habits variation in the future. I strongly recommend you to read.



1

The Current

1.1

The Definition of AIoT or AI+IoT

AIoT stands for artificial intelligence and internet of things. Broadly speaking, it refers to the integration and application of artificial intelligence and internet of things.

AI (Artificial Intelligence) refers to a technical science about the theories, methods, technologies and application systems to simulate, extend and expand human intelligence through research and development. As a branch of computer science, AI seeks to understand the essence of intelligence to produce a new, intelligent machine that reacts in a similar way to human intelligence.

IoT (Internet of Things): Built upon the internet, IoT is one step beyond connecting devices: it establishes connection between physical objects as well as between physical objects and people.

When AI and IoT are combined, massive amounts of data generated and collected by the IoT are stored on terminals, edges or clouds. These data are then analyzed intelligently through machine learning, thus allowing us to digitize and intelligently connect everything. On the technical level, AI enables IoT to acquire perception and recognition capabilities, while IoT provides data that trains AI algorithms. On the commercial level, the two work in synergy to enhance the real economy through promoting industrial upgrades and experience optimization.

1.2

The Origin, Background and Development of AIoT

AI (Artificial Intelligence) was first formally coined at the Dartmouth Conference, by pioneers in the discipline such as John McCarthy, who was the first to conduct in-depth academic research on AI.

The concept of the Internet of Things was proposed in 1991 by Professor Kevin Ashton of the Massachusetts Institute of Technology. In 1999, a research on Radio Frequency Identification (RFID) first clarified the definition of the Internet of Things: all things are connected to the internet through information sensors, such as RFID and bar codes, to achieve smart recognition and management. In 2017, at the "All Things Smart · New Era AIoT Future Conference", China officially proposed the concept of AIoT.

From the perspective of industrial development, the first-generation Internet (PC Internet) is essentially a network of computers. Users gain access to information on the internet through machines, and the main media for connection are signal lines/network lines; the second-generation Internet

(mobile Internet), by its very nature, is a network of people, and it's the reason behind a booming mobile devices sector which churns out smartphones and laptops. In addition, signal transmission of the network has evolved from fixed lines to radiowaves. With the popularization of the Internet, the number of netizens is gradually increasing, but the demographic dividend is gradually being exhausted, and the shipments of PC devices and smartphones, representatives of the two eras, have peaked. As network communication technologies are continuously innovated (the upgrade from the fixed network to the 5G network brings forth a comprehensive upgrade of bandwidth, capacity, and transmission rate) and device connection technologies see further development (the cost of networking is further reduced), the new generation of the Internet will grant connection to various devices, bringing us one step closer to the phase of "All Things Connected".

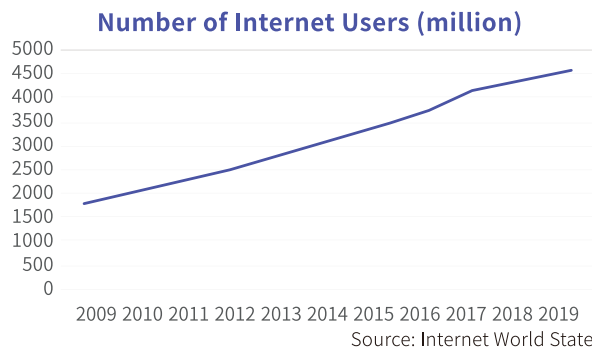


Chart 1: Number of Internet Users (million)

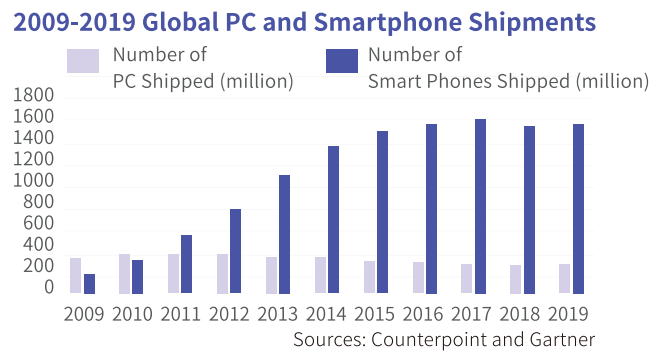
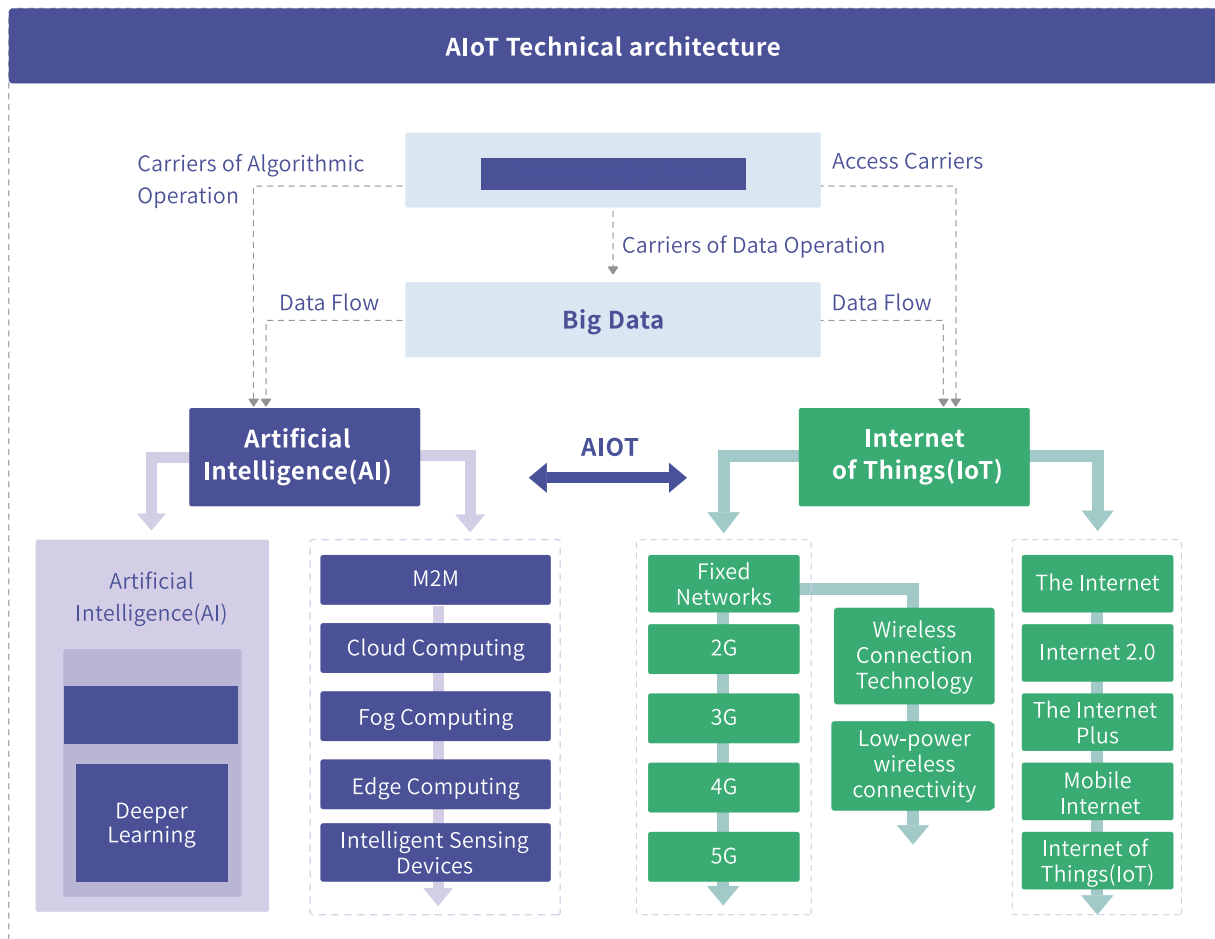


Chart 2: 2009-2019 Global PC and Smartphone Shipments

With the iterations of technologies such as AI, big data, and cloud computing, the ultimate development objective of IoT is "All Things Connected." AI technologies are used to analyze and process data collected by smart terminals to improve user experience and product intelligence, which ultimately leads to a shift in our lifestyle. Wu Hequan, an Academician of the Chinese

Academy of Engineering, predicted that for AIoT to become truly intelligent, it will go through three developmental stages: single-device intelligence, interconnected intelligence, and active intelligence. AIoT is evolving from single-device intelligence to interconnected intelligence, while the development of smart terminals is reaching maturity.



Source: EqualOcean, Guosheng Securities Research Institute

Standalone Intelligence	Interconnected Intelligence	Active intelligence
- Stand-alone devices accurately perceive, recognize, and understand the user's commands, and make correct decisions, execute, and provide feedback. - There is no active linkage between devices, and the user is required to give instructions for the interaction between the two devices.	Interconnected and interlinked product matrix, using "one cloud/central console, multiple terminals/sensors" mode. Break through the "island dilemma" of stand-alone intelligence, and continuously upgrade and optimize the intelligent scene experience.	The intelligent system is ready to provide services according to user behavior preferences, user image, environment and other types of information, and is truly capable of automatic learning, self-adaptation and automatic service improvement, and can proactively provide the services users need without waiting for users to give instructions.

1.3

An Analysis on the Macro Environment of the AIoT Industry

1.3.1 An Analysis on Policies for the AIoT Industry

Many countries across the world are attaching great importance to the development of the AIoT industry, and continue to introduce relevant policies and establish strategies to gain an upper hand in the international competition of future technologies, especially in developed countries and regions such as the United States, the European Union, Japan and South Korea.

China

National strategies: On November 3rd, 2009, Premier Wen Jiabao delivered a speech entitled "Let Science and Technology Lead China's Sustainable Development", in which he stated clearly that the Internet of Things is one of China's strategic emerging industries; in 2010, the Internet of Things was first included in the "Report on the Work of the Government".

Top-level design: During the "12th Five-Year Plan", the government strengthened its efforts in promoting the industry; in early 2013, the "Guidelines of the State Council on Promoting the Orderly and Healthy

Development of the Internet of Things" was formally released, which laid out the overall strategy of the Internet of Things and clarified developmental objectives.

Organizational structure: The Inter-ministerial Joint Meeting and Expert Advisory Committee for the Development of the Internet of Things was established to coordinate all relevant departments; **Development plan:** "Special Action Plan for the Internet of Things Development (2013-2015)"; "the Development Plan for the Internet of Things (2016-2020)" (to clarify the development goals of our main performance indicators, in the IoT industry by 2020).

Financial support: The central government has arranged dedicated funds for the development of the Internet of Things for 4 consecutive years, and has included the Internet of Things in the list of high-tech industries to be determined and supported. **Strategic upgrade:** During the "13th Five-Year Plan", the Chinese government emphasized the implementation of the "Cyberpower" strategy, acceleration of the building of "digital China", and promotion of a full integration of technologies such as the IoT, cloud computing and AI into various industries. In 2017, the State Council issued "The New-generation Artificial Intelligence Development Plan", elevated the development of AI into a national strategy. The "2019 State Council Report on the Work of the Government" proposed to "build an industrial Internet platform and expand 'smart+' ",

an initiative regarded as the government's first foray into a new era of all things connected intelligently; In 2020, the country emphasized the development of "new infrastructure", namely, cloud computing and artificial intelligence, blockchain, 5G, Internet of Things, industrial Internet and other technologies, as well as the integration of these technologies, empowering traditional industries to make smart upgrades.

United States

National Strategies: In 2009, the Obama administration proposed their key strategy to revitalize the economy and establish the US's global competitive advantage, namely the US Internet of Things strategy. And the American Recovery and Reinvestment Act (787 billion USD in total) proposed to focus on industries including energy, technology, education and health in terms of developing and applying IoT technologies through increased government investment.

Organizational structure/financial support: In 2015, the US government announced that it would invest \$160 million to promote the Smart City Initiative; the US Department of Energy established the "Smart Manufacturing Innovation" organization and invested \$70 million to promote the R&D of advanced sensors, controllers, platforms and manufacturing modeling technologies.

Strategic upgrade: In February 2019, US President Trump signed Executive Order No. 13859 to launch the new US artificial intelligence plan, as a national strategy to enhance the US AI leadership; at the end of February 2020, the White House Office of Science and Technology Policy released the "American Artificial Intelligence Initiative: Year One Annual Report", which outlined the progress of AI development in the United States and emphasized six key policies and practices.

The European Union

Strategies: In June 2009, the European Commission submitted the world's first IoT development strategic plan, titled "Internet of Things - an Action Plan for

Europe", in which the Commission proposed 14 IoT action plans.

Organizational structure/financial support: In 2015, the Alliance for the Internet of Things Innovation (AloTI), an organization that bridges the EU and the industry circle, was established with an investment of 50 million euros; in 2016, the Internet of Things - European Platform Initiative (IoT-EPI) was established with the purpose of building a sustainable European IoT ecosystem; through the "Horizon 2020" R&D program, nearly 200 million euros will be invested in the IoT to build an IoT platform that connects smart devices, which promotes IoT integration and platform research and innovation. The R&D program focuses on five smart applications that will be carried out on a large scale: connected cars, smart cities, smart wearable devices, smart agriculture and food safety, and smart elderly care.

Strategic upgrade: In April 2018, the European Commission issued a policy document "Artificial Intelligence for Europe", which proposed the EU way of artificial intelligence; in February 2020, the European Commission issued the "White Paper on Artificial Intelligence", emphasizing that the European AI strategy aims to improve innovation capabilities in the field, while simultaneously promoting the application of ethical and trustworthy AI technologies in the European economy.

Japan and South Korea

In August 2016, the South Korean government identified nine national strategic projects (AI, autonomous driving, smart cities, virtual reality, etc.) as new engines for new economic growth and improving the quality of their citizens' lives. The Ministry of Science, ICT and Future Planning of South Korea will invest over 2 trillion won to promote these nine projects, while South Korean carriers are actively deploying dedicated networks for the Internet of Things. In January 2019, the Ministry of Science and ICT of South Korea formulated and released the "Economic Activation Plan Based on Data and Artificial Intelligence" to promote the

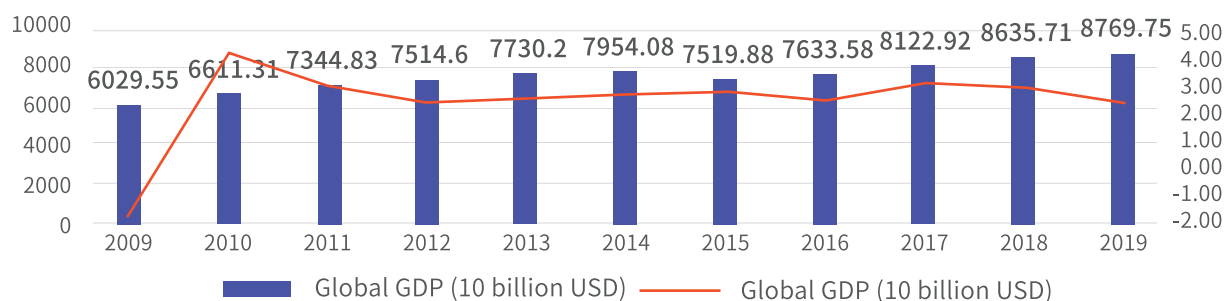
integration of data and artificial intelligence. In 2004, the Ministry of Internal Affairs and Communications (MIC), the authority of Japan's information and communications industry, proposed the "U-Japan" strategy. Subsequently, Japan began to promote the application of the Internet of Things in power grids, remote monitoring, smart homes, and Internet of Vehicles; In July 2009, the Japanese IT Strategy Headquarters proposed "I-Japan Strategy 2015", setting the goals to achieve a citizen-centered digital security and a society of vitality, and to strengthen the application of the IoT in the fields of transportation, medical care, education, and environmental monitoring. In January 2016, the Japanese Cabinet proposed "Super Intelligent Society 5.0", aiming to make lives more convenient through technologies such as the IoT, robotics, AI, and big data. In June 2018, the Japanese government proposed a new artificial intelligence strategy, "Integrated Innovation Strategy", and established the Promotion

Committee of Integrated Innovation Strategy.

1.3.2 An Analysis of the Economic Environment of the AIoT Industry

The global economy has slowed down (the growth rate of global GDP has decreased), and it is expected that 2020 will see a slower economic growth due to the impact of global trade disputes and the Covid-19 pandemic. Meanwhile, international competition has intensified, and countries are increasingly vying to become a technological power. Therefore, they have paid more attention to the development of emerging technologies such as artificial intelligence, cloud computing, communications, and the Internet of Things. Due to the overall macroeconomic environment, the investment environment for AI and IoT has gradually become more rational, and the commercialization of AIoT-related fields has become the key to future strategies.

2009-2019 global GDP (10 billion USD) and growth rate (%)



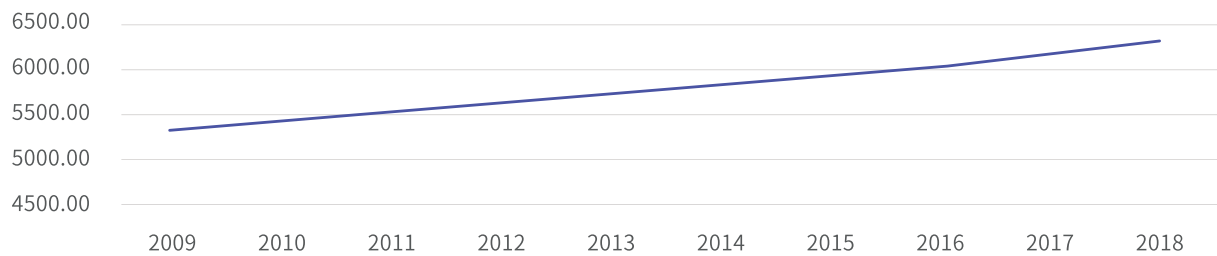
Source: IC Insight

1.3.3 An Analysis of the Social Environment of the AIoT Industry

Mass consumers: Globally, the per capita consumption continues to rise. Consumption upgrades have brought about changes in consumption mindsets. In addition, smart terminal

products, the most representatives of which are smart speakers and smart watches, continue to enjoy more and more variety, while their fast iterations also offer new functions. As a result, people are more willing to purchase smart products that could improve their lives.

Global Households Final Consumption Expenditure Per Capita (USD)



Source: IC Insight

Business environment: Digitalization has penetrated industries. Traditional industries, most notable representatives of which are manufacturing, medical care, and energy, are facing digital transformation. The application of the intelligent IoT is one important way to complete digital transformation. Driven by industrial applications, the business models surrounding the AIoT industry are constantly being innovated, developed and optimized. Services such as shared bicycles and telemedicine are all innovative business models based on the development of the Internet of Things.

1.3.4 An Analysis of the Technologies in the AIoT Industry

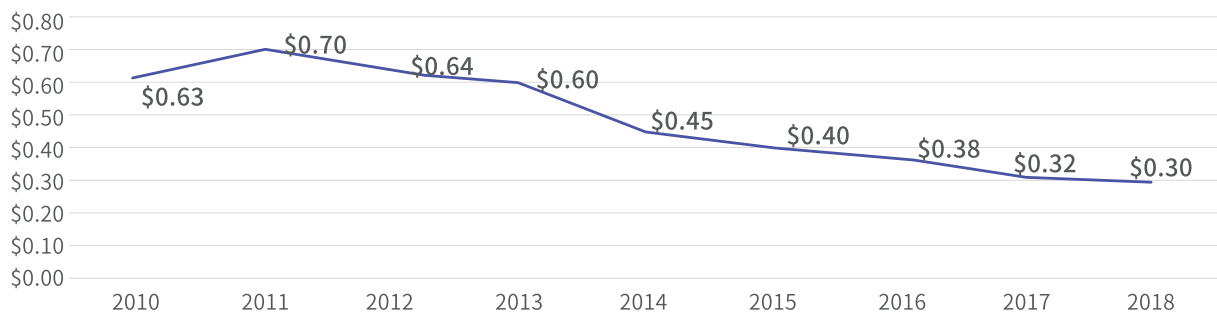
Sensing technologies:

In the AIoT industry, sensing technologies are the entry to data collection, and sensors are the

underlying components that perceive various information and data related to the objects, their status, and the environment. Sensors are gradually moving away from their traditional forms and becoming smart. They are now able to detect the external information, perform self-diagnose, process data and adapt to different situations. Currently, MEMS1 (Microelectro Mechanical Systems) sensors have become a new development trend. Due to integrated communications, CPU, batteries, etc., and a variety of sensors, MEMS sensors are small, lightweight, inexpensive, and easy to be integrated. They make the terminals smarter.

As sensing technologies develop, the average price of sensors continues to fall globally, and the cost of network deployment of smart devices has been greatly reduced, which supports the development of the AIoT industry from the infrastructure level.

The Global Average Price of Sensors (USD)



Source: IC Insight

Semiconductor chips:

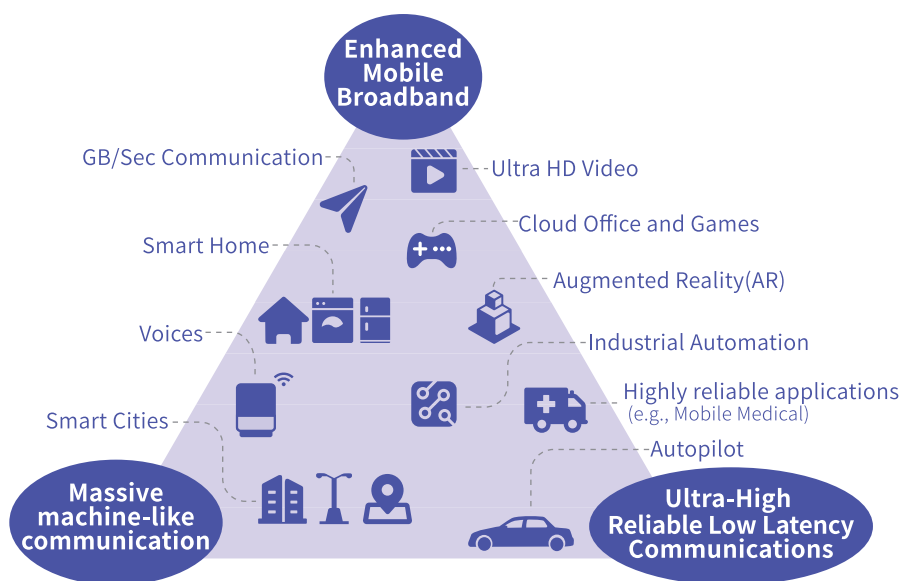
At this stage, AIoT devices still need smart phones or Wi-Fi to be connected to the network. In order to improve the flexibility and portability of AIoT terminals, it is necessary to ensure that the built-in batteries of AIoT smart terminals are small, lightweight and have a long battery life. Therefore, the built-in device processor (semiconductor chip) is getting more energy-efficient and high-performing. MCU2 and SoC3, which enjoy notable advantages in performance, cost, low power, reliability, and scope of application, have matured and become an important technical support for the AIoT industry.

Network and communication technology:

In the era of "All Things Connected", connected devices continue to increase. In order to simultaneously connect an enormous number of

devices and reduce latency, the iterative evolution of network and communication technologies are essential. Therefore, in order to support the development of the AIoT industry, the performances of network and communication technologies in terms of transmission rate, bandwidth, connection capacity, low power, delay, etc. have been greatly improved, including 5G, Wi-Fi6, IPv6, Zigbee5, LPWAN6 (NB-IoT7, LoRa8), among other network and communication technologies widely used in the AIoT industry.

Massive machine-type-communications (mMTC) in the three major commercial scenarios of 5G technology include narrowband Internet of Things (NB-IoT) and enhanced machine type communication (eMTC), which can be adapted to large-scale IoT applications.



LPWAN (Low-Power Wide-Area Network): It is suitable for IoT terminals. It has low broadband, low power consumption, long range, and large connection. It will cover 60% of IoT devices in the future.

Compared with Wi-Fi5, Wi-Fi6 has been comprehensively improved in terms of performance. The total bandwidth has been increased from

2.4Gbps to 9.6Gbps, the number of connected devices from 5-10 to 50, and the network delay reduced from 30ms to 20ms. All of these improvements enable communication with terminal equipment while reducing power consumption. Bluetooth technology is an open global standard for wireless data and voice communication. It is a radio technology that supports short-distance

communication between devices, enabling short-distance data exchange among fixed devices, mobile devices (mobile phones, PDAs, wireless headsets, laptops, etc.) and personal LANs within buildings. Bluetooth connects multiple devices and offers the solution to data synchronization. Its advantages include applicability among multiple devices, national working frequency bands and strong anti-interference, but it is insufficient in terms of power consumption and safety. BleMesh (Bluetooth Mesh) network is a new network topology of Bluetooth Low Energy (also known as Bluetooth LE) used to establish many-to-many device communication. Its advantages are low module cost, lower packet loss rate and delay during data transmission, directly supported by smart phones, portable networking, and strong anti-interference performance. Currently, BleMesh is getting the attention of the entire industry. It has certain

commercialization potential in smart lighting control systems, and could also be promoted and applied to other industries.

Zigbee is a short-range (10-100m), low-bit (250Kbps), low-power, low-cost, two-way wireless communication technology. It can work on three frequency bands: 2.4GHz (globally common), 868MHz (common in Europe) and 915 MHz (common in the US). It is mainly used for data transmission among various electronic devices with short range, low power consumption and low transmission rate, and can be embedded in various devices. The advantages of Zigbee include: low power consumption, low cost, large network capacity, reliability, security, and great scalability. However, Zigbee mainly uses the 2.5G frequency in the ISM frequency band, and has weak diffraction and insufficient wall penetration in the home environment, greatly affecting the signal.

Technical name	Wi-Fi	Bluetooth	Zigbee
Transmission speed	300Mbps	1Mbps	250Kbps
Communication distance (diameter)	100~300m	2~30m	10~100m
Spectrum	2.4GHz	2.4GHz	2.4GHz
Security	low	High	High
Power consumption	10~50mA	20mA	5mA
Cost	2.5dollars	2.5dollars	3 ~ 5 dollars
Chief application	Wireless Internet, PC, FDA	Communication, automobile, IT,multimedia, industrial medical education, etc.	IoT M2M industry (Smart grid, smart home, etc.)

A comparative analysis shows that Wi-Fi is currently the most widely used wireless communication technology with the highest transmission rate; Zigbee's advantages are ad hoc network and low power consumption, and Bluetooth's advantage is

easy networking.

Cloud computing and AI:

In recent years, artificial intelligence has fully entered the era of machine learning. With the support of

data mining, cloud services, data analysis and other technologies, AI now has access to massive pools of data for learning, and AI technologies and their core algorithms are constantly being upgraded and iterated. Core AI technologies, most notably, computer vision technology, natural language processing technology, and intelligent adaptive learning technology, have achieved great breakthroughs. Due to the fact that the technologies are becoming more and more mature, AI technology has gradually entered the commercialization stage, integrating with traditional industries to improve the production efficiency.

More connected devices will inevitably lead to a surge in data volume, so there will be a higher demand for data storage and data processing technology. The development of cloud computing and big data technology also provides support to the AIoT industry. Currently, more mature cloud computing technologies include hybrid cloud technology (for horizontal modular expansion), hyper-convergence technology (to solve the problem of storage device capacity, performance and computing power mismatch) and edge computing technology (to solve issues related to central capacity, network delay, transmission energy consumption, privacy protection, etc.).

The development of AI and IoT technologies are complementary to each other. AI technologies advance from learning big data, and the smart connection of the IoT requires intelligent analysis from AI. Therefore, developing these technologies in synergy helps the AIoT industry to grow.

Notes:

[1] MEMS: stands for Micro-Electro Mechanical Systems, which refers to micro components or systems that can be produced in batches, and serve to integrate micro mechanisms, micro sensors, micro actuators, signal processing and control circuits, even interfaces, communication modules, and power modules into one or multiple chips.

[2] MCU: Microcontroller Unit, also known as Single-Chip Microcomputer or single-chip unit, serves to moderately reduce the frequency and performance of the central processing unit (CPU), and to integrate memory, Timer, USB, A/D conversion, UART, PLC, DMA and other peripheral interfaces, and even LCD drive circuit into a single chip to form a chip-level computer, providing various control combinations for different applications.

[3] SoC: System-level chip, or System on a Chip. Academia in China and abroad generally tend to define SoC as an integration of microprocessor, analog IP core, digital IP core and memory (or off-chip storage control interface) on a single chip. It is usually custom-made or a standard product for specific purposes.

[4] IPv6: Internet Protocol Version 6, is the next generation IP protocol designed by the Internet Engineering Task Force (IETF) to replace IPv4.

[5] Zigbee: It is a wireless network protocol for low-bit and short-distance transmission. It is low-bit, low-power, inexpensive; supports a large number of network nodes and multiple network topologies; and it is also incomplex, fast, reliable and secure.

[6] LPWAN: Low-Power Wide-Area Network, also known as LPWA or LPN, is a wireless network used in the Internet of Things, enabling communication over long distances at low transmission rates.

[7] NB-IoT: Narrow Band-Internet of Things. It is a new narrowband cellular communication LPWAN technology proposed by the 3GPP, a group of standard organizations, in September 2015. Its core application is low-end IoT terminals (low current consumption), suitable for broad deployment in smart homes, smart cities, smart production, etc.

[8] LoRa: Long Range Radio is a low-power wide-area network protocol developed by Semtech. Under the same power consumption, it has 3-5 times the frequency communication distance of the traditional radio, achieving low power consumption and long distance simultaneously.

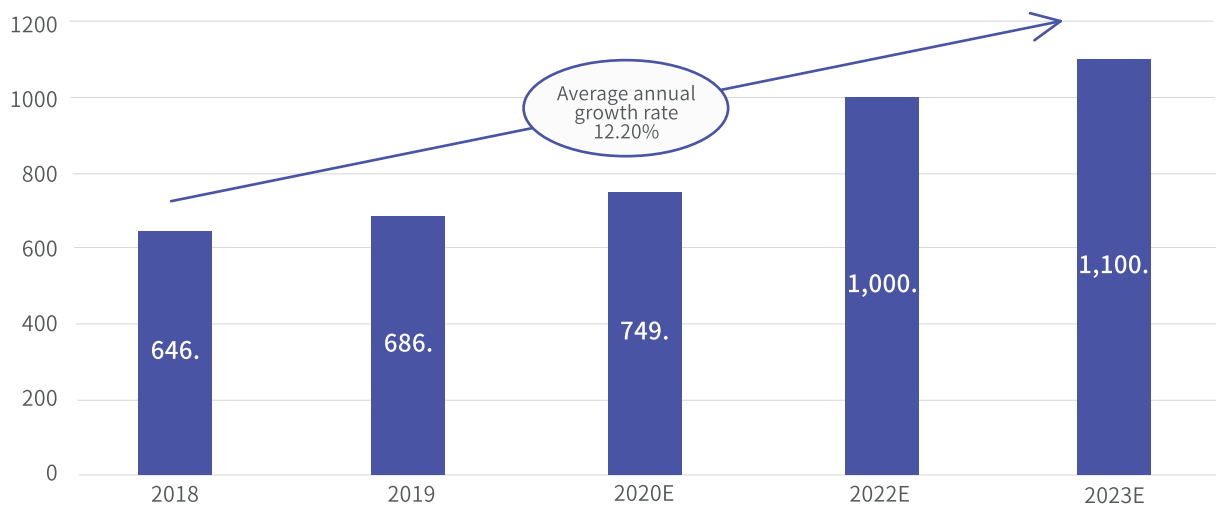
1.4

Analysis of the Global AIoT Market

AIoT market has been expanding due to the powerful convergence of artificial intelligence(AI) technologies and IoT applications. According to IDC, a leading international information technology data company, the global IoT market size was \$686

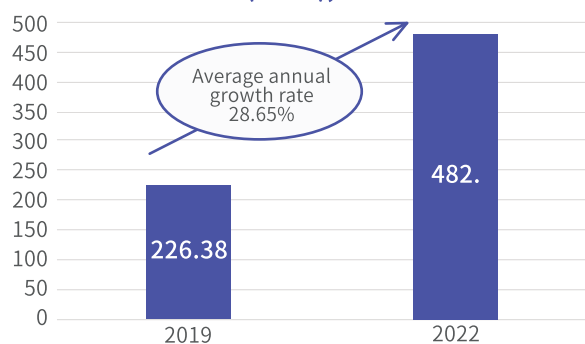
billion in 2019 and will exceed \$1 trillion by 2022. In the meantime, data transmitted via IoT has reached 14 ZB in 2019 and will reach 80 ZB by 2025. As IoT, 5G, big data, and other technologies develop, the penetration of AI in IoT market will rapidly grow in the next few years. Global Smart Business estimates that the global AIoT market size was about \$226 billion in 2019 and will grow to \$482 billion by 2022, with a compound annual growth rate of around 28.6%.

Global IoT Market Size (in USD million) and CAGR, 2018-2023



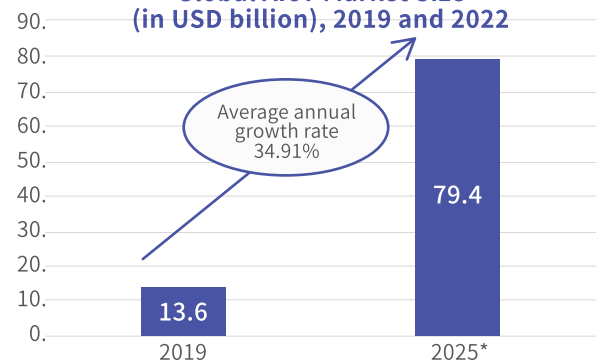
Source: IDC

IoT Data Size (in ZB), 2019 and 2025



Source: IDC

Global AIoT Market Size (in USD billion), 2019 and 2022



Source: IDC

China

Since many IoT companies and manufacturers (with a low AI adoption rate) are relatively young, China's AIoT market only took up a small share in the overall IoT market in 2019 compared with other regions, but it also means opportunities for future development. Global Smart Business estimates that China's AIoT market size in 2019 was about USD 55 billion, and thanks to recent policies on new infrastructure, it will reach USD 128 billion in 2022, with a compound annual growth rate of about 33%. The growth rate will surpass the United States, the European Union, Japan, South Korea, and other regions, making China one of the world's most potential AIoT markets.

The United States

As the world's largest AIoT market, the United States will remain on top for the next three years.

Global Smart Business estimates that the US AIoT market size in 2019 was approximately USD 68 billion, and will reach USD 136 billion by 2020 with a steady annual growth rate of 26%.

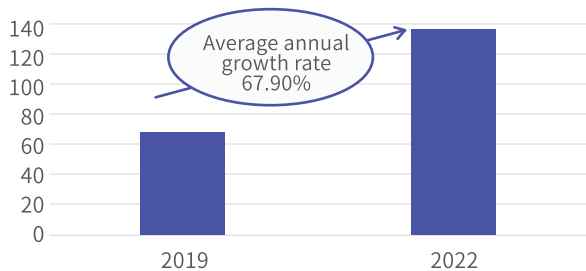
The European Union

Similar to the United States, the EU has a higher AI adoption rate. Therefore, despite its IoT market size was smaller than China in 2019, its AIoT market size was almost as big as China's and was about USD 55 billion. According to the forecast of Global Smart Business, the EU's AIoT market size will reach USD 120 billion in 2022, with a compound annual growth rate of about 30% and the potential to become a more mature and stable AIoT market.

Japan and South Korea

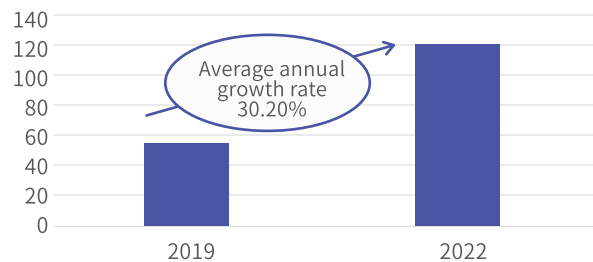
Japan and South Korea started early on the combination of AI and the IoT, so their technologies

US AIoT Market Size, 2019 and 2022



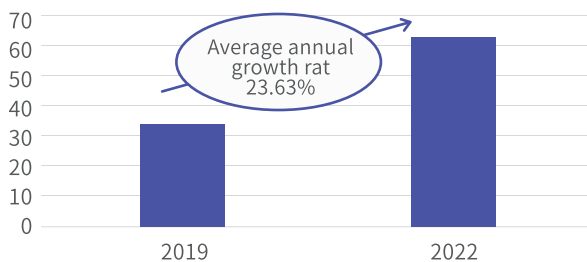
Source: AIoT Business

EU AIoT Market Size, 2019 and 2022



Source: AIoT Business

Japan & South Korea's AIoT Market



Source: AIoT Business

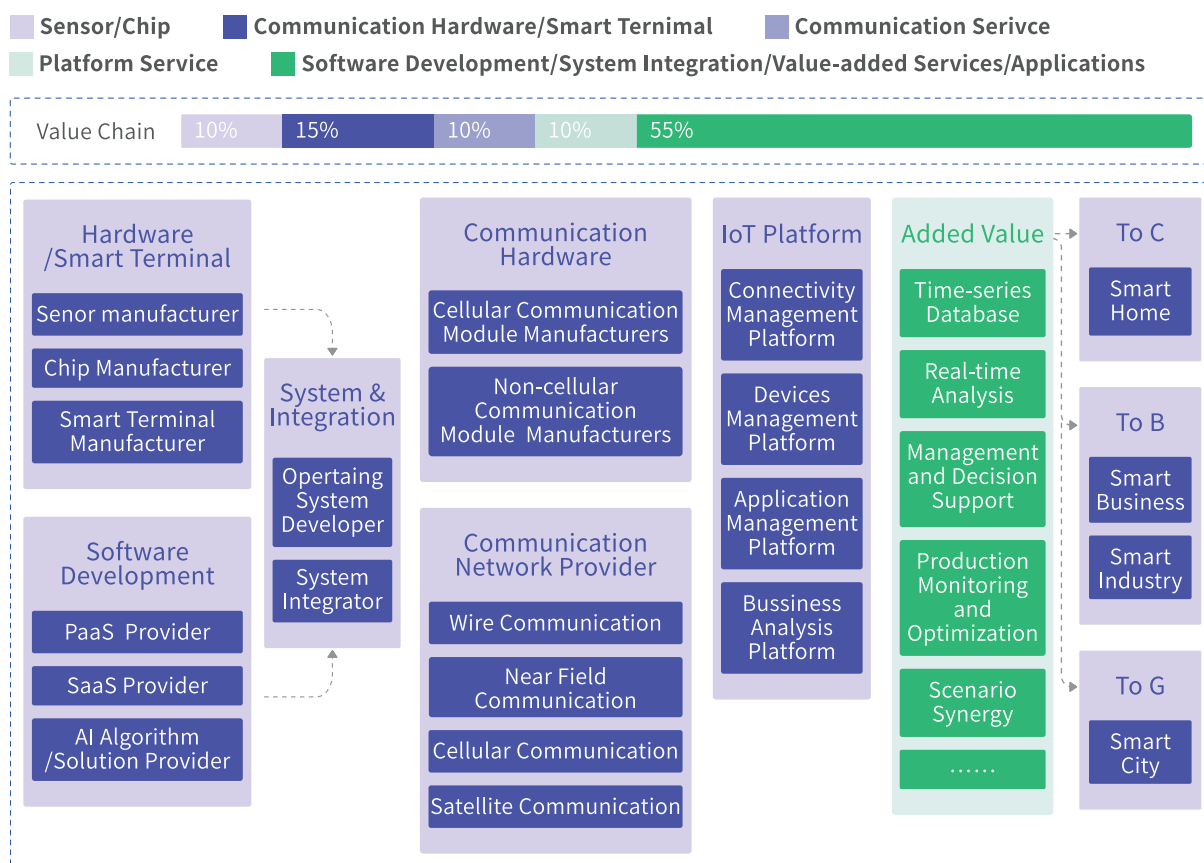
are relatively mature. The AIoT market size in 2019 was about USD 34 billion. However, since they have experienced a rapid growth at the early stage, the growth of the AIoT market in Japan and South Korea in the next three years will slow down, and the market size is expected to reach USD 64 billion in 2022, with a compound annual growth rate of about 24%, which is relatively lower compared to the US market.

1.5

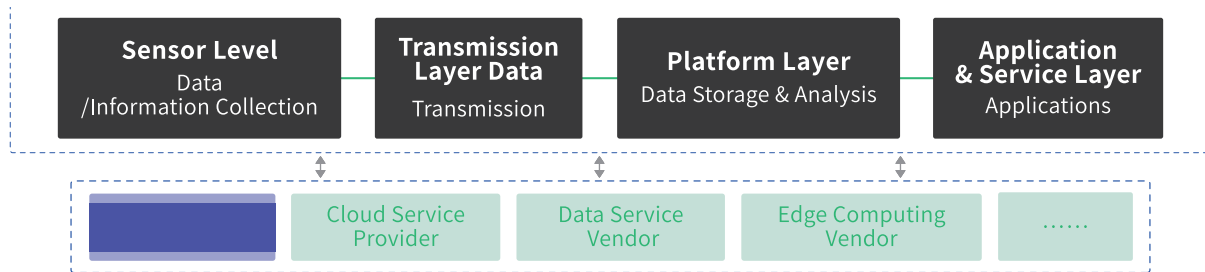
The Introduction and Analysis of the AIoT Value Chain

The AIoT value chain can be divided into four levels: sensor layer, transmission layer, platform layer, application and service layer. Sensor layer is to collect data and information, it includes basic components like sensors and chips, smart terminals, operating systems and software adapted to IoT smart terminals, and AI algorithms/solutions that support and analyze terminal devices, and the key player here is product/solution providers, such as iFlytek; transmission layer is to transmit data from sensor layer, it includes communications hardware and connectivity networks, and the key player here is service providers, such as China

Mobile and Orange; platform layer is to store and analyze data and the key player here is IoT platform providers such as Tuya Smart; application and service layer is to provide applications and services, with added values from AI technologies, for downstream companies, and the key players here include Baiseniaio, Schneider Electric, Siemens, etc. In conclusion, AIoT is the extension of IoT with more emphasis on AI chips, AI solution providers, and AI open platforms. Therefore, software development/system integration/value-added AI services have become an important part of the AIoT market. According to Ericsson, hardware/smart terminals (chips, sensors, modules, smart terminals) account for 25% of AIoT value chain, communication services account for 10%, platform services account for 10%, and software development/system integration/value-added services/applications account for 55%.



Source: EqualOcean



Source: EqualOcean

1.6

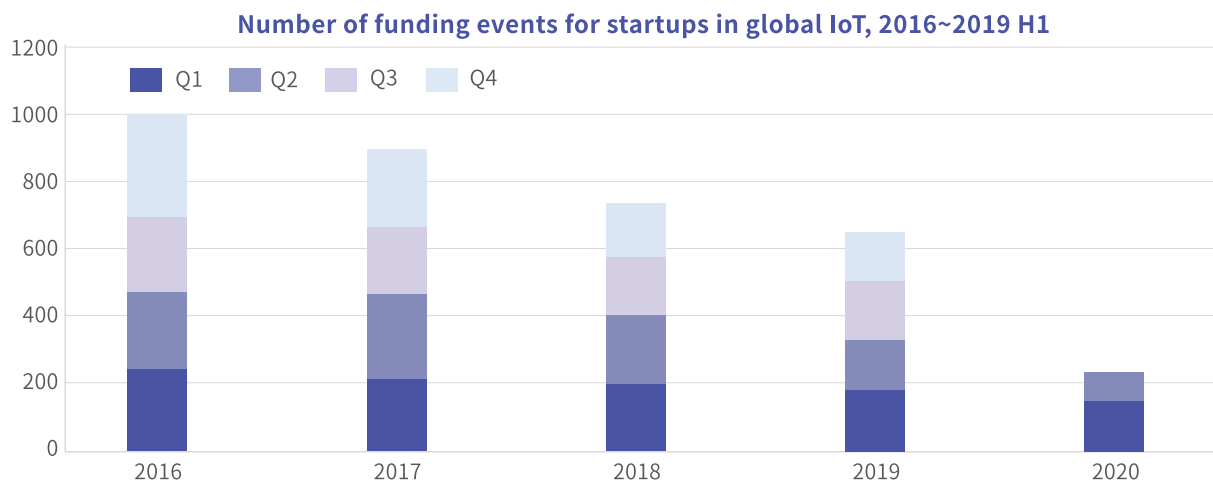
AIoT Investment and Financing Status and Investment Trends

IoT, AI and AIoT all have received a lot of attention of capital market in recent years. From 2016 to 2017, many startups just established but investment institutions were optimistic about AIoT's future and invested a lot in early-stage and mid-stage projects; since 2019, capital market has cooled down and as good projects and enterprises stand out, the amount of a single investment increases, but the number of investments decreases.

Venture Scanner's statistics show that IoT startups

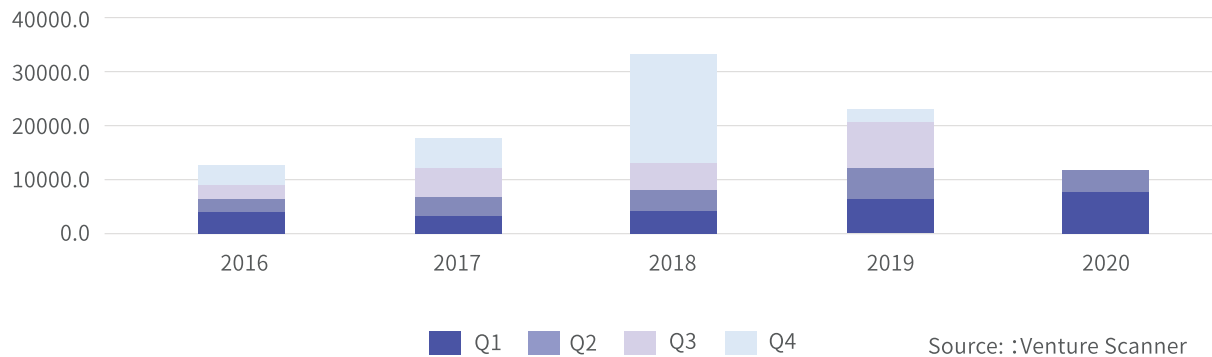
raised a great number of funds from 2016 to 2017, but the amount of each fund wasn't big so the total capital was relatively small; in 2018, the number of funds fell dramatically but the amount of each fund increased, so the total capital was large; in the first 6 months of 2020, the investment market has been cautious and the amount of one single fund has only increased slightly, so it is estimated the total financing amount will surpass that in 2019 by merely a little.

Based on the investing and financing activities recorded by itjuzi.com in the past 5 years (from 2016 to October 2020), the capital market has paid more attention to projects in a relatively early stage in this field with the most investments being Series A & Series A+ fundings every year. From 2016 to 2018, the capital market was enthusiastic: not only the number of investing activities accounted for a relatively high proportion, but also investors were



Source: :Venture Scanner

Total Amount of Funding for Startups in Global IoT (in USD million), 2016~2019H1

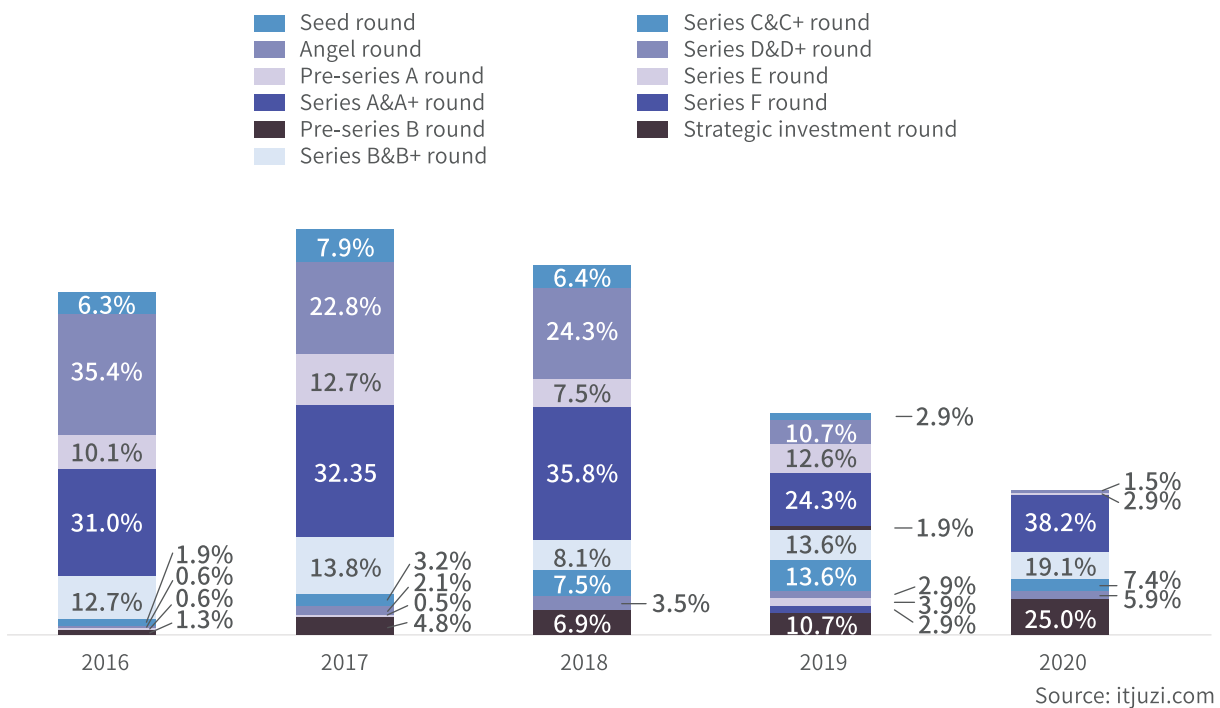


willing to invest in projects in the very early stage. The number of projects in angel rounds was 35.4%, 22.8% and 24.3% respectively from 2016 to 2018, which indicates the confidence the capital market had for IoT and AIoT. From 2019 to 2020, quality companies have stood out, and internet giants have entered the competition, and therefore the capital

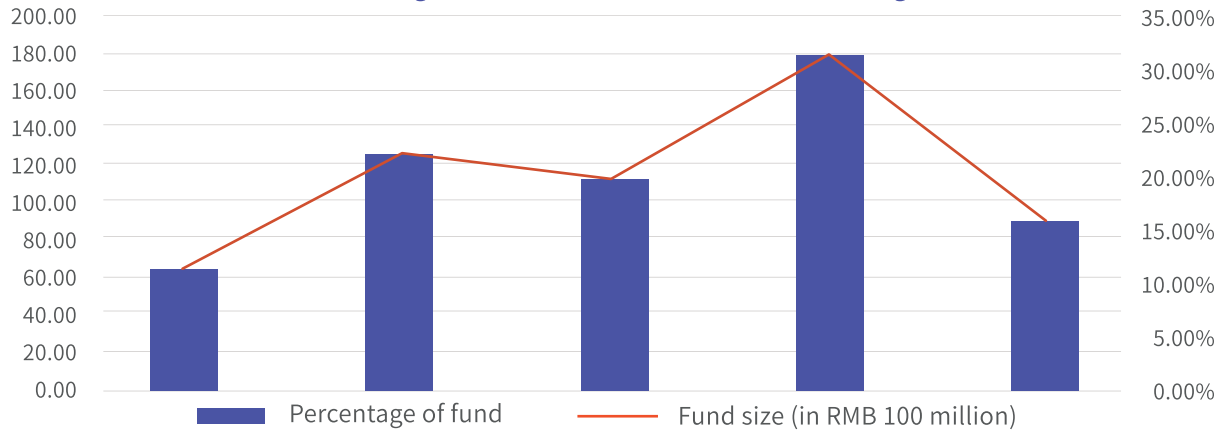
market has cooled off.

In terms of deal size, fundings in 2019 were the largest and single deal reached the highest level. Due to the pandemic this year, the capital market has grown tighter in general and it has also affected the investment and financing in IoT to a certain extent.

Distribution of funding events and rounds in IoT and AIoT, 2016-2020



2016-2020 IoT and Intelligent IoT Field Investment and Financing Scale Distribution



Source: itjuzi.com

(Note: If the investment size is not disclosed, it is not counted; “hundreds of thousands” is counted as 700,000, “millions” as 5,000,000, “tens of millions” as 30,000,000, “hundreds of millions” as 200,000,000; the USD to CNY exchange rate is 6.7, the euro to CNY exchange rate is 7.8, the GBP to CNY exchange rate is 8.6, the JPY to CNY exchange rate used is 0.064, and the INR to CNY exchange rate is 0.090.)

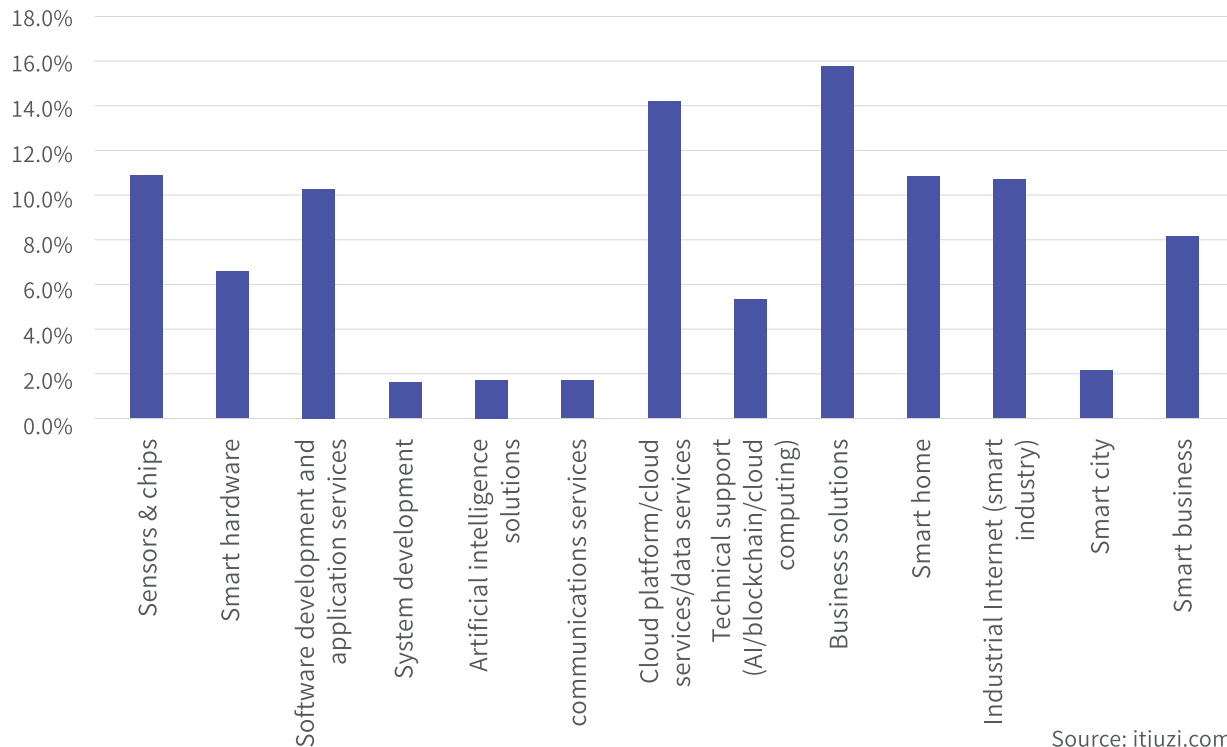
In terms of investment direction, sensors and chips, software development and services, cloud platform and data services are the major investment targets for sensor layer, transmission layer and platform layer respectively in AIoT. Generally speaking, Investors are more interested in investing in companies working in the application of AIoT, especially those who provide solutions or operation services. Smart home, smart industry and smart business (including smart retail, smart logistics, smart community, smart agriculture, smart education, etc.) are relatively popular investment directions.

Kevin Wang, a partner at Mount Morning Capital, has been looking at 5G and IoT, smart manufacturing, and enterprise services for long. According to him, the business models and market values of the AIoT companies worth investing will continue to evolve as technologies and enterprises develop. The first stage of the development is networking and

digitalization, with the aim to connect devices and digitalize internal business processes; the second stage is using data generated by the action of connecting devices to provide value-added services for operations and to help customers transform from traditional transaction-based enterprises to service-oriented enterprises; the third stage is the connection and integration of value chain components through multi-party collaboration to form a network of multipoint-to-multipoint services. Take Tuya Smart as an example, it provides IoT modules to help home appliance manufacturers and developers to connect devices to the cloud first, enables customers to create value-added services and new business models with operation data generated at the platform next, and finally integrates upstream and downstream resources of the industry chain to help customers access overseas ecosystem and market resources via a comprehensive developer platform.

Wang also pointed out that the connection of devices is the foundation of AIoT but the market for connectivity is limited, and the value created through the data generated by the connection is worth more attention. AIoT can be applied to many vertical industries, such as industrial engineering, logistics, energy, city management and other industries with huge market potential. Cost savings, efficiency improvement and business model reforms

Breakdown of investing and financing events in IoT and AIoT, 2016-2020



that are driven by AIoT data will create huge value. Investors should focus on how much value AIoT applications and services can create, how much profit AIoT technology or services providers can make, and how much money and time is needed. Wang shared 4 areas that he believes are worth

investing in AIoT in the future: value-added AIoT applications based on data, 3D vision and applications, low-cost sensors (MEMS), and IoT security (IoT will be adopted in a large number of active devices, such as automobiles and industrial production equipment, so its security is crucial).



2

The Practices

2.1.1

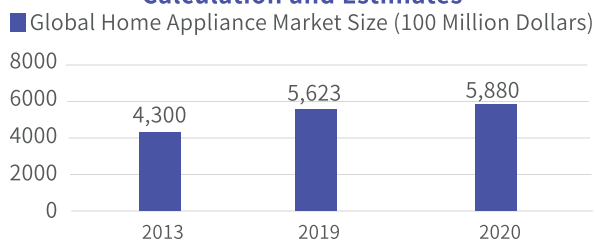
Major and Small Home Appliances

1. Overview of the Home Appliance Industry

As widespread adoption of AI and the IoT, the intelligentization development in the home appliance industry has made a preliminary progress. Meanwhile, the number of users for smartphones and smart speakers has increased very quickly, promoting the update and development of smart home products greatly.

According to the data from Statista, a world-renowned data analysis company, the global market size for home appliances reached 430 billion dollars in 2013 and the number is expected to be up to around 588 billion dollars in 2020. As for the major home appliance market, in 2019, the global sales reached 203.1 billion dollars, up by 3.4 % year on year.

2013-2020 Global Home Appliance Market Size Calculation and Estimates

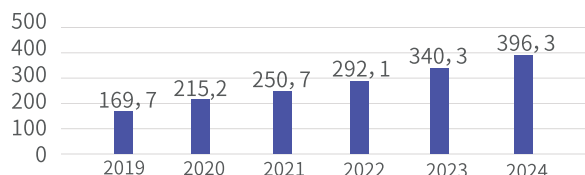


Source: Compiled by Forward Business and Intelligence Co., Ltd.

In the smart home appliance field, in 2019, the global market size for it reached 16.97 billion dollars and in 2020, the number is expected to reach 21.52 billion dollars, up by 26.8 %. In the next five years, the global market size for smart home appliances will achieve a compound annual growth rate that equals to 16.5%, reaching 39.63 billion dollars in 2024.

2019-2024 Global Smart Home Appliance Market Size Calculation and Estimates

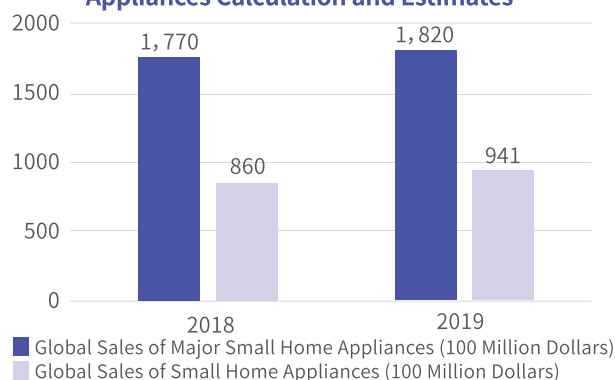
■ Global Smart Home Appliance Market Size (100 Million Dollars)



Source: Compiled by Forward Business and Intelligence Co., Ltd.

According to the data by GfK Temax, in 2018, the global sales for major home appliances reached 177 billion euros and the number for small home appliances was 86 billion euros, accounting for 32.7% of the global sales for home appliances.

2018-2019 Global Sales of Major and Small Home Appliances Calculation and Estimates



Source: Compiled by Forward Business and Intelligence Co., Ltd.

Compared with the traditional home appliance market, smart home appliances can meet diverse life demands of new consumer groups and largely improve the interactive experience of home appliances to create a cozy, intelligent and immersive life environment. According to the development trend, the smart home appliance industry will lead the consumption upgrade for a long time in future. The smart home appliance market has a great prospect.

1.1 Smart Major Appliance Industry

Smart major appliance refers to home appliances such as air conditioning, refrigerator, washing machine and television, featuring taking up a large space, high cost and low replacement rate and being the major application scenario in smart living. Currently, the market of smart TV, smart air conditioner, smart refrigerator and smart washing machine is pretty mature. The leading manufactures in the industry keeps updating the existing products, developing and introducing innovative and scenario-based ones.

Among traditional home appliances, the highest penetration rate is smart TV which can reach over 95%. Smart TV is also the most frequently used as well as the most interactive entry level smart product among the smart home appliances. The proportion of smart major appliances, for example, air conditioner, refrigerator, washing machine and etc. is increasing rapidly through innovation and iteration in the functions of remote control, connectivity and voice interaction.

1.2 Smart Small Appliance Industry

Different from the smart major appliance industry, the smart small appliance industry is more diversified, including smart sweeping machine, smart air purifier, smart heater and smart fan, being in various forms. It has market demands under different scenarios and provides great interactive experience based on its functions, such as device status alert, time-sharing and schedule setting and real-time remote interaction. The smart small appliances have gained a firm footing in the market place quickly for being easy to use and with clear functions and high replacement rate. At the same time, new brands in the industry have been growing rapidly. In particular, the emergence of creative products makes the industry enjoy broad market prospects.

1.3 Smart Kitchen Appliance Industry

People's passion for food has never diminished

though the ages. In the past, people were only concerned with eating with fill, whereas at present, they want to eat well. people's relentless pursuit of good food also changes the definition of modern kitchen.

In recent years, they have started to adopt a healthy diet supported by science and wanted to cook easily and smartly. Therefore, products such as smart range hoods and cooktop, smart oven, smart soft cooker, and smart air fryer have been developed. Different smart kitchen appliances provide targeted and professional cooking methods according to what the ingredient is. At the same time, these devices can help cook delicious food easily by being smart and connected with diversified recipes online to ensure the correct amount of ingredients and operate automatically. These functions allow the industry to develop and expand further.

1.4 Smart Pet Products

The pet ownership is on the rise and the pet economy is also growing. Having dogs or cats is not only for leisure. Instead, pets often offer emotional attachment. Pet owners have greater demand, with more and more young people hoping more than just keep their pets alive. A lot of people who were born in 1980s and 1990s are willing to spend their money on pets to please themselves and enjoy the life to the fullest.

With regard to pet food and accommodations, products such as smart pet feeder, smart drinking dispenser, smart self-cleaning litter and smart pet toys have been promoted for remote monitoring, regular feeding and real-time interaction. The smart pet products help pet owners to show their care and love in a real time way, let owners keep pets easier and make pets feel less lonely, and provide a concrete way for users to express their emotions. With an increasing number of young people who would keep pets, the acceptance and demand for smart pet products will also continue to grow. Market potential will be huge.

In a word, the continuous technological change

and consumer's pursuit to make life easier make the smart home the best choice in the future. And the improving and upgrading Smart home related industries also give consumers more choices. With growing consumer demand, all sectors in smart home market will develop rapidly. We can see that planning ahead will be helpful for business transformation.

2. Solutions

Currently, there are some smart kitchen solutions with functions such as the clouding platform for menus, interconnection between multiple devices and intelligent speech interaction, concentrated on kitchen and home scenarios. It makes use of synergistic partnerships between kitchen appliances to offer the best cooking experience from purchasing ingredients to personalized recommendations on ingredients, satisfying users' everlasting demands for various delicious food.

In the scenario of smart kitchen, the smart refrigerator is the central hub, recording and managing food ingredients in storage. It can also recommend healthy diets and recipes based on users' personal preference. Meanwhile, it can be linked to the food ingredient market, with food ingredient shopping lists automatically generated for recommended recipes, to materialize the smart purchase by one click.

With preset recipes, refrigerators can control the whole kitchen by connecting with smoke exhausts, gas stoves, ovens and fryers to realize the whole process of cooking including purchase, storage, cook and cleaning. Users can enjoy the convenience of smart kitchen.

In addition, through the connection with public clouds, screens on refrigerators can show videos from video doorbells, ensuring a holistic approach for the safety at home. With the speech function of smart speakers, users can use voices to control devices such as stoves, which is convenient and interactive.

SKYWORTH Air Conditioning

Shenzhen SKYWORTH Air Conditioning Company was founded in June, 2014 as a wholly owned subsidiary of SKYWORTH Group. It is an environmentally-friendly and intelligent air conditioning manufacturing company with capabilities of R&D, production and sales. It has top R&D and manufacturing teams in the industry with advanced laboratory equipment from both home and abroad and its sales channels cover all over the world. Currently, it has two manufacturing bases, namely Shenzhen Longgan Base and Zhuhai Jinding Base, with a total designed yearly production capacity of 5 million.

Among all home appliances, an air conditioner is the product that can directly offer a cozy and healthy environment for users and it is an indispensable part of smart home. There are two reasons for the success of SKYWORTH Air Conditioning: first, SKYWORTH wants to increase its product categories; second, it is a part of the company's smart home strategy in the era of smart home. In recent years, as the growth of air conditioning sales in the domestic market slows down, the market in China has become highly competitive. Many air conditioning companies are expanding their international market shares, so is SKYWORTH. Faced with various customer brands and customer demands, SKYWORTH also tries to find the best solution for its customers.

In 2019, SKYWORTH Air Conditioning released its voice-controlled smart Wi-Fi air conditioner. This air conditioner is not only intelligent, but also allows users to control other IoT devices by giving voice instructions to it. In this case, the air conditioner becomes the smart center of all smart home appliances and makes separated appliances connected with each other. The case also offers brand a new solution for home appliance intelligentization that one kind of home appliance can be more than just an ordinary product and it can be upgraded as the smart center to control other devices.

SKYWORTH air conditioners are sold globally. Unlike traditional home appliances, smart home

appliances face challenges such as various internet speeds and varied response time in cloud computing in different regions. As a smart device, when sold to different regions and countries, it needs to deal with issues such as connection to local data centers and clouds, distribution of networks and match with local mainstream smart voice assistants.

Based on global third-party AIoT platforms, SKYWORTH air conditioners can be controlled and managed by popular smart speakers such as Amazon Alexa and Google Home in the international market. In the past, SKYWORTH managed various clients' materials of different regions separately, which was inconvenient and time-consuming. However, with unified materials, now SKYWORTH only needs to maintain one material account for devices, which simplifies management and greatly boosts the efficiency of maintaining smart devices.

Qingdao Haier Smart Home

Haier Group was established in 1984. Qingdao Haier, one of the Global 500, is the main brand of home appliances in Haier Group and changed name to "Haier Smart Home" in June, 2019. Since its establishment, Haier Smart Home has founded dozens of manufacturing and R&D centers and offered eight kinds of products such as refrigerators, washing machines, air conditioners, water heaters and freezers. It is the only home appliance brand in China that has created a sound ecosystem for smart home from products, services to the brand.

As home appliance market has been saturated in recent years, it is a consensus in the industry to find new profit drivers. With the increase use of 5G technology for business and the development of IoT, UI and smart terminals have been upgraded. In the meantime, lots of customer demands have not been met yet. Home appliance companies are at the critical stage to intelligentize themselves.

Unlike other companies which have just started their smart home journey in recent years, Haier Smart Home began its own journey long time ago. In 2006, it founded and operated U-home Lab to test the reliability of smart home appliances. In 2010,

it released the first IoT refrigerator in the world. In 2015, it further expanded smart home market by launching the U+ App.

Many companies start their smart home business by offering one category of smart devices, which causes difficulties for interconnection between various categories of devices. According to relevant statistics, there are averagely over 40 electrical devices of more than 10 brands in every family. Due to different systems, these devices are separated from each other and they are difficult to be connected together.

Additionally, limitation of application scenarios is also the existing difficulty in the field of smart home appliances. Segmented scenarios at smart home are important indicators to test whether smart home appliances are "humane". Only by knowing about scenarios and customers' demands and discovering more segmented application scenarios can a company serve users better. Undoubtedly, customers also prefer brands that can cover more segmented scenarios.

As for existing problems of smart home appliances, Haier Smart Home deals with them in the process of intelligentization by its ecosystem and application scenarios. Haier Smart Home shapes itself as a solution provider for all IoT application scenarios, offering all categories of products including refrigerators, freezers, washing machines, air conditioners, water heaters and kitchen appliances. With these smart products, Haier Smart Home offers customers "5+7+N", a whole set of solutions for all scenarios, with features of "being a complete set, customization and iteration".

However, in order to offer more diversified scenarios and services, Haier Smart home cannot achieve the goal of covering all scenarios just by itself.

Therefore, in the course of intelligentization, it chooses to cooperate with Tuya Smart, a global AIoT platform, to enhance its scenario ecosystem for smart home by creating seven ecospheres including Internet of Clothes, Internet of Food, Internet of Air and Internet of Security.

GUANGDONG XINBAO ELECTRICAL APPLIANCES HOLDINGS CO., LTD

Guangdong Xinbao Electrical Appliances Holdings Co., Ltd was founded in 1995. It is a listed company focusing on developing, designing, manufacturing and selling kitchen appliances, homecare appliances, baby appliances, health and beauty appliances, intelligent appliances as well as electrical accessories and etc. Xinbao Co., Ltd is one of the export leaders of China's small household appliances industry, with a leading export volume of ten categories of small household appliances for 10 consecutive years.

Now, Xinbao has grown into a leading enterprise in China's small appliance industry, leading and participating in the formulation of a number of national standards. Owning multiple core technologies, more to the point, Xinbao has driven tremendous growth of the enterprise by industrial design, and has won many design awards including Red Star Design Award, Innovative Design Award, IF Award and Red Dot Design Award as a typical enterprise that evolves from "made in Guangdong" to "designed in Guangdong" and finally to "designed in China". It has been recognized as a National Enterprise Technology Center, Provincial Engineering Technology Research and Development Center, National High-tech Enterprise, with more than 3300 patents including nearly 300 invention patents. With a keen sense of the market, Xinbao deeply understands the increasing need for intelligent products in the market, and quickly starts to find the best way to upgrade its products to the level of intelligence. In the Canton Fair in 2018, Xinbao firstly met Tuya Smart and after primary communication and research, the two sides found themselves in great harmony and agreed to cooperation at the end of 2018.

As a well-known brand of small household appliances that are ready for export overseas, Xinbao has a wide product range and a huge capability matrix. Tuya Smart is also a rapidly-growing enterprise that has enabled thousands of companies with their products intelligence

upgrading, accumulating rich experience and comprehensive development programs.

Relying on the technology of Tuya, developers of Xinbao only need to embed the cloud module of Tuya into the existing circuit to complete the hardware development. In terms of software development, Tuya offers multiple SDKs for Xinbao to complete the integrated construction of control end, cloud side and equipment side, as well as to tremendously shorten the period needed from conceptual design to sales and use of products. Based on its own innovation and technology genes, Xinbao, joining hands with Tuya, has achieved rapid, efficient and low-cost intelligent upgrading for its current products, and quickly met the intelligent requirements of its global customers of its products. At present, Xinbao has accomplished intelligent upgrading of many of its products including its coffee maker, bread maker, humidifier, kettle and slow cooker, etc. The launch of those new products is greatly welcomed and recognized by the global market and its consumers.

Anker Innovations Technology Co., Ltd.

Ever since its establishment in 2011, Anker Innovations Technology Co., Ltd. ("Anker Innovations") is one of China's largest suppliers of export-bound consumer electronics, specializing in the design, research and development and sales of intelligent accessories and intelligent hardware. Anker has always been committed to shaping a Chinese consumer electronics brand for the world. Through continuous innovation, it has brought leading scientific and technological products to global consumers, a full demonstration of the strength of China's intelligent manufacturing. Anker Innovations has successfully created the smart charging brand Anker, and has successively launched independent brands such as Soundcore (Speaker and Headset), eufy (Smart Home) and Nebula (Audio and Video Entertainment) as it stepped into the smart home field. It has made three smart hardware brands over a period of nine years that were sold 1.5 billion yuan each per year,

winning nearly 80 million loyal users in more than 100 regions and countries around the world. Since its establishment, Anker Innovations has grown at an annual growth rate of more than 50%, far exceeding the industry average growth rate: revenue in 2018 reached 5.232 billion yuan; In 2019, the annual sales reached 6.655 billion yuan. In August 2020, Anker Innovations was listed on the Growth Enterprise Market of Shenzhen Stock Exchange, with a revenue of 6.019 billion yuan from January to September 2020. Its market value is about 50 billion yuan.

Anker Innovations has done pretty well in AIoT, smart home, smart acoustics, and smart security. For example, in the field of smart home, there are sweeping robots, wireless vacuum cleaners, smart bulbs, smart switches, and smart scales. In the field of intelligent security, there are security cameras, intelligent doorbells, intelligent door locks and other products, which occupy a large share in the United States, Europe, Japan and other markets, representing high brand presence and user satisfaction.

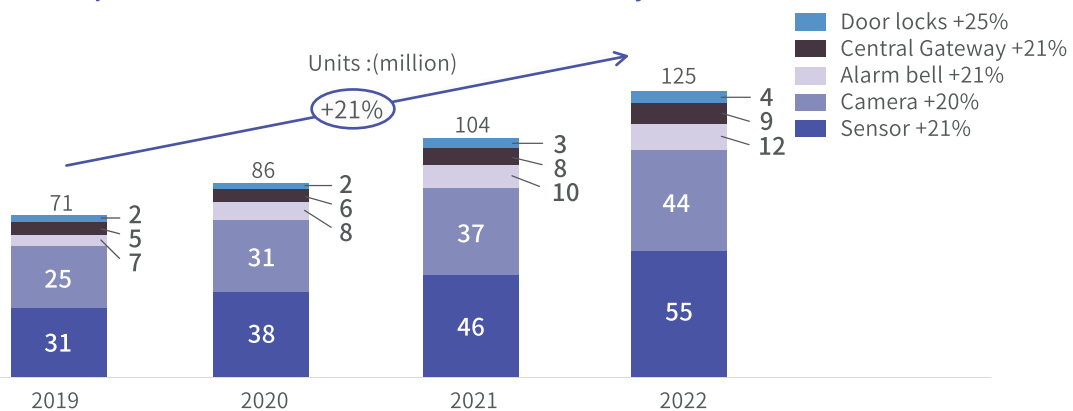
To build up its competitiveness in the international market and remove the original main products-conventional charger products, Anker Innovations has continuously increased its R&D investment,

actively worked on AIoT, based new growth points on smart home products. It had worked to launch wireless audio products and smart innovation products. The proportion of these two new product series in the main business income increased from 26.40% in 2017 to 41.97% in 2019. At present, Anker Innovations provides more than 1,000 product models, which better meet the diversified needs of the global consumer electronics market. On the pathway to the integration with AIoT technology and quick realization of the intelligent upgrading of traditional household appliances, Anker Innovations chose to carry out in-depth cooperation with Tuya Smart, the world's leading AI + IoT developer platform. Since 2018, Tuya Smart has been providing stable and secure cloud storage and connection solutions for Anker Innovations' intelligent hardware products, thereby effectively reducing its development costs and accelerating development progress. With the support of Tuya Smart's cloud module series services, eufy and other intelligent products under Anker Innovations brands are able to offer stable network connection and data transmission. A stable, efficient and safe interactive experience is ensured for products shipment quantity up to tens of millions.

2.1.2

IPC

The Compound Annual Growth Rate of Smart Security Products



Source of data: Boston Consulting Group

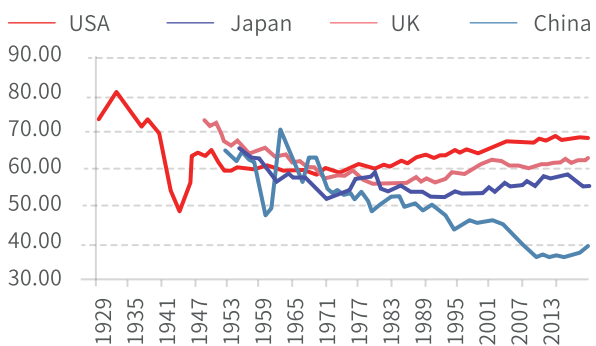
1. Market Size and Estimations

According to a 2019-2022 survey issued by Boston Consulting Group (BCG), a total of 44 million units of IPC will be shipped in the global smart security products market, representing an average growth of 20% over four years.

Looking at different countries, the sales volume of consumer IPC is closely linked to their respective economic status and household consumption expenditure. The National Bureau of Statistics reported that China's household expenditure accounts for less than 40% of its GDP, a number far smaller than other economies. Globally, the household expenditure accounts for approximately 69% in the USA, 63% in the UK, 56% in Japan and 54% in the European Union. Compared with only

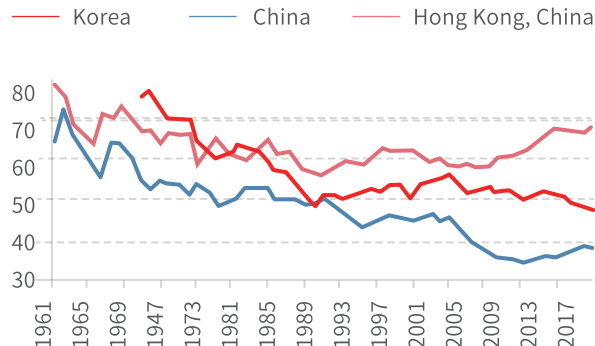
about 39% in China, the number is visibly smaller. From the global consumer IPC shipment data 2019-2020, the annual shipment to the North America accounts for over 60% of global amount, meaning approximately 10 million units, which is followed closely by Europe. In China, the market is on the track of recognizing consumer IPC. Currently, shipments were made mainly from the three biggest telecommunication operators, in which China Mobile and China Unicom are the major player, who shipped approximately 3 million units from 2019-2020. Riding on this trend, with growing population and escalating economic level, China's consumer IPC market could exceed that of the North America in 2022.

Comparison of household expenditure between developed economies and China (%)



Source of data: WIND, Research and Development

Comparison of household expenditure in emerging East Asian countries (%)



Source of data: WIND, Research and Development

2. Consumer IPC Industry Analysis (Industry Key Players)

Industry Key Players in China

Leading players in the market include 360 and Imou. Due to varying preference between Chinese and overseas consumers, mini cameras are not as popular as versatile cameras locally.

For those key industry players, China Mobile, China Unicom and China Telecom offered only versatile

cameras in the recent one year. Apart from these operators, another major player locally also includes online retailers, namely JD.com, Taobao and Pinduoduo.

Currently, IPC prices are trending down, overseas sellers priced at RMB250 on average, while it was only about RMB100 if sold by domestic sellers. It is observed that before IPC sales volume ticks up significantly, the prices are already kept at very low levels. If the trend continues, it is expected that

only a tiny fraction of the 1000+ manufacturers will survive here domestically.

International Key Players

The North America, as a demonstrable market, key players are Ring and Arlo. Consumer IPC has seen exponential growth because the two players began to educate the market three years ago. Many other established brands, such as GE and Philips who focus on smart lightings, are beginning to sell IPC products, riding on the trend of IoT smart products. In contrast to China's market, leading brands in the North America rolled out their respective star products for consumer IPC. Ring offers video doorbells, Arlo offers low-power IPC pack. The two brands are the forerunners of consumer IPC in the North America, whose product MSRP (suggested retail price) continues to remain high as brand influence has been boosted by over three years of marketing. Wyze, an emerging brand in recent two years focuses on low-priced mini cameras and versatile cameras, who marked a legendary sales record on Amazon by distributing over 1 million units in a year. More fresh IPC brands are emerging offering basic types of mini and versatile cameras, making the cheap mini cameras a household device.

3. Major Types of Consumer IPC

Mini Camera

Basic function type of IPC comprises of the body and a stand. The body has the major parts of imaging unit and audio receptor. The stand allows multi-directional rotation to adjust the suitable angle for installation. Main features include its convenience and portability. Once finished installation, the area under monitor is fixed unless adjusted manually. Other features include video, audio, infrared, indicator light, SD card and power jack.



Versatile Camera

Versatile camera supplements what a mini camera is unable to cover in a wider area, that by adding a cloud platform feature which allows users to control and change the position of the camera, hence adjusting the area under monitor. Thus, it is building on a mini camera that adds on cloud platform-related features.



Cloud Platform Control: Through mobile App, users can adjust the camera in 8 directions for monitoring the target area. The cloud platform can control the camera to rotate horizontally and vertically to adjust the area for monitoring.



Remark: Common types of cloud platform cameras can rotate approximately 300° horizontally, hence achieving an all-round monitoring through the lens width. Some of the upscale types supports 360° horizontal rotation, allowing fast rotation to any angle. These upscale cameras are more costly.

Default Setting: Areas to be monitored are usually fixed. Using cloud platform to adjust camera to certain positions repeatedly could be troublesome and may affect accuracy. The device has default setting function to pre-set certain camera angles as default, allowing simple click to rotate the camera automatically when deemed appropriate, thus enabling quick switch to monitor places such as door entrance and windows, where vigilant monitoring should be needed.

Patrolling: Adding on the default setting, the device supports automatic patrolling, monitoring all of the areas without manual manipulation. This feature is similar to automatic security patrol, monitoring the pre-set target areas one by one. The device also supports setting up of patrol clock, and how much time will be spent on monitoring a specific area. Remarks: Patrol function needs hardware support for frequent rotation, buyers may need to pay attention when making purchase.

Outdoor camera

Designed for outdoor purposes, which is susceptible to changes of environment as different from indoor. One key feature is water and dust-proof, with



improved versions supporting enhanced features of security and police-calling.

Water and Dust-proof: Typically marked as IPXX, with the first number as dust-proof level and the second water-proof level. It defines how a device can still operate under specific conditions, ensuring it will be functional under undesirable weather conditions such as rain, snow, wind or dust. Device gradings can be seen as below:

IP gradings (IPxx)

IP First number Second number

0 No protection No protection

1 50mm solid substance, eg. Hand-touch water drip, eg. condensation

2 12mm solid substance, eg. Finger direct water-spray, tilting not over 15°

3 >2.5mm solid substance, e.g. gadgets, power cable water spray, tilting not over 15°

4 >1mm solid substance, e.g. gadgets, thin power cable water-spray from various angles, moderate water-proof level

5 Dust-proof –moderate dust-proof level (no harm to device) low-pressure water-spray from various angles, moderate water-proof level

6 Secure and dust-proof High-pressure water-spray from various angles, eg. Ship cabin, moderate water-proof level

7 submerge in water 15cm to 1m

8 Persistent submerge in water possible

Common outdoor cameras should require at least IP65, while IP66 is suggested.

Color and night vision camera: In contrast to infrared light used in indoor area, some outdoor cameras are equipped with white light, since it eliminates the concern of disturbing people in an outdoor area, while also allowing the light to be seen by lawbreakers as an alarm. More details can be seen through color camera. Light and sound can be of alarming effect.

Low-power(Battery) Camera

The above camera types have their own characteristics and appropriate scenario, one

commonality is that they must be connected to power or internet, which means that the installation must be made near power socket or internet-covered areas, limiting the versatility of the devices to be installed. Longer power cables exposed presents certain risks and may be too visible to people. To solve the problems, a battery-powered camera is thus produced. Powering the device from batteries and Wi-Fi enables installation at any



designated place without needing a connecting cable, maximizing versatility while not having to compromise your home aesthetics.

Device Waking up: Devices on dormant mode do not capture pictures and conduct analysis. Usually a built-in sensor is installed to alert of capture and the time of it, and waking up the device. In a home setting, it is mainly used to monitor the people coming in and out, hence PIR technology to monitor if an invasion is being made.

PIR: PIR is the abbreviation of Passive Infrared Detector. This detector can target human movement while not affected by movement of pets and objects, enhancing its accuracy and lowering power use. PIR can be used on battery-type devices or other devices.

Battery Life: One key parameter of battery-type device is the battery life, which is a major factor

for battery charge frequency and its use. Battery devices usually are installed in areas with less human movement due to its wake-up mechanism. Hence, if people movement is frequent leading to frequent wake up of the device, the battery life will be significantly shorter.

Cases in the IPC Industry

Lloyd's

Enter just about any large retail store in Mexico, including The Home Depot, Walmart, Sam's Club, or Best Buy, and you're almost certain to find Lloyd's products.

But the company's beginnings—like that of so many successful companies before it—were humble, inspired nearly 30 years ago by the founder's desire for an automatic lighting solution in his apartment building's hallways.

He found one and he took it to market. And the rest is history.

Today, Lloyd's motion sensors, smart lights, and high-definition IP security cameras can be found in more than 400 stores across Mexico and South America. Lloyd's products are easily and remotely managed through any smartphone via the Lloyd's Smart application, which is available on Android and iOS.

Of course, Lloyd's hasn't always been plugged into smart technology. In fact, wireless technology the way we understand it today wasn't even around when the company started off many years by selling its motion sensors.

Lloyd's saw an increasing interest in and need for the integration of smart phone technology to its products, such as the ability to control its lighting or security solutions from mobile phone apps.

In Tuya, Lloyd's saw a chance to get an entire IoT ecosystem—app + connectivity + cloud—in one shot, plus the huge advantage of also being able to tap into Tuya's vast global manufacturing network. Thanks to Tuya, Lloyd's was able to launch its first smart home line. In Mexico, smart security is a market with huge potential, and Mexican families

invest heavily in security devices to protect their homes, both rented and owned.

Lloyd's smart camera set a smart home security precedent in the Mexican market, greatly reducing the price threshold of Mexican smart security products and making affordable and convenient smart security products accessible to more local consumers. For example, unlike traditional cameras that only have monitoring functions, Lloyd's smart cameras can actively respond to the recorded images and alert users to potential crime or intrusions.

Another example is Lloyd's family alarms. Unlike conventional products, which simply sound the horn, Lloyd's family alarms automatically send warning information to family members if the alarm is not cleared within one minute to ensure a timely response when danger comes.

These smart security products are more in line with the security needs of local consumers in Mexico and have become the best-selling products in the Mexican market.

In the future, Lloyd's plans to launch more smart home products around smart security to fully meet the needs of consumers. Building on their increased smart home presence and ease of new product introduction that Tuya has enabled, Lloyd's plans to broaden its reach not just geographically but also portfolio-wise as it builds smart home and smart security awareness in Latin America.

Hangzhou Meari Technology Co., Ltd.

Hangzhou Meari Technology Co., Ltd. is a smart technology company specialized in the R&D, production, marketing and operation of IoT, smart home, and civilian surveillance products. As a R&D- and technology-focused company, Meari has built a full-fledged R&D team, with over 80 R&D engineers working on architecture, hardware, embedded software, APP and server. It is particularly competitive in low power consumption products. The Meari product line boasts a complete set of civilian surveillance products, including various types of cameras, doorbells, garden lights and

baby monitors. Its products have penetrated from developed markets including Europe, America and Australia to developing markets including Southeast Asia and South America, and have gained popularity on e-commerce platforms such as Amazon and AliExpress.

With the rise of smart home, demand for civilian surveillance products has been increasing, especially in North America, where demand has surged driven by leading companies such as Arlo and Ring. However, civilian surveillance products are different from traditional security products, which impose high requirements on App, server and cloud architecture, as well as ongoing demand for value-added services such as cloud storage and AI. To address these pain points, Meari encapsulates the interface between security devices and App quickly through its access to the global cloud and App SDK. With the ability to invoke relevant APIs, developers only have to develop embedded software to realize connectivity between devices and App/the cloud.

In addition to smart security products, Meari has been expanding its business and diversifying its product portfolio by accessing other smart platforms, developing other smart home products with surveillance module as the core, such as mopping robots, pet feeders, and lamps.

In terms of global business, Meari also has rapid access to smart voice platforms such as Amazon and Google through the global AIoT platform, which allows it to update third-party voice service in real-time and enhance the performance of its smart products.

Meari offers a diverse product portfolio with ten-plus models of civilian surveillance products. With an annual production capacity of over 5 million units, it manufactures products of its own brands and serves dozens of well-known players in the industry. Its products have presence in dozens of countries around the world, and are available in most of the major supermarket chains in Europe and the United States.

2.1.3

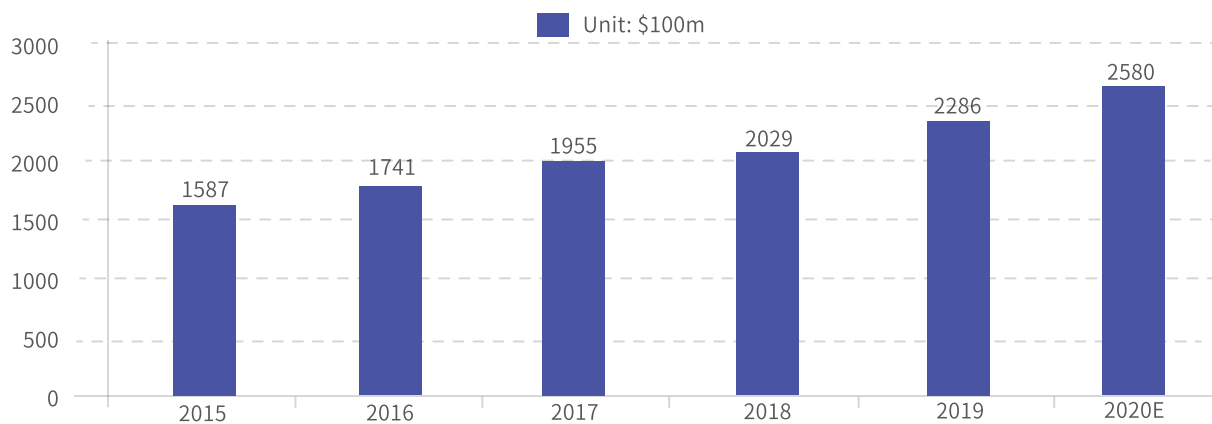
Sensor

1. Overview of the Sensor Industry

At present, about 40 countries in the world are engaged in the development, production and application of sensors, among which the United States, Japan and Germany are quite strong. There are more than 6,000 research and development institutions and about 26,000 different types of products. Sensors evolved through three generations of technology: structural sensors,

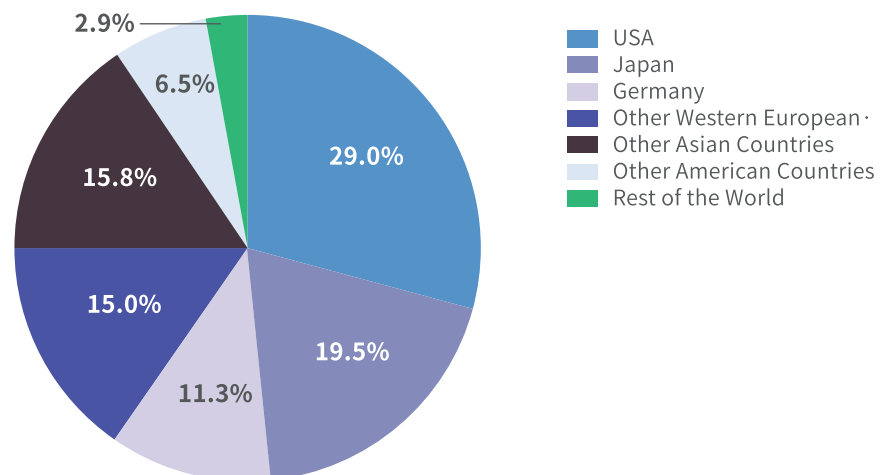
integrated sensors and intelligent sensors. China's sensor industry has formed a spatial pattern featuring four major regions (the Yangtze River Delta, the Pearl River Delta, the Bohai Rim, and the central and western regions) based on its obvious geographical distribution characteristics. Here is a general introduction to the sensor industry with a few charts.

2016-2020 Global Sensor Market Size Forecast



By China Business Intelligence Network (www.askci.com)

The Market Share of Sensors in Major Countries and Regions

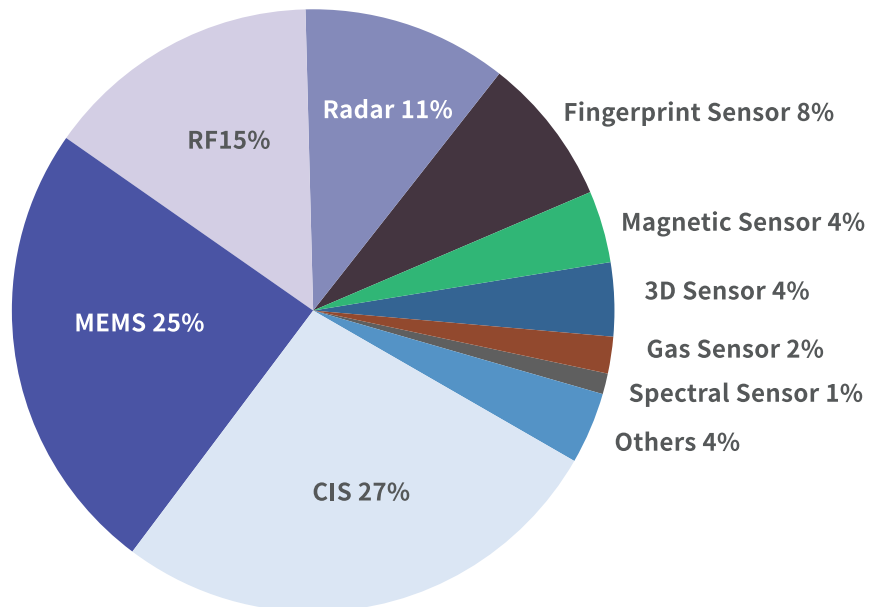


Source: Yole Collated by Forward Industry Research Institute @Forward-The Economist APP(www.askci.com)

The global sensor industry has been growing steadily from 2015 to 2020, and now it is a huge market worth over \$250bn.

The United States is the largest sensor market in the world with a share of 29%, followed by Japan and Germany

2018 Global Sensor Market Competitive Landscape (Unit: %)

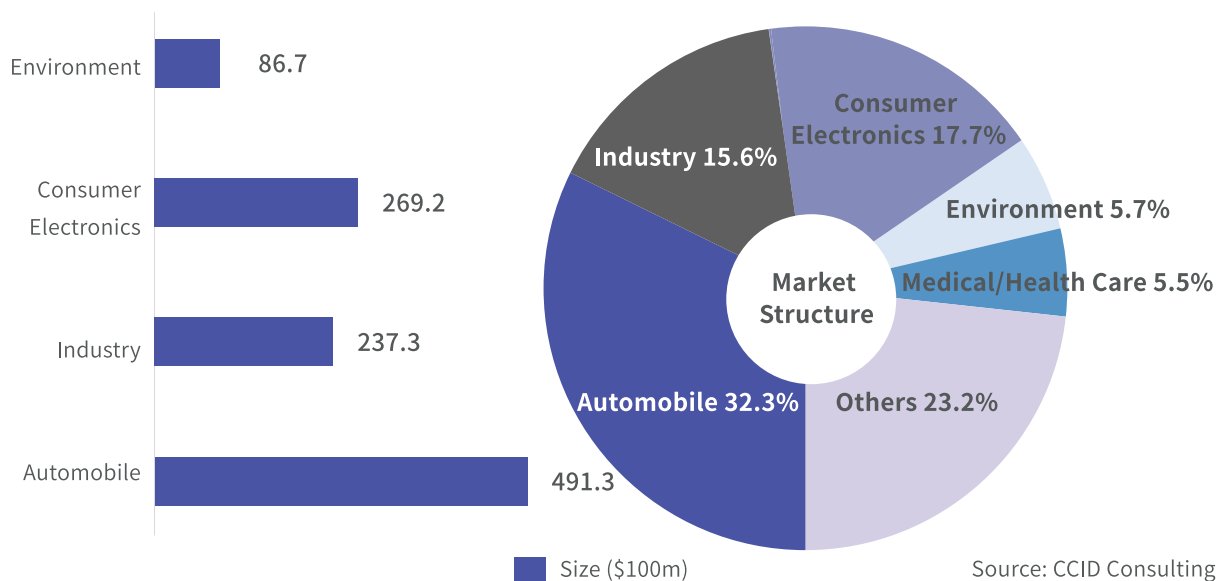


Source: Yole Collated by Forward Industry Research Institute @Forward-The Economist APP(www.askci.com)

From the perspective of product structure, CMOS image sensors (CIS) accounted for 27% of the global market in 2018, followed by MEMS sensors

(micro-electromechanical system) with a share of 25%. Fingerprint sensors as a type of single-material sensor enjoyed 8%.

2019 Global Sensor Market Size and Structure

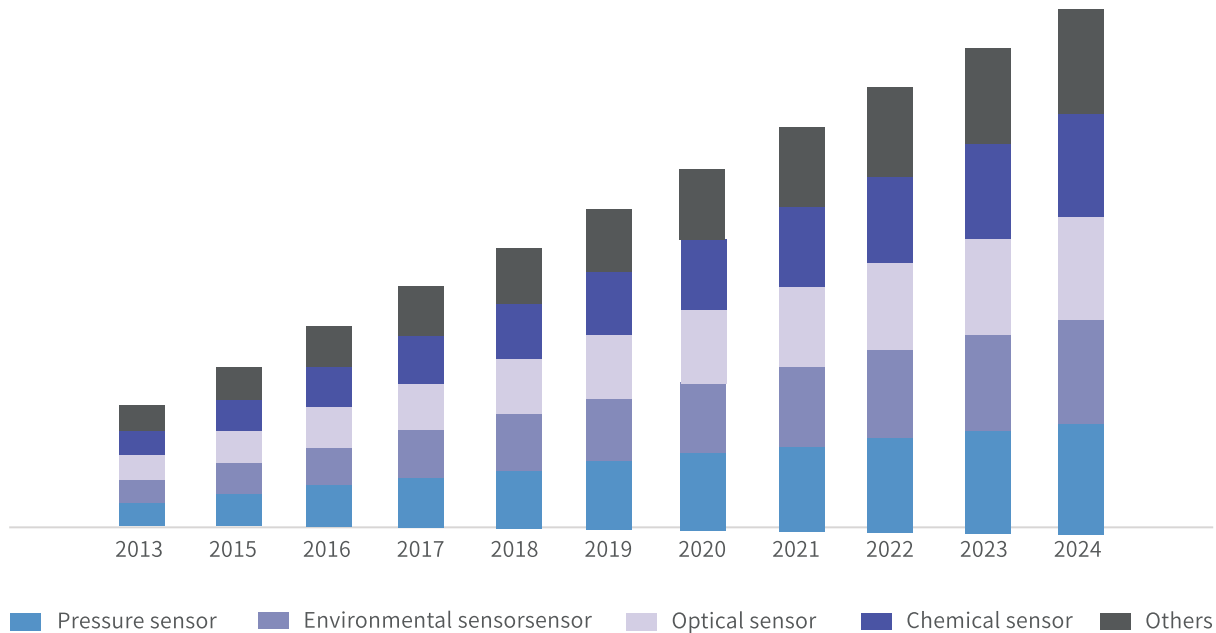


Source: CCID Consulting

From the perspective of market, sensors were mainly applied in automobile, consumer electronics

and industry which accounted for more than half of the market share, about \$100bn.

World IoT sensors market size. By product, 2013-2024 (USD Million)

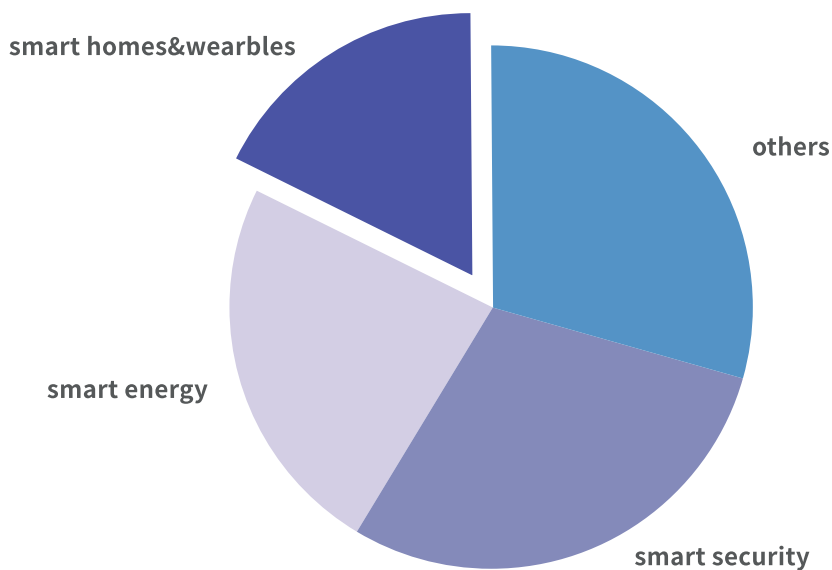


Source: Market Intellica

From 2013 to 2024, the global market size of smart sensors is expected to grow rapidly with a compound growth rate of 18.2%, reaching about

\$1.4bn in 2019. Each type of smart sensor (pressure/environmental/optical/chemical) shares a similar volume.

World IoT sensors market research report 2024 (covering USA, Europe, China, Japan and etc) market share by application, 2019(%)



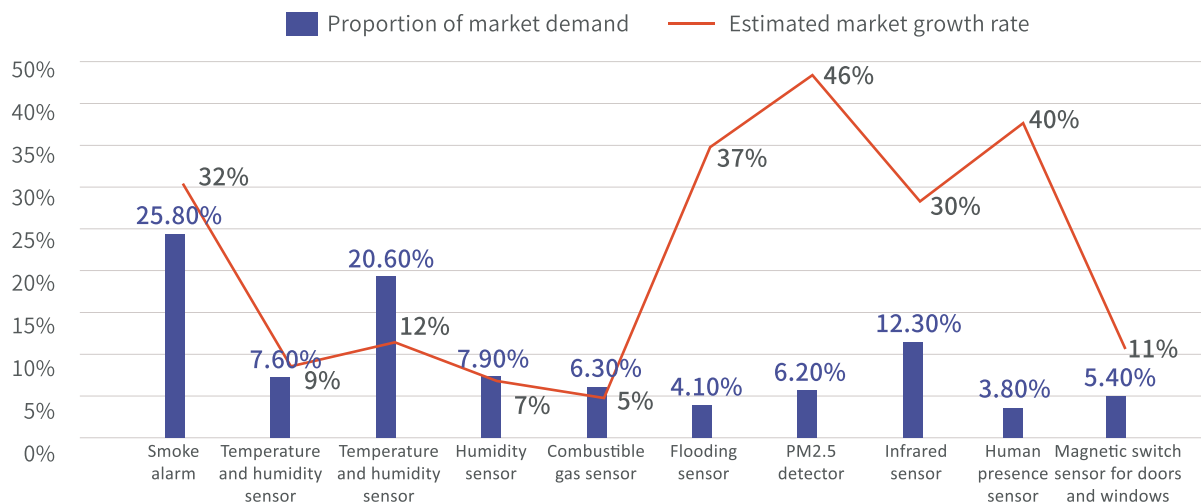
Source: Market Intellica

From the perspective of application, smart security enjoyed the largest market share (about 30%),

followed by smart energy management (about 23%) and wearable devices (13%).

Sensor application scenario

Demand for home sensors



Source: Baidu Index

Smoke alarms, temperature sensors and infrared sensors accounted for more than 50% of the demand. As people pay more attention to the environment and health, PM2.5 detectors had the highest growth rate in demand. In addition, due to the needs such as elderly care and enhanced awareness of security and fire protection, the demand for human presence sensors, smoke alarms and infrared sensor increased significantly, all above 30%.

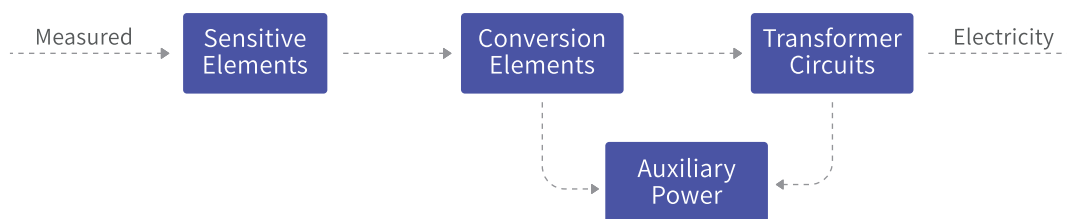
2. Sensor Solutions

A sensor is a detection device that senses the measured information and converts it into electrical signals or other required forms based on certain rules, so as to meet the needs of information transmission, processing, storage, display, recording and control.

Sensors are featured by miniaturization, digitization, intelligence, multi-functionality, systematization

and networking. As the primary condition to realize automatic detection and control, sensors and their development enable objects to have senses such as touch, taste and smell, making objects come to life. According to their basic perception functions, sensors are generally divided into ten categories: thermal sensors, light sensors, gas sensors, force sensors, magnetic sensors, humidity sensors, sound sensors, radiation sensors, color sensors, and taste sensors.

Sensors are usually composed of four parts: sensing element, conversion element, conversion circuit and auxiliary power supply. The sensing element directly detects the measurand and outputs corresponding physical quantity signals. The conversion element converts the physical quantity signal into electrical signal. The conversion circuit is responsible for amplifying or modulating the electrical signal. The conversion element and conversion circuit usually need to be powered by the auxiliary power supply.



2.1 Cases in the Sensor Industry

Sensor products are essential in various fields including home appliances, security, commercial lighting, elderly care, hotels and apartments. Some major players in the industry have already produced intelligent sensors to match them with other intelligent products and improve the overall experience. For example, traditional security and fire protection brands Heiman and Siterwell have launched intelligent smoke alarms and made big sales. Traditional sensor manufacturer Multi IR has intelligentized its human presence sensors, door/window magnetic sensors and temperature and humidity products, gaining a good reputation in the industry.

Siterwell Electronics Co., Ltd.

Founded in 2010, Siterwell Electronics Co., Ltd. is a high-tech enterprise specialized in the R&D, production and sales of security products and solutions. Based on IoT and smart home, Siterwell is committed to building one-stop industrial solutions catering to multiple scenarios such as smart security, smart fire fighting, safe city and smart city. Data collection and data processing are of great importance for smart security, which contributes to the huge market size of smart sensors. According to China Business Research Institute's 2019 Research Report on China Sensor Market, the market size of China's sensor industry was nearly 150 billion yuan in 2018, which further expanded to nearly 200 billion yuan in 2019.

With the AIoT platform Tuya Smart's strong

technical know-how in IoT, Siterwell quickly built a real-time and reliable big data platform based on its own sensing devices, providing better services to the smart security ecosystem.

Using Wi-Fi modules, Siterwell developed smart smoke detector and smart water detector, upgrading traditional devices to wireless smart devices. Users can remotely control smart smoke detector through the mobile app, keeping track of home security even when away from home. When the alarm is triggered, in addition to sound and light effect on the spot, users can also receive notification on their mobile app.

Moreover, users can monitor all aspects of the device's operation on their mobile phones, including product fault, battery and voltage status, etc., to ensure that the device is working well; through the cloud, Siterwell's alarms can be connected to other smart products in the ecosystem, and integrated into a customized smart home solution.

Siterwell's smart security devices support wireless operation and remote control, demonstrating overwhelming superiority over traditional stand-alone alarms. They have been widely recognized and accepted by end users. Smart smoke detector and smart water detector not only meet urgent needs in home security, but also offer better user experience with smart operation, ease of use and practical design. Currently, Siterwell's smart sensors are among the best-selling products in Australia and many European countries, receiving positive reviews from the market.

2.1.4

Smart Lock

1. Analysis of Smart Lock Market and Industry

1.1 Global Market Overview and Forecast

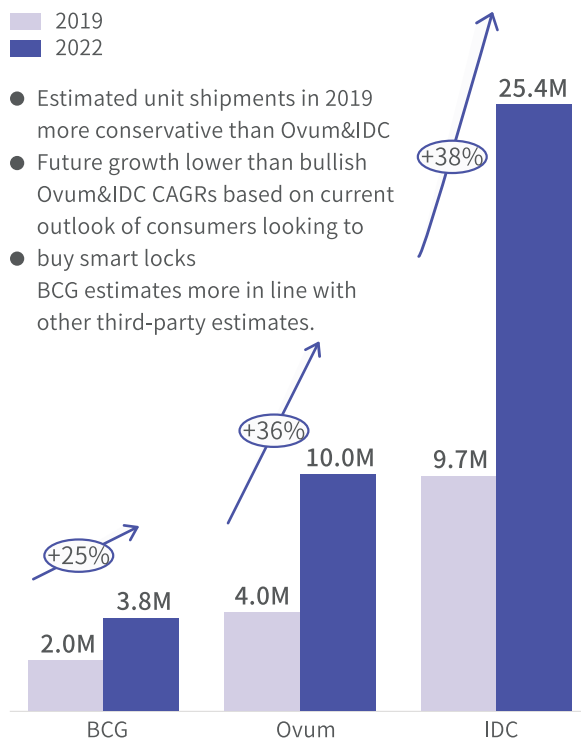
The global smart lock market size is expected to reach USD 24.20 billion by 2024, according to a new report by Grand View Research, exhibiting a CAGR of 60.1% during the forecast period. Rising awareness about smart home solutions, surging demand for portable connected smart devices, and growing preference for dynamic keyless locking/unlocking mechanisms are some of the primary factors fostering the growth of the smart lock market.

Regionally, developed countries are attaching greater importance to smart lock market. As a predominant market, North America has more than 1.5 million homes that are using smart locks. As

IDC's statistics suggests, nearly 9.7 million units of smart locks were traded in 2019. The market size is set to upsurge at 38% annually, reaching 25.4 million units till 2022. BCG's estimation is relatively conservative. The market capacity was about 2 million units in 2019, and will increase to 3.8 million units by 2022 at an annual rate of some 25%. In terms of market volume, it is reckoned that America (North and South) will account for over 50% in the global smart door lock market between 2020 and 2022.

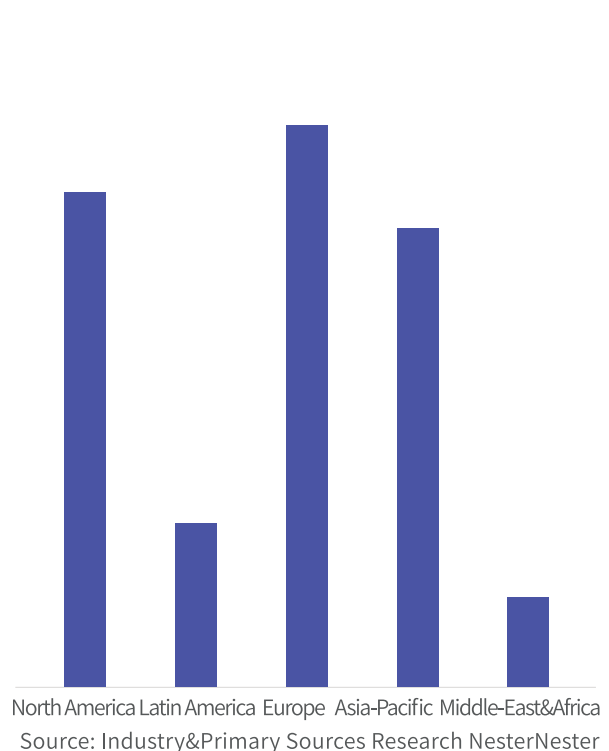
European market is following close on the heel, given its growing momentum in the development of hospitality industry and construction of new hotels. In respect of market growth, smart lock market in Asia Pacific region is anticipated to grow at the faster rate, owing to fast progress in urbanization and continuous increase in disposable personal income in China, India and Indonesia in particular. In 2019, more than 17 million units of smart locks were shipped in China where vast market opportunities from retrofitting existing households and adoption of smart locks in urbanization are the strong driving force.

Unit volumes for smart door locks



Source: Industry&Primary Sources Research NesterNester

Global Smart Door Lock Market Share(%) by region-2021



1.2 Smart Lock Industry Analysis

Professional Players

In the global smart lock market, the prominent players are three security groups, namely Assa Abloy, Allegion, and Spectrum, each of whom has abundant and mature brand lines and product portfolios. Among them, Yale, August and Mul-T-Lock that are well-known to overseas consumers, come from Assa Abloy. Schlage is a core consumer brand belonging to Allegion. A mass-market brand in Spectrum, Kwikset together with Baldwin in the Group is focused on premium products.

Ecosystem Partnership

Amazon, Google and Apple, the three Internet giants all have introduced businesses and ecosystem planning relating to smart lock products.

In Amazon's smart lock business (Amazon Key), the product unit that incorporates smart camera and smart lock from the company's ecosystem enables consumers to grant user-set one-time password to Amazon delivery people based on the APP, and to watch the real-time video recorded by the camera after the courier enters their home. This is to solve Amazon's last-mile shipping problem, and to promote the implementation of its ecosystem of smart home.

Alphabet, Google's parent company has got its smart home division, Nest merged into Google's hardware team. It is expected that Nest will integrate AI service and Google Assistant into more hardware products, so that the smart door lock products can be controlled via voice.

Apple Homekit is one of the ecosystems that are connected with all leading smart lock brands in the North America market.

Start-ups

Latch is a North America-based start-up specialized in commercial smart lock for apartments. Nuki is a European company focused on smart locks for household retrofitting. And igloohome has been offering Asian markets with a full range of products,

including smart locks and lock boxes. All of these companies are typical innovators fueling the development of smart lock market.

1.3 New Trend of Smart Lock Market and Product

Communication Capacity: Wi-Fi keep-alive solution that allows real-time connectivity features plenty of advantages, such as convenience of real-time control, and cost benefits of no need to purchase gateway, thus becoming a weathervane in the market.

Interaction with Devices: Given the increasing penetration of smart home, consumers are in stronger demand for the interaction with door locks, including video door phone and intelligent audio voice control.

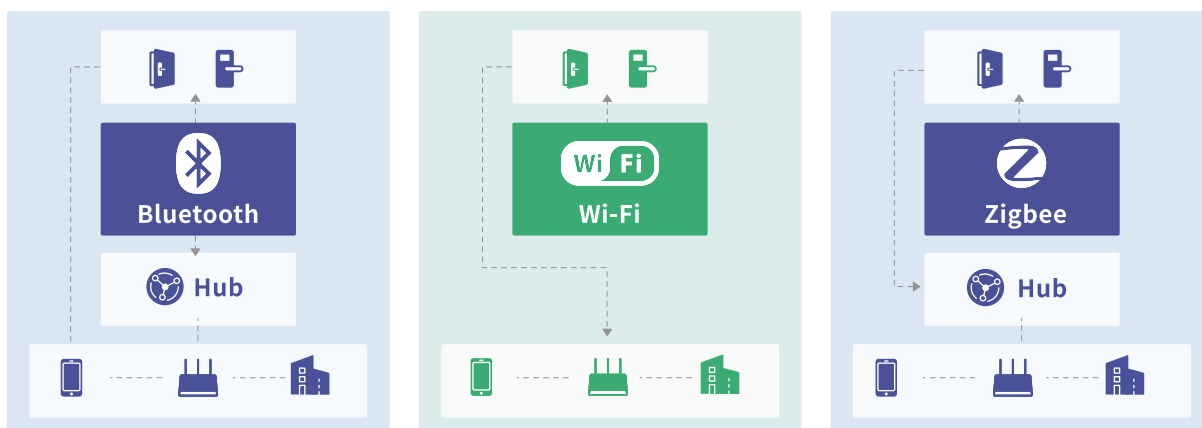
2. Solution of Smart Locks

2.1 Overview of Smart Lock Solutions

Generally, smart lock solution is an integrated solution that consists of smart lock, smart home system and hardware "connected to cloud". Relying on wireless communication module, smart lock App, IoT cloud platform service, industry SaaS, and application system etc., the smart lock solution is dedicated to empower door lock enterprises to provide smart solutions at fast pace and low cost. The solution is comprised of Wi-Fi, Zigbee, Bluetooth, NB-IoT, and other telecommunication modes.

Comparison Between Various Telecommunication Modes:

Connectivity	Power Consumption (4 Batteries)	Gateway	Function and Features	Use Case
Wi-Fi (Not Keep Alive)	6-12 Months	Home Router	Generally, weak networking schemes are adopted, most of which transmit data unidirectionally. The scheme consumes a lot of power when working, and is offline when not working.	Used in household both at home and abroad (suitable for the single product of door lock in particular)
Zigbee	9-12 Months	Zigbee Gateway	Strong networking scheme is adopted, which can tell the status of door lock, provide two-way communication, and have comprehensive functions.	Whole-house systems, and scenarios in apartment
Bluetooth (directly connected with mobile phones)	9-12 Months	/	Convenient and safe, it is directly connected with mobile phones, and adopts a weak networking scheme. Due to physical distance-related limit, the door lock status is provided with a lag.	Used in household both at home and abroad
Bluetooth (Gateway)	6-12 Months	Bluetooth Gateway	Similar to Zigbee, not only can it be connected with mobile phones for close control, but also can be managed remotely.	Used in household both at home and abroad
NB-IoT	12 Months	/	Similar to Wi-Fi, it features low power consumption, but has a relatively long network delay.	Used in domestic household and apartments
Wi-Fi (Keep Alive)	3-6 Months	Home Router	It consumes more power than Zigbee, but has similar functions.	Mostly used in overseas households



2.2 Core Functions in Smart Lock Solutions

Smart door lock, born to be a must-to-have basic product, has an abundance of extensible functions. Different from conventional mechanical locks, smart locks have these advantages that can be divided into four categories:

- Forgetting keys is a headache facing all in daily life. Smart locks are compatible with plenty of unlocking methods using fingerprint, password, door card, face recognition, and finger vein etc., thus allowing you to go out of home without taking

a key;

- Smart locks, like your butler, can tell you every occurrence out of your door, including the real-time door opening record, doorbell ringing, entering incorrect password, warnings like low battery, and information like the coming back of the old and young etc.
- Door lock permission is distributed in an intelligent way, thus catering the needs in various scenarios, such as life service, social networking, and business management. The smart lock supports remote door

opening, member management, one-time password, and off-line password (that can be created and used when the network is disconnected).

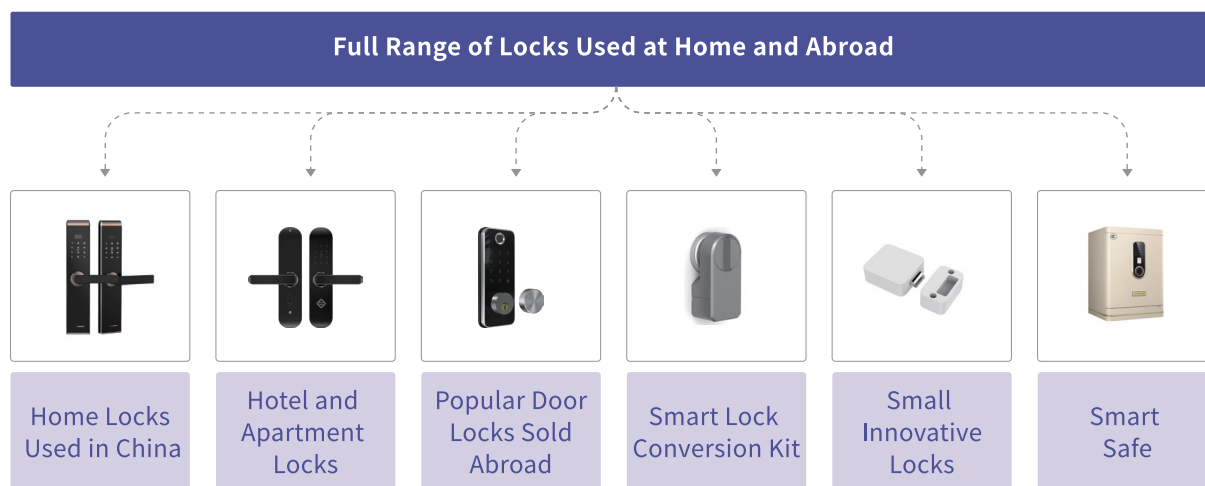
- Last but not the least, the lock is more a gadget that can interact with household living scenarios than a smart device. Put it into perspective. Door opened, light at the entryway turned on, electric curtains pulled slowly, timer of hot water heater set, aroma diffuser activated, all are working to generate a pleasing and comfortable experience after you are back home.

2.3 Products and Applications of Smart Lock Solutions

Smart lock solutions have upgraded the full range of mechanical locks used both at home and abroad, including household door locks used in China, commercial door locks used by hotels and apartments, popular locks sold abroad, smart lock conversion kit that allows to keep existing deadbolt, and such developments of smart locks as small Bluetooth padlock, smart cabinet lock, key box, smart safe, gun safe and other innovative locks. Therefore, apart from developments for household use, the smart lock is the core product in apartment and hotel SaaS. Integrated into SaaS systems in the industries, for instance, long and short-rent apartment, hospitality and real estate, smart lock solutions have expanded market opportunities

widely for enterprises.

In terms of solutions, smart locks in various forms and for multiple application scenarios have their distinctive features. For instance, home lock solution that has a higher commonality is able to upgrade conventional mechanical and electronic locks into smart lock by connecting cloud and APP via mainstream module. Besides, the solutions can provide vast number of value-added services, including third-party voice and audio control, SMS and Phoning for security alarming, and video cloud storage etc. Generally, the solution costs RMB500,000 less per year than the independent research and development by door lock companies. The connection can be completed in 7 days in the best case, and the mass production of smart lock products can be realized within one month. Commercial door lock solutions are focused more on connection efficiency and cost performance. Given the target of minimizing retrofitting cost, Bluetooth cloud key adopted by hotels and other SOC solutions are more suitable for the upgrading of a large number of rooms in hotels. Furthermore, commercial scenarios, such as apartment lock, hotel lock and office building control, should be accompanied by various SaaS systems, so as to realize smart space management and improvement of renting and living experience.



3 Cases in the Smart Lock Industry

VOC

Founded in 2012 and headquartered in Wenzhou, Zhejiang, Zhejiang VOC Technology Co., Ltd. (hereinafter referred to as VOC) is a R&D-oriented company integrating high-end intelligent hardware manufacturing, SaaS platform R&D method supplier and independent brand operation. VOC develops and manufactures smart door locks, smart doors, and smart safes under its own brands. In 2019, it was among Forbes' "Top 100 AIoT Chinese Companies".

Used at the entrance of a smart home, smart door locks are the most critical devices in home security. In recent years, the market for smart door lock has grown rapidly, and a variety of new technologies have sprung up. In 2019, competition intensified and network connection became a standard feature for smart door lock products. As one of the leading brands in the smart security, VOC has been making vigorous moves to develop its smart door lock business as well.

Despite their variety, networking solutions on the market back then had inherent weaknesses, such

as unstable connection, frequent data loss, high power consumption, and slow technology upgrade. In order to address these bottlenecks, VOC not only put in more efforts in technology R&D, but also searched for innovative solution for smart lock network connection.

After integrating the Wi-Fi connection solution on a third-party IoT development platform, VOC was able to utilize the platform's relevant APIs, and further connect its devices to App and the cloud by developing embedded application software. It only took VOC half a month to complete the integration of its smart door lock and the Wi-Fi connection solution, which saved the company a great deal of time and costs and allowed it to launch the finished product quickly for higher market share.

After the launch of the finished product, VOC continued to optimize the product's performance through refined data operations to better meet the market demand. It now offers various functionalities including device distribution review, device condition monitoring, active device calculation, App usage analysis, and real-time failure reporting. With big data and AI tools, the operation of smart products can also be smart.

2.1.5

Health

1. Industry Overview

Affected by the Covid-19, the global economy continues to take a slide, and countries around the world have attached even more importance to the development of the healthcare industry, which will enter the era of universal access to healthcare. The healthcare industry boasts tremendous market potential, with an array of segments closely-related to personal health, including health care, health(care) devices, health management, leisure & fitness, and health consultations.

The global healthcare industry was valued at USD 4.5 trillion as of 2018, maintaining a 6.5% yearly growth, and accounted for 5.3% of the world's economy, with key areas including personal health, healthy diet, sport & health, health tourism, medical health, health & real estates, etc.

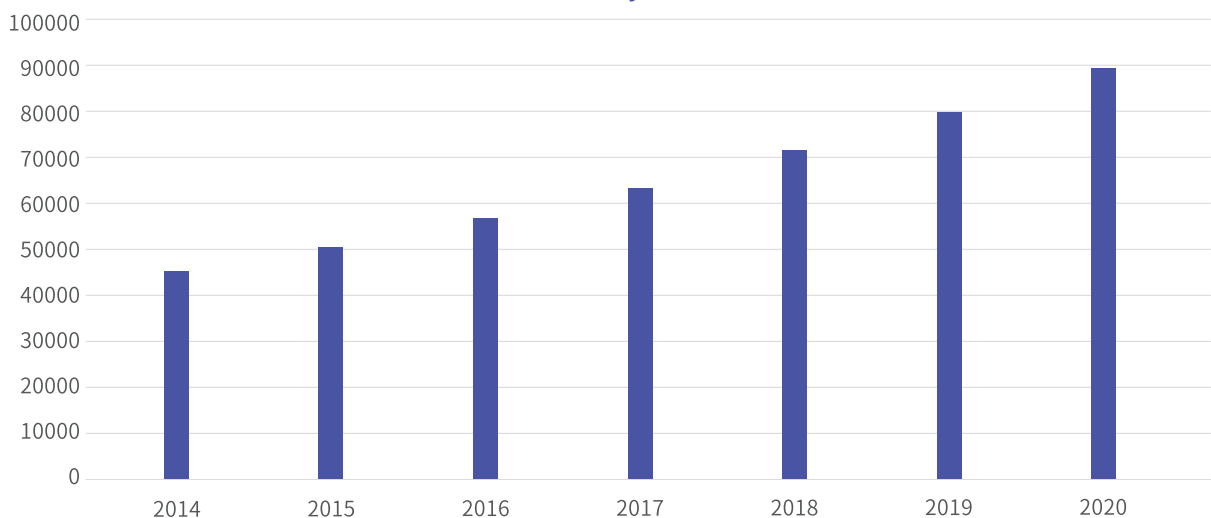
China's healthcare market was valued at RMB 4.5 trillion in 2014, and it is expected to grow almost

twice as much as of 2020, amounting to RMB 9 trillion. In 2023, it is expected to be at RMB 14 trillion and at RMB 16 trillion as of 2030. The coming decade holds a golden era for the development of the healthcare industry.

The future trend of the healthcare industry will be going digital, constructing a user-centered healthcare model through smart devices that are driven by data in an intelligent way. Devices, data, intelligence, users, artificial intelligence (AI), these core concepts of the healthcare industry's development coincide to profoundly align with what internet of things (IoT) entails.

In the fields of sport & health wearable products for sports and home fitness continue to gain intelligent market share on a yearly basis. According to IDC, a market intelligence agency, the global shipment of wearable devices increased gradually over 2012-2018, with an average annual rate of growth reaching above 150% from 2012 to 2015. In 2017, 115.40 million units of wearable devices were shipped, meaning a 12.7% increase year-on-year. In 2018, 122.6 million units were shipped

2014-2020 China's Healthcare Industry Market Value and estimation of 2020



Source: askciresearch

globally, meaning a 6.24% increase year-on-year. It is expected that in 2022, the global shipment of wearable devices will amount to 190.4 million units, representing a five-year CAGR of 11.6%. Bluetooth protocol has been upgraded to BLE 5.0, which brings faster transmission rate, longer transmission range, lower power consumption, and the development of wearable devices. With fitness watches and bands already claiming substantial market presence, other innovative wearable products such as smart eyewear, earphone, rings and shoes, are getting more attention from consumers. Wearable devices can effectively record users' activity data, transmitting data to cloud storage using IoT technology. Users' historical data will be stored and shown directly to them on mobile Apps. Home fitness devices are now more than just fitness devices. Manufacturers leverage on the opportunities presented by the IoT development, and make their products smart – from bigger machines such as treadmill, elliptical machine and spinning bike to smaller ones like dumbbell, skipping rope and hula hoop – they produce data which will be connected to mobile records and stored. These products are gradually favored by consumers.

In the field of medical health, the market share of the current home devices is also growing rapidly. In 2017, the global medical device market value exceeded USD 400 billion, and the value went up to USD 427.8 billion in 2018, and was estimated to reach USD 600 billion by 2024, meaning a 5.6% CAGR between 2017 and 2024. For at-home medical device, the market was only valued at RMB 41.9 billion in 2014, it grew to RMB 94.8 billion in 2018, representing a CAGR of 22.6%. The market is estimated to worth RMB 150 billion by 2020. Medical wearable devices can collect users' health data and upload them to platforms for statistical and analytical purposes, giving advice to users with the connection to medical services. At-home blood pressure monitor, glucose meter, pulse oximeter, ear thermometer and thermometer are widely-used for families, and smarter versions of the products are

becoming increasingly popular every year. Medical wearable devices play an important role in users' self-monitoring and health data monitoring, allowing access to effective health data for doctors and services providers.

Personal care products are transforming to become IoT-connectable as well. It is expected that China's personal health appliances market will worth RMB 32.56 billion in 2020, the CAGR between 2015 and 2020 will be 15.5%. In 2018, electric shaver, hair care appliances and electric toothbrush recorded a retail sales volume growth of 24% year-on-year, and 40% year-on-year growth in terms of sales value. Manufacturers are also trying out ways to product smart personal care products, such as toothbrush, shaver, hair clipper, facial steamer and hair dryer. They do not account for a high proportion in market, while their market share is increasing significantly. Product users can also feel the service and experience beyond product functions. Products are becoming smarter and data-driven in sport & health, medical health and personal care. Data generated by these products will help provide a better condition for data-driven services quality, enabling corporations to become more diverse, and giving birth to new market and development opportunities.

2. Solutions

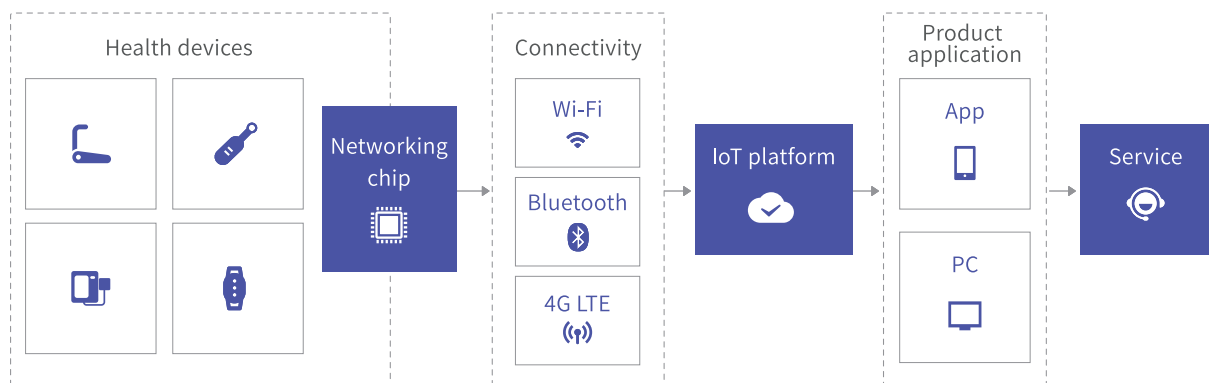
For the health industry, devices as vehicles for data collection are of significant importance. All health products and services rely upon users' data to pinpoint customer issues, allowing accurate user services to be provided, hence the ability to collect and upload data to cloud drive has become a prerequisite for health products. Health devices collecting users' data have become increasingly relied upon various scenarios, where services providers can provide more customized services to users according to their respective health data. As market demand changes, traditional offline devices are being gradually replaced by smart ones in the health industry. Market share of smart health products increases every year. Traditional

manufacturers are seeking their ways of producing smart devices that align with their business development goals. Smart health products usually revolutionize the value chain in six areas, namely smart hardware, data communication, front-end software, cloud platform, smart data and health service. They are driven by data, providing health

services through smart devices as a comprehensive health package for users.

The core of smart health product hinges on the abilities of networking and cloud platform, smart product solution with width and depth, and product services. The solution can be explained as follow:

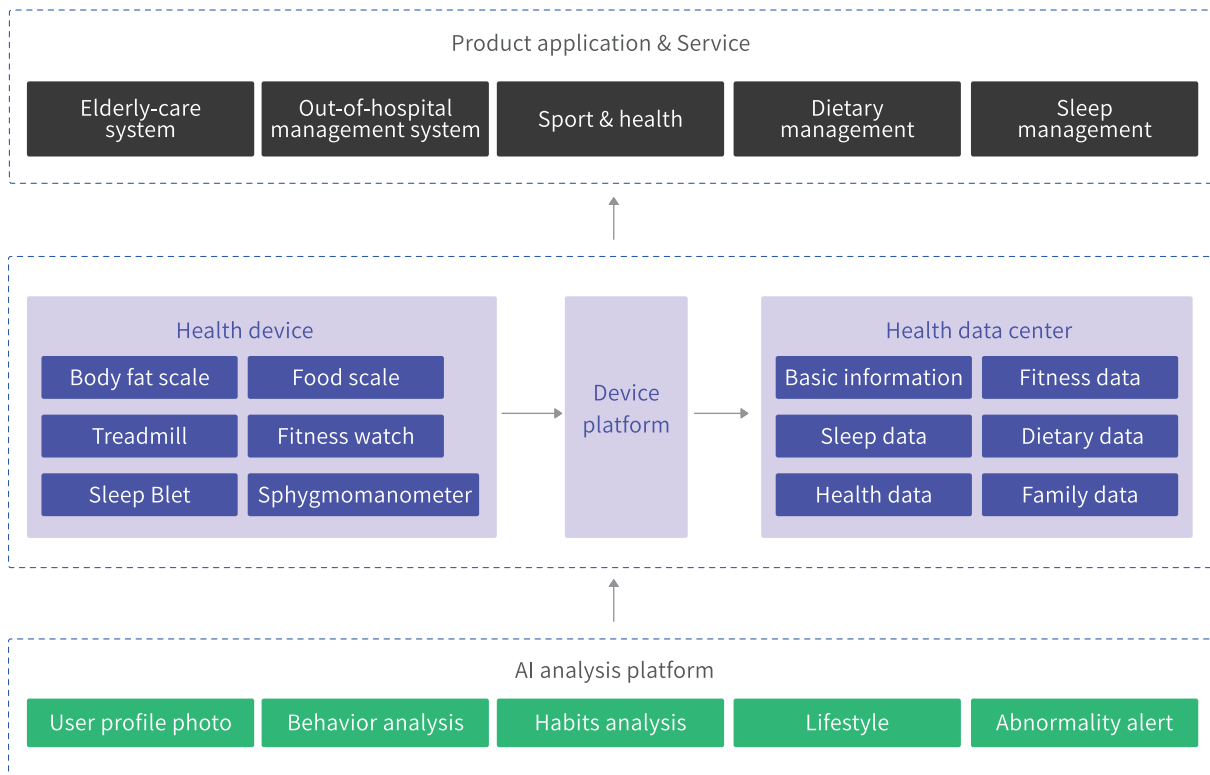
General solution of Internet of things for health equipment



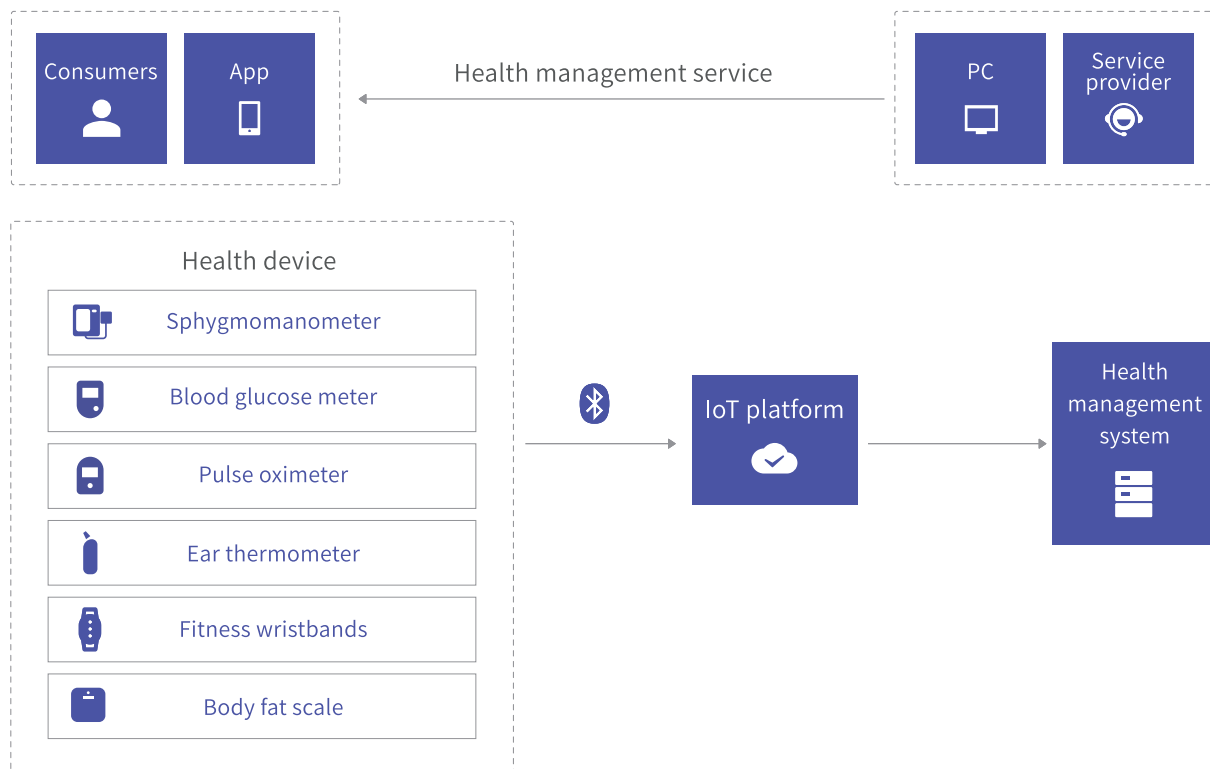
Connectivity is imperative for health devices to be smart. Deriving from such standpoint, Bluetooth technology is characterized by its convenience and low power use, hence most wearable health devices and personal care products are featured with Bluetooth connectivity. Bluetooth 5.0 version has better performances. In contrast with Bluetooth 4.2, the 5.0 version is twice as fast in transmission, and has 800% as much the transmission volume has increased by 800%. The transmission bandwidth is increased from 1M to 2M, with 4 times as much the transmission range increased by 4 times. Meanwhile, Bluetooth 5.0 technology entails lower power use and higher broadcast capacity, and versions of 5.1 and 5.2 have an enhanced precision

of up to centimeter. Home fitness machines such as treadmill and elliptical machine will still apply Wi-Fi connection which allows continuous connectivity, thus any data could synchronize with the cloud drive at any time. Given accessibility to Wi-Fi in home setting, these machines and other home devices have become more convenient and interactive. On the other hand, some outdoor sports products transmit data without being connected to a mobile phone, usually using NB-IoT or 4G. The cloud platform, its application and service solutions structure:
The cloud platform, its application and service solutions structure:

Cloud platform, application and service solution architecture



Example of health management service platform



3. Industry Case Analysis

IoT is already common in the health industry. It is popular for sport & health, medical health and personal care. Below is a smart healthcare project incorporating smart devices, IoT cloud drive and health management system, and its main business is to offer health management services as solutions package to people who need at-home care.

The whole system encompasses three core elements, namely smart devices, IoT cloud drive and health management system.

Smart health devices are mainly used for collecting users' daily health data in a home-setting, users could evaluate their health status based on the statistics shown on the devices. For users of healthcare needs, especially for people with chronic illnesses, daily blood pressure, blood glucose and blood oxygen monitoring have become a part of their daily routines. Most of the people have the devices at home to assess their health index in a timely manner.

IoT acts as a bridge connecting data from devices with application systems, making health data full of vitality. After data is collected, they will be synchronized to cloud drive and stored, then these data will be processed and analyzed for each user, generating more meaningful and comprehensible statistics.

Health management system uses data generated from devices and synchronized to IoT platform for developing higher-level applications, allowing service providers to collect corresponding users data and provide services pinpointing users' needs. Smart healthcare project uses data collected from devices, consolidate the data and prepare weekly or monthly reports, and provide professional comments and advice to users.

Helian Health

Founded in 2014, Helian Health, knowledgeable in medical industry and The Internet of Medical Things (IoMT), aims to build a large online platform to serve patients, doctors and hospitals. It provides hospital Wi-Fi, medical apps for patients and

clinical workers, as well as one-stop hospital IoMT solutions, etc. Helian Health now works with over 1,900 hospitals in 245 cities across China and served more than 900 million outpatient visits; with its Wireless access points (APs) reaching nearly 100,000, Helian Health is currently the largest hospital Wi-Fi service provider in China.

In April 2018, as the executive meeting of the State Council pushed to promote "Internet Plus Healthcare", Internet-powered Healthcare has been developing in full swing. The medical industry has gradually moved closer to Internet market from physical clinics and hospitals, and medical applications are coming out to provide healthcare services catering to different needs in old and new scenarios. And this requires traditional medical institutions to improve its services and efficiency through the integration of informatization and intelligent technologies.

Helian Health initially entered the medical market as a hospital intelligent network provider (Wi-Fi business), and has become the industry leader with 60% market share within 4 years. Helian Wi-Fi now has covered 1,900 public hospitals nationwide, with more than 97 million end users (i.e. patients) and 1.3 million daily active users.

The operation and maintenance of equipment in more than 1,900 public hospitals is the biggest problem faced by Helian Health. For example, breakdown is fairly common to medical equipment, and it requires engineers to deal with it on-site. Although a simple reboot can fix the problem at most of the times, Helian needs to ensure engineers are always available to keep equipment going without causing delays in diagnoses.

Another characteristic of working in medical industry is high demand for accuracy and reliability. This low tolerance for errors means demanding technical requirements, tendency to collaborate with big, stable platform and preference for mature technologies.

Helian Health cooperates with the global AIoT platform, Tuya Smart, to deploy smart single plugs and power strips in hospitals, and maintain a large

number of equipment through Tuya's operation and maintenance platform. When there is a problem with the equipment, it can be rebooted by restarting the socket in the SaaS back end, which reduces labour cost and improves the maintenance efficiency. Helian Health also has developed an operating platform for hospital equipment management based on Tuya Smart Cloud development platform, which provides real-time data on any equipment status for all hospital devices.

Monster

Monster®, the world leader in premium headphones, speakers, and power accessories, has been a catalyst for innovation and big ideas. After discovering that cables in hi-fi systems influenced the sound, Head Monster Noel Lee developed Monster Cable, which became an immediate hit with music lovers. Monster went on to engineer the sound of Beats® headphones and has now become the world's leading manufacturer of high-performance headphones, all featuring Pure Monster Sound™ technology. Today, the company offers advanced connectivity solutions for professional musicians, home entertainment, computing, mobile, and gaming, as well as high performance AC Power and air conditioning products. Monster continues to lead in innovation, with over 500 patents granted and 100 patents pending worldwide, offering more than 5,000 products in over 160 countries. Monster also prides itself in helping those who are in less-

than-fortunate circumstances through Monster Cares.

Monster announced at CES 2019 that it is teaming up with Tuya Smart, the world's leading AI+IoT (AloT) Platform, to co-create a new line of "Monster Smart Powered by Tuya" smart home products.

These products include innovative solutions for controlling everything from lighting and home entertainment to power, security, and more.

The partnership between Monster and Tuya will facilitate the development of an entirely new category of highly efficient, easy-to-use, and secure smart products for the home and office.

Monster Smart Powered by Tuya products will benefit from Monster's world-renowned expertise in product design and development, supported by Tuya's unsurpassed AloT Platform, including big data capabilities that enable geolocation and environment-sensing features.

Initially, the product lineup will include the next generation of the Monster IlluminEssence products, with new power, home entertainment control, security system solutions, and more to be announced in the coming months.

Lee noted, "'Always Deserve Better' is why we've focused on better audio for 40 years. And now we think IoT and smart products will help consumers have a better life in so many ways and we're looking forward to directing our innovation with Tuya in all things smart – starting with lighting, power, and security."

2.1.6

Lighting

1. Overview of Lighting Industry

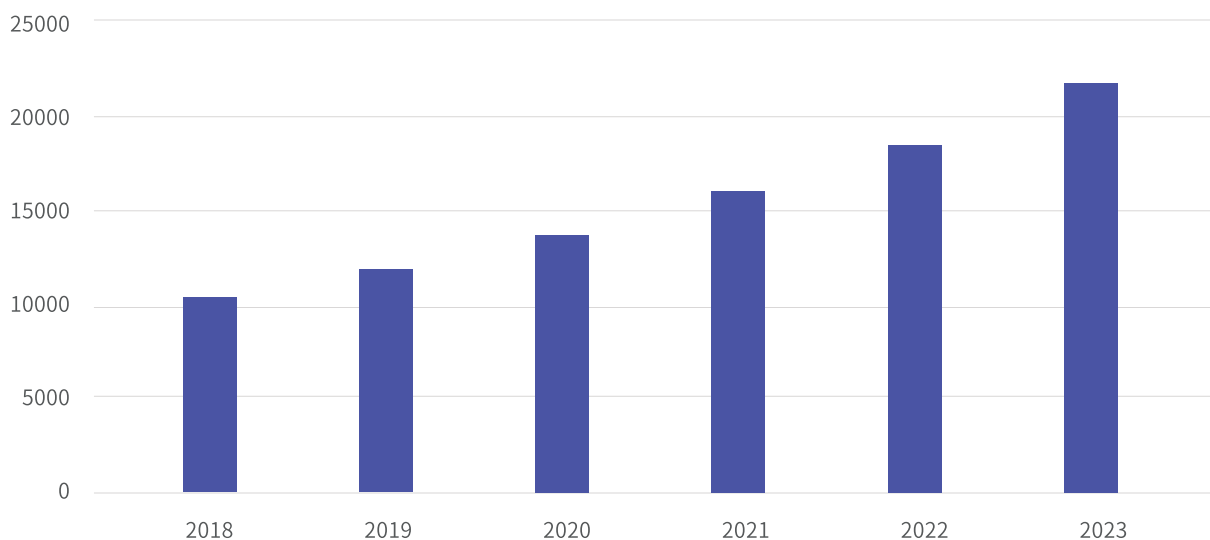
According to the investigation report published by Omdia in 2020, the annual sales of global smart lighting and connected controllers will reach \$21 billion in 2030, a double increase from \$10 billion in 2018.

The investigation report points out that while the expected sales will double in the coming few years and enjoy a pretty growth curve, it is also worth noticing that consumer's lack of understanding about the technological advantage of smart lighting will become a major factor to impede the greater market growth. Currently, light industry are paying more attention to emphasize the ways of controlling the lighting and which automatic mode to choose, which are not impressive enough to persuade consumers to change their traditional lightings into smart ones. With people's living standards

increasing, consumers are paying more attention on the health, thus the positive impact of smart lighting on people's health will become an important driving factor for consumers to upgrade their lightings into smart ones, however the impact is hardly mentioned in the publicity materials.

There is a widely accepted concept concerning smart lighting's impact on people's health, namely, "Human Centric Lighting". According to this concept design idea, human body can regulate hormone production from sunrise to sunset so as to guide the schedule for work and rest. The invention of light, however, has disrupted regular variation brought by sunlight, thus causing people's schedule in disorder. The lighting system should be in accord with the laws of nature to benefit people's health. Scientific study indicated that relatively high color temperature in light help people concentrate and reduce the risk of making mistakes in work or study, medium color temperature can decrease fatigue feelings and is suitable for long time use, low color temperature can create cozy environment and is

Total Smart Lighting and Connected Controls Market:2018-2023 (Millions of US Dollars)



source: <https://www.omdia.com/resources/product-content/global-smart-lighting-market-set-to-double-in-size-by-2023-despite-consumer-unawareness>

suitable for leisure. Inappropriate use of light may bring unpleasant results. For example, the use of cool white light before sleep will disrupt melatonin production thus interfering with the sleep and influencing children development. So it is suggested to use a lower color temperature like warm white light before sleep.

LED light source with its energy-saving, stable, triggered the fourth generation of lighting source reform. Now with the rapid development of various technologies, lighting system as the most important part of smart home, will be given more capabilities. So helping consumers realize and accept those capabilities will become a significant driving factor to boost smart lighting revolution.

2. Lighting Solutions

2.1 Miniaturization Solutions

Demodularization

With the rising market acceptance, sales of smart lighting are surging, so it is becoming increasingly important to control cost of single product. It remains the top priority for different ends of the supply chain to figure out how to control the cost without sacrificing the quality of product. In 2020, some lighting factories have already tried to reduce the PCB of wireless module, simplify the whole production procedures to control cost by combining communication module and driver board together. Meanwhile, this production plan has also brought some challenges to the lighting factories including refined SMT processing capabilities, wireless calibration test capabilities, RF design capabilities, board-level anti-interference design capabilities and process control capabilities.

Highly Integrated Chips

Previously, due to the small share of smart lighting in the industry, many driving solutions were pieced together from the driving solutions in traditional industry, such as power supply chips from home appliances and RGB driving chips from outdoor

displays. In 2020, the major lighting driver factories has made great advances in the level of driving chip integration with fewer peripheral components, lower energy consumption, wider adjustment range, more precise adjustment control, and the original design focusing on the intelligent lighting solutions.

Three-dimensional Structure

There are many types of lighting sources: such as A type, PA type, BR type, GU type, MR type, etc. The intelligent upgrade of small light sources may face many challenges and the structure, heat dissipation, light type, and wireless signal processing need to coordinate with each other. At present, there is a minimum mass-production solution that can embed the power supply, driver, and wireless modules into the E14 lamp holder through a three-dimensional structure.

Antenna Upgrade

Accordingly, the antenna designs of these different types of light sources are also constantly changing. The antenna can not block the lamp beads and should be characterized with the radiation performance, directional performance, as well as other features including the miniaturization, easy installation and easy fixation. Each link of smart lighting design is worth deeply exploring, including the inventions of PCB printed antennas, wire-type monopole antennas, as well as ceramic antennas and tries in making antennas by using aluminum substrates and aluminum lamp cups.

2.2 Sensor Fusion

As the eyes, ears, nose and mouth of AIoT, sensors need full-time and omnibearing coverage. People's reliance on light make lighting products so ubiquitous that as long as there are human activities, there will be lighting products. This wide coverage of lighting products is very suitable for combining sensors and smart light sources, which can not only be used to control the light, but also increase the security attributes of the intelligent system, including intrusion detection, illumination

detection, smoke detection, image collection, etc. For example, solar lawn light are featured with illumination detection, human body pyroelectric induction, MESH networking, and solar power supply. Through the App, it can be set to a normal lighting mode where the light is on when people come, or an alarming mode where automatic video will be recorded and reminders be sent when people come.

2.3 Multi-Protocol Interconnection

Commonly used smart IoT communication methods such as Wi-Fi, Bluetooth, Zigbee, Cellular network, etc., all have their own best applicable scenarios, so how to interconnect these devices will play a vital role to constructing smart IoT.

Based on this idea, super gateway solutions, including aggregation gateways and voice gateways, will reconstruct the linking center. The aggregation gateway can support multiple communication protocols at the same time and can realize the interconnection and intercommunication of multi-protocol smart devices such as Wi-Fi, Zigbee, Bluetooth with one gateway, so as to create a more powerful smart home system.

2.4 Custom Scenario

When the smart IoT devices used by users reach a certain number of categories, the joint actions among products will make the smart system smarter. While autonomous learning capabilities, have not yet been achieved in smart devices, custom scenarios setting will provide better experience for people to enjoy the convenience from intelligence devices. For example, setting home mode: when you return home at night, the smart door lock will automatically be opened, followed by the soft lighting mode, then the fresh air system, and the air conditioning system will be turned on with the alarming mode of the sensors at home canceled. When you go out of house pressing the leaving button, or when the indoor sensor cannot detect the owner's activity for a long time, the leaving mode can adjust the above-mentioned equipment to the off state and the sensor

into the alarming mode.

Users can add these smart scenarios one by one in the App, or just find a large number of default scenarios in the scenario database to quickly complete the setting.

3. Cases in the Lighting Industry

Foshan Electrical and Lighting

Founded in 1958, Foshan Electrical and Lighting Co., Ltd. is a well-known enterprise focusing on the R&D and production of high-quality energy-saving lighting products. Since its establishment, it has been dedicated to promoting green lighting products, providing customers with comprehensive lighting solutions and professional services. With sound and efficient production operation system and quality management system, it is now one of the strongest brands in China's lighting market. In recent years, on the basis of its portfolio covering all elementary lighting products, Foshan Lighting has been expanding its business in smart lighting and health lighting. Product lines of its brands, including FSL, Fenjiang, QL, and Fozhao Electrical cover home lighting, commercial lighting, office lighting, outdoor lighting and many other categories. Around 40% of its products are for export, serving customers from over 110 countries and regions across the world.

One problem that has arisen as Foshan Lighting goes global is the lack of interoperability between different products and platforms. Now, major communication protocols on the market include Bluetooth, Zigbee, Wi-Fi, 2.4G, DALI, DMX512, while products from different companies or cloud platforms cannot connect with each other. As a result, users have to install several Apps on the cell phone in order to use products from different companies, which is inconvenient and inefficient. Nowadays, with various types of smart products emerging, customers have higher requirements for user experience. How to meet the customers' "all-round needs" and enhance product reliability is a serious question that each smart manufacturer must

answer.

Centered around smart lighting products, Foshan Lighting has been diversifying its product line by integrating smart hardware on third-party AIoT platform. With its well-developed one-stop solution for smart home, consumers can enjoy complete services and a carefree life.

In terms of product development, Foshan Lighting uses module SDK to develop smart lighting and smart security products, so that products can be deployed into the network quickly, and can ensure “ever-lasting” network connection under normal circumstances. The Foshan product lines covers light bulbs, light strips, light strings, downlights, ceiling lights, security alarms, etc. all of which are constantly updated and boast high malleability. Foshan Lighting’s products offer optimal user experience and good value for money, which help them quickly gained popularity in both online and offline channels at home and abroad. Its light source products have long been among the top three best-selling products on Amazon's e-commerce platform.

Calex

A Dutch decorative lighting company founded in 1970, Calex is the best-selling decorative lighting brand in Western Europe and the European decorative lighting market leader. Calex’s parent company, Electro Cirkel B.V., has been around for nearly 60 years.

Calex offers more than 400 SKUs in 15 categories. Its lighting products are characterized by a full range of dimmable, vibrant colors and high intensity whites from cool to warm.

About six years ago, Calex began to see the huge growth and opportunity of the European smart lighting market. The penetration rate of smart bulbs in Europe was 3.8% in 2019 but is expected to reach 10.7% by 2024, according to Statista. In 2015, Calex launched a Bluetooth smart light bulb at a price of €25, but did not sell many of them because of the relatively high price and the need to improve the product experience. That’s when Calex realized it needed to partner with a smart home and

smart lighting market expert to improve its pricing competitiveness and get a true foothold in the market.

In 2018, Calex partnered with Tuya to develop and launch a €10 Wi-Fi smart bulb. Using Calex's smart light bulb app, users can create various smart scenarios and automations, such as using voice control to turn a bulb on or off or connect it to an alarm clock. The lighting can also be used with various other home appliances, including refrigerators and washing machines.

Thanks to the combination of a powerful smart lighting app and affordable pricing, Calex's smart bulbs quickly took hold in the European market. Within a few months, Calex smart bulbs could be found in the main retail channels of six Western European countries, and in less than a year, Calex was able to distribute more than 5 million products bringing more than 1 million smart households to life.

Globe

Globe Electric, founded in 1932 and headquartered in Montreal, designs and manufactures LED lighting and electrical products for the consumer market. Working with the top North American retailers, Globe is a leading provider to the retail and consumer segment, and is widely known for bringing new and innovative technologies to market. Partnering with Tuya in 2017, Globe has brought their vast experience in lighting and the ways in which consumers interact with lighting controls to the relationship. Strong collaboration between the Tuya and Globe development teams has resulted in compelling product introductions, including a floor lamp that was featured by both Google and Amazon as part of their hot new product showcase at CES in 2020.

Feeding off their many years of experience in category management positions with the leading retailers, Globe has consumer insights and a data driven decision making approach to guide their product development. This has enabled a focused approach, leveraging the technical expertise

of the Tuya team while driving innovation at the product and category level. Opportunities within connected products are limitless, but there remains the issue of a massively fragmented industry with the result being added confusion for consumers on interoperability, and ease of setup as the hurdles to more widespread adoption. Further, while there are certain product categories that are super saturated, there remain more niche products and features that are experiencing tremendous growth as they satisfy a market need.

The next phase of adoption, product and technology introduction has the potential to move the needle for manufacturers and retailers in the industry. The key will be accurately identifying the use cases, consumer needs, and enhancing, wherever possible, the simplicity in use and setup.

“The smart home industry, despite several years of sensational growth and popularity amongst consumers, remains in its infancy,” says Adam Chaimberg, Chief Merchandising Officer of Globe Electric. “The realm of IoT, AI, and smart home is like a great story; we are only finishing the introduction,” continues Chaimberg. Globe has built out a robust product roadmap across their key categories, with a keen eye towards meeting consumers where they are technologically but also with respect to more subtle aspects, such as how consumers live and how home automation can positively impact their lives. Despite nearly 90 years of lighting and electrical design and manufacturing, this is a company that behaves and acts with the speed and enthusiasm of a nimble startup.

Wipro Enterprises Limited

Wipro Consumer Care and Lighting (WCCLG) caters to the Fast-Moving Consumer Goods (FMCG) segment which deals in personal care, home care, lighting and furniture products. Established in 1945, WCCLG is now a company with revenues of over Rs.7700 Crores and a global workforce of over 10,000 from 22 nationalities and a marketing presence in over 60 countries including India, South East Asia, East Asia, Africa and the Middle East.

WCCLG has been working with Tuya, since 2018, which has helped Wipro to become the No.1 smart lighting brand in the Indian market with a comprehensive product portfolio that covers smart bulbs, smart battens, smart downlights, smart panel lights, smart LED strips, smart COB lights on both Wi-Fi and Bluetooth. The Wi-Fi based products target at the consumer lighting market for individual home use, that enables users for smart home lighting experience at extremely low-cost price of Rs.699, which is around \$9, with overall functions of remote control, dimming, color changing, timer/scheduler, smart scenes, and automations with other smart home devices. All the smart devices are connected to Alexa and Google voice platform, that helps users control the connected devices via voice commands. Wipro Smart LED turns your home into a party lounge, a mini movie theatre, an office, a yoga class, even a campaign spot for your kids! It's 16 million color combinations create mood lighting suitable for every occasion. The “Wipro Next Smart Home” App is a cross-protocol and scalable app that not only controls smart lighting, but also other category products, which includes electricals, home appliances, security products, and healthcare products. This gives benefits to end users as it is platform-agnostic, and be it products that work on Wi-Fi, Bluetooth or Zigbee, they can use the same app to connect and configure. This helps in creating a smart home with an easier and seamless experience. With rich product lines and the vendor partner eco-system, that Tuya provides, Wipro can choose from over 200,000 products from more than 30,000 manufacturers. This helps cut the smart new product development time from one or two years to simply one or two months, thereby improving the product lifetime management efficiency by 10 times. Besides consumer lighting and smart home businesses, Wipro has also entered into the smart commercial lighting segment, by adopting Tuya SaaS lighting system, so as to provide complete wireless lighting solutions for SMBs – which include offices, hotels, schools, retailers. Compared with traditional wired solutions like Lutron or

Casambi, the Wipro wireless commercial lighting could help forge a same lighting solution at only 8%~10% of the total cost. It not only reduces the cost significantly, but also is a revolution in the reduction of wiring and helping improve project implementation efficiency. The system allows the installer a hassle-free implementation experience with wireless scanning and auto connection, and even plug-and-play. The management and settings of the lights thus become handy. For small deployments it even does not require electrician or technical expertise. Through SaaS web management portal, the administrator could monitor the real-time device status and power consumption statistics in a transparent way. The system also supports hierarchical settings and administration authorities to support headquarter and branch management in a same dashboard. The scalable system allows innumerable lighting device connections to cater to different scale of project installations. The solution is becoming an important part of Wipro home service segment.

Based on the rapid development of domestic smart business and good expectation of global IoT market, Wipro is now expanding their domain into multiple smart categories of smart electricals, retrofit solutions, security kits, and also has a plan to launch smart products overseas in the US, UK, Middle East and South East Asia, etc.

Brilliant Lighting

Smart Technology is already changing the way we live around our homes. By connecting your lighting, home appliances and security and partnering with Google Home or Alexa – this innovation has the power to transform our everyday lives.

With its comprehensive scope and intuitive design, Brilliant's range of Smart Technology has the capacity to transform virtually every aspect of both households and businesses. Working its magic through your Wi-Fi connection, our Smart

Technology range allows you to manage your home electronics, appliances or devices wherever you are, at any time, instantly.

Brilliant has a wide range of solutions ranging from lighting, electrical, air movement and smart technology.

Brilliant's Smart Technology is fuelled by the simple yet powerful BrilliantSmart App, designed for ease of use and controlled directly by voice or smart device. Just say the word, and your house instantly obeys — even from hundreds of kilometres away. Brilliant Lighting has partnered with Tuya since 2018 to launch a range of smart home products dubbed BrilliantSmart. The BrilliantSmart range includes about a dozen products, including lighting, security cameras, home appliances, and sensors, that can interact with Google Home and Amazon Alexa and can be controlled from an Android or iOS app without the need for a separate hub. These products all proudly wear the "Powered by Tuya" badge. By relying on the Tuya IoT Platform, end users benefit from smart scene control to power their devices and appliances on or off according to predetermined schedules.

BrilliantSmart technology is simple to operate via a large range of lighting, security, switches or electrical products, which can be controlled either individually or by each family member. To make these benefits accessible to everyone, BrilliantSmart is designed with the broadest compatibility in mind. All Smart Technology is fully connectable via your mobile, tablet, Alexa or Google Home device.

Brilliant is ever expanding its smart offering, always at the forefront of new technology to ensure customers' needs and ease of use is prominent in what we do. Brilliant is now introducing BLE Mesh systems to assist large scale use of smart technology, which will assist customers in their smart experience if they require large amounts of smart products.

2.1.7

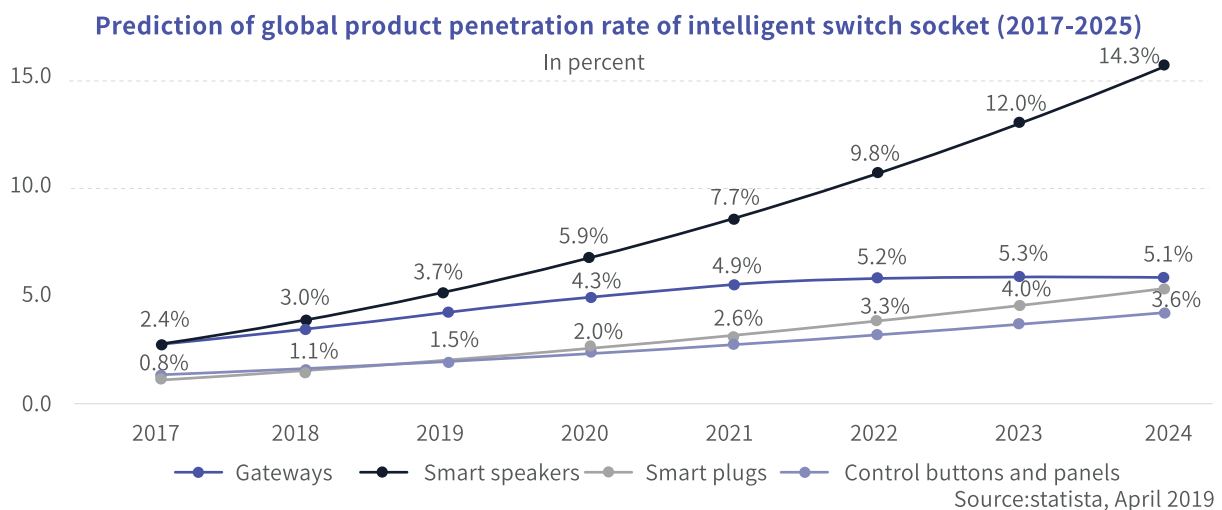
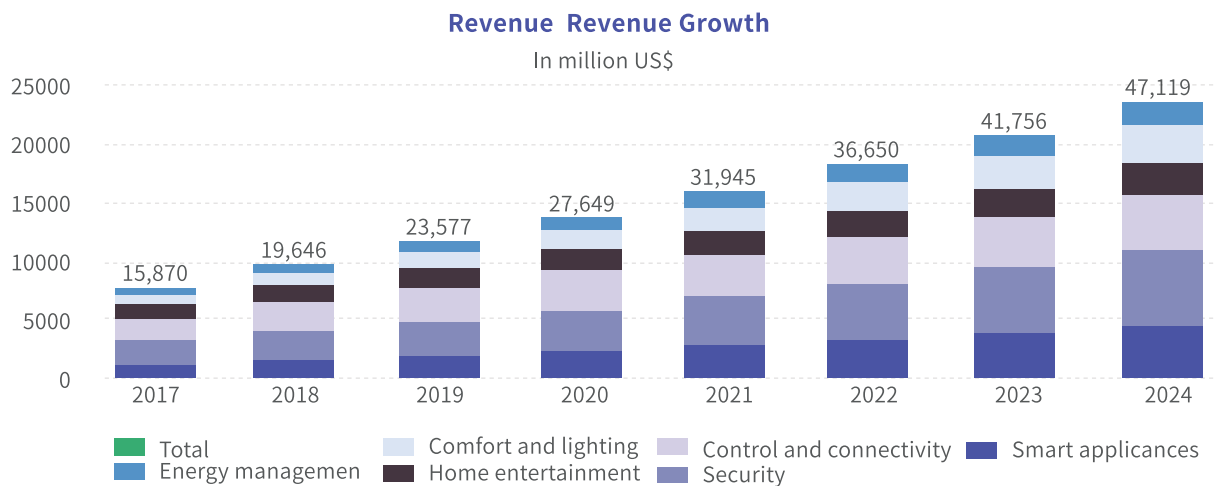
Smart Electrical Engineering

1. Global Development of Smart Electrical Engineering Industry

With the enforcement of “new infrastructure” policy and further development of AIoT technologies, smart home products have gained increased attention from customers, in which a new round of explosive growth will surely take place. According to Statista’s data, smart home market value will exceed \$195.2 billion by 2025. Smart switch and socket, one of the first popular smart home products, have yielded great dividends to the development of IoT, intelligent

manufacturing and other emerging industries.

As basic devices in people’s life and work, smart switch and socket products will witness its penetration going up to above 8% in the global market by 2024. Thus, the smart electrical engineering market can provide sustainable and abundant business expansion opportunities. Owing to progress in IoT, big data, and cloud computing etc., and the establishment of ecosystems such as “smart city”, “smart community”, and “smart home”, the application of smart electrical engineering has been extended incessantly, and the industry has witnessed continuous transformations in aspects of upstream players, downstream channels, and product demands etc.



1.1 Increased Number of Players in the Industry

Accelerated Smart Transformation in Conventional Power Companies

It is an inevitable development trend in the industry that more and more conventional electrical enterprises realize the importance of digital power and smart energy. From the bystander to the player, a number of companies have laid out their smart power product system. Starting from the whole-house smart home products including switch and socket, upstream exporters and OEMs, as well as traditional electrical engineering enterprises like Schneider Electric, Siemens Electric, and Simon Electric, have attempted to improve their product lines' comprehensive competitiveness through the layout of smart electrical engineering product line .

Active Participation of Players from Other Industries

Smart electrical engineering products, with its smart solutions, endow their traditional counterparts with playable and expandable attributes. Not only are there more opportunities for product innovation and function integration, but also many differentiations have been realized. The smart electrical engineering enterprises and giants such as Haier and Lenovo, have attached great importance to the smart electrical engineering market.

Continuous Extension of Channel Boundary

Smart electrical engineering product is characterized with the features of the electrical product and the intelligent technology. It inherits from traditional electrical engineering products in terms of installation, function and usage, but its main highlights are the brand-new function and interaction process. It is necessary for the market to speed up training users and lowering the user threshold. Sales channels and strategies are more diversified.

Online channels, for example Amazon and China's Tmall have paid more attention to explain product

use scenarios, distribution network and other new experiences, in addition to displaying information on common product. Offline channels, conventional hardware stores, DIY channel and retail shelves have also launched their smart electrical engineering products.

To further lower the bar for installing and using the smart products, China has found the step-by-step development of real estate channel for delivering a house with refined decoration, home decoration channel for housing improvement, and channel for business upgrade in hotels and apartments etc. Each channel is actively trying to set up an offline experience store and smart home showroom, so that the customers can have direct experience in smart product.

1.2 Diversified Product Needs

Diversified Product Interaction Mode

Conventionally, electrical engineering products interact with each other by touching on physical buttons. With the help of the smart technologies, the products can be controlled remotely on APP, and in near field through the instructions from smart speakers. This is the typical interaction mode in the 1.0 generation of smart home.

As AIoT technology further develops, customers have higher expectations of interacting with the smart products. In the future, AI computation may become the same infrastructure as water and electricity, so that the less people will rely on screens and actively-sent instruction. With the help of such core intelligent driving forces as big data and algorithm, smart electrical engineering products together with other smart products will make a difference in our daily life in a way that is people-oriented and more consistent with how human interacts, so that users are enjoying them subconsciously.

From Smart Product to Smart Scenario, From Smart House to Smart Space

At the early stage of smart home development, its

focuses are enriching product types and interaction approaches, and improving product experience to the extreme. So there are emerging popular products going viral in the global market, including smart single plug and smart panel. Smart product solutions are laying emphasis on the scenario experience, considering customers' rising needs in safety, lighting, entertainment, energy and other comprehensive scenarios. In these scenarios, several devices are connected by means of interaction, automation and other strategies to build various scenario modes, including "going back home", "leaving home", and "audio & video". These scenarios are the foundation of smart home. The whole-house smart applications based on smart scenarios are no longer exclusive to home settings. A lot of public areas, and business scenarios have been exploring into the user value and business value generated by smart products, in turn creating vertical solutions to the scenarios of community, school, hotel, apartment, and office building where

smart electrical engineering products play a critical role.

2. Solutions of Smart Electrical Engineering Industry

2.1 Multi-product Solutions

Electrical engineering products are everywhere in our daily life. A number of the products, including power management, lighting control, intelligent metering, and low-voltage distribution etc., have been developed for convenience, energy saving, safety and comfort. Typical products are as follows:

Electrical Socket: including all kinds of portable conversion plug, power strip, outdoor socket, grass plug, and innovative composite products, such as lighting and plug (scene light socket) composite, and infrared and socket composite (air conditioning controller) etc. These easy-to-use smart products have gone viral in the global market and are thought

Feature	Wi-Fi	Zigbee	Bluetooth mesh
Main Applications in the Field of Smart Power	Socket/Switch/Breakers etc.	Whole-house Smart Solutions Switch/Curtain Motor/Scene Control	Small-business Smart Lighting System: Switch/Curtain Motor/Scene Control/Light modulator etc.
Transmission Rate	Hundreds of Mbps	20-250kbps	1 Mbps
Number of Connected Devices	Dozens	Hundreds	Hundreds
Network Structure	Star Structure	Mesh Structure	Mesh Structure
Advantages	Fast Rate	Many Connected Devices + Stable Network	Cost + Many Connected Devices
Development Trend	Wi-Fi&Bluetooth Integration, Distribution Network Optimization and NFC; Wi-Fi 2.4GHz/5GHz Dual-band Integration; Low Power Consumption, Fast Connection	Zigbee 3.0 Standard Protocol Local Control + Edge Computing Low Power Consumption	Bluetooth Mesh Standard Protocol Low Power Consumption

highly of by customers.

Smart Panel: It is a basic product in a smart home. There are lighting control systems including light switch and dimmer that directly control lighting fixtures and light sources, in-wall curtain switch that directly controls traditional curtain motor, fan switch, hot water heater switch that controls water heater and other electrical appliances, and add-in card power switch used in hotel scenarios. Furthermore, new products have been provided, such as scene switch, central control panel, and wireless scene remote, which makes it possible that one button can be used for scene control, voice control, multi device management and other functions.

Conversion Kit: To refit conventional electrical engineering products into smart ones at lower cost, many conversion kits have been developed, including cassette on-off devices (switch box) for lighting control and curtain control, conversion kits for garage door motor and irrigation.

Low-voltage Distribution: Products include circuit breakers and air switches etc. In addition to the basic protection function of breakers, the product is integrated with other functions such as smart metering, alarming management, and remote switching.

Smart Metering: There are electric meters, water meters, gas meters, heat meters and others. The device collects energy consumption data and uploads it to the cloud, and monitors historical energy consumption trends.

2.2 Multi-protocol Connectivity

As the basic networking capability, wireless communication protocols serve as an important access method in the smart home sector. The main connection protocols used in electrical engineering products, include: Wi-Fi, Zigbee, Bluetooth mesh, Sub-G and NB-IoT, etc. The application scenarios and development trends are as follows:

The communication protocols above all have their best application scenarios. Various communication protocols will coexist in the coming space intelligent solutions. To achieve better connectivity control for devices with different communication protocols, multi-protocol super gateway or router-gateway integration products will emerge to support the connection of sub-devices using multiple communication protocols, and to integrate voice control capabilities, thus empowering the connection hub of smart products.

2.3 Digital Electric Solutions

With the further development of big data computing and device perception, it is critical for the smart electrical engineering industry to figure out how to apply electrical products' specifications and establish digital solutions. The industry focuses on electrical equipment's data collection, monitoring, analysis, pre-warning, and early intervention by using big data computing, to discover problems in equipment and user end immediately, assist customers in decision making, improve user experience, and make full use of big data, thus taking a stride from smart home application scenario to smart business, smart industry and smart city.

2.4 Smart Energy Solutions

Focusing on "power", the solution by connecting with multi-ecosystem devices in IoT, can realize power consumption monitoring, intelligent scheduling, and energy efficiency calculation, finally delivering targeted energy-saving management strategies to provide customers and end users with impressive energy efficiency and economic benefits. This is also an important direction for the development of smart power solutions, since there are urgent needs in areas of business lighting system, smart green buildings, household energy management, and long and short-term apartment leasing.

For instance, electricity and water meters, and air switch can collect energy consumption data for

end users to visually monitor power consumption and manage prepayment. When the power of photovoltaic equipment is high, the system can automatically turn on some equipment, such as water heater socket and power supply, and car charging pile, etc. When the power is low, the equipment of low importance level can be automatically shut down to save energy. While increasing the efficiency of photovoltaic power generation, it can also extend the life cycle of the equipment, significantly improving the economic benefits of the system.

3. Cases in the Smart Electrical Engineering Industry

Apeman

Shenzhen Apeman Innovation Technology Co., Ltd., founded in 2016, is a consumer electronics company focusing on motion imaging and IoT. It includes intelligent imaging and AIoT products in its product ecosystem and has independently designed and developed a series of smart home products, such as intelligent electronic devices and intelligent lighting products.

In 2018, when developing IoT products, Apeman faced the problem of speed to market. They needed rapid design ideation, robust networking connectivity, and integration with Amazon Alexa for traditional electrical and lighting products. They solved their time-to-market problem with Tuya's SDK technology module. Now, their hardware products can be operated in a more secure, convenient, and energy-efficient way by connecting the Powered by Tuya device to an Amazon Echo or other mainstream smart speaker to enhance the user experience for Apeman end users.

Tuya has established a deep cooperation and partnership with most voice service platforms, including Amazon and Google, so that the product can immediately leverage the third-party voice service capability. Systems and processes specially developed by Tuya for efficient production tests, data operations, and after-sales problem processing

enables Apeman to obtain assistance with software and hardware support quickly.

Apeman's Teckin series of intelligent electrical and lighting products using Tuya's intelligent SDK module has been listed on the Amazon online platform, allowing them to break into the European and American markets. The safety, convenience, and stability of the products have also helped establish and enhance Apeman's reputation. After more than four years of development, the Teckin series of intelligent electrical and lighting products that Apeman designed and launched have provided safe, convenient, and intelligent IoT life experience for tens of millions of users in Europe and the United States.

Apeman's product goal is to bring the safest and most convenient home experience for European and American users. The company plans to create an integrated smart home life experience and cooperate with foreign design teams through region-specific enhancements.

Okasha Smart

Okasha Smart is a smart product solution provider that has a portfolio of smart devices for everyday life. IoT smart devices from Okasha Smart are equipped with the latest cloud computing and AI technology, which makes them more secure, user-friendly, and affordable. Their wide range of devices cater to the everyday needs of security and energy efficiency for homes, hotels, and offices, as well as for corporate, industrial, and educational institutions.

Okasha Smart formed in 2007 by providing renewable energy and power solutions to households and firms. Their sister companies, Power Highway® and Solar Max®, have a nationwide sales and distribution network within Pakistan offering renewable energy systems including solar energy, wind power, and hydro power equipment and products. Every project of theirs is turnkey, with a mix of design, stability, and performance. Before coming up with their latest smart solutions and devices, they worked with both

government and private sector companies and individuals over the years and have presented in international forums, helping to establish their brand trust globally.

By fully leveraging Tuya's IoT Platform, Okasha Smart is able to introduce affordable smart home products to its customers with various options by means of multiple wireless protocols, a network of more than 30,000 competitive manufacturers offering more than 200,000 devices, and most importantly, a stable and cost-friendly cloud service. This has helped Okasha Smart to shorten its development cycle, lower development cost, and minimize operational cost.

Some of the core competencies of Okasha Smart are:

- Easy installation and management
- Solutions for both households and corporate companies
- Innovative technology
- Professional and competent customer service

- Internationally certified products

Smart devices from Okasha Smart include lighting, electrical products, home security kits, and home appliances connected via Wi-Fi, Zigbee, and NB-IoT protocols to meet various business demands. For example, Wi-Fi devices are targeted at consumer retail business for individual home use, Zigbee devices for real estate projects, and NB-IoT devices for smart city projects.

Keeping up with the demands of time, the partnership between Okasha Smart and Tuya has generated products to keep up with the latest innovation and technology. Together, they aim to provide effective and efficient smart solutions and devices to end users, so that they can enjoy a better living experience. In the future, Okasha Smart and Tuya will also continue their in-depth cooperation in the IoT field for different smart solutions such as a smart commercial lighting system and smart hotel system to continue to provide value to companies in the region.

2.2.1

Smart Business

Smart Business aims to improve business performance and comprehensive competitiveness by coming up with effective business proposals with the help of collecting, managing and analyzing business information and data through technological means and gathering business knowledge and insights.

Based on the current technological development, AIoT and its core technologies (5G, AI, VR and IoT) are being used in different business scenarios to promote the digital transformation in various business fields, create brand-new smart business models, so as to provide smart and personalized services for consumers. Generally speaking, the market of smart business consists of smart retail, smart catering, smart hotel, smart apartment, smart community and etc.

The development of smart retail is based on the New Retail model. In order to improve the customer experience, digital transformation has become an important means for the global retail industry to meet the challenges. With the support of technologies including network communication, cloud computing and IoT, retail companies are able to collect user data to the maximum extent. The operation efficiency and customer stickiness can be better improved with the data integration and smart data analysis provided by data service platforms with AI technology.

Smart hotel and smart apartment aim to provide intelligent hardware and services, so as to improve user experience, enhance safety, reduce energy cost and human cost.

Smart Hotel

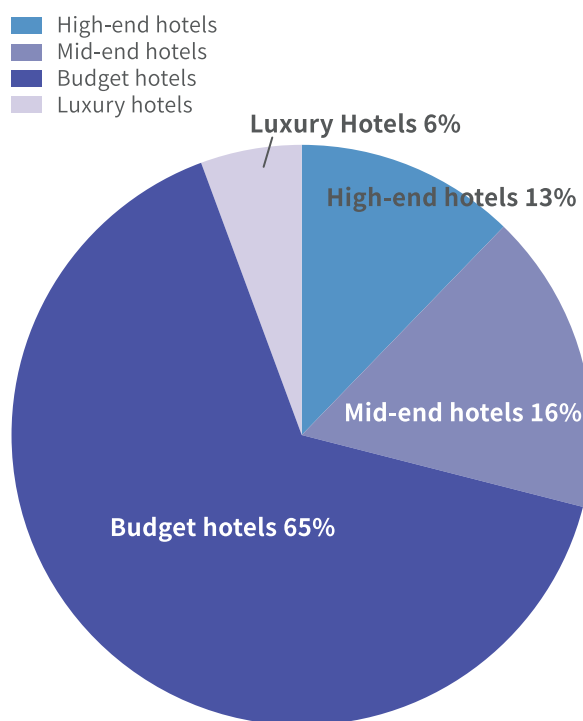
1. Overview of the Hotel Industry Development

The Chinese hotel industry maintains a pyramid-

shaped market structure in terms of quantity and grade. iiMedia Research's (Ai Media Consulting) big data monitoring in 2019 shows that the proportion of hotels serving the mass market reached 92.6%, reflecting the people's livelihood attribute of the hotel industry. At present, mid-end hotels have become the mainstay of development, which will pay more attention to the segmentation needs of personal consumption and provide personalized and high-quality services.

With regard to the operation, the traditional hotel industry has low profit margin due to the high staff & operational cost, and serious product similarity. In 2017, the hotel industry's profit margin was only 1.0%, down 9.1% from 2016. Therefore, the industry urgently needs to make a major breakthrough in reducing the cost, increasing the efficiency, adopting digital management, improving guests' services experience, and increasing non-room revenue.

Distribution of Guest Rooms in China's Hotel Industry in 2019



Data source: iiMedia Research

2. Definition and Status Quo of the Smart Hotel

2.1 Definition

Smart hotel aims to manage hotels in a highly efficient way, reduce energy consumption and improve the guests' services experience through intelligent promotion and marketing, digital asset management, intelligent process management and accurate performance management, relying on the new generation of information technologies of cloud computing, IoT and AI.

2.2 Advantages

The traditional hotel industry is facing problems such as weak marketing, inefficient management, high staff costs, and serious service similarities. Smart hotel has a competitive edge in these regards:

Excellent Customer Services

Through the use of diversified smart devices, smart hotel provides one-stop services that are contact-free, high-tech and user friendly to improve customer satisfaction and loyalty.

Operational Cost Reduction

The use of smart devices and information systems can effectively improve the operation management and service efficiency to reduce the human cost and energy consumption.

Operational Data Collecting

Smart platforms and devices could collect and manage guest data and operation data to improve the operation and service efficiently with the big data and AI.

2.3 Status Quo

The development of China's smart hotel can be traced back to 2001, when some high-end hotels began to develop the smart hotel mode according to Standard for design of intelligent building 2000. In the scheme, a large number of information

technology capabilities such as "5A" automatic control system were applied, and information systems and equipment began to replace human operation partially.

In recent years, as the new generation of technologies such as IoT, cloud computing and big data grows, the influence of "smart hotel" is further verified in terms of the technical capacity, the market demand and the transformation effect. More mid- and high-end hotels have increased their investment into smart development. Accordingly, the tech giants, such as Baibu, Alibaba and Tencent, and start-ups have entered the smart hotel industry, which has become a hot outlet for investment.

According to the China National Tourism Administration, the market investment of intelligent transformation in hotel in major cities exceeds 100 billion yuan. Besides, the number of hotels increase by 20% each year, meaning the promising prospect of the application of smart systems.

3.1 Smart Hotel Solutions

Smart hotel aims to provide intelligent and accurate services for guests based on the data collected from right before check-in to after check-out.

Before Check-in

Membership System: Guests are able to become hotel member through the OTA channels, hotel WeChat official account, official websites, or marketing activities to follow the updates and enjoy the benefits of membership.

Online Booking: Guests are able to inspect and choose rooms and make reservations at any time through the OTA channels, hotel WeChat official accounts and official websites, and prepay the hotel rooms by the third-party payment methods, such as UnionPay, WeChat pay and Alipay.

Self-Check-in: Guests are able to complete the identification through the WeChat Small Program, the self-check-in machine or the robot in the lobby,

or they could come to the front desk to complete the check-in on iPads or computers. After getting the authorization from hotel's PMS, guests can open the door automatically by using mobile phone, fingerprint and face recognition.

3.2 In-room

Smart Elevator: It is very safe and convenient for Guests to take the smart elevator through QR code scanning or facial recognition.

Smart Door Lock with Facial Recognition: Guests are able to open the door with the convenient way of facial recognition.

Voice-control Room: After entering the rooms, guests are able to enjoy a great welcome experience. The lights, curtains, air conditioning, and stereos will be switched on as programed to create the most comfortable environment. In addition, guests could use the robots, mobile apps, iPads or specific control devices to control the smart devices (lights, air conditioning, curtains, ipTV systems, stereos and etc.)

Social Entertainment: Guests are able to use the devices such as robots, phones, iPads and stereos to interact with their friends; they could also watch TV and play the game, watch on-demand movies, order food, book cars or tickets, make laundry appointments, go shopping in the hotel's online shopping center, redeem membership rewards, and check the energy consumption.

Room Service: Guests are able to order room services through mobile apps, confirm the visitors through the video doorbells, and book robot delivery services.

Smart Common Areas: At the canteen, guests are able to order the food by iPads, touch screens or QR code scanning, with the food being delivered by robots. The bill can be tied to the room or paid

directly through the third-party payment systems. At the meeting room, guests could sign-in and attend the meeting through video-conferencing, phones and iPads. Guests could enjoy the services through the facial or finger recognition, or WeChat at the entertaining area where there are shopping centers, SPA, swimming pools, mahjong rooms, bars and gyms.

3.3 Check-out

Quick check-out: Guests are able to check out through the self-check-in machine (using room card, ID card or facial recognition) or the mobile apps and autopay could be completed with the consumption list printed.

Booking Invoice: Guests are able to get the digital or paper invoice through the WeChat small program.

Reviews after Check-out: Guests are able to review expense details, leave reviews through WeChat small programs or official websites, redeem membership points or go shopping on hotel's online shopping centers.

4. Technology Empowerment of Smart Hotel

The construction of smart hotel prioritizes the solutions that integrate the software and hardware. Hotels can improve the efficiency and reduce the cost through connecting with the third-party information platforms and being compatible with mainstream manufacturers' hardware equipment. Based on its budget and human resources, hotels could do research by themselves or work with the third-party platforms to choose intelligent platform and scheme, as well as complete construction landing.

1. Developing the smart hotel management platform independently is for those high-end hotel groups with adequate budget and R&D capabilities.
2. Working with the third-party PaaS platforms is for those hotels that have R&D capabilities to meet specific demands.

Working with high-quality smart third-party Smart SaaS platforms is for those mid-end hotels or long tail hotel projects, which can carry out branding OEM. The cost of R&D and maintenance is relatively low, and the construction deployment is convenient, and it can achieve the fastest landing.

5. Cases in the Smart Hotel Industry

Xshuai Technology

Established in July, 2015, Xshuai Technology is a high-tech enterprise incubated by Haier.

As the pioneer and leading player in “internet movie projector”, products of Xshuai Technology has won many renowned awards in the industry, including 13 software patents, 5 patents for utility models and 9 appearance patents. Xshuai Technology has been reported by CCTV programs including Focus Interview and CCTV News. Besides, Xshuai Technology has made its appearance during “national innovation week” (mass entrepreneurship and innovation) consecutively. What’s more, Xshuai Technology has also participated in “Twelfth Five-Year National Science and Technology Innovation Exhibition” of China.

Since 2016, Xshuai Technology has been focusing on hotel industry and dedicated to develop a cloud platform intelligence system catering to hotel, providing solutions about smart filming and smart client-controlled system by learning from the successful experience of Haier smart family solutions and conducted in-depth research ranging from data analysis of hotel customers and AI application in future hotel industry.

Currently, Xshuai Technology has been applied in over 200,000 hotel rooms and become first tier system supplier for the top 10 hotel groups in China including huazhu and jinjiang. Products of Xshuai Technology are compatible with mainstream smart devices in the industry. Xshuai Technology has become strategic cooperative partners of many first-tier smart hardware manufacturers including Haier, Hisense and Philips.

In 2019, Xshuai Technology introduced smart

solutions in all scenarios, which can be used to promote “smart living habits” by establishing IOT guest room experience scenarios through smart hardware, customized system and authorized films so as to eventually create a smart living ecosystem featuring human-centric.

Private Theater Theme Hotel is a smart theme hotel equipped with large screen projector and smart customer-controlled system. Located in Hohhot of Inner Mongolia, the hotel is adjacent to several business zones including Changle Palace and Mall City and enjoys very convenient transportation. More than 40 rooms in the hotel are all equipped with whole set of smart hotel products designed by Xshuai Technology, including Xshuai smart projector H8, smart customer-controlled products (curtain, lighting, air conditioner, large screen, voice communication, etc), customers can control the products in the room via voice assistant.

In order to meet hotel’s demand to upgrade smart system, Xshuai Technology help hotel to install customer-controlled internet system, smart door locks and electric curtains so that customers can experience multiple functions including opening doors without card, smart control of scenarios, screen control interaction, one-button delivering, AI interaction and self service check in and so on. Thus hotels can operate with high efficiency and low energy costs, provide better services, realize value-added extension and deliver better experience for customers in using smart devices and screen control interaction.

By integrating with tuya, a third party AIoT platform, Xshuai has successfully combined AI with large screen filming system, smart TV system and smart control system in the room. Residents can control different devices in the room through one device, which has made the room become more intelligent and entertaining and caters to residents’ customized needs.

BTG Homeinns

BTG Homeinns is one of the three franchised hotel

giants in China consisting of the former BTG Hotel Group and Homeinns Group, owning nearly 20 brands and almost 40 products for accommodation. By the end of September, 2019, it operated over 4000 hotels in over 400 cities in China. According to statistics by China National Tourism Administration, the market value for the intelligentization of hotel rooms was over 100 billion RMB in major cities in China in 2019, and the number of hotels grows by around 20% every year. In 2019, BTG Homeinns and Huiyi Technologies announced and created the Smart Hotel Innovation Institute together. The institute studies the development of the hotel industry extensively and organizes its research work concentrated on functions, extensions, technology and entertainment from the perspective of guests. It aims to establish industry standards for smart hotels in the next 3-5 years, which can improve accommodation experience, enhance hotel management and operate hotels with technology.

By studying fundamental needs of guests and critical points for hotel development, BTG Homeinns creates updated smart and innovative services by comprehensive and systematic research of guests, hotel owners, hotels, city life and other aspects. In this case, BTG Homeinns launches “Wenshu”, a smart general control platform for hotel operation, to promote its smart hotel business.

The rapid development of “New Infrastructure” and the gradually accepted intelligentization tendency of hotels have greatly helped hotel industry in China recover from the coronavirus breakout and made smart hotels reach new heights. Various smart systems spring up like mushrooms, which boosts the level of intelligentization for hotels. However, these new systems are separated from each other and difficult to manage, making people feel confused about the real meaning of intelligentization and digitalization of hotels.

At the early informatization stage of hotels, PMS is definitely the primary data system. It acts as the information hub for hotels and other application systems need to exchange information such as

guests’ identities, rooms and billings with it before operating separately. However, PMS apparently cannot fulfill the task as the primary data system these days because now all kinds of smart hardware and sensors become sources of important information. In the era of smart application of IoT, huge amount of data produced by hardware and smart systems require storage, cross-system exchange and real-time analysis, which makes PMS, a system focusing on management of guests and booking reservations, hard to meet these requirements.

Wenshu Platform is an open system which can be accessed by various smart systems and creates opportunities for new application scenarios. The key value of the platform is to liberate hotels from business operation with PMS and allows them to manage the “application system” based on the general control platform with functions of internet connection, control and scene interaction. By connecting and analyzing smart devices, business operation and group behaviors of guests, smart hotels can operate better to meet guests’ demands and improve its management. It can also reduce repeated back-office work for hotel management, which allows staff to offer more front-office services to guests.

Smart Apartment

1. Overview of the Smart Apartment Industry

1.1 Definition

Smart apartment aims to meet various needs of renters, increase income, reduce the cost, improve the efficiency, provide personalized and humanistic services for renters and manage the apartment in a highly efficient way through making the management process available online, digital and intelligent with the new generation of the ITs such as the IoT, big data, AI and mobile internet, and with smart devices as the carriers.

1.2 Advantages

The apartment rental industry has been facing problems such as high operational cost, complicated installation procedures, high risk of rental arrearage, complex management process and low digital capacity. In comparison, the smart apartment has the advantages as follows:

Cost Saving

Converging the intelligent hardware and management software could reduce the labor costs to the maximum extent and optimize the effectiveness.

Management Optimization

Energy consumption can be reduced to the greatest extent through integrating the big data with the digital operation platforms. By collecting data online, the unmanned monitoring can be realized, and management cost can be decreased.

Tenant Experience Enhancement

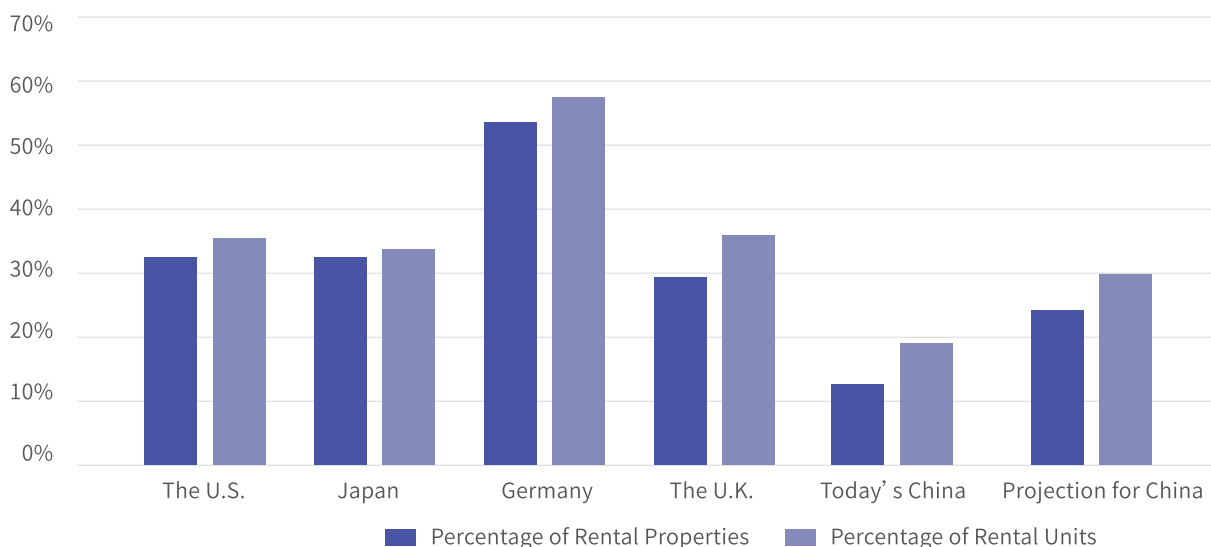
The intelligent devices in the apartments will make tenants feel impressive, simplify the rental process and improve tenants' satisfaction and loyalty. In recent years, with the progress of science and technology and the upgrading of consumption, people are no longer satisfied with the basic living needs but pay more attention to the life quality. The majority of renters are people, born in 1980s and 1990s, who have stronger demands for apartment products with technology, experience, scene and customization. Therefore, "Smart apartment" are attracting more attention.

2. Analysis of the Apartment Rental Industry

2.1 Analysis of the Global Rental Housing Industry

According to the international data, by 2018, America had a population of 300 million, with a rental population of about 100 million, and the rent Gmv of about 1 trillion yuan. Japan had a population of 120 million and the number of people there living

International Comparison



Data Source: L+Research Institute, the research unit of real estate agent Lianjia

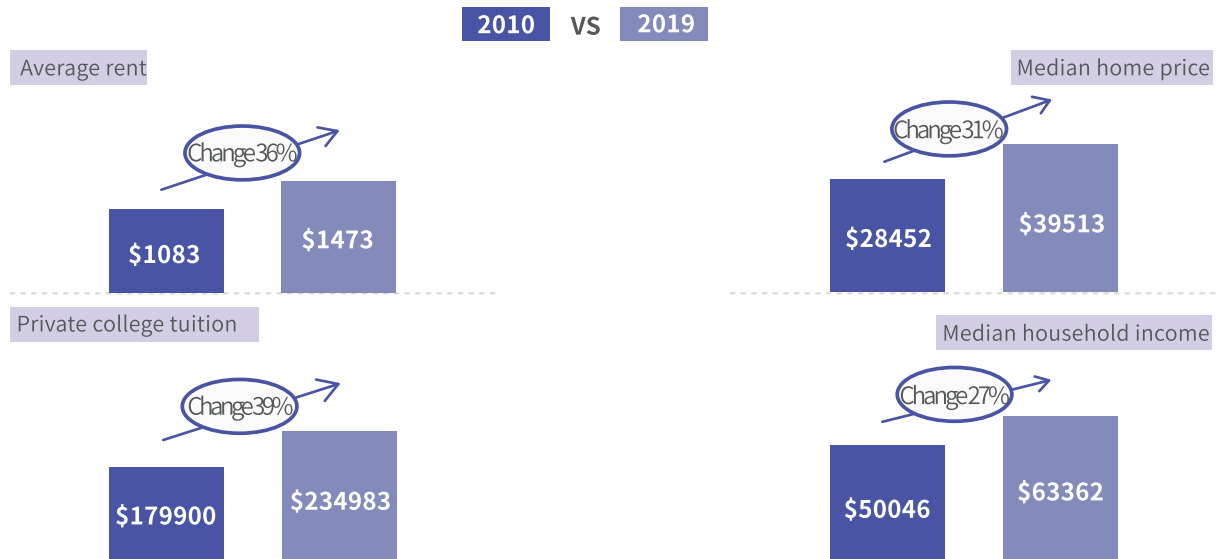
in rental housing was around 34 million, with its rent GMV bring around 720 billion yuan in total. The proportion of rental properties in developed countries was around 30%, while it was only 12% in China, which shows that there is expected to be significant potential growth in the rental market in future.

2.2 Analysis of Rental Housing Industry in Major Countries

The United States Market

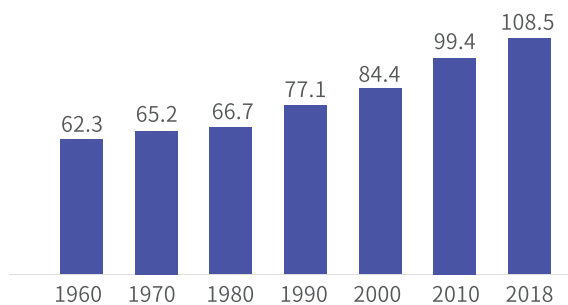
Since 2010, the national average rent in the U.S. increased by \$390 with a rising rate of 36%, boosted by increasingly valuable land, progressively

Rent, Home Price, College Tuition and Income in the Past Decade

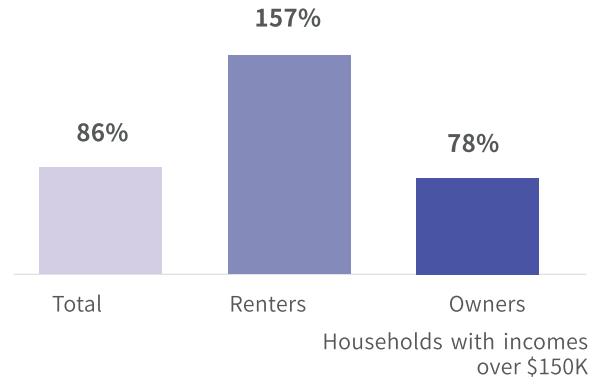


*2019 median household income is based on CPI-adjusted data
Source: Yardi Matrix, PropertyShark, usnews.com, U.S.Census

The Number of American Renters at the turn of Each Decade



Increases in the Number of High-Earning Renters and Owners This Decade



Data Source: Rentcafe: The Decade in Housing Trends

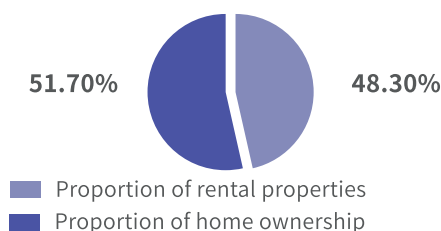
sophisticated apartments, and the booming job market.

In the U.S., renting gained higher popularity in the past decade. Since 2010, the number of renters increased two times (+9.1%), higher than that of homeowners (+4.3%), showing a considerable shift in the American lifestyle. The growth rate of the number of households with annual income over 15W (+ 157%) is twice as fast as that of high-income households (+ 78%). It represents that more high-income Americans are renting houses, and the rental housing market plays an important role in the social stability and people's normal life in the United States.

Germany Market

Based on the statistics of the Eurostat, the proportion of rental population in Germany was 48.3%, while only 51.7% of the population had the

Chart of the proportion of renters/owners in Germany



Graphics: ASKCI Consulting Co., Ltd.

China's Rental Housing Market Forecast		
Time	Number of Tenants (100 million people)	Rental Housing Market Size (trillion yuan)
2015	1.6	1
2020E	2.0	2
2025E	2.5	3.2

Graphics: ASKCI Consulting Co., Ltd.

ownership of housing. This country with a large rental housing market, has the highest proportion of renters in the EU.

German government's rental laws and policies play a critical role in the industry, which regulates the rental fee, the supporting facilities, usable space and housing safety for guaranteeing the habitability. At the same time, in order to manage the real estate brokerages strictly and protect the interests of both landlords and tenants, Germany introduced Housing Brokerage Law, regulating the behaviors of brokerage agencies.

One of the important characteristics of German's rental housing market is that most people prefer to rent.

China Market

According to the Report on China's Long-term Rental Housing Market Outlook and Investment Opportunity 2020-2025 released by ASKCI Consulting Co., Ltd, the rent GMV in 2015 exceeded 1 trillion yuan in total, paid by approximately 160 million people. It is expected that the number could reach 2 trillion yuan in 2020 with 200 million renters, 3.2 trillion yuan in 2025 with 250 million renters. In addition, according to the research report published by the Oriental Securities, in 2030, the number of renters is expected to be 270 million with the market value of 4.2 trillion yuan.

China has a large population and a rapid growth in demand in rental housing market, which is still in the primary stage. Chinese people's attitude towards housing rent has changed, and there is an unprecedented potential growth in the apartment rental market.

3. Smart Apartment Solutions:

"Improving apartment management efficiency and enhancing the tenant experience" is the fundamental purpose of the smart apartment solutions. The efficiency is improved mainly through online management, centralized control and simplified procedures. For example:

1. With the connection of smart door lock and

property management software, the password to open the door can be sent to renters through messages. Tenants are able to visit the rental properties with no need to deliver the key.

2. The water and electricity meter reading can be done remotely with the intelligent water-energy meter systems. One-button power cut can realize smart collection of fees and allocation of water and electricity charges, which reduces the burden of tenants.

3. With connecting to sensing equipment, the most energy-consuming appliances or lights could be turned off when there is no one in the public area for a long time to meet the needs in use and avoid wasting energy.

4. Smart devices in the apartment can supply tenants with better experience by making life more efficient, secure, comfortable and intelligent.

The essential demands of smart apartment are:

Technological empowerment

In the solution of software and hardware integration, the high compatibility with the third-party devices can help improve the debugging efficiency, so as to reduce the investment in the software and hardware in the preliminary stage.

Cost Reduction

For clients who hope to rent the apartments, guest houses and other properties, various measures such as adopting unmanned monitoring system, energy consumption control, low-cost upgrading and sustainable development, are trying to reduce the operational cost and increase competitiveness.

First, renters can reduce the manual labour expenditure and realize the operation with low labor cost through the self-service check-in and online payment of tenants.

Second, no rewiring is required with the wireless solution of smart devices, and the maximum operating income can be obtained with the least time cost at the same time of operating and upgrading.

Thirdly, the unmanned automatic cut-off of high-

power electrical appliances could save energy consumption.

Lastly, the data generated by the smart devices can be checked online, so as to detect anomalies and take preventive actions.

3. Cases in the Smart Apartment Industry

HUIYI TECHNOLOGY

As a national chain commercial IT comprehensive service provider, HUIYI TECHNOLOGY can realize the high-efficient response model (24 hours *7days a week) in 300 cities of 31 provinces nationwide with the advantage of more than 200 professional operation and maintenance team of service engineers stationed in 48 cities. Meanwhile, focusing on the development philosophy of using smart innovation to empower society, HUIYI TECHNOLOGY has long been dedicated to providing smart scenario solutions that caters to actual needs for apartment rental industry.

Previously, it's challenging to refashion smart apartments. What's more, it usually requires high cost and complex wiring construction. A common challenge facing the whole industry is how to renovate traditional apartments into smart apartments with low cost and high efficiency.

In terms of construction, by applying the apartment's universal SaaS construction model, HUIYI TECHNOLOGY can finish the essential work online including distribution of construction work, management of project progress, whole project acceptance and management of builders so as to finish batched installation and operation of the apartments' equipments with high efficiency. By using the API capabilities of smart apartments' PaaS, HUIYI TECHNOLOGY can seamlessly integrate apartments' SaaS functions into clients' backend without changing software, thus realizing unified backend management and reducing the cost and time in software developments.

By establishing its own backend auditing system on brands owners, HUIYI TECHNOLOGY can audit clients that already registered on the system so as

to better manage its clients, including developing new clients, managing clients and providing service for clients.

Through smart apartments' PaaS on AIoT platform, HUIYI TECHNOLOGY's construction team have already finished the installation of smart door locks, intelligent access control of townhouse's doors, smart water and electricity meters and smart indoor appliances controlled by customers in the boutique apartments of Sunshine Hotel. The construction team also assist the apartment team in providing guidance for the daily operation and management of equipments by using apartments' SaaS platform, which has not only improved customer's living experience and boosted brand names, but also greatly reduced the management burden of the operation team.

Currently, HUIYI TECHNOLOGY has already finished installation service work for 106 boutique apartments in Sunshine Hotel .

Nanjing LuYi Apartment

Located in the college town of Jiang Ning District of Nanjing, LuYi Apartment strives to create Internet+Youth Venture community which covers both long and short rental smart apartments and various patterns including internet fitness, online gaming and online teaching forums with the objective to establish a community in the college town that combines the function of living, studying and entertainment.

The three phase projects in total contains 500 apartments and it is expected to finish 62 long rental apartments and 65 short rental apartments for phase I project this year.

By introducing one-stop solution including smart device (smart door locks) and apartment management software, LuYi Apartment makes it possible for the apartment management team to remotely send the password to tenants through the apartment SaaS so that they can independently view apartment without housekeepers. The apartment management team can also remotely send temporary password to the house cleaners

and maintenance man to help them deliver quick door-to-door service.

By installing smart electricity and water meters, the apartment management team can remotely control the meters through the apartment's SaaS for power outage so as to remind tenants to pay their electricity bills. Meanwhile, the apartment management team can provide reasonable charge in public areas to help accommodate tenants' concerns of the charge sharing in these areas and can realize digitalized energy consumption and smart energy management by remotely calculating statistics.

Equipped with a whole set of interior smart devices including intelligent switch, PIR, curtain, air conditioner, TV, temperature and humidity sensors, the apartments can present different automated scenarios with the help of the management team by using the apartments' SaaS. The management team can then expand the scenarios to other apartments to ensure tenants can experience smart scenarios (lights on when they open the door) at the start of their occupancy.

After their occupancy, tenants can use App (Zugo) to remotely control and check the status of the smart devices and choose the automated scenarios according to their preferences.

Based on various scenarios including available apartments management, house viewing before occupancy, tenants occupancy, tenants service, LuYi Apartment further integrates smart door locks, electricity and water meters, interior smart devices and management system, which has not only greatly improved the operation efficiency of the management team and reduced human cost and management risks, but also provided young tenants with smart devices, thus, the quality of the apartments was boosted and it has also provided a safer, more comfortable and more convenient living experience for tenants and helped clients to have their own apartments with different features and establish the brand name of the youth venture community.

2.2.2

Smart City

As a promising business scenario in the application of AIoT, smart city that counts on plenty of cross-sector technologies and solutions consists of smart real estate, smart security, and smart commercial lighting.

Smart Real Estate

1. Overview on the Development of Smart Real Estate Sector

According to the report by Prospective Industry Research Institute, China's property sales exceeded 10 trillion for the first time in 2016. The country's commercial housing sales reached 15 trillion in 2018. Although the trend is continuing, the growth rate declines sharply, and the growth was 1.5% slower than 2017.

Fueled by massive demographic dividend, traditional housing sector has witnessed continuous breakneck growth over the past two decades. But due to policy tightening, the disappearance of demographic dividend, fierce market competition, and the serious problem of homogenization, the sector has been facing the risk of transforming from a growth market to inventory market. The traditional development mode of purchasing land for house selling has been phasing out of the mainstream, while the real estate operation mode is now a breakthrough point in the sector. Operation mode applied in the property sector drives the transition of players from physical space provider to digital home service operator. The downstream's digital transformation in the real estate sector featuring a huge market volume has explicitly created impressive smart business value for the upstream players.

Given the macro policy, the principle of "house for living in, not for speculation", and the recently-announced "three red lines", the housing sector is forced to shift more attention to product and operation for competitiveness.

The housing sector is required to innovate products, reduce costs and improve efficiency, and evolve from house development to operation. First, the sector is increasingly concentrated with more fierce competition, which makes it necessary to innovate products continuously to stand out. Intelligent technologies should be the focus. Second, due to the increase of labor cost, it is urgent to reduce the cost and improve the efficiency of property management. Last but not the least, the sector expects to get exposed to and understand customers, so that they can do more accurately in product development and project planning.

In terms of technological development, in the post-internet era, cloud computing, big data, AI and IoT technologies are on the highway of development, which drives the application scenarios more mature. With higher expectations on "living" a pleasing life, customers are looking forward to more healthy, convenient, comfortable and intelligent life experience.

In this context, the leading housing developers have established their technology subsidiaries, for example, Vayi Tech and Vanrui Tech in Vanke, Evergrande High-tech and Xingluo Technology in Evergrande, HSUNION in China Overseas Land & Investment, and Shimao IoT in world Trade Center (Shanghai) Group, etc. Most of these tech companies were set up in the past two years. Smart property has been turned into a group standard from a regional pilot project. The housing sector has been including smart home into group purchase. Besides, the developers have started to establish an integrated IoT platform for whole-house intelligent/smart community. For instance, Vanke, CIFI, Languang, and other house developers have built up an integrated real estate IoT platform. Leading tech companies are dedicated to developing smart property business. The smart property sector mainly consisted of companies focusing on smart home and community previously. In recent years, prominent tech companies including Tuya Smart, Sense Time, Megvii, and iFLYTEK, etc. begin to make progress in the area of smart

property.

Driving force of Smart Property Development

2. Industrial Chain and Roles in the Smart Property Sector

Hardware suppliers. The basic hardwares mainly consist of lights, door lock, security products, curtains, environment-related products; and the additional products include all kinds of home appliances.

Whole-house intelligent technology providers. There are two kinds, namely start-ups and traditional companies, mainly focusing on video door phones and switches.

Integration suppliers. The integration business is devoted to developing whole-house intelligent solutions and establishing intelligent community.

Smart property platform. For example, Tuya Smart, Sense Time, and iFLYTEK, etc.

Tech Companies Affiliated to Property Developers. Over the past years, tech subsidiaries established by house developers have been playing three roles. They are solution providers to facilitate projects, official functional departments to develop and uphold intelligent technology standards in real estate groups, and players in exploring and implementing the strategy of property + intelligent technology.

3. Smart Property Solutions

3.1 Pain Points of Smart Property Business

Devices do not interact with each other, provide bad experience, and can't be extended. Power and lighting, security sensors, and small and big home appliances from various brands need more than one App, thus generating unpleasant experience. The basic and additional devices fail to interact, resulting in failure to meet owners' needs on extending intelligent device.

Indoor and outdoor scenarios are little integrated. There is the absence of effective interaction between home space and public space. Smart home is isolated from smart community, leading to

data silos. In the end, households have no access to one-stop smart life experience.

Design, construction and operation are expensive without any management. When scheming intelligent solutions, designers are faced with high threshold and are low-efficient; a number of projects are delivered at the same time, and device debugging is low-efficient and impossible to be controlled; after moving in, home owners find that a vast number of device operation and aftersales problems are out of control.

Due to the lack of data, house developers find it impossible to manage users. Intelligent solutions are isolated from community services, since the data is in the hand of equipment suppliers instead of real estate companies who can't get aware of proprietors' experience and feedbacks. Meanwhile, without data collection and analysis, developers can only find it hard to figure out owners' needs, thus failing to provide them with accurate operation services.

3.2 There Are Two Mainstream Modes in the Sector. Take Smart Home as an Example:

One-stop solution. Whole-house intelligent solution supplier provides one-stop solution consisting of software and hardware, as well as project implementation, featuring a main strength of responsibilities clearly defined.

Division of work. Work is distributed among platform providers, tech companies affiliated to property developers, and hardware and device suppliers. The developer tech subsidiary, playing a critical role, provides project solutions, with three strengths as follows:

First, deliver user experience. All users are using the same interaction gateway, such as App. Diversified brand ecosystem on the platform, and property management and life services extended from "living" work together generating an integrated and rich intelligent experience.

Second, realize group-level management and control, reduce cost, and increase efficiency. The whole-chain management covering planning,

construction, debugging, and equipment operation, as well as the all-in-one management platform that integrates intelligent devices, intelligent public areas, and whole-house intelligent solutions, enables to reduce the cost while increasing the efficiency of property management, and to facilitate the operation and profit earning for property management business.

Finally, empowers house developers to lay a foundation for data enablement business. Smart home data is collected as a reference for evaluating the improvement of real estate product quality and customer experience, and to support community service operation.

3.3 Value of Smart Property Business

Improve product competitiveness. User focused, people, devices and services are connected in a certain space to create intelligent scenarios and pleasing experience, so as to enhance the competitiveness of property products, yield premiums, and improve absorption rate.

Reduce the cost and increase the efficiency. A unified management platform linking the whole house with public areas can realize integrated and intelligent management on information, devices, and services, thus reducing cost and increasing efficiency.

The second building-up curve. Adopt intelligent solutions as an entrance to your “home” to connect with users, reaching and understanding them to offer them precision products and services, and to set up an all-new business mode, in turn increasing value and profits. Shaping a second building-up curve allows real estate companies to upgrade from developers to operators.

Commercial Lighting

1. Overview on Commercial Lighting Sector

As people cannot live without lighting, and spend part of their time at home, a set of smart and flexible home lights is a must. The other part of people's time is spent on work and commercial activities, for

example work, shopping, studying, traveling, etc. Therefore, commercial lighting can cover multiple application scenarios, including office buildings, schools, commercial space, warehouses, parking lots, exhibition halls, libraries, factories, stations, etc.

Nowadays, people spend 90% of their life in buildings, so green and healthy buildings are what people lay the greatest attention to. It is reducing building energy consumption that is critical for the construction of green buildings. The dominant energy consumer in a building is HVAC that accounts for 45%. The second highest is lighting that normally takes up 30% of the total energy consumption.

There are lighting stipulations both in the US LEED green building certification rules and China's green building certification standards. Due to the new LEED standard, lighting control system that is playing an increasingly significant role, has been regarded as a must-have and included into the prerequisites in some projects. Furthermore, the control system has been extended from the traditional artificial lighting to cover daylighting, measuring, monitoring, innovation, etc., creating an integrated system, which helps to win a higher scoring in LEED evaluation and obtain a higher-level LEED certification. According to the Energy Saving from Networked Lighting Control (NLC) Systems report by the US DLC, smart lighting control system has a notable effect in reducing energy consumption. On average, 47% can be saved. Most notably, warehouse can consume 82% less. In offices, the system helps to save energy by 63%. Buildings can shelter people from danger, and impact people's health. In May, 2018, IWBI launched the trial version of WELL v2 globally to promote the development of healthy buildings based on edge-cutting scientific and medical know-how, and counting on healthy building standard and certification system. WELL has been adopted by more than 30 countries. In WELL, the light solution advocates people's exposure to light, which is meant to create a luminous environment

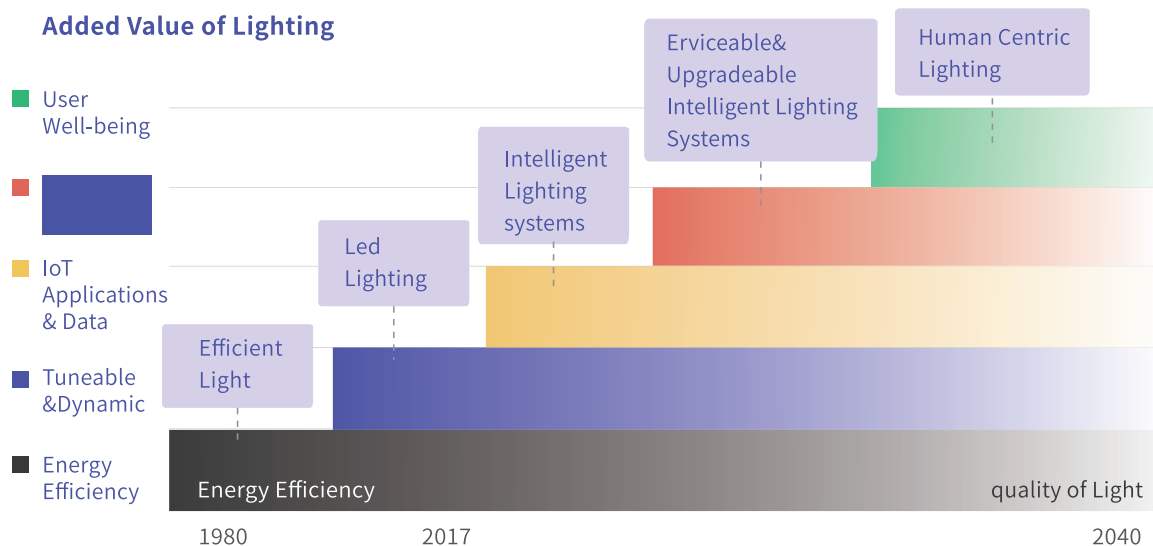
Summary of inferred NLC savings by building type results.

Building	Total	unique	Control factor(% savings)	
			Average	25th--75th percentile
Assembly	5	1	0.23	0.10 - 0.29
School	7	1	0.28	0.09 - 0.57
Manufacturing	28	3	0.30	0.09 - 0.43
Retail	29	1	0.44	0.39 - 0.49
Restaurant	2	1	0.47	0.41 - 0.53
Office	39	3	0.63	0.43 - 0.82
Warehouse	4	2	0.82	0.78 - 0.85
Overall	114	5	0.47	0.28- 0.76

Data Source: «Energy Saving from Networked Lighting Control (NLC) Systems» by DLC

beneficial to vision, psychological and physical health. Playing a significant role in healthy buildings, light control system provides solutions pertaining to circadian lighting, automatic control, on-off and dimming, daylighting and shading, indirect illumination, scenarios, etc. As the prerequisite in WELL certification system, light control system is

also recognized and playing a role. Global Lighting Association has clearly depicted the development roadmap of future lighting. In the future, lighting will gradually evolve to service-oriented and upgradable intelligent lighting system, and ultimately to the human centric lighting that is beneficial to people's health.



Source: Global Lighting AssociationSource: Global Lighting Association

2. Commercial Lighting Solutions

As lighting should be people-centered, its products, design and application should be focused on health and comfort. Currently, specifications can make a difference in realizing good luminous environment, including reflectivity, luminous flux, color temperature, glare, and CRI for lamps and light sources, as well as environment-related indicators like illuminance, evenness, brightness contrast, consistency, shadow, etc. Some software are able to simulate and compute the quality of illuminous environment.

But natural lighting is not consistent throughout the day. Sun's position, color temperature, and illuminance are different in the morning, at noon, and at nightfall, thus exerting various impacts on people's psychological and physical conditions. Similarly, it is impossible to rely on unchanging artificial lighting to deliver the best and comfortable illuminous environment. Besides, people's requests for the light environment vary in application scenarios. For example, the light environment is needed to refresh people in studying for a higher learning efficiency. In a restaurant, a comfortable and elegant light environment is necessary for working up an appetite, facilitating communication, and ensuring privacy. In other occasions, different behavior settings have different requirements for light environment. For instance, a small meeting room needs to have the settings of greeting, speaking, discussion, summarizing, etc. Sensitivity to light varies among age groups, for example, the old and the young have varying degrees of sensitivity for light with different requirements. Therefore, only the intelligent lighting control system featuring dynamic lighting can generate a people-centered illuminous environment.

The needs of light environment for commercial use depend on the place and settings of application:

- There are multiple subsectors in commercial building industry, whose needs are different from each other. Office buildings, transport connections, stadiums, performance centers, museums,

hospitals, schools, factories, street lamps, landscape lighting and other application scenarios have their own uniqueness.

- Given the professional aesthetic requests, a specialized design team will be needed.
- Safe-to-use is rather critical. In case of an accident, not just an individual will be impacted. So there are high requirements on the reliability of products and systems.
- There are higher demands on energy saving, in particular in the application scenarios previously using a number of high-power light equipment and lamps.

The IoT-based commercial smart lighting system can give a boost to many benefits.

Firstly, in terms of professional aesthetic needs, visual effects for lighting can be created, typically the light levels in certain application scenarios, and focus on highlighted objects. The expression is realized not solely through parameters or software simulation, but also needs adjustment according to the real environment. The whole process can be enabled by a smart lighting control system. Secondly, to meet the need of multi-scenario application, a smart lighting control system can rely on pre-setting, sensors, and other approaches. Thirdly, clock manager, and smooth dynamic control methods help to control timing, time sharing, and zoning, thus realizing various scenarios at different time, and dynamic lighting effects such as color temperature, illuminance, and even color adjustment.

Fourthly, detecting state parameter and monitoring software are used to warn on to-be-scraped devices, inform of lighting devices out of service, and implement a range of lighting control strategies like soft start, delayed start, soft shutdown and power supply voltage surge protection, easy for centralized management and equipment maintenance.

Fifthly, energy can be saved with the help of the control system. Energy saving strategy can be pre-set, so that light will be turned on when people are coming, and will be turned off or down when people

leave. Light balancing, a control method making use of natural light helps to save energy by 15-75%, and extend the lifespan of light sources by 2-4 folds. A systemic intelligent lighting control system takes an effect in three visualized ways, namely on-off, dimming, and color adjustment (including color temperature and color). But in the system, various technologies are adopted such as light source, electrical, microelectronic, computer, automatic control, communication, and networking technologies. In existing bus and wireless protocols, there are 485, KNX, Lonworks, DALI, and DMX512, the relatively long-life wire protocol; Zigbee, Wi-Fi (TCP/IP), Bluetooth, and Zwave, the flexible protocol; and Lora, NB-IoT, POE, LIFI, GPRS, and 5G, the emerging protocol. Devices include smart switches/relays, dimmers, dimmable electronic drivers, smart lamps, control panels with CPU, computer software, wireless modules, etc. The current main dimming methods consist of: leading edge phase control, trailing edge phase control, PWM pulse width control, 0-10V control, DALI control, etc. To achieve perfect dimming effects, it is necessary to ensure a wide dimming range and create a perfect atmosphere; deliver excellent dimming consistency and overall effect; have a smooth dimming curve without jitter or flicker; protect drive circuit and light source; and use safer and more reliable lamps.

Apart from the basic control functions listed above, a complete smart commercial lighting system is based on IoT platform, and suitable for the new and inventory commercial lighting market. It provides the market with a complete solution ranging from devices to software control and to construction, and realizes green and healthy buildings through device management, energy control, and human centric lighting. Besides, a digital and visualized management platform is offered for product maintenance and operation after sales, so as to enable users to have access to intelligent business, and reduce management cost.

An IoT-based smart commercial lighting system should be developed to cover the five function

modules of monitoring, sensing, measuring, managing and controlling. "Monitoring" stands for the functions of equipment failure alarming, life alarming, data analysis, etc. "Sensing" means the functions of human centric lighting, automatic illuminance balancing, movement detection, etc. "Measuring" covers the functions of energy consumption measurement, equipment usage time gauge etc. "Managing" represents the functions of access management, construction management, centralized management of projects at various places, etc. "Controlling" indicates the functions of graphic control, scheduled appointment control, scenario-based control, and basic functions including single light control and group control for on-off, dimming, and toning.

Furthermore, an IoT-based smart commercial lighting system should be a one-stop solution applicable to various scenarios using pluggable installation without complex wiring, which can help to increase application and management efficiency, thus realizing green and healthy buildings. The system consists of client interface to meet end users' needs on integrated control; management interface to provide data overview, and device visualized management, and energy management platform to realize equipment centralized management; and construction management platform to achieve construction management, rapid network distribution, and convenient deployment.

An ideal IoT-based smart commercial lighting system boasts the features as follows:

- Impressive functions,
- Compatible with multiple network protocols,
- Powerful ecosystem,
- Digital operation management,
- Security of network data,
- Sustainable service supporting system.

The system can be integrated with natural lighting, air quality monitoring, environment temperature monitoring, visitor management, safety management, and AI computing and prediction to establish a comprehensive solution for smart buildings and community. Using BIM-based three-

dimension system for three-dimension presentation and visualized operation management allows to improve customer experience and effects, and accelerate the development of green and health buildings.

3. Cases in the Commercial Lighting Industry

Construlita Group

Construlita Group is one of the largest domestic lighting brands in Mexico and Central America, providing solutions for residential, commercial, and industrial applications.

A 35-year veteran in the lighting industry, Construlita has created a brand image driven by innovation, creativity, and design. The company does businesses in nine countries, including Mexico, Colombia, Costa Rica, El Salvador, Nicaragua, and Honduras.

Through its brands TecnoLite Connect and Construlita Connect, Construlita provides smart solutions for residential, telecommunications, and professional services firms, empowering significantly enhanced customer experiences through behavioral data analysis.

Traditional wired lighting systems face problems such as complicated wiring work and high installation costs. Although wireless lighting solutions are gradually becoming mainstream, upgrading from wired to wireless lighting also brings new challenges such as dealing with a distribution network and figuring out how to manage multiple devices at one time.

Using the Tuya AIoT Platform, Construlita has been able to make this essential transition to wireless commercial lighting and develop a commercial lighting PaaS solution via a new brand: Construlita Connect. Construlita Connect offers the full range of lighting products and easily incorporates different types of devices, including sensors, switches, circuit breakers, water meters, and cameras.

Construlita Connect can also transform traditional solutions. Wireless smart commercial lighting

solutions greatly improve efficiency and significantly reduce upgrade costs, relieving companies of the burdensome installation and repairs involved with using wires.

Through the flexible, automated solutions and intelligent control of its commercial lighting PaaS offering, Construlita helps its partners and customers save on energy and labor, improve user experience and management efficiency, and reduce operating costs.

Lighting & Equipment Public Company Limited.

Founded in 1993, Lighting & Equipment Public Company Limited. (L&E) started with an initial capital of 25 million Baht, marketing fluorescent luminaries to electrical contractors and reaching out to governmental agencies. In 2018, the annual revenue was 2,923 Million Baht, and 69% of that came from project business. Now, L&E ranks No. 1 in project lighting industry in Thailand, with a 20% share of the overall lighting market of Thailand, and an influence covering most SEA countries such as Vietnam, Cambodia, Indonesia, Malaysia, Myanmar, etc.

L&E has been working with Tuya since 2018, and started with retailing business. L&E expanded rapidly from Bluetooth & Wi-Fi lighting products to electrical outlets, sensors, IP cameras, promoting ICON Link as its smart home brand. Soon, L&E stepped up to the second place in retailing channel of smart lighting, as most attempts from Thai brands, including L&E itself, failed due to high costs, lacks of variety, and poor customer experiences.

For the first time, L&E is able to introduce affordable smart home products to its customers, as Tuya has helped provide various options in terms of multiple communication protocols, more than 200 thousand ready-to-go products from more than 30 thousand competitive manufacturers, and most importantly, a stable and cost-friendly Cloud service. All these helped L&E to shorten its development cycle, to lower its development fee, and to minimize its operational cost.

In 2019, L&E faced challenges from some smart building solution providers such as Lutron and Signify. The top management team of L&E saw Smart Lighting with great significance, and decided to go deeper with Tuya for the potential IoT technology, that could add to its project lighting business. L&E knows what kind of solution works in the Thai market, but it took quite a long time for L&E to start forging its own from scratch, and by then the market share had already been grabbed by its competitors. As a result, L&E reached out to Tuya for a solution, and Tuya, in return, provided a Lighting SaaS for smart building scenarios. There are in total 6 things Tuya provided with Lighting SaaS:

- Lighting Luminaires including light tubes and panel lights
- Multiple sensors such as humidity, temperature, luminance, and human motion
- A control App for its users
- A web system for monitoring and management of the whole building
- An installation app for builders to connect all the devices when Internet is not in place
- A robust and powerful cloud service

This wireless system enabled L&E to compete against other bidders, as the overall cost was reduced by more than 90% comparing to that of a wired solution. With the automation capabilities, light will automatically go off when no one is in this room or area, lighting condition will be adjusted according to the specific time of the day and the readings of luminance sensors. A heat map will inform managers which area generated most human activities, and administrators and technicians will know the running status of all devices, and if there's a maintenance needed to be arranged. L&E has a great foundation of customer base, and now L&E could help its customers to improve management efficiency, to save energy, to bring down installation costs, and to boost user experience for every person who works in these buildings.

Sichuan Languang Development Co., Ltd

Sichuan Languang Development Co., Ltd ("BRC" or the "Company") is a TOP30 enterprise in Chinese real estate industry. Languang Development strives to provide innovative solutions for living and lifestyles, and to create happy living environments for people. The Company was restructured and listed in the Shanghai Stock Exchange in 2015, since then the brand value has reached RMB24.28 billion in 2019, making it one of the "TOP100 Chinese Real Estate Development Enterprises" for the 13th consecutive years. The Company was ranked as one of the "TOP20 Chinese Real Estate Development Enterprises 2020", and "TOP11 Brand Value for Chinese Real Estate Enterprises 2020". In 2019, BRC's sales value exceeded RMB100 billion for the first time, amounting to RMB101.554 billion. As the demand for smart living continues to strengthen among Chinese consumers, real estate projects of premium quality rolled out new properties that incorporated a wide range of high-tech smart home designs in order to seize a larger market share, to increase customer stickiness and to provide value-add potentials. Smart home design has become a selling point for developers to facilitate sales and enhance properties' value-add and competitiveness.

Smart living has gradually become a tailwind for the real estate industry. BRC, as an enterprise incorporating technological development in its genes, we have already constructed a scalable blueprint for smart living. With the central mission of developing real estate projects, BRC has constructed cloud platforms for AIoT smart living and smart marketing, and has launched intelligent solutions and digitalization across the entire properties industry's value chain, including smart living, smart communities, smart business and smart marketing.

In 2019, BRC has preliminarily completed the construction of its self-developed AIoT Smart Living Platform. There are, however, a wide array of products available for the platform, making cross-brand integration and compatibility just unavailable yet. Since cloud services, product manufacturers

and system integrators in the real estate industry offer mostly customized products and services, and given the lack of ready-to-use products, BRC has to invest more to improve the AIoT Smart Living Platform, which would mean a longer time horizon for payback.

To upgrade real estate products for smart living, and to cater to the increasing demand for the same, BRC sees the urge to expand its internet of things offerings quickly, especially for household appliances, large or small.

BRC collaborates with Tuya Smart, a globalized AIoT platform, to jointly established the "BRC & Tuya Smart – IoT Innovation Lab". After being integrated into the Tuya App SDK, AIoT Smart Living Platform can configure network and manage all Powered by Tuya products, including the IoT devices developed by BRC, thus expanding the BRC product matrix rapidly. BRC is poised to meet the demand for fully smart living homes both in the factory-installed and aftermarket-installed products market.

Okura. Co., Ltd

Established in 1962, Okura. Co., Ltd is a real estate company with extensive influence in the Japanese real estate industry. Its business involves comprehensive real estate related businesses such as land acquisition, home development, housing construction, housing sales, and housing renovation. Over the past 50 years, Okura has developed more than 60,000 homesteads and independent houses, and about 512 apartments. Based on such a huge housing construction and zoning foundation, Okura is vigorously promoting smart city planning to seize the development opportunities in the era of intelligent connection of things.

In business, Okura focuses on life basics, "housing", and develops business in Japan around one-family construction, apartment, new town development, apartment, real estate renovation, and other fields. Also, in 1974, with the goal of "providing customers with a fast and comfortable life", a membership-based resort and recuperation business was

launched, and it was actively expanded nationwide on a large scale. In the new era, in order to provide customers with a more comfortable, safe, and secure life, Okura is actively introducing the latest technology. In recent years, Okura has actively promoted the smart city plan to maintain the initiative in the AIoT era.

To fulfill this, Okura has built smart whole-house model rooms in Chiba, Wakayama, Okayama and Aichi prefectures, so that more Japanese people can experience the convenience of smart real estate. At present, Okura's real estate businesses, such as residential and apartment under construction, will gradually introduce whole-house smart solutions to provide a smart experience of intelligent connection of things. With the same mobile app or smart speaker, users can operate the smartest devices in the house, including lights, curtains, air conditioners, etc.

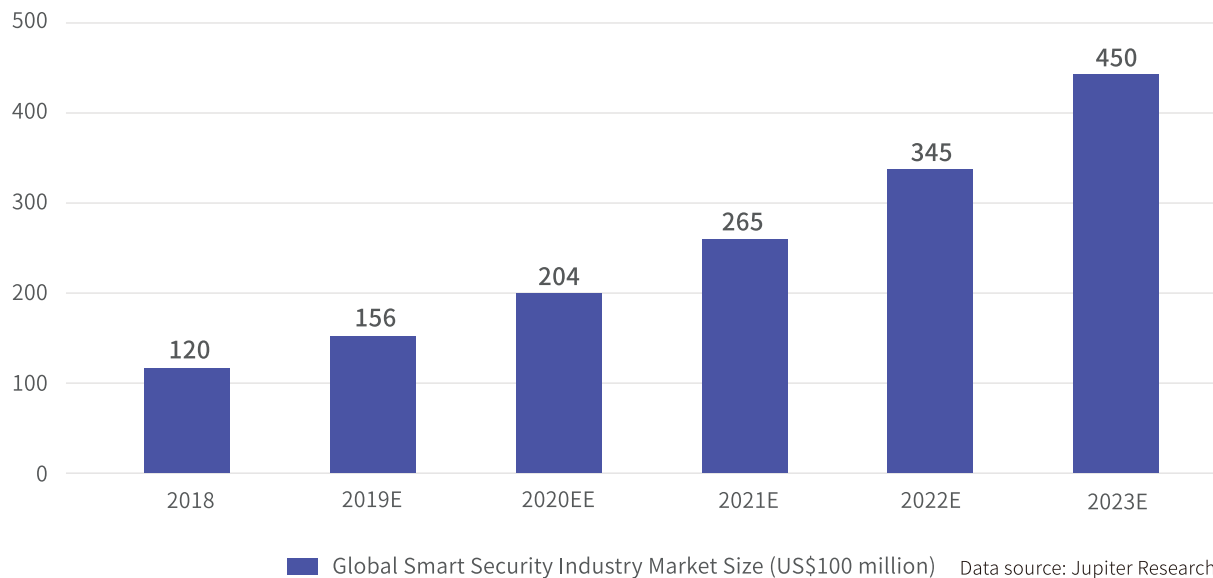
For real estate developers, AIoT technology is becoming a new decisive point in the real estate industry. More and more consumers tend to choose projects that bring their own smart whole-house solutions or houses that can combine smart cities, security, and smart elderly care so that the aging Japanese population will have a safer and more independent residential environment in the future. In the future, Okura also plans to build smart whole-house model rooms in Hokkaido, Sendai, Kyoto, Gifu, and Okinawa to make the concept of smart real estate be popularized in Japan more quickly.

Smart Security

1.Overview on Smart Security Industry

With the rapid development of global economy and people's standard of living, people have paid more attention to the security of their private wealth, as it is not pursuing wealth but safely owning wealth that is the concern. Among the public, security means protection, while the industry players believe security stands for high tech-based protection in which information tech-based service, picture transmission, and storage technology are counted

Statistics and forecast of the global smart security industry market scale from 2018 to 2023



on to avoid health and wealth risks.

As Juniper Research's report suggests, global intelligent security market size will go up from \$12 billion in 2018 to \$45 billion in 2023 at an CAGR as high as 30.26%. Currently, the physical security market is playing a dominant role, accounting for 65%. In the global Top 50 intelligent security companies in 2019, Chinese players had an eye-catching performance.

In China, security industry planning is a national strategy. Traditional security systems have witnessed the increase in penetration. The industry has undergone four stages: beginning, growth, explosion, and saturation.

At the beginning stage in 2003, the Golden Shield Project was initiated, and the infrastructure of the public security communication network and computer information system was established, which laid an application foundation for the security electronic equipment, and delivered development opportunities for the industry;

In 2005, the industry was at growth period when the real opportunity for the industry to bloom up was the launch of the Skynet project. The large-scale

distributed video surveillance network layout led to a surge in the demand for surveillance equipment; Since the start of the Xueliang Project in 2016, the security facilities in big cities have become increasingly saturated, and security monitoring platforms have begun to penetrate counties and villages. The smart security industry, which focuses on home security and public safety, quickly caught the first train empowered by AIoT and began to innovate the traditional security industry.

In recent years, driven by the principle of a safe city project strongly supported by the government, many technology giants have laid out a diversified footprint to seize the blue ocean market in face of the cake of AI+ security. AI+ security is one of the main tracks with the fastest commercial deployment of artificial intelligence technology and the largest market capacity. AI technology began to be adopted in 2015. Self-monitoring and active identification have become the mainstream for video surveillance products. Various vertical applications based on AI technology are constantly emerging. China's security industry has already transitioned from strategic investment to a highly mature situation.

Compared with the highly mature security industry in China, there are still many new scenarios in the international security market that has not been fully developed, and there are huge market opportunities to be explored. Although the security industry originated in the United States, after more than half a century of development and evolution, it has gradually developed into a large-scale mature industry covering the global market.

Most of the international security hardware suppliers are from China. The service models of American security operators are mostly monopolistic, their services are expensive, and their hardware options are not diversified and are mostly sold in the form of kits. But some international small and medium-sized security service providers and channel providers are in need of a more cost-effective platform or need to build up their brands, so the customized service providers of Chinese security App and SaaS management platform have flooded into the international market. Notably, due to the huge economic, cultural, and political differences among countries, the mature security market is only in Europe and the United States. The smart security market in many regions is still in its infancy. For the Chinese security enterprises, the international security market has much more to be tapped than the Chinese market.

Since smart homes are still a kind of user experience demand, there are still certain market differences between smart home market and the just-needed security market, and the market and user habits need to be cultivated and impacted.

By comparison, the international security market has greater opportunities. "Going out" to the global market can generate more profit in a faster manner than "staying" in the mature Chinese security market for companies to provide hardwares, software and complete solutions. Video surveillance, access control, and anti-theft alarm are the three major products in the security industry. However, in terms of current market trends, video surveillance is still the mainstream product in the security industry. AI security industry has many players, a large

market and a long track.

Core players in the smart security industrial chain:

Upstream: Chip manufacturer, hardware manufacturer

Midstream: Security vendors, AI companies, cloud service vendors

Downstream: System integrator, project integrator, engineering construction service provider

Most companies only play one of these roles, and it is rare to see such platform companies as Tuya Smart that integrates diverse hardware ecologies, AI technology and cloud services into one.

2. Smart Security Solutions

Mainstream Solutions in the Smart Security Industry

From security hardware to software, aiming at the distribution market, companies rely on 2B/2G (business-oriented/government-oriented) resources, and the security business and cloud platform strategy are strongly coordinated.

Companies provide enablement from the bottom of the industry, work along both lines of investment and merging, focus on foundation-started cloud development, and advocate secondary development of Paas layer.

Intelligent development, and unified establishment and planning of smart city structure are the trend. It is a must to avoid repeated underlying architecture, to share data and resources in real time, and to maximize the use of computing resources.

The applicable mainstream security solutions at home and abroad, and their highlights are as follows:

1. There are self-developed systems. It is hoped to expand the hardware product ecosystem, but the cost of docking one by one is high.

Solution: Integrate smart hardware ecosystems, and only need to dock PaaS to support device access.

Highlights: Based on years of practice in the IoT industry, a wealth of open interfaces has been deposited, which completely covers multiple business scenarios such as authorization management, user management, distribution network management, equipment control, and

scene automation.

2.Existing security product channels/brands have a certain degree of influence, and are expected to be used to increase revenue.

Solution: Intelligently upgrade existing products by inserting cloud modules to expand sales channels at home and abroad.

Highlights: Save the cost of hardware development, and expand the channel market with the help of the brand image of the solution provider.

3.There is a rigid need for security scenarios in business, which drives to seek suitable solutions.

Solution: Build a complete set of smart security system at low cost, and coordinate with hardware sales, operation services, and software value-added services to support profit earning in all aspects.

Highlights: Flexible device authorization mode, support integration of App SDK, OEM App, public App scan code and other authorization methods. Developers obtain user and device data by using OpenAPI, and control devices through permissions.

Video surveillance: Alarm message feeding and operation: trigger the alarm from the alarm device, visualize the alarm push, perform alarm verification through video review, and make alarm processing based on the video content feeds.

Non-gateway single-product devices (Wi-Fi, BLE, NB-IoT) can be virtualized as a security gateway in the cloud, so that they have the ability to deploy and withdraw security devices, and provide flexible configuration of pan-scenario security capabilities.

Highlights: Based on the huge smart hardware ecosystem, App and platform support flexible customization, adapt to multiple scenarios, and meet the needs of subsequent expansion.

Relying on the ecosystem of AI + IoT platform, big data and huge hardware product, smart security is a comprehensive smart security solution for families, communities, zones, buildings and business scenarios, covering security operations, elderly care, campus protection, smart fire protection, property management, chain commerce and other smart security fields. This is to enable global security industry partners to quickly enter the global market.

Therefore, the smart security solution that is most in line with the big security trend in the industry currently has the characteristics of full-stack SaaS, zero development and visualized security.

Under the background of AI, big data, and the Internet of Things empowering the security industry, it is now the beginning of the outbreak of artificial intelligence in the security industry. Companies will use this opportunity to transform and upgrade their traditional business models to get closer to the general trend in the overall security industry. The polarization in the industry will also become increasingly obvious. Some companies that have not kept up with technological development will fall behind, and those companies that understand the lifeblood of the market will have more opportunities in the future.

3. Cases in the Smart Security Industry

Intelbras

Founded in 1976, Intelbras is a leading Brazilian smart home security brand and one of the top three IP camera manufacturers in the world. They're a one-stop home security solution provider offering the full range of home security devices—including sensors, door locks, energy saving systems, and connectivity—to create safer living and working environments for people worldwide.

Intelbras serves customers across Brazil with over 200 dealers and 120,000 agents. Intelbras also has four factories in South America and more than 3,300 global employees. The company generated around \$372 million in revenue in 2019.

COVID-19 has brought new opportunities to the world of smart security, and Intelbras has responded by creating a new human temperature monitor.

Launched in early 2019, this new monitor is being used in different communities and office buildings to remotely detect people entering buildings who have a high temperature or fever. Combining its capabilities with those of a smart camera, the

detector can warn and directly send a notification to the security guards or medical workers as soon as someone with a fever is detected.

Intelbras has also formed a strategic partnership with global leading AIoT platform provider, Tuya Smart, to realize smart transformation and device controlling across different product categories, as well as offer a better user experience.

Intelbras' app, Izy Smart, can control all Intelbras smart home products. It also supports smart scene linking and smart scene automation for users to enjoy a truly convenient smart life.

Intelbras has also launched its top-rated smart light bulb in Brazil. It features voice control with smart speakers, where users can select different colors and modes, such as reading mode, leisure mode, and music mode.

Zebronics—Connecting to Global IoT Capabilities

Founded in 1997 and headquartered in Chennai, Zebronics is India's top IT peripherals, audio/video, LED TV, healthcare, mobile accessory, and surveillance brand, providing products that are designed well but also affordable for any household. The company has over 1,100 employees across 31 offices and 127-plus Zeb Care service centers. These central offices are backed by strong network of dealers, resellers, and integrators that add another 50,000-plus retail locations across the country. The Zeb Care centers provide support to the consumers and the channel network.

The demand for home audio and video products has increased with the rise of smart homes in India, and Zebronics has responded by developing a comprehensive home smart video product line, including PTZ cameras, IP cameras, a four-in-one camera, a fisheye camera, and a smart Wi-Fi camera.

Tuya has enabled Zebronics to have quick access to intelligent voice platforms such as Amazon Alexa and Google Assistant, and, through this, Zebronics has created a smart home app named ZEB Home. They have also launched a smart IP camera based on Tuya's platform and will soon add more IP

cameras to their existing line.

Zebronics is committed to becoming a leading brand in the field of smart security and surveillance in India. The company has an in-house R&D department monitoring the latest developments in the field of technology and innovation to find best possible products and services for the Indian smart home market.

Thanks to the continued quality of products and services it provides, the loyalty of country-wide dealers, these dealers' faith in Zebronics as a brand, and the backing of Tuya technology, Zebronics has been able to find and maintain success in the Indian smart home market.

2.2.3

Smart Home

1. Overview of the Smart Home Industry

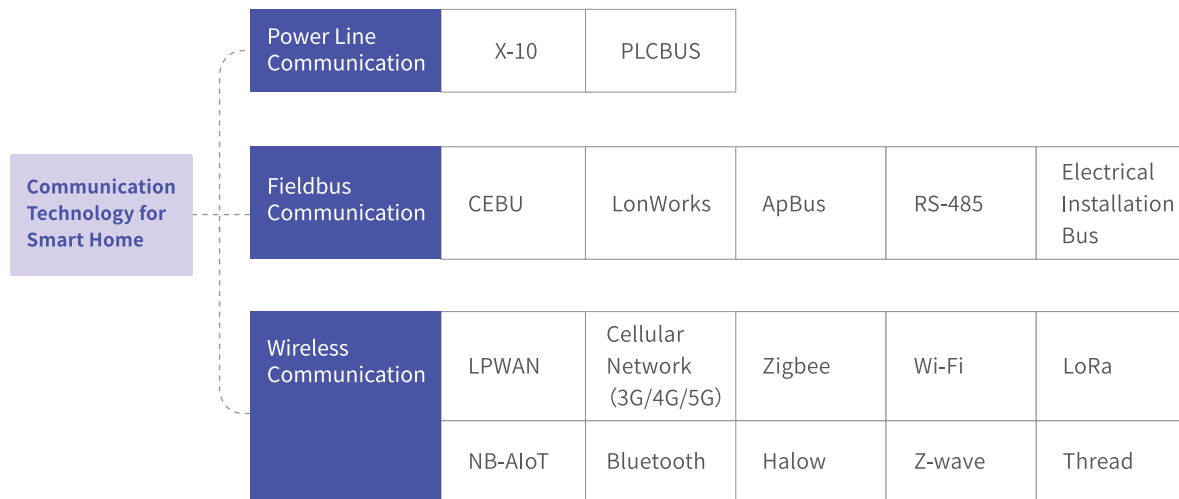
1.1 Trend in Smart Home Product: From Wired to Wireless

The global economy was in the Electrical Age from 1920 to 1980, when the development of electrical technology laid a solid foundation in hardware control for the smart home industry. Households around the world began to have access to electricity, and the growing residential demand led to the booming development of automated home devices. Various kinds of electrical appliances were invented, creating the early form of smart home. With the coming of the Information Age from 1980 to 2018, smart home technology and solution evolved more rapidly, and smart home product began to transform from wired to wireless.

The communication technology used in the smart home control system iterates continually, from power line communication to fieldbus communication, and then to wireless communication. Based on these three methods, three major ecosystems of smart home communication were formed. Starting from 2019, as the global economy enters a new cycle

and the Digital Age, devices with human-machine

interaction are becoming smarter and better.



Meanwhile, connecting device to the cloud under wireless protocol and processing high-value in cloud through edge gateway have become a major trend for smart products.

1.2 Trend in Smart Home Communication

Technology: Cross-Protocol Communication

Currently, there are mainly three categories of communication technology for smart home applications.

These three communication technologies can also be divided into only two categories: wireless and wired. In reality, wired solutions have high data transmission speed, low sensitivity to external environment, and strong anti-interference capability. However, they also have drawbacks, namely, the long construction period, the need of complicated wiring in advance and the fixed location of device, which lead to the wired solutions unsuitable for house remodeling or later decoration. In contrast, wireless solutions are smarter and simpler, which can automatically network, expand and change terminals flexibly. With the development of wireless communication technology, wireless solutions' performance in power consumption, transmission distance, transmission rate, and anti-interference capability has been greatly improving.

With the global deployment of cloud base stations, wireless protocols, apps and device-to-cloud connectivity have become the mainstream forms of smart home products. Developers adapt different communication protocols according to type of device and application scenario.

Most smart home appliances, large and small, now support human-computer interaction, and the iteration of home appliance is faster than that of pre-installed product. As home wireless routers and mobile devices with Bluetooth module are widely accessible, Wi-Fi and Bluetooth are often used for smart upgrades, which can be completed and used immediately without complicated network configuration.

Meanwhile, most pre-installed devices, such as smart electrical products, lighting, home theatre control panels, often adopt the Zigbee protocol with strong anti-interference capability, low power consumption, excellent networking performance, and low latency, and thus short-distance signal transmission is relatively stable. They also support the scene linkage control of different equipment combinations through the smart gateway hub. With the advancement of 5G mobile base stations, 5G technology is about to bring a new round of leaps and bounds in communication technology

for the smart home industry. According to the 2019 Analysis Report on Development and Trend of China's 5G Industry, written by Forward Industry Research Institute, one of 5G's key strengths is that it can deliver speed of 1Gbps for mass mobile users in hotspots. Also, according to IMT-2020, compared with 4G, 5G has better performance in user experience rate, traffic density, latency, mobility and peak data rate.

As technology evolves from 1G to 5G, more functions have been realized. 3G began to support video, and 4G began to support VR, while 5G's peak data rate will reach over 10Gbps with its average data rate being between 1Gbps and 2Gbps. As 5G offers faster data transmission, it will enhance the flexibility of smart home. Through mobile communication technology, more hardware will become smart and connected to smart home devices, ushering the world into the age of "cross-space IoT" and "mobile IoT".

Changing from wired products to wireless products, from power line carrier technology to 5G+AIoT, the new era of Internet of Everything, the smart home product is now entering a new era of great connectivity, when everything is connected. Cross-protocol connectivity is an important trend for the coming development of IoT devices. Devices with different protocols will become fully digital and interact in the cloud, so as to help businesses to make smart decisions in production, manufacturing, operations, sales, etc., and provider users with more

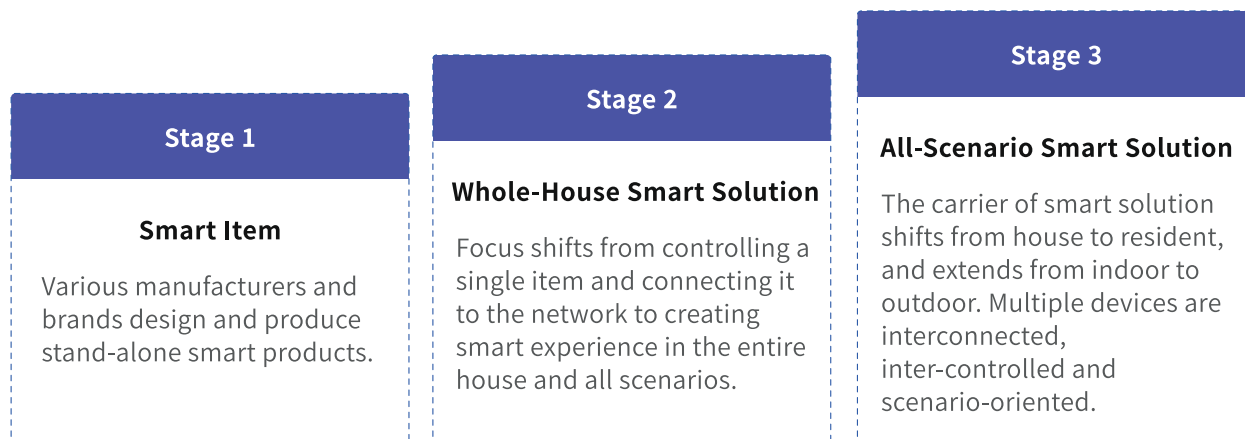
personalized "ID-based service".

1.3 From Smart Device to Smart Scenario

The development path of smart home clearly indicates that China's smart home technology and solutions are 3-5 years later than those of developed countries. For instance, Amazon launched the smart speakers Echo in 2014, which led to the rise of voice speakers in the world. But in China, the promotion of smart speakers took place between 2017 and 2018. Speakers were the most popular items back then as it was the first carrier of AI technology in smart home. After 2015, major domestic manufacturers began to join the race and vigorously promote their own hardware as entry-level products for smart home, including those specialized in smart lighting, smart electrical devices, smart door locks, and smart home appliances. After several years of promotion, Chinese consumers' acceptance of integrated smart home solution gradually increased. Around 2019, smart panels that are more in line with the habit of Chinese household gained more popularity in the market, and became a major entry-level product of smart home central control system. Nevertheless, the centralization of market demand has led to product homogeneity and intensified competition, and thus manufacturers began to focus more on design, materials, processes and the form of touch-control.

The COVID-19 pandemic in 2020 gives the entire

Products Replaced by Scenarios



world a huge blow. In China, the epidemic has been basically under control since the second quarter, and many Chinese manufacturers that used to focus on exports began to turn to domestic market, competing as the “New Made-in-China”. Such trends have led to the diversification in products, and needs for greater connectivity between people and communities, between communities and urban management units. Governments have speeded up the application and management of behavioral big data on living environment. Smart home is expanding from indoor scenarios to outdoor ones, as well as scenarios that are interconnected with human behavior, such as communities, commercial buildings, automobiles, hotels, etc. More manufacturers are now aware that large-scale user

growth cannot be achieved by only one company, but by breaking the boundaries and realizing connectivity. Digitalization of the living environment and various scenarios can only be achieved with the help of global smart platforms such as Tuya Smart, and a more open smart ecosystem.

2. Smart Home Solution

2.1 Whole-House Smart Solution

Whole-house smart solution aims to provide multiple control methods, connect different devices and scenarios, improving the quality of the house and creating smart, safe, comfortable, healthy and convenient living experience.

Value of Whole-House Smart Solution



Safe

Home Security-Video Surveillance
Intrusion Alarm
Emergency Button
Energy Security
Gas Leak Alarm
Smoke Alarm
Water Leak Alarm



Comfortable

User-friendly Interaction
Voice Control
Mobile Control
Automatic Connectivity



Healthy

Automatic monitoring of indoor and outdoor temperature, humidity, PM2.5, formaldehyde and other environmental indicators
Interconnected HVAC, humidifiers, purifiers creating a healthy environment with constant temperature, moisture, and oxygen level

Recommended Package for Whole-House Smart Solution

Elementary Package



Security



Lighting



Voice



Central Control

Standard Package



Security



Lighting



Voice



Central Control



Environment



Shading

Premium Package



Security



Lighting



Voice



Environment



Shading



Healthcare

Subdivided by function

1. Smart Lighting	2. Smart Shading	3. Smart HVAC
Centralized lighting control Voice Control App Control Timing Control Device Orchestration Control Scenario Orchestration Control	Curtain Control Panel Curtain Voice Control App Control Timing Control Device Orchestration Control Scenario Orchestration Control	Central Control of HVAC App Control Timing Control Voice Control Scenario Orchestration Control Constant Temperature, Moisture and Oxygen Level Control (HVAC devices will be connected to sensors, which monitor indoor environment)
4. Smart Security		
Security alarms can be directly turned on or when home owner is at home, away from home, or at a pre-set time point. Gas, smoke, and water leak detectors as well as emergency button are on 24/7, and real-time phone calls will be made and real-time notification will be sent in case of alarm. Magnetic sensors installed on the balcony, and at doors and windows are on when home owner is asleep or away, and real-time phone calls will be made and real-time notification will be sent in case of intrusion. Smart magnetic door sensor and security camera records each and every entry.		
5. Smart Energy Saving		
Underfloor heating and central air conditioning are switched to energy-saving mode at different time period of the day according to season or when the home owner leaves the house. Working time of dishwasher, washing machine, water heater, and other home appliances are adjusted automatically to avoid peak hours. Brightness and color of lights are adjusted automatically according to daylight; lights will be turned off when the home owner leaves the house. Energy consumption of major devices is automatically recorded, which are controlled according to scenarios.		
6. Smart Health		
When washing up, the mirror serves as a display, showing messages, previous sleep data and corresponding advice, and playing audio and video. When the toothbrush is picked up from the charger, the mirror shows the a 3-minute countdown for teeth-brushing. Personal health information such as blood pressure, weight, body fat and muscle mass percentage, bone condition, skin condition, etc. as well as personalized plans and advice are presented on the mirror in real-time.		

1. Subsystems of Whole-House Smart Solution

The diversification of whole-house smart products offers various product combinations, allowing the

flexible product combinations can be carried out according to functions, scenarios, and purchasing power.

Subdivide by scene

1. Coming Home

When you open the door, magnetic door sense detects the change and the light in the hallway will be opened.

When you choose the “at home” mode in the hallway, lights in the living room and dining room will be opened, and curtain will be drawn. You can also set the mode at turning on the main light of the living room or the spotlight at the entrance.

2. Audio & Video Entertainment

When you watch TV programs or a movie, you can use the smart speakers or remote control to turn on the “home theatre” mode, and the TV will be opened automatically, some of the lights turned off, and curtains drawn to create a comfortable environment for entertainment.

3. Sleeping

When you go to sleep, you can use the mobile app to choose the “at sleep” mode, or say to the speakers “I’m going to sleep”, and the lights in the bedroom and bathroom will be turned off automatically, and curtains closed, creating a quiet and dark environment.

When you wake up for the bathroom, the sensor will detect your movement and the night light and the light in the bathroom will be turned on. With the fully automated process, you don’t have to reach out for the light switch, avoiding

4. Getting Up

When you get up, you can stop the alarm clock or simply tell the speakers “I’m getting up.” Then the light of the bedroom will be turned on automatically, the curtain will be opened, the sheer curtain will remain closed, and gentle music will be played. Here starts a new day.

5. Leaving the House

When you leave the house, you can use the smart speakers or the control panel at the entrance to open the “away from home” mode, then all the lights and appliances will be turned off, curtains closed, and security alarms on. You will be notified on your phone when there are any abnormalities.

6. Environment Control

Temperature sensor, humidity sensor and other environment device can be connected to the central air conditioning, humidifier, dedicated outdoor air system. When sensors detect difference between actual temperature and humidity and pre-set level, the HVAC can be automatically turned on/off.

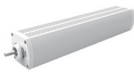
7. Security

Smoke detector, water leak detector, emergency button, security camera and other security alarms will be on 24/7, and the working time of magnetic sensors used to detect any intrusion from the balcony, windows and doors can be configured manually according to your need. Any abnormality can trigger a push notification to mobile phone or a phone call, ensuring the security of your house even when you are asleep or away.

Example of Elementary Package of Whole-House Smart Solution

Product							
	Multifunctional Gateway	Switch Panel	Magnetic Door Sensor	Infrared Detector	Water Leak Detector	Gas Leak Detector	Valve Manipulator
Quantity	1Unit	10Units	4Units	4Units	2Units	1Unit	1Unit

Example of Standard Package of Whole-House Smart Solution

Product						
	Smart Curtain	Temperature and Humidity Sensor	Smart Plug	Temperature Control Panel	Security Camera	Smart Door Lock
Quantity	2set	4Units	6Units	4Units	1Unit	1Unit

Example of Premium Package of Whole-House Smart Solution

Product						
	BGM	Air Quality Monitor	Smart Mirror Set	Sleep Monitor	Night Light	Emergency Button
Quantity	1set	4Units	1set	2Units	2Units	2Units

2. Packages for Whole-House Smart Solution

2.2 Software for Smart Home

When bringing a smart home solution to reality, the efficiency and labor cost of the process is determined to a large extent by the standardization level of each process step, including pre-sales communication, solution design, quotation, installation, commissioning, after-sales, etc. In order to address the common needs of smart home designers, service providers, integrators and other

businesses, industry ISVs (Independent Software Vendors) have launched a series of software for the smart home industry, which is conducive to helping practitioners quickly get started, and master standardized operation and implementation. These applications and tools have greatly enhance the efficiency of materialization. For example, Tuya Smart's Whole-House PaaS provides one-stop solution covering the entire smart home business process, and aggregates capabilities in design, construction, operation and maintenance onto one platform, cutting labor cost and raising efficiency.

3. Cases in the Smart Home Industry

Advanced Info Service Public Limited Company

Advanced Info Services Public Limited Company (AIS) is a “Digital Life Service Provider” which consists of three core businesses namely mobile, fixed broadband, and digital service. Established in 1990, AIS is a company with revenues of over 180,000 million Thai Baht in 2019 and global workforce of over 10,000. As Thailand’s largest GSM mobile phone operator, AIS has maintained its leading position with 45% revenue market share and is serving 41.1 million subscribers nationwide. AIS has been in collaboration with Tuya since 2019, and is now Thailand’s leading IoT brand. AIS IoT system brings a brand-new life experience to people with rich smart products and a perfect smart system. Smart devices from AIS include lighting, electrical products, home security kit and home appliances, etc. with Wi-Fi, Zigbee and NB-IoT protocols to meet various business demands, such as Wi-Fi protocol devices target at consumer retail business for individual home use, Zigbee protocol devices for real estate project and NB-IoT protocol devices for smart city projects etc.

“AIS Smart Life” App is a super App with integrated AI + Big Data to offer the user an interconnected and interactive Experience. With “AIS Smart Life” App, people can connect devices of different brands, categories and communication protocols which use Tuya solutions, remote control and voice control smart devices. All the devices which connect with “AIS Smart Life” App work with each other and realize many kinds of smart scene. For example, with Geofence function of “AIS Smart Life” App, when people are 2 kilometers away from home, the air conditioner will automatically turn on, rendering the space cool, when you arrive. AIS IoT system makes life easier, safer, and helps link AIS service and security system, automatically. With Tuya operation and maintenance service, when the devices have issues, AIS can lock the device location immediately, quickly view device

information, locate problems and help the user solve the problem in a very quick time. It helps AIS offer a very good after sales service for smart solution.

AIS also uses Tuya security SaaS for various projects. AIS security system offers protection in and around your home. With security sensor kits, cameras, doorbell devices, you can keep a watch anytime and everywhere. You get a notification and call whenever there is a stranger break in. All you have to do is, open “AIS Smart Life”, see what has happened and call the police. AIS security system also helps connect with the police center, so as to alarm them of something happening at your home, thereby helping them get the information and also so that they can come and check.

AIS and Tuya will continue the in-depth cooperation in the IoT field for different smart solution such as smart commercial lighting system, smart hotel system etc. and make different fields smarter.

Schneider Electric

As a Fortune 500 company, Schneider Electric has been leading the digital transformation of the energy automation sector. Its digital products and solutions which have a significant global influence, cover five end markets—that is, building, data center, infrastructure, industry and home. This global company has 140,000 employees in over 100 countries.

In recent years, Schneider has been collaborating with enterprise IoT platforms within the industry, actively building an open ecosystem and a smart home ecosystem, which move closer to end users by extending its business from infrastructure to smart home and whole house smart solution, so as to realize full coverage of businesses within the ecosystem.

In 2012, Schneider launched wireless smart home products based on first-generation Zigbee. At the same time, it introduced a smart home control system to the Chinese market, which could control speakers, home theater, air conditioning, curtain lights, security alarm and other appliances and applications.

In September 2019, Wiser, Schneider Electric's smart home automation platform that offers a consistent user experience by integrating products and functions from third-party partners through its "Works with Wiser" mechanism was released. Moreover, Wiser brings together Schneider's strengths in energy management, security, lighting control and temperature control into a single platform, creating new value for users. For partners such as developers, system integrators and electricians, it offers a comprehensive experience and one-stop end-to-end solutions covering multiple aspects including configuration, selection and installation.

Wiser Smart Home Automation Platform is designed to serve the real estate industry and its end customers. As projects with smart whole house solution gradually gain popularity, smart whole house solution has become an important parameter for builders' competitiveness. To better serve builders' needs in smart home and produce better smart whole house solutions, Schneider Electric adopts the open cooperation strategy, collaborating with platforms and manufacturers from various fields.

So far, Schneider's whole house solutions have been materialized in China, Vietnam and many other markets. Throughout this process, Schneider has been working with global AIoT platform Tuya Smart, making smart whole house construction more efficient and easy by connecting to Tuya's whole house PaaS. The partnership has enabled Schneider Electric to batch deliver its smart products, and builders to manage all projects with only one application. In a best-case scenario, LAN-based installation and deployment at a single household can be completed within 10 minutes. Such connectivity also allows customers to control all devices with one app.

Kogan Australia Pty Ltd

Kogan Australia Pty Ltd was founded in 2006 by Ruslan Kogan, now is the most significant local online business brand in Australia and New Zealand,

with over more than 8 million active subscribers. Kogan.com is an Australian portfolio of retail and services businesses, including Kogan Retail (the Kogan.com and DickSmith.com.au retail websites), Kogan Marketplace, Kogan Mobile, Kogan Internet, Kogan Insurance, Kogan Health, Kogan Pet Insurance, Kogan Life Insurance and Kogan Travel. According to the research from Telsyte, nearly 5 million Australian families--half of the country's households--have installed at least one smart home device in their homes by the end of 2018. As one of the largest e-commerce platforms in Australia, Kogan has partnered with Tuya Smart, the global AIoT Developer Platform, to launch smart light bulbs, smart sockets and smart plug-ins of its own brand. Kogan is Tuya's only partner who has sold more than 200 SKUs smart products with Tuya solution. All the smart devices are connected to the Alexa and Google voice platform, that users can voice control of the connected devices.

Kogan Smart LED turns your home into a party lounge, a mini-movie theatre, an office, a yoga class, even a campaign spot for your kids. It's 16 million color combinations create mood lighting suitable for every occasion. The "Kogan Smarter Home" App is a cross-protocol and scalable app to control smart lighting and other category products, including electrical devices, lighting, security & sensors, small appliances, white appliances, healthcare & entertainment and outdoor products. This gives end-users benefits that no matter Wi-Fi, Bluetooth or Zigbee products, they can use the same app to connect and configure.

Kogan is the bellwether of Australia's smart range. All the brands will check their website every day to see if new smart products are coming. Its online business advantage can sell the products directly to the end-user without any middleman profit, and its smart globe is already sold at AU\$6.33 price, which is the lowest price in the whole market. It is believed this price will increase its sales a lot soon and will affect the entire market to an aggressive environment in the smart range.

Since the Corona-Virus issue, online business is

booming in 2020. As the biggest online website in Australia and New Zealand, Kogan share is four times higher than before in the stock market, continues increasing based on the current situation. We do believe Kogan will do a more fantastic job in the smart range in the following days.

Baiseniaio

Baiseniaio Smart Home is a subsidiary of Baiseniaio IoT Technology (Zhejiang) Co., Ltd.. Established in November 2018, Baiseniaio is committed to becoming the world's leading provider of smart home products and services. Through the service of one-stop smart home products, it aims to provide overall solutions to the intelligent life in the future for customers.

Baiseniaio enables the intelligent upgrading and transformation of traditional home building materials industry by integrating more smart home solutions, thereby building a new retail scenario of smart home. Smart home is a natural strongly correlated network for home building materials industry: whole house customization can realize the linkage of the whole house intelligent home scenario, and customization of ceiling, cabinet and bathroom can create the intelligent kitchen and bathroom. If a traditional home building company intends the intelligent transformation but does not know where to start, Baiseniaio is here to help. As its name suggest (Baiseniaio's literal translation is birds with hundreds of colours), Baiseniaio can provide rich and diversified smart scenarios on the base of different home scenarios, ranging from bedrooms, kitchens, living rooms to bathrooms, with everything included. Baiseniaio works with real estate developers and traditional home building materials companies to carry out intelligent upgrading starting with the supply chain-end. And ileadsun, an integrated wall panel manufacturer, is one of its partners. Baiseniaio now offers a wide assortment of smart hardware products and allows customers to control all smart home products across brands and categories, only by means of one App, which addresses customers' pain points that they have to

use different APPs to manipulate different brands of equipment. Baiseniaio from software to hardware sides provides intelligent solutions for the whole house.

Since its establishment, Baiseniaio has been working in the field of smart home and continued to perfect its products. Collaborating with Tuya Smart, Baiseniaio has been developing its AIoT eco-platform and has contributed to projects such as smart real estate, smart office, smart hotel and smart nursing home, which enable its industry application solutions to come true. It serves hundreds of projects in China, and provides the ultimate whole house intelligent experience for tens of thousands of families.

BARDI

The two most important considerations for smart home adoption, according to a recent survey by Global Web Index, are: 1. Can the devices be interlinked? And 2. Can they be remotely operated and monitored?

BARDI Smart Home Indonesia (BARDI), being powered by Tuya, can answer both of these questions with an emphatic "yes". All of BARDI's products are compatible with all other Powered by Tuya products and can be controlled via a single mobile app, and that has been key to the company's success in the smart home market.

"We're growing at our own speed with Tuya ready to support us on scaling the business," said Ryan Maurice Tallulah, CEO of BARDI. "Our technical support was initially provided by Tuya, and now we have our own after-sales team of four members." "We believe it does not stop there," Ryan continued. "Since Indonesia is still in the relatively early stages of smart home adoption, Wi-Fi is the best protocol for penetration. However, as the market matures, we foresee that Zigbee or Bluetooth mesh will be the protocol of choice. Tuya provides all three protocols and many more."

With the background of being Indonesian digital marketing agency with Google Premier Partner badge, BARDI is one of a select group of Indonesian

businesses that has managed to actually grow during the COVID-19 pandemic.

Next Digital, BARDI's parent company, specializes in SEO, Facebook advertising, social media, video content creation, and website building, has decided to start its own brand as a way of verifying its own digital marketing strategies.

"We wanted to focus on products historically done by service providers that can now be done DIY, like car detailing, pest control, and smart homes," said Ryan. "We eventually decided that smart homes are the most visually marketable with the widest demographic target. Also, we checked on Google Trends and saw that the search volumes for smart home are growing exponentially."

With close to zero investment on technology, BARDI was able to grow from three simple smart home SKUs, launched in the fall of 2019, to more than 30. They also created a BARDI-branded Powered by Tuya smart home app that integrates with Google Home, Alexa, Siri, and SmartThings, and was able to deploy this app within a week of its creation. Also, with Tuya's connections in the smart home market, BARDI has been able to launch a soft bundle package with Google Nest Mini and have privilege consideration to exclusive exposures in JD.ID, one of the leading ecommerce platforms in Indonesia.

Smart Community

1. Overview of the Smart Community Industry

In the past two decades, China's reform and opening up with its rapid economic growth has greatly promoted the development of residential construction. In the 21st century, residential construction in China will enter a new development stage with focusing on the quality. The focus of the real estate industry is also shifting from large-scale land acquisition and property construction to property management featured with "high quality", "good experience", and "comprehensive service". Making residential construction and community

smarter is becoming the trend, and smart communities have mushroomed. As the smallest construction unit of the smart city, smart community will inevitably become one of the indispensable components of smart city.

With new infrastructure projects, the governments of China are paying more attention to promote intelligentization, digitalization and informationization of communities. Such efforts are based on the basic needs in community governance, namely, using AI, IoT, cloud computing, big data, edge computing and other cutting-edge technologies, taking community management and community services as the entry point, and aiming to realize people's aspirations for a better life. As a result, a unified community management and community service platform is built, creating a new model of modern community management and community service.

At the same time, several ministries and department at various levels such as the National Development and Reform Commission, Ministry of Science and Technology, Ministry of Housing and Urban-Rural Development, Ministry of Public Security have introduced policies, plans and standards to promote the building of smart community, which also highlights the importance of this task.

Smart community integrates information of people, places, things, situations, events, organizations and housing, and coordinates resources in public management, public services and commercial services. Relying on a comprehensive service platform and the moderately advanced infrastructure construction, it promotes the modernization of community governance and community management, and the intelligentization of public services. It serves as an innovative model of community management and community service, and is one of the important ways to achieve the goals in China's New Urbanization Plan and to build a community service system.

According to China's plan, preliminary demonstration projects of smart community should be built by leveraging modern technology



comprehensively based on local conditions, integrating various community resources, and strengthening capacity building in community service. These display sites should have sound infrastructure, efficient community services and governance, diversified public services, and the ability to serve local residents with smart technology, as well as sufficient support in policy, organization, human resources, and fund.

2. Smart Community Solution

Smart community system is a system with smart information technology as its foundation. It aims at integrating various community resources. The overall structure of the system consists of the infrastructure layer, platform layer, application layer, security and operation and maintenance system, open system and other parts.

Infrastructure Layer: The infrastructure layer provides smart perception of people, things and objects in the community. By means of a unified IoT base platform and the sensor networks, this layer connects and manages devices in smart homes and smart communities, including facial recognition entrance, vehicle recognition access barrier, elevator control, monitor device, lighting, smart well covers, fire protection system, smart whole-house system and other commonly-seen hardware, so as to perceive, identify, monitor, control and collect data from these infrastructures within the community.

Digital Platform Layer: The digital platform layer is responsible for the convergence, governance, storage, analysis, smart modeling and the exchange of data, including those of basic objects, dynamic perception and other businesses. It unifies and standardizes the building of basic and common services related to access, device, event, scenario, project, and space. Through the platform open interface (open API), the upper application can be uniformly enabled to assist the standardization of the upper application construction and realize the data exchange and ability sharing.

Smart Application Layer: The smart application layer mainly consists of smart community platform

and property owner control terminal (App / small program, etc.). The former is used by property manager for digital, smart and online management of community property, with the goal of improving community governance and service efficiency, as well as community service applications. The latter is used by residents, who are able to use and control smart devices and services in their own houses and in the community with this platform. Meanwhile, it realizes the connectivity and linkage of both indoor and outdoor devices.

System Operation and Maintenance Layer: The system operation and maintenance layer guarantees the security of the smart community platform. A unified end-to-end security system, including multiple mechanisms such as user privacy, data security, cloud platform security, secure development lifecycle, security operation and maintenance, business security and risk control, terminal security and others.

3. Cases in the Smart Community Industry

Zhejiang Uniview Technology Co., Ltd.

Zhejiang Uniview Technology Co., Ltd. is a solution provider and pioneer in the fields of global public security and intelligent transportation with panoramic, digitally intelligent, IoT technologies as its core. Within 8 years from 2011 to 2019, its sales revenue has increased by 15 times. In 2018, Uniview ranked fourth in the global intelligent video surveillance market. The R&D staff accounts for 50% of the total number of employees working in research institutes in Hangzhou, Shenzhen, Xi'an, Jinan, Tianjin and Wuhan. The global intelligent manufacturing base in Tongxiang produces 10 million high-end video security surveillance equipment annually with clients spanning 145 countries and regions.

By the end of 2019, Uniview has completed 249 Xue Liang Rural Surveillance Programs, 741 Ping An Programs, around 450 Smart Transportation projects and 280 landmark complex projects. In recent years, Uniview has been an active partner in

the building of Smart Community, and has provided solutions in Yuhang District in Hangzhou, Sanhe, a county-level city in Langfang, Hebei Province, and Jinnan District in Tianjin.

Take Yuhang District in Hangzhou as an example. It has 14 subdistricts, 6 towns, 184 villages and 159 communities with a registered household population of 1.04 million and registered floating population of 1.65 million. The total area of the district is 1,228 square kilometers. For the past few years, with the increasing influence of land acquisition and housing demolition in its surrounding areas and intensified support for the industrial upgrading, the industries, featuring low productivity, small scale, loose structure and poor capacity has moved inside quickly and the inflow of migrant workers accelerated. Yuhang has the largest floating population in Zhejiang Province, which creates huge problems for the grassroot social governance and public safety.

Therefore, Uniview designed and developed a Smart Grid Management Platform with an interface of five function modules. Through the functions of information gathering, risk identification, conflict resolution, coordination and livelihood services, the capacity and efficiency can be improved while the burden reduced for the grid administrators. 18 pilot communities in Yuhang District have deployed the Uniview's system, including subsystems such as for video surveillance, vehicles management and personnel access control. Various types of Uniview's products have been installed to provide three protective circles. In the first circle, Face Recognition Access Control Terminal and Intelligent Monitoring and Recording System of Vehicles were deployed at the gate entrance/exits. By providing the authentication mechanisms and real-name management system, the public safety can be further increased. In the second circle, Uniview installed IP cameras to monitor the main roads and public areas to avoid disputes through recording. In the third circle, its face detection system was installed on the gate to units for only allowing people living in the unit to go in and out for

enhancing the security. It can also help avoid the awkward situation of forgetting keys and improve the convenience for the residents. In this way, the legalized, scientific, refined and organizational level of urban and rural community's management can be improved in a comprehensive way.

Aurine Technology Co., Ltd.

Established in 1993, Aurine Technology Co., Ltd. in Fujian Province is a leading provider of smart community products and solutions that integrates R&D, production, sales, and service in the IoT industry. It has been awarded as "Top 100 Security Defense Enterprises in China", "Top 10 Competitive Video Door Phone Suppliers for Real Estate in China" and "Top 10 National Brands of China's Security Defense" and has been on the "Forbes China's Up and Comers List".

As an important promoter of smart community and smart home, with the ability of in-depth application development of high-tech chips, Aurine is able to create new values for community life by providing the paradigm of hardware + software + platform. Based on its deep understanding of the industry and innovative application of products, Aurine provides a complete solution, products and services to partners and clients.

At present, Aurine has 2500 new smart community projects annually, and has empowered 30,000 communities, providing services to over 30 million users nationwide. Through launching smart community projects with well-known real estate enterprises such as China Overseas Property, Luneng Property, Country Garden and China Vanke, Aurine provides a complete solution and technological service to thousands of clients. There are four pain points in managing traditional community, including low efficiency in operation and maintenance, high complexity in application, information silo and complicated management process. The top priority of community is to ensure public security. However, the traditional security model obviously fails to meet the needs of property owners nowadays.

In order to meet the demands raised by the Comprehensive Management Bureau and Public Security Bureau, Aurine's Xue Liang Smart Community Solution, integrating the Face Recognition and Intelligent Access Control System, License Plate Recognition System based on Video images, and Wireless Sniffing System, focuses more on access control monitoring and makes sure everything is traceable, so as to effectively strengthen the community's security capacity and emergency response capabilities. In the meantime, through the connection with the databases of Public Security Bureau and Comprehensive Management Bureau, the data that is related to people, vehicles and houses can be managed in real time and the alarm linkage can be enabled. In this way, "people, houses, vehicles, parking lots and internet" can be monitored in a three-dimensional, visible and manageable way.

In addition, through deploying the "Aurine's Smart Community Integrated Devices Management Platform" in the community's Integrated Control Center, applying the Internet Technology and Software Engineering Technology on the basis of community's intelligent and integrated system, and deploying the software platforms, the intelligent systems, information systems and all devices can be united as one "organic" system.

In the implementation stage of smart community projects, Aurine found out that it is difficult to deploy multiple smart devices. In the process of project implementation, typical applications cannot be used for multiple devices, rooms, networks and etc. By cooperating with the third party, the AIoT platforms, for its solutions that are dedicated to the project implementation, Aurine is able to help complete a series of deployment operations such as smart device join, room completion, scene configuration, and so on in a complex on-site environment, so as to establish a fast and batch implementation capability. The AIoT platforms, through connecting with the smart community's PaaS, managing and operating all the business data and devices data that does not violate the user privacy, can get

through the security information system of the community, and help improve the self-management function. Industrial Internet Market Size

Data source: the China Academy of Information and

2.2.4

Smart Industry

1. Smart Industry Overview

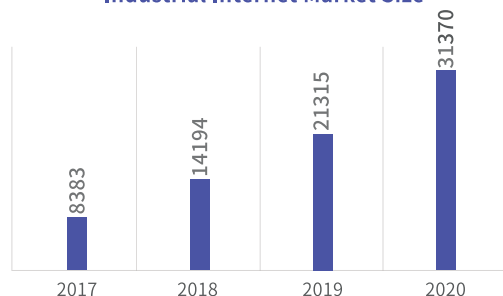
In the context of Made in China 2025 (MIC 2025), which aims "to accelerate the integration of next generation IT into manufacturing industry and to make intelligent manufacturing the main priority", "Smart Industry" came into being. Based on cloud computing and combined with edge computing, Smart Industry adopts multiple cutting-edge technologies, such as AI algorithm, big data, digital twin, etc., and applies internet to different aspects of industries, including equipment, control, data, etc. to achieve industrial intelligence. Compared with traditional industries, Smart Industry puts emphasis on integration, connectivity, data drive and mesh collaboration.

Currently the mainstream manufacturers in this field include:

- software manufacturers including MES (manufacturing execution system);
- equipment manufacturers;
- operators;
- cloud services providers;
- AIoT manufacturers;

These manufacturers either use their own advantages to expand upstream and downstream, or seek changes in other fields. Both are because of the bright prospect of Smart Industry. According to a report released by the China Academy of Information and Communications Technology, the market size of the Industrial Internet will reach 3 trillion RMB by 2020.

Industrial Internet Market Size



Data source: China Academy of Information and Communications Technology

Communications Technology

(Y axis unit: RMB 100 million)

There are many factors that factories need to consider when building production lines, mainly including:

- Product attributes,
- Product life cycle,
- The volume of orders,
- Production process,
- Production efficiency,
- Input-output ratio.

But even after considering all these factors, there are still many problems in production:

- Growing product differentiation, which makes it difficult to scale up production and keep manufacturing costs low in order to meet the users' personalised needs;
 - Frequent product upgrades, which result in constant updates or replacements of production lines;
 - Higher requirements for better quality, demanding a better control and traceability system.
 - Labor-intensive enterprises, most of which depend on workers to record the information, easily leading to errors, bringing low efficiency, and lacking data analysis;
 - Data silos, which delays issue handling process;
- Considering the problems listed above, Smart Industry needs to develop in below areas in the future: bring manufacturing to cloud and digitalize

manufacturing; improve edge computing and increase availability of terminal capabilities; enhance device connectivity and data sharing. The goal of all manufacturers in Smart Industry is to integrate upstream and downstream manufacturers, tear down data silos, and achieve efficient collaboration.

2. Smart Industry Solutions

Manufacturers are now offering different solutions according to their own strengths. Software manufacturers like MES have expanded their business horizontally and vertically to cover more part of supply chain and offer software solutions; equipment manufacturers have a strong advance on data collection and control; operators focus on “connectivity” and provide additional services while promoting solutions like 5G; cloud service providers emphasize the application of cloud computing in all kinds of industrial scenarios, while bringing other types of vendors to clouds to provide services; AIoT vendors build interactive platforms based on IoT, focusing on the construction of an ecological chain, and often offer platform-based services (PaaS). Here are a few examples of specific solutions to Smart Industry.

Smart Industry Platform with Smart Infrastructure

A Smart Industry platform needs to address common problems in traditional manufacturing, such as poor planning and processing, low efficiency, low traceability and poor quality control, in order to view, track and control production and gain real-time production data. The platform needs SaaS capabilities to provide on-demand applications for production, and PaaS capabilities to provide infrastructure, and the construction of the platform should be based on production equipment. Take electronic manufacturing industry as an example: equipment data collection includes collecting raw data from a local server or data acquisition devices, data processing (edge computing), and data uploaded to cloud; visual technology can be used for code scanning, testing,

production monitoring and shape recognition; procedure and process control is on cloud and not limited by the physical location of the server; complete production information query and varied electronic dashboards fully demonstrate the value of real-time data in production and provide basis and guidance for future production.

In addition, the platform offers a range of PaaS capabilities: advanced planning and scheduling engines that are continuously optimized by algorithm and that can make best use of production resources, digital twins for industrial equipment to create a real-time replica of physical equipment on cloud, and AI algorithm-based analysis to predict future maintenance and other things.

Integrated Supply Chain and Manufacturing

More integration between upstream and downstream manufacturers is needed to share business insights and data for better decision-making. The optimal production is not only manufacturing but to fulfill the needs of all players of the supply chain within limited time and resources. Smart Industry focuses on overall improvement and the local optimization brought by overall improvement.

The relationship between upstream and downstream manufacturers in traditional industrial production is linear and closely dependent. A common problem is that a delay in the upstream manufacturer can hold up the production in the downstream manufacturer and it's difficult to change that. Meanwhile, product lifecycle management and traceability along the supply chain is often merely a concept and rarely get addressed. Integration can turn this "linear structure" into a "chain". All nodes on the chain therefore are visible to every player to avoid problems caused by one single issue, reach "a dynamic equilibrium" and control risks. In this way, the synergy of the collaboration will be enhanced as more players join in, instead of "the longer supply chain, the more problems" in the traditional supply chain, and therefore the whole industry becomes "smart".

Of course, the driving force behind this change

comes from the demand side that wants to create an industry centered on services rather than manufacturing. So even after a product is sold, it can still affect the supply chain, and give feedback to improve the system, growing "smarter".

Large-scale Product Customization

The traditional way of mass production with assembly lines is driven by supply side, and it meets customers' requirements through standardization. While large-scale product customization combines "scalability" with "non-standardization", two seemingly contradictory concepts in the past, and are demand-side driven. This new production method requires more flexibility in production, shorter response time for new requirements and better prediction. And it needs big changes in organizational structure and product R&D. The benefits of large-scale product customization are also evident: less pressure in inventory and more flexibility for manufacturers.

Virtual Production

Virtual production refers to the remote production management and remote equipment operations based on virtual models, using technologies like AR/VR. There aren't many real cases that actually are adopting virtual production, but as automation develops this is a trend, especially for high-risk or remote operations since virtual production is a perfect solution to ensure safety and timeliness. However, it's worth noticing that this process requires extensive data collection and precision control technologies.

3. Cases in the Smart Industry

Hangzhou Hongshi Electrical Co., Ltd

Established in 1973, Hangzhou Hongshi Electrical Co., Ltd is specialized in the production of electrical accessories based on British BS standards and Chinese GB standards and series of smart home products. It has excellent capabilities of design and development, mold making, manufacturing

and quality management. It owns a provincial-level company research institute, a research center cooperated with Hangzhou Dianzi University, a national-level laboratory and an innovation and creative design center in Shenzhen.

The company produces over 80 million pieces of electrical accessories, selling products across regions in Europe, America, Middle East and Southeast Asia. Series of British BS Standards electrical accessories designed and developed by the company has been respectively approved by BSI, ASTA, NSAI, PUB, ITS and 11 testing agencies in other countries and regions and received quality approval certificates from these agencies. With the help of CCPIT, the trademark of the company “SWE” has been registered in more than 120 countries such as members of the Madrid System, members of the African Intellectual Property Organization and countries in the Middle East.

In 2017, the company, which firstly was concentrated on the production of traditional electrical appliances, noticed the development smart home appliances and started its journey of R&D on smart products. In recent years, it has launched series of smart home products, including some new categories such as universal remote controllers, single smart sockets and wireless switches. Its products are sold in more than 50 countries in the world. However, during the production and R&D, the company find it challenging to use traditional production lines to produce smart products which require a more intelligent manufacturing approach.

By using the PMS cloud smart manufacturing

system, the company has managed manufacturing plants more effectively. It establishes a production line information management system based on the status of current production lines; it collects, supervises and manages manufacturing information online; it supports to track product quality and ingredients, and reserves the access for the enterprise resource planning. Meanwhile, the company effectively controls the manufacturing process to realize the paper-less and visualized manufacturing process, which improves the management of production lines extremely well.

Also, the company uses data sharing to facilitate the development of business, which further makes full use of enterprise resources. It quickly allocates outside resources, adjusts excess capacity and sensible allocation of resources by visualizing and sharing cross-region resources, establishing the whole product supply chain, and creating the information sharing network for all business activities. In the map mode, it can directly see the distribution and capacity of professional production units in different regions and the detailed information about these units, which makes it more convenient to choose outsourcing. It cultivates a healthy and benign environment for competition based on data, which creates a win-win situation for both suppliers and customers.

With intelligentization of production lines and plants, the company not only increases its efficiency and capacity for producing smart products, but also realizes two intelligent transformation in terms of products and production lines.



3

The Challenges

3.1

IoT Platform Security

I. Potential Threats of IoT Security

Even though the services of IoT platform have facilitated the automation and intelligent transformation of enterprises and realized product intelligent upgrades which bring technology and convenience to consumers' lives, the more interconnected the world is, the more extensive the harm will be caused and the more difficult it is to maintain safety once data is leaked and the system is attacked.

The security expert Longwei Liu of Tuya Smart pointed out that throughout all links of the IoT industry chain, basically every link might produce security risks. For example, lack consideration of security design at the R&D stage. Leakage of authentication information and key of intelligent devices caused by the faulty process at the manufacturing stage will lead to the risk of intelligent devices. Device information leakage, network configuration QR codes replacement, and return and exchange equipment modification at the sales stage may all be attacked and exploited.

At the use stage, the design flaws of network configuration activation and device control, and the security flaws of three-party interaction including authentication, authorization and information encryption will bring potential security threats. Besides, the firmware might be hijacked or replaced during Over-The-Air(OTA) upgrade process. We summarize the top 10 greatest security threats of the IoT field:

1. Incompliant IoT Vendors

The majority of security issues are originated from insufficient investment in resources and time in the aspect of security from vendors. For example, the Bluetooth pairing status is still visible after the first time fitness tracker pairing for most Bluetooth fitness trackers. A Smart fingerprint padlock can be

accessed through the Bluetooth key with the same MAC address as the padlock device. The specific risks include:

- Weak, guessable or hardcoding password
- Hardware issue
- Lack of security update mechanism
- Old and unpatched embedded operating systems and software
- Insecure data transmission and storage

2. Users Lack Knowledge and Awareness of Security

Over the years, Internet users have learned to avoid spam or phishing emails, scan virus on personal computers, and use strong passwords to protect Wi-Fi networks security. However, IoT is a new technology, users are unfamiliar with its functions. Although most of the risks of IoT security issues are still in manufacturing, users and business processes may pose greater threats.

3. IoT Security Issues in Device Update Management

Another source of IoT security risks is insecure software or firmware. Although manufacturers can sell devices with the latest software updates, new vulnerabilities are almost inevitable. Updating right after new vulnerabilities are spotted is critical to maintaining the security of IoT devices. However, some IoT devices still operate without essential updates comparing to auto-update smartphones or computers. Another risk is that the device will send a backup to the cloud and have a short period of downtime during updates. Hackers may take advantage of the window to steal sensitive information if the connection is not encrypted and the updated file is not protected.

4. Insufficient Physical Reinforcement

Lacking physical reinforcement can lead to IoT security issues. Although some IoT devices should be able to operate autonomously without user interference, they need to be physically protected from external threats. Although some IoT devices

should be able to operate autonomously without user interference, they need to be physically protected from external threats. Sometimes, these devices are placed in a remote place for a long time and might be physically altered, for example, a USB flash drive with malware. However, installing security sensors and transmitters on low-cost devices is a challenging task for manufacturers, and users are responsible for maintaining the physical security of IoT devices.

5. Botnet Attacks

A single malware-infected IoT device will not pose a real threat, but a collection of them can be a serious threat. To launch botnet cyberattacks, hackers create multiple malicious applications by infecting devices with malware and command them to submit overloading requests to knock down the target. IoT devices do not receive regular software security updates like computers, so they are vulnerable to malware attacks.

More importantly, botnets can pose security threats to power grids, manufacturing plants, transportation systems and water treatment plants. For example, hackers can trigger cooling and heating systems simultaneously to reach the maximum capacity of the power grid, causing nationwide blackouts once the scale is large enough.

6. Industrial Spy and Eavesdropping

If hackers control surveillance by hacking into IoT devices, they can not only monitor the scene but also demand a ransom. Therefore, invasion of privacy is another critical issue of IoT security, and many different sensitive data might be leaked and used in attacks against its owners. In addition, several IoT devices such as health devices, intelligent toys, and wearable devices record user information. At the industry level, hackers can collect a company's big data and expose sensitive business information. Some countries have begun to ban specific IoT devices with security issues.

7. Hijacking IoT Devices

Ransomware is known as one of the most malicious types of malware ever. It will not corrupt sensitive files but encrypt them to block access from users. Then the hacker who infects the device will demand a ransom in exchange for the decryption key to unlock the file. With the constant evolution of ransomware, the IoT devices with poor security might also become targets.

It is rare to see a ransomware-infected IoT devices case, yet wearable devices, healthcare devices, intelligent homes, and other intelligent devices, as well as the ecosystems, might be at risk in the future. The good news is that most of the IoT information is stored in the cloud so that malware might not be able to lock critical data, but it could still lock the device's functions. For instance, a car cannot be started unless a ransom is paid.

8. Data Integrity Risks of IoT Security in the Medical Industry

IoT devices can be intelligent thermostats, HVAC, TVs, and medical equipment...etc. Sometimes the above devices will send unencrypted data to the cloud, which could allow hackers to access the medical IoT device, control the device, and alter the data.

9. Rogue IoT Devices

We have already known the rapid growth of the number of IoT devices. According to the prediction of Ericsson, the number of IoT devices will reach 18 billion by 2020. With such a large number of devices, problems might arise in business and home networks. Rogue devices or fake malicious IoT devices start to be installed in the secure network without authorization. A malicious device can replace the original one or turn into an add-on to collect or alter sensitive information. These devices break network boundaries and become rogue access points, thermostats, cameras, and man in the middle (MITM) that intercept communication data without the end-user knowing. Other variants of rogue device might also emerge in the future.

10. Mining Digital Currency

Mining cryptocurrency requires enormous CPU and GPU resources. As a result of that, one more IoT security issue comes to the fore – taking advantage of IoT Trojan Horse to cryptocurrency-mining. The open-source cryptocurrency Monero is one of the first batches of cryptocurrencies that are mined by hacked IoT devices (such as cameras). Although a single camera does not equip with powerful resources to do cryptocurrency mining, a large number of devices can accomplish the task.

In the era of IoT, massive user data is transmitted to the cloud from network devices. The more diverse of IoT devices, including household consumer devices, public service devices, large-scale industrial devices, energy devices, and transportation devices, the more complex the security issue of IoT will be. The stronger publicness of the devices, the higher they related to public safety in society. International organizations and governments need to establish worldwide IoT standards to manage security in cities, homes, nuclear power plants, manufacturing processes, and other fields.

In the future, the IoT security field still requires a robust security solution system to support. In this way, bring higher standards on cloud security because any design of cloud platform permission might lead to huge security risks. At the endpoint security level, a wide variety of intelligent devices makes IoT security more complicated, and hardware attacks might threaten the personal safety of users. The security expert Longwei Liu of Tuya Smart pointed out that due to difficulties of intelligent device upgrades and management, the security issues of products that have been delivered cannot be effectively patched in a timely fashion. Plus, due to the lack of consistent standards of industry techniques and huge differences in computing power among devices, until now, IoT intelligent devices lack the support of a unified security solution.

At the current stage, due to fragmented products, exaggerated product capabilities and diverse usage scenario, the IoT industry has no specific security

standards. The security levels of IoT products and platforms on the market are inconsistent. Most of the products do not have a proper security design and have huge security risks because of hardware cost management. For example, most of the products except mainstream platforms do not implement Transport Layer Security Protocol (TLS) encryption. TLS aims to provide three fundamental guarantees for information transmission: confidentiality, identity verification, and data integrity.

In addition to the above security risks, the privacy security of the IoT industry is also facing huge challenges that involve collection, utilization, storage, and legal regulation of privacy data. Many intelligent devices are like probes of personal life and collect all aspects of information related to one's daily life to compose a full picture of a person. Therefore privacy security and compliance are the bottom lines of all services.

II. IoT Security Measures

Regarding these potential security risks, the current major security measures of the IoT industry include:

- In the product R&D stage, Implementing completed Secure Software Development Lifecycle (SDLC) to satisfy security requirements and verification from product design, development, coding to delivery. Simultaneously, privacy compliance design and auditing are also required. Longwei Liu brought out that the existence of data sovereignty allows access with the user's consent. Same for the platform like Tuya Smart, there is an explicit character definition between the platform and the user. Regarding the user and device data under the OEM application, the platform needs to gain access through the authorization of clients and users.
- In terms of endpoint product security including devices and applications, reinforcing a multi-layer approach to protect codes, keys, and data is required.
- In terms of intrusion prevention, an in-depth defense mechanism is required. By simulating red

and blue confrontation, the mechanism could detect attacks, intercept them precisely, and inspect the security and robustness of the entire system and network.

- For business security, establishing a completed risk management system is required to audit abnormal user behaviors and assess risks. To be more specific, enterprises can also enhance the safety factor of the device both in hardware and software in the following ways.

For hardware:

- Encryption key management aims to ensure that the key is inaccessible under plain text. Device should be able to create and store the key (including private key) securely to accomplish unique identifier and configuration real safety.
- Cryptographic accelerator, Hash function, and True random number generator aim to accelerate encryption computation on the device. The hardware support can save computing time and power.
- Providing security storage access to protect specific parts of RAM and flash memory and to prevent unauthorized access. An independent storage area can isolate sensitive code and data from unsafe ones. At the same time, the write-once secure storage can prevent code and data from unsafe ones. At the same time, the write-once secure storage can prevent code and data from tampering and reprogramming.
- Providing access protection for debugging and programming, which would reduce the risk that hackers use debuggers and programming interface as attacking entry points.

For software:

- An integrated and optimized commercial-grade software provides certified application frameworks

and standard APIs. Besides, it also supplies hardware security functions an easy-to-use interface through a drive API.

- An encrypted library that contains various APIs provides security functions like macro security and root of trust and is equipped with the ability that could identify trusted sources and codes.
- Native support for common communication protocols and transmission protocols, such as Hypertext Transfer Protocol Secure (HTTPS), Transport Layer Security Protocol (TLS), and other designated cloud protocols.
- Updating the software and patching vulnerabilities in time.

According to the expert from SGS-CSTC Standards Technical Services Co., Ltd, in addition to technology, management is also needed, such as IoT risk assessment, process management, and security assurance...etc. Hence, Enterprises require to set up an IoT security management system. "As a worldwide recognized third-party inspection, verification, testing and certification company, SGS is aware of the big picture that IoT companies are doing a good job on information security, and the application of security technology has always been at the forefront of the market, but we need to pay more attention to data and information control problems such as excessive collection, unauthorized usage, and data trading." The expert said that some of the companies certified by SGS-CSTC Standards Technical Services Co., Ltd are already aware of security issue of user privacy, so they will apply for ISO/IEC 27018 certification. The ISO/IEC 27018 is a certification that pursues the Code of Practice for Protection of Personally Identifiable Information (PII) in Public Clouds.

3.2

The Chaotic Standards for the IoT Industry

1. Status Quo of Standard Confusion

Currently, one of the core challenges facing the IoT industry is the incompleteness of its standardization system. “The essence of a standard is de facto an industry consensus. It takes time to reach such consensus. At present, although there are some standards about the IoT, a complete standardization system has not yet been well established and accepted. The Internet had also gone through a long period of adjustment before reaching an industry consensus”, argued Zhang Feng, vice-chairman and secretary-general of Zhejiang Digital Economy Association.

Some experts pointed out that the essence of the IoT is one of the reasons for fragmentation of its standards. The heterogeneity represented by the diversity of IoT technologies and standards corresponds to the diversity of things in the world to be interconnected by the IoT. There may never be a real need for an all-inclusive standard. Just as updated applications and use cases continue to emerge in the IoT industry, so will the IoT protocols suitable for its deployment.

The interaction between sensors, devices, gateways, servers and user applications is the basic feature of the IoT. What enables all these intelligent devices to talk and interact is the IoT protocol, which can be regarded as the language used by IoT devices for communication. Only when there is a communication medium and all devices in a specific IoT ecosystem can share and use a common “language”, can connectivity be achieved.

The IoT protocol provides either an Internet protocol that has been used for a long time or an IoT protocol specially developed for the communication of connected devices. The main purpose of the unified standard for the IoT is to avoid further division, so as to maximize the interconnection and simple control of equipment, and reduce the risk of security

threats.

However, the IoT communications connection alone involves use of many technologies. Wired includes KNX, RS485, TCP/IP, CAN-BUS, LonWorks, PLC, etc. Wireless includes Zigbee, BLE Mesh, Duplex RF, Z-Wave, EnOcean, NB-IoT, LoRa, and the rapid landing of 5G also injects more innovative power into IoT. There is no absolute difference between advantages and disadvantages in various networking technologies, especially the common networking technologies in the market, which are developed and applied to meet specific needs. Let's take Wi-Fi, Bluetooth and Zigbee, the most common short-range wireless standards in the field of IoT smart home, for example. Wi-Fi is used for high-speed data transmission connection, such as video; Bluetooth is used for connecting mobile and wearable devices. Zigbee, on the other hand, provides stable, scalable and interoperable network support for numerous control sensing and lighting devices. They are classified by their role in the network, inclusive of protocols for connectivity infrastructure (e.g. 6LoWPAN), communication (Wi-Fi, Bluetooth), data transmission (MQTT, CoAP, XMPP), security (DTLS), device management, and telemetry technology (LwM2M).

It is evident that all technologies have special application situation to exert their features. With the continuous enrichment and humanization of application scenarios and the support of new technologies, especially AI, the development trend of networking technology is to integrate and apply various technical standards to bring better user experience.

Today, the IoT supports dozens of different IoT protocols. As pointed out by Longwei Liu, a senior security expert of Tuya Smart, the IoT industry involves a huge industrial chain and subdivided fields. In different scenarios, the technical requirements and standards are different. At the same time, the computing power span of intelligent devices is also very large, ranging from sensor devices the size of a thumb to large devices such as automobiles. The computing power and business

requirements they carry also show great differences. The IoT industry needs formulation of unified standards, including classification and classification standards for intelligent equipment, as well as safety requirements and testing standards for various actual business processes, such as those for distribution network, remote control of equipment, near-field control. In addition, there are differences in product models and product interaction experiences. At the same time, different national and regional alliances compete fiercely in standard setting, which increases the difficulty of cooperation between standards.

However, in the past few years, there were some protocols in the field of the IoT, hoping to provide versatility without compromising security, deployment speed or simplicity. One of the IoT protocols is OMA lightweight M2M, which can meet the specific requirements of various equipment

management use cases, then it can provide a solution suitable for a purpose and meanwhile, propose a general standard.

Of course, the diversity of IoT standards is not equal to the complexity and redundancy of standards. The scenarios and requirements involved in the IoT are ever changing. There can be no unified standard to meet different needs. However, at present, the biggest challenge in standard setting is that there are too many competing IoT standards and many standard application scenarios overlap. Such redundant IoT standards not only lead to standard confusion, but also hinder the formation of the standard system and the development speed and scale of the IoT.

Take the wireless standard Zigbee for example. The same standard will also cause confusion due to standard iteration and non-standard application by manufacturers.

Communication Technology	Advantages	Disadvantages	Communication distance	Security	Application Scenario
Bluetooth	Low power, straightness, low delay	The transmission distance is short, and the transmission rate is generally incompatible with protocols between different devices.	10-300m	High	Mobile phone, smart home wearable
Zigbee	Low power consumption, low cost, short delay network capacity, short range	The ability to penetrate walls is weak, and the cost is high. The ability of ad hoc networks is poor.	20-350m	Medium	Industry, Automotive, Agricultural Medical, Smart Home
Wi-Fi	Wide coverage, convenient use and low cost	Large potential safety hazard, poor stability and high power consumption	20-300m	Low	Smart Bus, Subway, Park Smart Home
LiFi	Convenient to use, high safety factor, environmental protection and energy saving	Environmental interference is large and standards are not uniform.	Indefinite distance	High	Smart Home, Bar, Light Control Visible Light Place
GPRS	Fast speed and convenient transmission distance	High cost, stability to be improved	No distance limit	Medium	Smart Home, Industry, Medical IoT, etc.
Z-wave	Stable technology, low power consumption and strong anti-interference, supporting equipment linkage	Short transmission distance and high cost	0-2 0 0 m	High	Smart Home, Hotel, Industry
RF 433	Fast speed and long transmission distance	Networking is not supported, equipment is incompatible and anti-interference is poor.	0-5 0 0 m	Medium	China Smart Home, Agriculture, Local IoT
NFC	High safety factor and low power consumption	The transmission is short, the speed is slow and the cost is high.	0-2 0 m	Ultra high	Transportation, smart cards, finance
UVB	Safe and accurate transmission	High cost, great technical difficulty and high power consumption	0-5 0 m	High	Industrial, automotive, medical
Modbus	Good compatibility, high safety factor and intelligence	Transmission lag, high cost	0-1 km	Extremely High	Industry, Automotive, Smart Home, Unmanned Aerial Vehicle

The form is produced by the Electronic Engineering Network.

1) Evolution of Technical Standards

Each technology will iterate from time to time to solve the problems found and add new features to meet the market demand. Zigbee had application layer protocols for different vertical industries before, such as Zigbee Home Automation (ZHA), Zigbee Light Link (ZLL) and Zigbee Building Automation (ZBA). While Zigbee 3.0, which integrates different standards, was introduced in 2016.

Of course, this is the only way for standards to mature continuously and meet the market demand. Generally, relevant standards organizations will reduce the impact of iteration on the existing market through compatibility of agreements, publicity and other methods.

2) Non-standard Application of Standards

vendors may have joined some private protocols due to business models or differential competition when applying open standards.

However, when they did not participate in the relevant product certification plan, they still claimed to use the open standard, resulting in different application experiences and sending wrong signals to the market. At the same time, in order to improve the viscosity and security of users, some ecosystem platforms often adopt the strategy of “private garden” in the early stage, adding special requirements for their own platforms to the standards to allow access, which also increased the differentiation of unified standards.

In the past 20 years, the IoT has continued to develop rapidly in the world. It has played a role in many industries such as manufacturing, medical care, automobile, safety, transportation, etc. It has greatly enhanced the capabilities of enterprises and brought them economic value. In the process of applying IoT technology, what enterprises really need is to understand the value brought to them by each standard and their own business needs and requirements, to understand the advantages and disadvantages of the protocols provided by the market, to select the most suitable protocol for actual scenarios and established use cases, and to

establish a relatively unified standard system and a small ecology of interconnection.

For consumers, unified standards represent convenient product experience. If a user purchases a home thermostat that supports IoT, he will want the device to use open standards that allow third-party applications to communicate and control the thermostat and other home IoT devices. The user also hopes that the device can support effective security standards so that hackers cannot break through intelligent systems, invade homes or control home devices.

The ‘private gardens’ of platforms and the equipment that cannot communicate with each other restrict consumers’ freedom to product choices, and the cumbersome product configuration greatly reduces the use experience, so they either don’t want to buy or stop buying another intelligent products. In order to meet the specific requirements of multiple standards and multiple ecosystems, equipment manufacturers need to invest a lot of resources to realize basic ‘connections’, instead of providing better functional products, which cannot expand production scale, reduce costs and upgrade the products themselves. This hinders the rapid development of the market in both demand and supply.

2. Solutions to Standards Confusion

Looking at the whole world, the EU also has a relatively centralized official organization for standard-setting. It organizes enterprises to participate in the formulation of standards. At the same time, many standards can enforce market access and be more practicable.

Governments, enterprises, trade associations, alliances, experts and scholars have all played an important role in the formulation of standards. Longwei Liu thinks that in the formulation of standards or rules, the government should be an initiator, enterprises should be the main contributor to the standards with more focus on practical application. Experts and scholars can provide some forward-looking opinions. The common solution

is that trade associations or enterprises work with each other to form a unified standard and promote it. Based on the operating system and development system, it may be relatively more feasible to develop a unified AIoT standard.

Quite a lot of IoT standard alliances led by enterprises, institutions and governments have been established in the world. Today, some of them have stood out amid the competition, matured and started to certify products on a limited basis, including Wi-Fi Alliance, Zigbee Alliance, LoRa Alliance, etc.

Among them, Zigbee Alliance has launched Zigbee 3.0 as a unified standardization solution. Zigbee Alliance is a non-profit standards development organization. Member companies voluntarily join and contribute to the creation and promotion of various IoT standards. Be it the introduction of a new standard or the update of existing standards, they do it based on the needs of the market.

The alliance first introduced Zigbee 2004 Network Layer Protocol to achieve interconnection among devices. However, due to its low speed and low power consumption, Zigbee network needs yet to support many 'small devices' with limited computing power and no user interface. If a sensing control network containing devices from different manufacturers is to be built, the devices in the network must be able to 'know' and 'interact' with each other. For example, A is a switch and B is a light bulb, and in this case, A can control B.

According to the requirements of these scenarios and in order to meet the needs of different vertical fields, the alliance has defined a series of application layer specifications of device types, attributes and functions based on network layer protocols. Zigbee Home Automation (ZHA) was launched in 2007, Zigbee Health Care in 2009, and Zigbee Light Link (ZLL) in 2012. It is also the introduction of these application layer specifications that marks Zigbee has become a full stack protocol that covers the network layer and the application layer. It achieves not only interoperability but also interconnection and interaction between devices.

With the rapid development of the IoT over the years, the boundaries of vertical fields are no longer so distinct, the number and types of devices contained in a single scenario are increasing. Chip manufacturers have also introduced chips with higher computing storage capacity and lower cost. In order to respond to this market trend, Zigbee Alliance members have integrated and opened up a number of application layer specifications which previously applied to different fields, and introduced Zigbee 3.0 specification. And through the specification of network behavior, they have ensured the forward-looking compatibility of the previous specifications to significantly improve the interoperability between different devices while also ensuring the interconnection with the existing products in the market.

Therefore, it is workable for integrating standards that the major participants in the market comply with the market demand, cooperate and communicate with each other on alliances or other platforms, and work together for common prosperity.

In the process of standards integration, there are not only the standard-setting organizations acting as a platform for cooperation and exchange among members of the industry, but also the government, enterprises and experts, who can play different roles. The government ensures a healthy and orderly competitive environment and introduces appropriate incentive policies to support the development of the industry. Enterprises work together on the field of basic standards, while continuously innovating and improving product differentiation and functions. Experts and scholars use their own expertise and knowledge to review standard technologies, come up with opinions and suggestions, and popularize knowledge of technical standards amid the industry, improving product differentiation and functions. Experts and scholars use their own expertise and knowledge to review standard technologies, come up with opinions and suggestions, and popularize knowledge of technical standards amid the industry. With regard to the formulation of industry technical standards in China, the Ministry of Industry and

Information Technology has issued the Notice of the General Office of the Ministry of Industry and Information Technology on Further Promoting the All-round Development of the Mobile IoT (hereinafter referred to as the Notice), pointing out that it is necessary to accurately grasp the evolution trend of global mobile IoT technical standards and industrial structure:

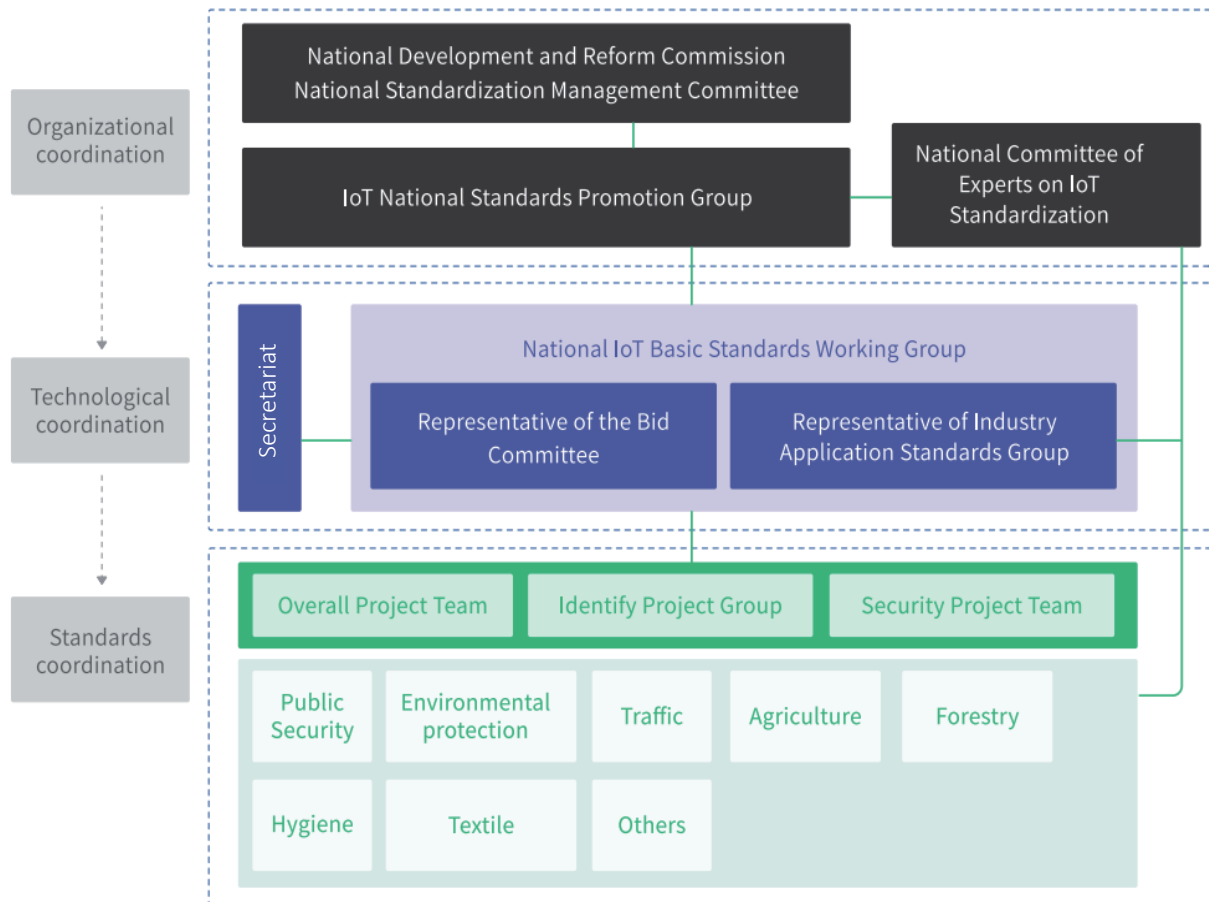
1. Formulate Standards for the Integration of Mobile IoT and Vertical Industries

NB-IoT standards will be more quickly incorporated into ITU IMT-2020 5G standards. Facing key areas such as smart home, smart agriculture, industrial manufacturing, energy meters, fire smoke, logistics tracking, financial payment, etc., formulation and implementation of technical standards and interconnection standards will be advanced, such as mobile IoT terminals and platforms, and the standardization level of industry applications will be elevated.

2. Consolidate the Basic Security of Mobile IoT

A security standard framework for the mobile IoT will be set up, and a series of classified security management standards for key links will be established such as IoT cards, terminals and gateways. Enterprises and research institutions are encouraged to increase the research and application of trusted authentication technology for mobile IoT terminal, block chain traceability and other security technology means. The goals are to speed up the construction of mobile IoT security supervision technology, improve the security situation awareness, card management, risk alert and other real time surveillance capabilities. In addition, the National IoT Basic Working Group has set up an "overall project team" to develop standards for China's IoT terminology, architecture, testing and evaluation system and others.

	Standard Setting Measures
Perception Layer	Formulate 500 technical standards directly related to sensors in the instrumentation and sensitive device industry; Establish a basically complete set of RFID standard system to support China and complete RFID basic technical standards and application standards for major industries; Formulate sensor interface standards and define data acquisition signal interface and data interface; Formulate standards such as public document framework, data exchange format and performance test for biometric identification; Formulate coding standards for audio, image, multimedia and hypermedia information;
Service Support	Carry out standard-setting work for such areas as SOA, WEB services, cloud computing technology and intermediaries; carry out research on a series of standards for information sharing and exchange in the IoT, collaborative information processing, and information fusion models for perceived objects; Carry out big data standardization work, cloud computing standardization work;
Business Application	On June 8, 2016, China's National Standardization Administration formally replied to the establishment of the Standards for National Medical and Health IoT Application "Working Group (Biao Wei Gong Er Han [2016] No.39), marking the formal establishment of China's 6th Working Group for National IoT Industry Application Standards, following the establishment of working groups for public security, environmental protection, transportation, agriculture and forestry.



Organization Chart of National IoT Standardization Work
Source: National Health Commission, PRC

III. Standard Analysis of Subdivided Fields

Smart Home

Taking the promising smart home industry for example, global smart home manufacturers use different communication protocols and key technologies, which results in separate ecosystems that are difficult to be compatible with and makes it difficult for them to integrate the smart home ecosystem, thus causing inconvenience to consumers. Consumers often need to download different apps for smart products of different brands and use them in different ways.

Zhou Jun, Secretary General of the China Smart Home Industry Alliance, stressed that in the field of smart home, there is no enterprise that covers

all products. "In the age of consumer electronics, and in the age of home appliances, there will be no dominance by a single company. This phenomenon is very common in the software sector, so many software companies will have the idea of dominating the IoT. However, the industrial chain of the IoT is too long, making it impossible for one enterprise to integrate all players including chip manufacturers, module manufacturers, designers, product manufacturers, channels and stores. That is not something one enterprise can empower. So far, no OS has been completely successful."

In December 2019, Amazon, Apple, Google and Zigbee formed a Working Group to develop and promote a new patent-free connection standard for better compatibility between smart home products

Security will be a basic design principle. The project is based on a common belief that smart home devices should be safe, reliable and seamless in use. The goal is to simplify development for manufacturers and increase product compatibility for consumers.

Based upon Internet Protocol (IP), this project aims to realize communication among smart home devices, mobile applications and cloud services, and to authenticate devices by identifying a series of IP-based specific network layer technologies. The Working Group of the industry will employ an open source approach to develop and implement a new and unified connectivity protocol. The project plans to use smart home technologies that have been tried and tested in the market, such as Amazon, Apple, Google and Zigbee Alliance.

Board members of Zigbee Alliance, such as IKEA, Legrand, NXP Semiconductor, Resideo, Samsung SmartThings, Schneider Electric, Meijie (formerly Philips Lighting), Silicon Labs, Somfy, Tuya Smart and Nanjing Federation of Things, also joined the Working Group to support the project.

The project aims to make it easier for manufacturers to make devices compatible with smart home voice services, including Amazon's Alexa, Apple's Siri, Google's Assistant, etc. The planned protocol will supplement the existing technology, and members of the Working Group encourage manufacturers to continue use of the existing technology for innovation.

The types of smart home devices for this project include lighting and electricity (e.g. Bulbs, lamps, switch sockets), air conditioning control, entrance guard, security, home entertainment (TV, audio, etc.), network access, etc., including almost all major smart home equipment.

As for the communication protocol standards of smart home, Zhou Jun believed that in the future, the chances are that one technology will not ban another; instead, they definitely coexist. "Zigbee is the mainstream protocol for smart home control. Bluetooth is mainly used for lamps, and its security system and panel system are not so many at

present, which do not constitute the ecosystem of smart home. But Zigbee has formed an ecology and the technology has upgraded to the third generation", added Zhou Jun.

In addition, Zhou Jun also mentioned a lack of delivery standards in the smart home industry.

"Uncertain project delivery standards are a big concern. All software companies have different genes, each family environment is different, and workers' training and salary are also problematic. For example, there is no unified national delivery standard for the installation of simple intelligent door locks. In the future, delivery will become one of the core competitiveness of IoT enterprises."

In addition, another major strength of European, American and Japanese enterprises lies in product quality and detail innovation. The development of the IoT in the United States is supported by the entertainment industry. There are many kinds of household appliances, including speakers, televisions, players and others for home cinemas.

These products have been well integrated and controlled. In this scenario, the content protocol of the products is opened up. Japan is based on consumer electronics and is especially good at innovation of micro-products. Over the years, Japan has also made a lot of refinement in the pension industry.

The most typical practice in Europe is building intelligence. China's smart home is characterized by a wide range of application scenarios, a lot of demand and a fast development speed. However, manufacturers do not have high enough quality requirements for products. Apart from the serious homogenization of products in appearance design and technology, there is still lack of uniform defined measurement standards for lots of basic technologies. For example, how many milliseconds of delay from the switch signal to the gateway is considered acceptable? In addition, the connection between enterprises and consumers is not close enough, and there is no proven market research as the support for product and technology development, which may lead to the disconnection

between products and real consumer demand. In early 2018, the General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China and SAC approved three national standards for smart home series, namely, Numbering of IoT Smart Home Data and Equipment, The Descriptive Method for IoT Smart Home Equipment and General Technical Requirements for Smart Home Automatic Control Equipment. The IoT smart home is defined and standardized in detail in five aspects: textual and graphic identification, data and device coding, device description, user interface and design content.

The formulation of these standards has provided technical guidance for the design, production and operation of smart home products, accelerated the industrialization of China's smart home products, and provided a standardized guarantee for the promotion of China's IoT technology in smart home appliances.

Zhou Jun pointed out that the process of setting standards in Europe and the United States is relatively market-oriented, because there are too many standards involved in the consumer electronics field and it is difficult to rely on the state government to force the formulation of standards. For example, there is naturally a market standardization system for PC, Type-C and USB because they represent a huge market volume. If such standardization system is not used, manufacturers will be backward. The practice of the United States is that several large factories integrate protocols into modules, and then set up third-party organizations and alliances to carry out certification for external entities.

Zigbee, Wi-Fi and other alliances are very powerful and omnipresent as third-party specialized organizations, and their technical experts are focusing on the research and development of the next generation of Wi-Fi technology. " In addition, he also mentioned that there are many competent departments involved in the formulation of industrial standards. For example, the building standards of real estate, internal electronic products, cloud

and SaaS are managed by different regulatory authorities. It is very difficult to formulate a unified standardization system for smart real estate. The possibility is therefore that the formulation of national systems and standards may not keep pace with the progression of technological innovation.

Smart Hotel

Up to date, in the construction architecture of the hotel IoT, the intelligent systems introduced to the application layer exhibit considerable diversity, including diversities in front desk self-service check-in machine, intelligent guest control, intelligent light control, intelligent ladder control, network, information release, building intelligent control, intelligent door lock (access control), green irrigation, garage management, remote meter reading, private wearable equipment, etc. A large number of different standards and resulting solutions and products are also introduced into the network layer and perception layer.

Zhang Xingguo, COO of the China Hospitality Technology Alliance, argued that as a whole, the use of standards lacks the commonness and characteristics of the industry and is rather disorganized and chaotic. For example, some communication protocols in intelligent customer control use Wi-Fi, some use Zigbee, and some use Bluetooth. Even the widely used indoor wireless communication Wi-Fi, which has a relatively high degree of standard uniformity, also has wrong and disordered versions. These versions come with low compatibility and functional commonness, which makes the user experience poor and hinders the performance of sensors and application systems. In general, in the construction of smart hotels, it is common for the sensing layer, network layer and application layer to use chaotic standards.

There are many reasons for confusing inconsistency of standards. The main reason lies in 1) the suppliers' limitation of talents and knowledge reserves; 2) understanding and cognitive differences on the characteristics and limitations of various technical standards; 3) the non-synchronization

between the timeline generated by technologies and standards and the suppliers' timeline for developing specific products; 4) the technical standard which in itself is also a process of gradual iteration and improvement; and 5) the most important thing is that the hotel industry lacks overall, forward-looking and authoritative guidance on the basic requirements (functions and safety) and technical standards for smart hotel application scenarios.

As far as the hotel itself is concerned, the technical strength of major hotels or hotel groups tends to be traditional IT, namely, traditional Internet technology, and they are unfamiliar with the intelligent hotel control technology and scene design under the emerging IoT technology. Throughout the construction of smart hotels, they mainly purchase products and schemes from third parties. These hotels are quite unfamiliar with various technical standards in the three-tier architecture of the IoT, and of course, they lack a sense of discrimination in choosing standards and performance of products provided by the market. In that case, it is impossible for them to come up with constructive suggestions and requirements.

This situation, accompanied by the diversity (including protocols, architectures, devices and features) generated by different suppliers and different product solutions, directly leads to elevated access costs, low data exchange efficiency, reduced accuracy of process execution, weak background data reprocessing, and weak positive feedback and intelligent control of the system. This has delayed the development of the potential of the intelligent IoT, resulting in a great rise in the application cost of the hotel IoT. What is more noteworthy is that with the introduction of a large number of intelligent application systems, the accumulated security risks (including data security, personal privacy and system security risks) in the perception layer, network layer and application layer are rapidly increasing.

Regarding a consensus on industry standards, Zhang Xingguo thinks: "With the increase of practical activities, we gain more understanding

and experience of some technical standards of the IoT and the characteristics they exhibit. We have a thorough understanding of scenarios for innovative hotel intelligent application. Therefore, grasping the adaptability of various technical standards is on the increase and a consensus is going to form. The construction of Chinese-style smart hotels has become the consensus and trend in the current construction of the IoT. "

"At present, there are indeed chaotic technical standards in the construction of the IoT in the hotel industry (mainly smart hotels), which also comes as a normal phenomenon. In practice, the need and awareness of standardization can make us avoid detours and improve the effectiveness of construction." stressed Zhang Xingguo. The diversity of standards can, to some extent, enable the characteristics of different technologies to be effectively put into tests, although such tests may mean great costs for 'tuition'.

On the one hand, hotels can know more and better about their operation status and the needs of the guests, have better management and meet guests' potential experience. On the other hand, there also are risks of privacy leaks and data abuse. Therefore, the construction of smart hotels should not only be focused on better unification of technical standards, but also on strengthening and perfection of non-technical data and information management processes and of legal supervision.

When it comes to the consistency of technical standards, Zhang Xingguo pointed out: "We are more inclined to add more principle guidance from the government's technical supervision department, provide some guidance on the implementation of technical standards as the reference for ICT departments of developers and hotels, and maintain a certain amount of diversified space in the application of specific products and systems. In doing these, we are able to make our IOT intelligent products more distinctive and survive the severity of the market selection.

However, given the key point that IoT equipment is more secure and challenging than traditional

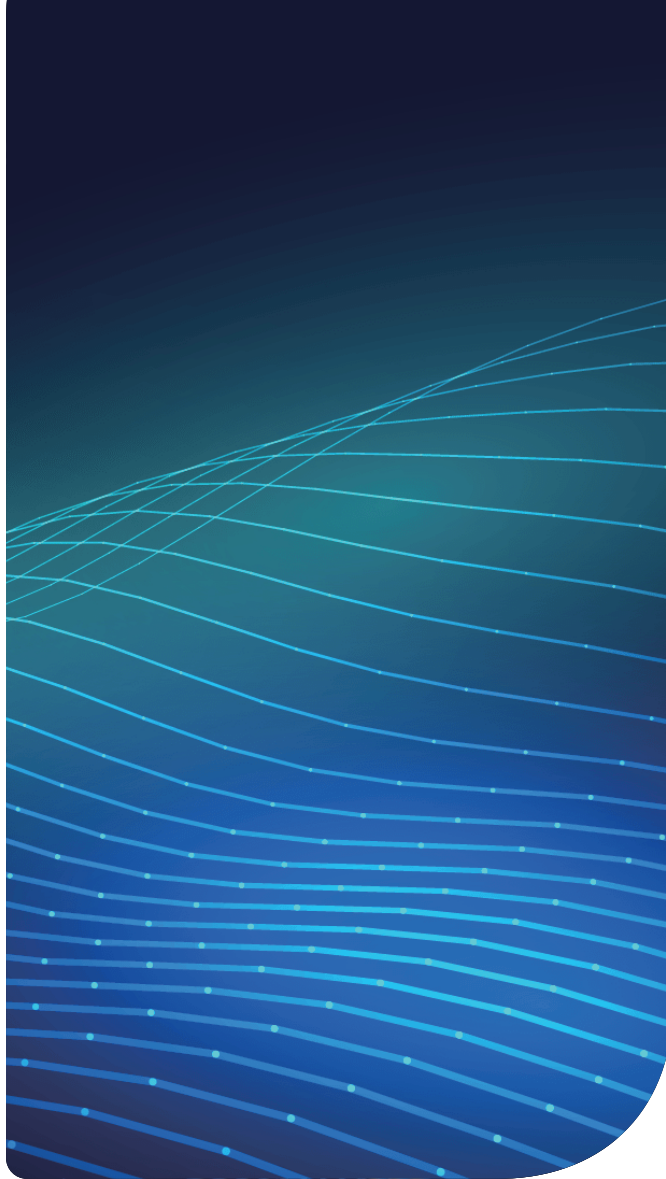
networks, the priority is to strengthen the security control legislation for IOT intelligent products (systems). For example, a stricter and more operational non-technical management process for data security should be proposed, including encrypted storage of data, fault tolerance and remote backup of data, interface protection, identity checksum authorization, continuous update of IoT equipment, patches, use and restriction of data and so on. Only in this way can hotels avoid data and privacy crises that are worse than the chaotic diverse standards as they are carrying out intelligent construction of the IoT.

Zhang Xingguo believes that in the process of standards formulation, governments, enterprises, experts and scholars, and hotel industry associations are in different positions, which determines their different roles. One clear thing is that they should do something in the process of IoT or hotel intelligent construction.

Government specialized departments should play a role in promoting and leading the technical standards of the IoT. Industry associations can find

problems, promote the establishment of standards, coordinate contradictions and interests, draw up lessons from the past, improve the process of industry standards and the final implementation of standards. Enterprises (including suppliers of equipment and systems, service providers and hotels as users of intelligent scenes and applications) should be duty-bound to carry out scene innovation, make trial-and-error use of standards and technologies and do summary, and practice and implement the established technical standards of the industry and the country.

Experts and scholars are the explorers of the standardization of IOT intelligent technology and the creators of public opinions; they are also a promoter of hotel intelligence. More importantly, it is also necessary for them to have a public mindset beyond the connection to interests and become presenters of new technologies and standards. The most valuable thing is to become a “whistleblower” for the problems arising from the profoundly significant construction of the IoT intelligence for China’s hotel industry.



4

The Prospects

4.1

Developers Are Playing a Key Role in Driving the Industry

Developers are playing a key role in driving the industrial ecology of IoT.

IoT device in smart internet era combines the virtual internet world with the real physical world, which is different from the era of PC internet and mobile internet when PC and smart phone are the major carriers and products are mainly composed of codes. The highly variable application scenarios and different kinds of hardware devices make it extremely difficult for technological companies to develop IoT device on its own. Instead, it requires the participation of tens of millions of IoT developers to develop the customized products catering to the needs of each client.

According to the IDC's forecasts, by 2023, the number of part-time developers in China will be double compared with that in 2019, increasing to 3.6 million from 1.8million with a compound annual growth rate of 12.2%. By 2020, about 15% of client experience applications will realize hyper-personalization through continuously combining various data with innovative reinforcement learning algorithm.

IoT developers, who are usually regarded as the service provider for a certain project, could be smart hardware manufacturer, development team or individual developer, including product manager, UI designer, software engineer, hardware engineer as well as test engineer. As it is highly collaborative to develop smart hardware, without the support from toolkit and platform, individual developers can hardly finish the whole process on their own.

Statistics from Evans Data Corporation show that there were 23 million developers in the world in 2018, of which more than 2 million focused on IoT. It is expected that the overall number of developers will reach to 27.7 million in 2023, and the proportion of IoT developers will further increase with the fast expansion of the industry.

Greg Gorman, head of the IoT developer's ecosystem in IBM, once stated that " the research scopes of IoT developers are relatively wide and cover many technological fields including security, internet service, systems engineering, cloud programming, software structure and embedded development". Developers with compound skills will be increasingly important in the project. Currently, developers in IoT areas generally possess one or several key skills in the following areas.

1. Hardware Development

The core of IoT is device connection, including digital-priority device connected with other devices (machine to machine), or physical-priority device that implant embedded circuit in sensors, both of which require the knowledge in hardware design. Device design includes process and storage functions. Device can be equipped with microcontroller or more detailed SoC, the latter

combining more modules (CPU and I/O device) with integrated circuits.

2. Internet Connection

Connection is another key feature of IoT. It enables the device to communicate with other device and application and service operating in cloud. Internet design and management remain the basic skills in IoT, considering the large number of connected

devices and the possible impact brought by internet design and decisions.

3. Big Data and AI

By means of data mining, modeling, statistics, developers can train AI system, which can be used to predict analysis in sensor data streams in real time, or to make decisions automatically in response to incoming data and can be applied to historical data to identify the patterns or anomalies in data. Currently, numerous connected devices using AI to help conduct real-time analysis are available in the market and there is a rising trend in widespread adoption. For example, the smart thermostats, such as Nest, use AI to learn user temperature preferences and adjust energy usage accordingly.

4. Application Design and Development

Applications provide users with an interface for interacting with IoT devices and using data, which are usually developed in high-level languages, such as Java, Swift, and Node.js. Application development is not an easy task and the developers mastering the relevant skills will be more popular in the market. Developing applications can also produce a marked role in constructing automatically, deploying, managing and operating the open platforms for IoT applications. For example, Tuya IoT cloud development platform can be completed produced by the APP in five minutes.

5. Security Compliance

Internet security remains the key issue in any discussion about IoT. Since IoT devices are easily influenced by the security flaws, developers attach great importance to internet security. Thus, security engineering skills are of great importance, including threat assessment, encryption to ensure data integrity, insurance of network architecture and application security, event monitoring, activity logging and threat intelligence.

The reason why developers are so important is that they are the cornerstones of the industry. Therefore, the flow of developers determines the success of

the industry ecology.

In the era of mobile Internet, one of the main reasons why Apple and Android can rapidly emerge and surpass Nokia, a superpower of feature phones, is that they have formed their respective ecosystems by gathering developers through app store and successfully developed a wide range of applications. At this stage, Internet companies attracted developers into their own platforms and ecology by using Open API and open source. For example, Google provided API of Google Map for other website services to call, and also built Google Code to provide its open source projects to developers, which eventually attracted a large number of highly sticky developers.

In the early days of the mobile era, six ecosystems were in competition, including Apple, the Smartphone leader, Linux-based Android, BlackBerry, the first choice for businessman in North America, HTML5 launched by W3C, the development platform crossing Apple and Android operating system, and Microsoft Windows Phone. The reason why Apple and Android stood out is having more developers. The first consideration for developers is the user base and monetization, followed by the demand degree for technology:

1. Which platform has the most users and is most likely to succeed to launch App?
2. Are the development tools easy to learn and use?
3. Is the technological development advanced? Is it possible to lead the technology development of the next generation and become a long-lasting general technology field?

The following "competitive barrier" is actually the Matthew effect driven by competition among various companies. The more developers an ecosystem attracts, the more applications it will produce, which will bring better service to customers. This will attract more customers to use the application and encourage more developers to join the ecosystem to share the dividends. The number of developers in the world is limited. The ecology of the company or technology they decide to join will decide the competitive barrier of developers ecology.

To some extent, developer's ecosystem in IoT industry is facing the same situation. IoT developers would also consider some key questions. Which platform covers the largest number of users and communication treaties, produces the most commercial returns and convenient development tools and infrastructure. Whether the platform's technology can lead the trend and be applied in the long run. Platform that can solve the above problems will undoubtedly attract more developers. As developers are becoming increasingly important, more technology companies tend to develop "developer relations", which means to create a dynamic third party developer ecosystem by conducting two-way communication with developers and the project demanders. A healthy and dynamic developer ecosystem lay a solid foundation for the success of IoT platform.

Open platform and open source ecology are particularly important to establish developer relations. For this reason, technology giants have spared no effort in this regard. Microsoft purchased Github for 7.5 billion US dollars and Google was the leading investor of Gitlab with 100 million US dollars, making Gitlab's valuation more than 1 billion US dollars. Tencent Cloud has invested 100 million US dollars into Coding. All these actions aimed to attract more developers into their own sphere of influence.

Warner. Hans, CTO of AWS once expressed his view about developer on AWS summit, "AWS has always been willing to establish a modern framework for software development by collaborating closely with software developers instead of telling client what tools they need." As the world's biggest cloud service provider, AWS has established a close cooperative relation with Tuya, which is a global AI+IoT developer and the first choice for many IoT developers in using cloud services. Besides, Alexa ecosystem developed by Amazon has also contributed to the rapid development of consumption IoT industry.

Starting as an operating system company, Microsoft was once criticized and negatively perceived

by developers due to the non-open source and closed nature of the Windows system. Therefore, it has always attached great importance to grow the developer ecosystem. In addition to acquiring Github, the world's largest code storage website and open source community, Microsoft has also increased its investment in the open source field, which has gradually changed the attitude of the developers toward it in recent years.

AIoT development platforms such as Tuya having been rising for several years, have also dedicated to incubating the developer ecology based on their own characteristics and improved the infrastructure through the long-term promotion of common industry standards and the provision of global cloud services. What's more, it has also continued to optimize the development framework and kits to meet the three major needs of developers including data storage and analysis, device connection management and application development at the same time, and provide comprehensive support from hardware, cloud, OS to SaaS to maximize the convenience of platform tools.

Tech giants are trying to touch developers with affectionate emotions and it is the best reflection of the key role of developers in the IoT ecosystem. For the ecosystem, if the platform can provide open source or open capabilities to solve their pain points, the high-value developers can become core ones through community operation and interaction with developers. The developers will be loyal to and fond of using corporate tools and products. In this way, they can complete development in high quality and become the best spokesperson and communicator of the platform.

In general, the rapidly increasing IoT developers are not only participants and promoters of the new technology era, but also valuable and limited resources. Development platform that can attract the largest number of developer users in non-standardized fields, that is developer ecosystem, can build their own barriers, therefore replicating the success of Apple and Google in the mobile Internet era.

4.2

Open Platform Will Become the Main Driving Force of the Industry

When the AIoT has become the opportunity of the era that is hard to ignore, the enterprise chief intelligence officers begin to take the return on investment (ROI) of entering the AIoT market into consideration. The value of the AIoT platform is that it can centrally manage decentralized and fragmented IoT applications and provide greater flexibility in cross-industry deployment. Choosing a right IoT platform is a key strategy for large and medium-scale enterprises to develop sustainably in the commercial market.

Under the circumstances, the open platform emerges at the right moment. It originated from the open technology platform, and gradually developed into a one-stop development platform covering functional interfaces, development tools, SaaS solutions and market channels after attracting a large number of developers.

The most important role of an open platform is to prevent developers from reinventing the wheel by offering open sources and open techniques, so that enterprises that lack R&D capability or an individual can quickly obtain technical skills. In this way, the open platform improves industry efficiency and cultivates the next industry leader.

What is an Open Platform?

In the internet era, packaging and releasing web services as a series of machine-readable data interfaces for third-party use is called OpenAPI. The platform that provides OpenAPI is known as an open platform. Through the open platform, developers can not only process complicated data interactions, but also use the development platform as an operating system to develop various applications. The AIoT open platform mainly provides technical interfaces and opens standardized technical tools. With the publication of open platform API or function, external developers can quickly acquire platform capabilities without editing the source code of the software system. Many large e-commerce platforms, such as Amazon, Taobao, and Youzan, have adopted this model that merchants could entirely leverage the functions and resources of the platform to set up online shops without developing

by themselves.

The AIoT industry is similar to e-commerce. Taking Tuya Smart's open AIoT cloud development platform as an example, the platform opens up various cloud services including OpenAPI. The services cover general capabilities of core scenarios such as device control, intelligent homes, and smart scenes, and integrate the PaaS capabilities of vertical industry such as intelligent security, intelligent commercial lighting, intelligent community, intelligent hotel and intelligent apartment. Based on Tuya Smart's existing PaaS capabilities in the vertical industry, developers could directly leverage platform resources to establish an intelligent city, intelligent business, and intelligent industry rapidly. In the AIoT industry, diversified user requirements are barely fulfilled by a standard solution of a single company, therefore third-party development is needed. So that's why the developer plays an

important role in AIoT ecosystem. One of the critical factors that Apple and Android surpassed and defeated Nokia, the leader of the feature phone market, and Microsoft, the king of the PC era, in the smartphone era is relying on open source and application stores to gather tons of developers to meet the needs of all kinds of users.

Taking Tuya Smart as an example, in addition to its open technical interfaces, it provides developers with an efficient AI+IoT development platform, allowing them to develop a featured App, which can control intelligent hardware in ten minutes. Besides, developers can directly connect different types and brands of intelligent hardware without bridging different communication protocols based on the fundamental logical layer of Tuya Smart's platform. Among them, the cloud development platform further improves the development efficiency of AIoT developers, not only meeting the top three developer requirements including data storage and analysis, device connection management, and application development, but also providing multi-layer supports such as hardware, cloud, operating system (OS), and Saas, etc..

Types of Participants in Open Platform

According to the attributes of enterprises, there are five major types of enterprises entering into AIoT open platform:

The first is cloud service providers. When the growth of the mobile network slows down and the fad of industrial network surges, these providers hope to extend their network advantages of accumulated techniques, business, and ecosystem to IoT.

Currently, they mainly provide base layer computing resources and application enabling platforms.

The second type is telecom operators, virtual network operators, and communication equipment manufacturers, etc. Its original core business is to connect users. However, these complacent businesses lost the once-in-a-lifetime chance of the mobile network era, putting themselves into "dumb pipe" dilemma. For this type of enterprise, the IoT is a crucial opportunity to get rid of "dumb pipe".

Connection management and application support are the main two services.

The third type is software solution providers focusing on enterprise applications, having expertise in design, production, management, and operation. They have been in the industry for a long time and equipped with rich software development and service experience. Under the fad of the Internet of Everything, they expect to integrate with this new opportunity to provide better service and enhance service efficiency. In this condition, companies transform the industry experience into data models or tools by establishing platforms, and offer application development platform services.

The fourth type is traditional enterprises in a vertical industry. Companies utilize their own understanding and experience of the industry to create a vertical platform. After accumulating sufficient data, data realization is the key point of their deployment. That is essentially different from the IoT companies' model that creates a platform first then collects data later.

The fifth type is start-ups. Since they are optimistic about the IoT future development potential and have software and hardware experience related to industry segmentation selection, some companies choose to leverage past industry experience to build platforms that serve customers. Although they are under pressure to survive, at the current stage lots of start-up businesses are SaaS solution companies instead of stand-alone selling platforms, and their services are extended to some segments that are hard to reach by general-purpose platforms. Hence, these start-ups have unique advantages to survive in the market.

Value Analysis of Open Platform

At the emergence stage of the AIoT industry, a great number of companies chose to build their own platforms until influential platforms were developed. Yet, establishing self-developed platforms has greater technical difficulties, involving hardware, firmware, operating system, data storage, communication channel, cloud service, edge

computing, back-end service, and other techniques, which are hard to bare for many small and medium-sized enterprises.

For small and medium-sized enterprises, bearing greater pressure of revenue and survival, facing lower-than-average net margin and financing difficulties, which directly shorten the average lifespan of these enterprises. The decentralized nature of the industry causes a huge technical gap between entities. Besides, the scale of developers is under the growing phase and still very limited, plus the Siphon Effect of talents from the leading companies, causing self-developed platforms even more difficult to realize for small and medium-sized enterprises.

For large enterprises, the biggest reason why self-developed platforms are not definitely effective is its closeness. The ideal IoT platform has features of massive connection, high availability, high replication, and high degree of standardization, while the reality is that the problems of limited connections, high degree of project customization, and insufficient degree of standardization still exist. Those problems affect user experience and hinder the scale-up development of the AIoT industry.

In addition to technical issues, even though the hardware companies claim that their self-developed IoT platform is an open ecosystem, the potential competitive pressure still exists, including competition between vendors of the same type of platform, and competition between platform vendors and clients who might build a self-developed platform in the future. Besides, homogeneity in IoT techniques would cause the problem of reinventing the wheel and the capabilities provided by each platform are similar. Eventually, the platforms need to rely on the ecosystem to form competitive barriers.

Now the industry has two deployment strategies under this circumstance. One is to keep implementing the “closed” strategy like the iOS system. Enterprises set key points by deploying IoT and expand to all aspects to reach a closed-loop IoT. The obvious feature of the strategy is that

the enterprise fully controls the production rights of all developers under its IoT platform to develop products that fully comply with its development strategy. The benefit of this strategy is that the enterprise can improve user experience greatly, and improve customer stickiness, and customer loyalty through a “full-pack of intelligent hardware”. However, the strategy has low deployment efficiency, so it cannot cover all relevant IoT fields rapidly.

The other one is the “open” strategy like the Android system. The system opens up its platform to let various hardware vendors join with no charge and allow users to control intelligent devices through the portal provided by the platform. The benefit of this strategy is that the enterprise can deploy IoT system rapidly at a low cost to form an ecosystem. In December 2019, Amazon, Google, and Apple jointly announced a working group alliance called “Connected Home over IP (CHIP)” to develop and create an internet protocol smart home standard. The goal of CHIP is to increase compatibility and coordination among smart home devices and provide a better user experience. For developers, the standard simplifies the development process and reduces the cost. Manufacturers only need to add the new protocol on top of the original structure to adapt voice services of multiple platforms at once instead of adapting one by one.

Although the emergence of CHIP makes it possible to break the barrier of communication protocol, CHIP is an alliance among industry leaders instead of a platform. Either for consumers or manufacturers, a third-party is needed to integrate cross-brand and cross-category smart products. In the early years, the role was played by a system integrator which customized smart home appliances from different brands and combined them into a whole-house smart system to provide limited solutions for end-users. Nowadays, third-party open platforms emerge in the upstream industry chain, developing rapidly based on its neutral property. In addition to provide functional interfaces and development tools, the platforms have a critical

contribution to break the barriers among different brands and communication protocols.

Tuya Smart is one of the typical representatives of third-party open platforms. It has explicit platform positioning “Neutral, Open and Third-party” since its establishment. Tuya Smart launched “Powered by Tuya (PBT)” ecosystem a few years ago and popularized in the industry. PBT is an interconnected smart sign. The products with the sign can be controlled by a unified App that can also control other products of different brands and categories rather than using multiple Apps of different brands. The reason why PBT products with different brands can be controlled by the same App is that they are connected to Tuya Cloud. One of the reasons why the PBT product ecosystem grows so fast is that smart home devices with any communication protocol can be connected to Tuya Cloud. With the gradual expansion of the influence of

the open platform, we can gather more industry resources and realize a co-creation ecosystem.

After boosting the implementation of industry standards, the industry ecosystem can even be established. Different roles in the open platform, including hardware manufactures, module manufacturers, platforms providers, software developers, and system integrators, jointly promote the AIoT industry to accelerate commercialization and scale development.

The open platform provides base layer operating system, basic development environment and tools, cloud service resources, and market channels, and allows related enterprises who involved in the ecosystem to leverage its resources to enrich their products and gain more chances to promotion. In this way, it will facilitate the progression of the overall industry and open platforms will become the main driving force of the industry.

4.3

Convergence of Cutting-Edge Technologies and IoT

In the era of internet of intelligence, technologies are either developed in series, evolved complementarily, or integrated with pioneer technique to commercialized industry, rather than developed independently. We believe that the IoT products in the future will have a complex system that keeps incorporating revolutionary technologies like 5G, Internet of Things (IoT), Artificial Intelligence (AI), Cloud Computing, Big Data, etc. Nowadays emerging infrastructures such as AI + IoT = AIoT and Blockchain+ IoT = BoT accomplish functions that standalone IoT can't achieve.

In this chapter, we will focus on converging leading technologies and IoT as well as their commercialized application.

1. Multimodal Deep Learning is Breaking through with Development of AIoT

It's obvious that AI enables IoT intelligence, and there are three aspects of AIoT: data, algorithm and computing power. Data is composed of multimodal heterogeneous data from IoT nodes. In terms of algorithm, multimodal deep learning is gradually mature.

Modality is a biological concept proposed by Helmholtz, a German physiologist. Creatures receive information from their sensory organs and experience. For example, humans have visual and auditory modalities.

Now AI is well-developed in recognizing a single text, image, or voice, and is more advanced at

recognizing voiceprint, fingerprint, or iris. This approach that uses a single sensor and a single algorithm to solve a task is called "single modality". However, the situation becomes more complicated when AI needs to deal with more than two types of modality data source, namely "multimodal". How to do integrated modeling from multimodal data becomes an issue, which we called "heterogeneous gap". At the current stage, the computing system is far less accurate than the human brain in processing multimodal data, nevertheless problems such as mapping quality, alignment compatibility and noise interference in multimodal deep learning have been progressively addressed, and some simple multimodal applications are arising.

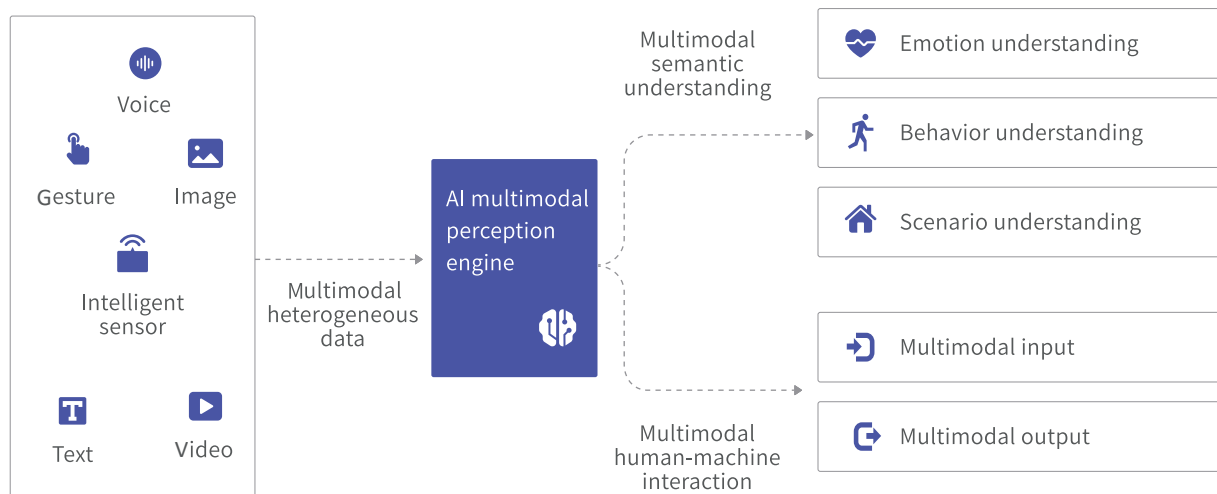


Fig. 1: Multimodal data processed by AI multimodal perceptual technique

IoT devices can collect three types of heterogeneous data sources: 1. voice interaction: semantic understanding, voice command, etc. 2. machine vision: human faces, shapes, environmental objects, etc. 3. multi-dimensional sensor: temperature, speed, infrared signal, etc. With the integration of the three perceptions, the IoT system can utilize vision, audition and other sensory organs (gustation, tactile sense, and emotional understanding) to better serve users rather than just recognize objects and do voice interaction.

There are some preliminary applications of

convergence of multimodal perception and IoT in an enclosed space. For instance, a smart screen device could adjust/control brightness, volume and content through voice, vision and other sensors to select proper content for minors. Starting from temperature and humidity sensor, vision and voice command, a smart air conditioner could provide a temperature control solution based on the number of people and space layout. At a virtual conference, the program can do camera auto-tracking and facial recognition as well as auto noise reduction according to the speaker's voice and image data.

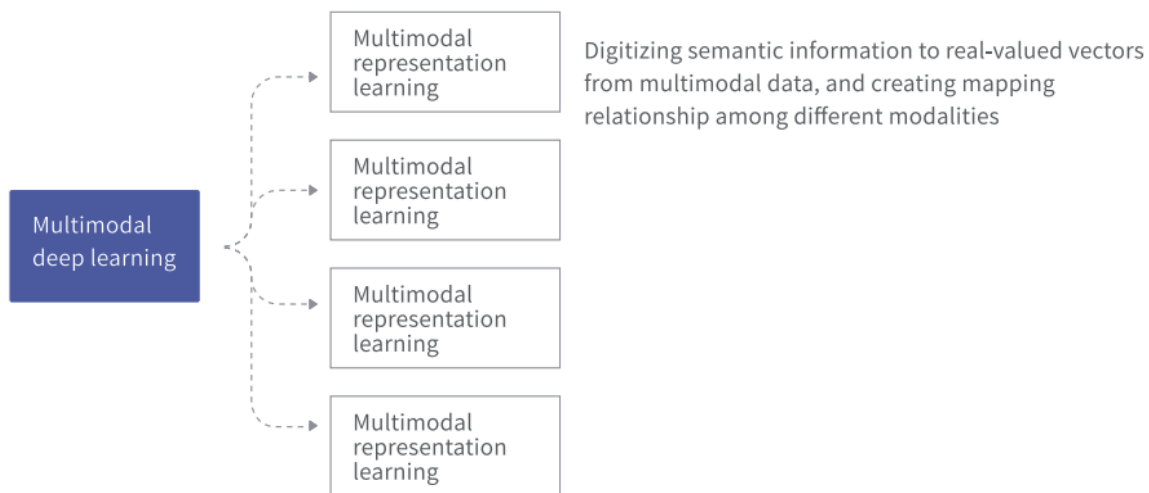


Fig.2: Research directions of multimodal deep learning

2. Convergence of Blockchain and IoT to Solve IoT Security and Trust Issues

Blockchain is a leading-edge application of decentralized data storage, peer-to-peer network, consensus protocol and cryptographic algorithms in computer science technology. It is equipped with features such as decentralization, transparency, openness, autonomy, immutability and anonymity. Major countries around the globe place emphasis on Blockchain. The Central Political Bureau of the Communist Party of China held the 18th workshop on progression and trends of blockchain on October 24th, 2019. President Xi emphasized that blockchain is a core technology that leads to innovation and boosts technology development

as well as industrial transformation. According to the "Worldwide Semiannual Blockchain Spending Guide" published by IDC in November 2019, the United States is by far the biggest blockchain market, followed by Western Europe and China. To apply blockchain, which is a virtual digital technology, to the real economy, the convergence of IoT technology is inevitable. The current centralized trust management mechanism of the IoT network would benefit from a decentralized approach of blockchain to resolve security and trust issues. It can be said that blockchain and IoT need and strengthen each other, the applications such as supply chain management, industrial network and IoT payment are role models of implementing virtual

to reality to accelerate industry development. Data is the key to the convergence of blockchain and IoT, firsthand data source created from IoT and blockchain is a trusted IoT data pool. At present, the Internet of Things network is based on centralized trust management data, and data privacy protection, traceability, security and credibility are all facing challenges. Blockchain technology starts from replacing the traditional centralized data storage model to solve the problem of data being vulnerable to be attacked and tampered. At the same time, the blockchain platform also provides data transactions and data confirmation services.

In addition, decentralized coordination between IoT devices enables future growth of IoT device accesses to provide “centralized services”, which would bring cost and capacity challenges to the fore. Now, all parties are exploring how decentralized blockchain IoT (BoT) coordinately supports IoT entities such as IoT server, gateway and terminal. By allocating one or more blockchain IoT nodes (BoT nodes) and decentralized applications (dAPP) on an IoT entity, the IoT entity is connected to the BoT nodes through dAPP to achieve coordination. Besides, it achieves digital identity authentication and adds the identity to the chain in the IoT world. Digital identity is a unique numeric code that is condensed by real identity information of a user and the device, for query, identification

and authentication. Based on the cryptographic technique and the secure algorithm of blockchain, the digital identity authentication within the IoT environment becomes more efficient and secure. Every digital identity of a user or a device will keep receiving reliable authentication service after being certified by a professional institute and added into the chain.

The last part is the trust of network collaboration. At the current stage, IoT is majorly applied by telecom carriers and enterprise internal network, and among networks, there are isolated data islands. It is difficult to establish an effective trust mechanism when it comes to collaborating among multiple carriers and organizations. Yet features of blockchain such as distributed framework and equal participants will offer an opportunity to establish a low-cost trust mechanism to equally benefit from data as a business asset.

With regard to the application of BoT, we notice that not only conventional IoT fields, such as infrastructure of smart city (transportation, municipal administration and intelligent utilities), intelligent manufacturing, environmental monitoring and internet of vehicle are powered by blockchain to enhance security and data reliability, but also supply chain finance, payment and health care are deeply penetrated by BoT application.

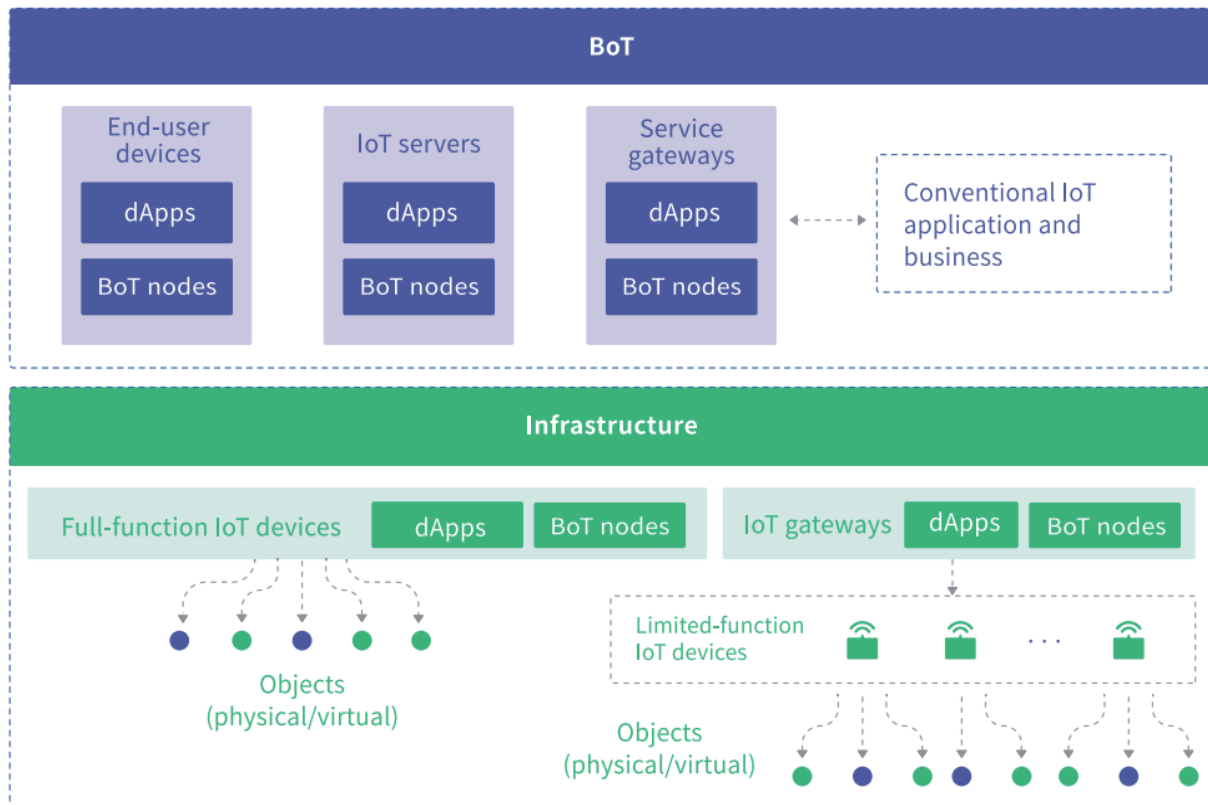


Fig.3: BoT Fundamental framework

Application and Development of IoT + Blockchain white paper, China Communications Standards Association, 2019

3. Digital Twin Utilizes IoT to Create a Virtual Replica in the Real World

Digital twin refers to a virtual copy of the physical world by using sensor updates, physical models and fleet history integrated with multi-science, multiphysics, multiscale to simulate reality. It is obvious that there are two sides to the perceptual world: the digital twin represents virtual and simulation technology, while IoT stands for physical techniques. If IoT is the first step of perceiving the

real world, then the digital twin is the process of digitalizing the real world.

Although the concept of digital twin was introduced by Professor Michael Grieves of the University of Michigan in 2002, the technique has only been applied on a small scale for a long time. To expand the scope of digital twin applications, it must be supported by real-world medium and massive corresponding techniques. We discovered that with the gradual maturity of base layer complementary

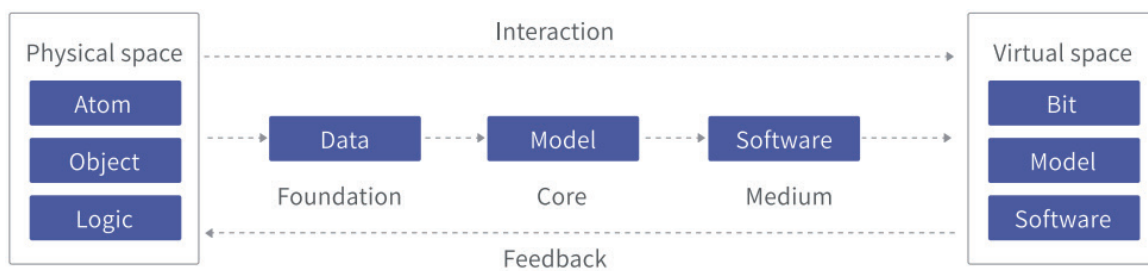


Fig.4 : BoT Fundamental framework

technique like IoT and corresponding techniques such as cloud computing, big data, IoT and AI, in-depth development and larger-scale application of digital twin have begun to accelerate.

Digital twin has been selected as “Gartner Top 10 Strategic Technology Trends” for three consecutive years, revealing its huge potential. According to the Gartner survey in February 2019, among the organizations that have already implemented IoT 13 % of respondents claim to already use digital twin and 62% are either in the process of establishing the technology. Over two-thirds of companies that have implemented IoT will have deployed digital twin

within the next three years. People in the industry keep positive attitude toward that digital twin would leverage IoT medium to accomplish industry IoT and digital transformation from 2020 to 2022.

What digital twin can reinforce IoT, a base layer complementary technique, is that it could establish analysis and prediction of the whole picture based on limited data and information by modeling and simulating the real world in a virtual space. Digital twin has greatly improved the complexity and operational efficiency of IoT management platform and ecosystem, as well as increasing the efficiency of IoT device deployment.

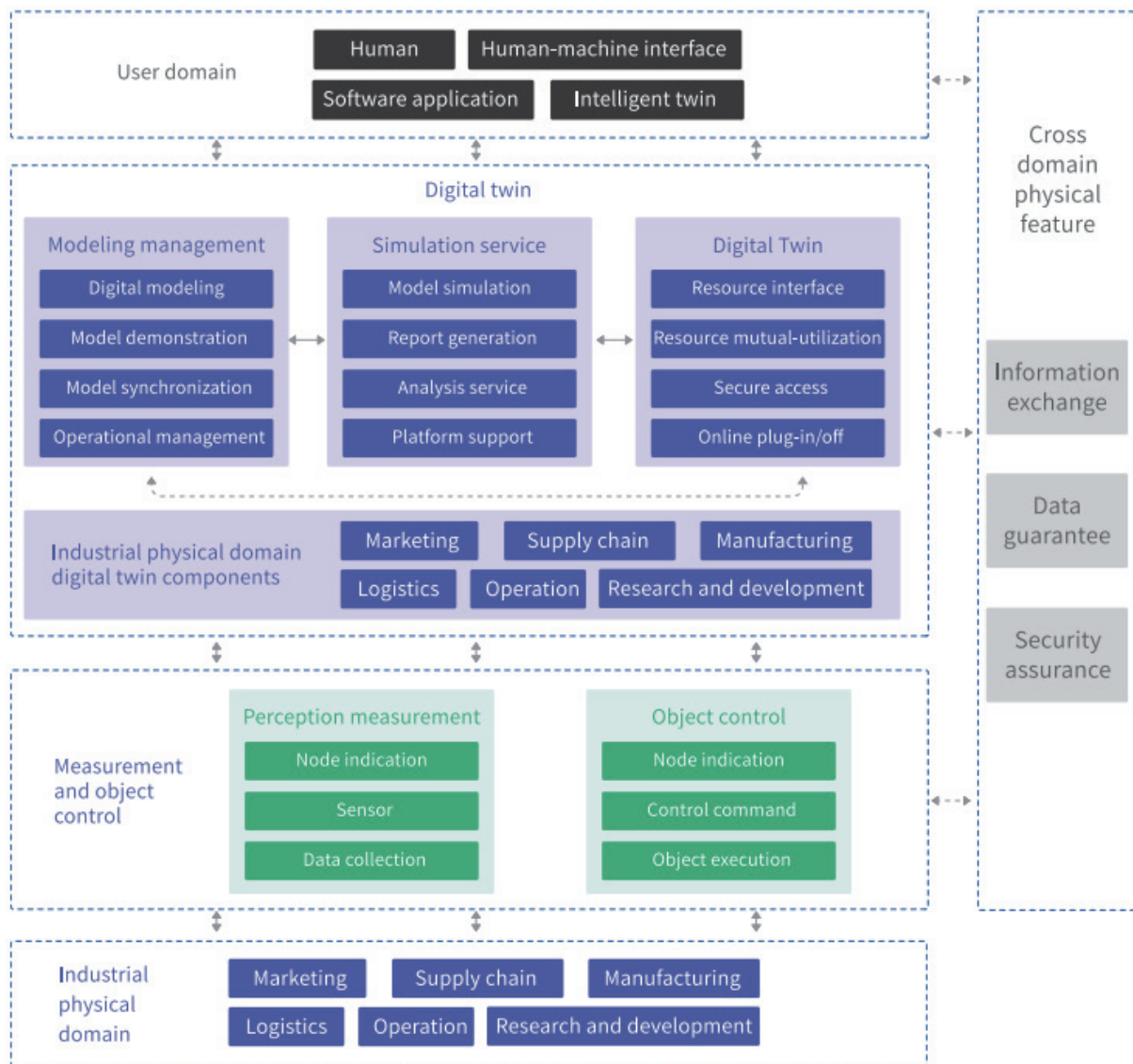


Fig.5 : Digital twin industrial system framework
Digital twin technology white paper, Digital Twin Laboratory, September 2019

In terms of application, the digital twin concept is first applied in manufacturing and IoT application in manufacturing is also in a leading position.

Hence, the best current practice of digital twin and IoT applications is in the manufacturing industry, for example, product development and design, intelligent manufacturing and additive manufacturing.

In addition to the manufacturing industry, the management efficiency issue of urban governance (intelligent campus, intelligent transportation and intelligent city) and business services (marketing, logistics and after-sales service) will be addressed accordingly. Especially in improving the overall operational efficiency of managing three-dimensional urban space, digital twin city will gradually mature with the establishment of basic IoT sensing networks and communication networks in urban space. Once a real-time connection between the digital world and the real world has been established, the physical urban life cycle will be digitalized, modeled and visualized for the governor. Municipal administration, transportation, security, public affairs, etc. will be featured with timeliness of sensor monitoring, interactivity of information transmission, scientificity of development policies and intelligent control and management.

4. Brain-computer Interface May Profoundly Change the Relationship between Human and Machine

Brain-computer Interface is a pathway between the human brain and external devices such as intelligent hardware and network, it enables signals from the brain to directly interact with a computer and composes a bidirectional closed-loop control. The brain sends a command to control an external device and the external device gives feedback to the brain, which allows the brain to adjust control strategy in real-time to maintain system stability. There are four steps to achieve the consequence: signal collection, decoding, encoding and feedback. There are two types of Brain-computer interface, invasive and non-invasive, depending on how the information was collected. Invasive brain-computer interface implants electrode array into the brain by surgery to detect neuronal activity and encode the relevant information. Non-invasive brain-computer interface uses an external device in contact with the scalp to detect signals of the brain. In 2020, both approaches have achieved major breakthroughs as a result of the efforts that academia and technology companies have made.

Neuralink is the representative in the field of invasive brain-computer interface, and the company

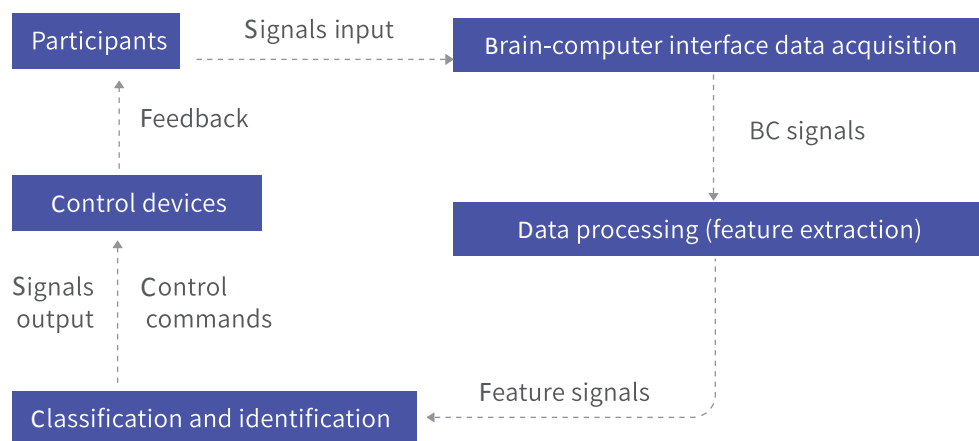


Fig.6 : Basic structure of brain-computer interface

revealed the latest generation of brain-computer interface product: a coin-sized chip that can be implanted into the brain and a precision robot to surgically install the chip underneath the skull. The chip can read brain activity and pulse, and also transmit the data wirelessly. The surgical robot makes the implanting process much easier and safer.

In the non-invasive brain-computer interface field, BrainCo showcased the human brain intelligent operating system (Brain OS) and two pre-research products at Harvard University on August 27, 2020. There is no need to implant a chip. Participants only put on a wearable device so it can collect and process electroencephalography (EEG) and electromyography (EMG). Regarding the two pre-research products, one is to use brain wave imaging technology to restore the picture seen by the human eye or imagined in the brain, the other one is using an EMG control system to collect EMG signals of the forearm muscle group to process and determine participant's intention.

The ultimate goal of the brain-computer interface is to enhance human capability. It is possible to integrate signals from human brain with IoT network devices to achieve a new generation of Brain-machine IoT (BMIoT) through a brain-machine interface (BMI) whether it is an invasive or non-invasive brain-computer interface. Human beings might be able to interact with intelligent devices through their minds, that would tremendously alter the relationship among users, smart home, vehicle system and smartphones. Brain controlling everything will no longer be a scene in science fiction films.

5. Quantum Technology Has the Potential to Profoundly Impact IoT in Terms of Computing Power and Security Encryption But Has Greater Uncertainty

On October 17th, 2020, The Central Political Bureau of the Communist Party of China held the 24th workshop on research and prospect of quantum technology to emphasize the importance

Institution						
Scale	72 (22) qubits	5 (5) qubits	50 (20) qubits	49 (8) qubits	4 (4) qubits	50 (20) qubits
	99%	99%	96%	96%	99%	95%
	Advance in micro fabrication, quantum software and hardware; better technological skills	Advance in micro fabrication, quantum software and hardware; better technological skills	Advance in micro fabrication, quantum software and hardware	Advance in micro fabrication, quantum software and hardware	Advance in micro fabrication, quantum software and hardware; focus on bosonic qubits	Advance in micro fabrication, quantum software and hardware

Fig7: Superconducting quantum computing current status
Data source: University of Science and Technology of China, July 2019

and urgency of quantum development and reinforce its strategic planning and system layout.

There are three aspects of quantum technology: quantum computing, quantum communication and quantum measurement. Among them, quantum communication exploits the quantum superposition state or quantum entanglement effect of microscopic particles for information or key transmission, which enables two main methods: quantum teleportation and quantum key distribution. Quantum computing is the most challenging goal of quantum technology, and it has been deemed as the top point of the next generation of the information industry.

Quantum computing is the core development of next-generation computation to improve computing power when Moore's Law is about to fail. Quantum computing uses a quantum qubit as a basic computing unit and uses physical properties such as quantum superposition states and entangled states to achieve an exponential increase in computing power.

To implement quantum computing, quantum computers and quantum algorithms are the two most important parts. In terms of quantum computers, Google, IBM, Intel and other industrial companies are actively engaged in joint researches on key technologies with academic institutes, with the main focus on superconducting quantum computing.

However, the commercialization of superconducting quantum computers still has a long way to go.

It should be noted that although the computational speed of quantum computers is faster than classical computers theoretically, it is fundamentally different from classical computers in terms of logic and readout methods, thus specific algorithms are needed to realize the logical operations.

While the majority of the computational problems have not had superior quantum algorithms than their classical counterparts, theorists have developed efficient quantum algorithms for some specific problems, such as prime factor decomposition (Shor algorithm), disordered search (Grover algorithm), and solving special linear equations within logarithmic complexity (HHL algorithm).

Particularly, the HHL algorithm not only satisfies the computational requirements in AI such as fitting, inference and optimization but simply requires a small-scale quantum computer with 50-100 qubits to demonstrate its supremacy. Hence, it has been considered as a key point to break through the bottleneck of AI computing power utilizing quantum computing.

At the current stage, the convergence of quantum computing and IoT has not been studied much yet. The promising direction is leveraging quantum computing to achieve the computational acceleration of specific AIoT algorithms.

4.3

The Widespread Adoption of the B2B Industrial Internet of Things (IIoT)

The Internet of Things (IoT) is a typical niche market with the feature of fragmentation. As an empowering technology, it almost has been tested and adopted in various industries.

Different from the rapid development of the Consumer Internet of Things (CIoT), the IIoT is still exploring the large-scale application although it started earlier. The industry standards of Internet of things are not unified, and the integration, accuracy and cost performance of the overall solution need to be improved, which also restricts the popularization of IIoT to some extent.

Generally speaking, on the one hand, there is an apparent negative correlation between economic values generated by the IoT and “population density” within the application scope. In these specific areas with “low population density”, if markets are mature, general volume and price insensitive, the IIoT is easier to popularize.

On the other hand, the widespread adoption of the IIoT in commerce is related to whether its clients have the willingness and ability to pay at the same time. As for clients’ demands such as compliance, risk avoidance, efficiency improvement and cost reduction, the IIoT is expected to play an important role in asset management and hedging.

In summary, in the Chinese market, the willingness of paying for IoT services is based on demands in this order: compliance→risk avoidance→increased efficiency→cost reduction. The development path of applying new technologies in China is usually from serving governments(G), businesses(B) to customers(C). Industries such as civil affair management, energy (including electricity and fossil fuels), traffic-related fields (including vehicles, transportation and logistics), real estate, communications (including communication devices and telecommunications companies) have the stronger ability to pay.

1. The Negative Correlation Between the Economic Values of the IIoT and “Population Density” in Specific Areas

Common communication networks require high population density, but it is not the case for the application of the IoT. Due to the low population density in vast territories, clients always tend to use the IoT to reduce time and economic cost caused by traffic. Or they hope to realize self-service operations to reduce business and labor costs by decreasing unstable influences from migration.

Taking China as an example, common communication networks serve 99% of the

population within a relatively small territory (around 30% of the territory based on relevant data). The remaining territory and 1% of the population are the important reason why clients are willing to pay. Due to the low returns of investment, companies are not willing to offer services to the remaining territory and the 1% of population with low prices. In China, governments and state-owned enterprises pay for services offered to these users. In theory, it is a better solution to use the IoT to serve them.

Progress of Newly-Built 3G/4G Base Stations by China's Three

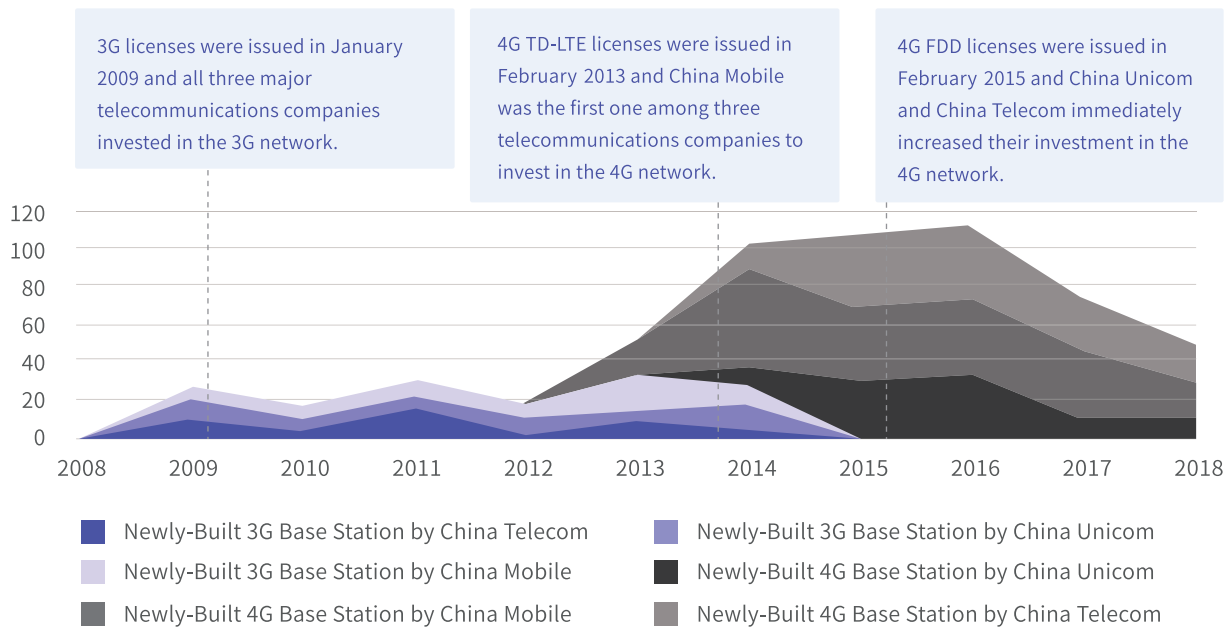
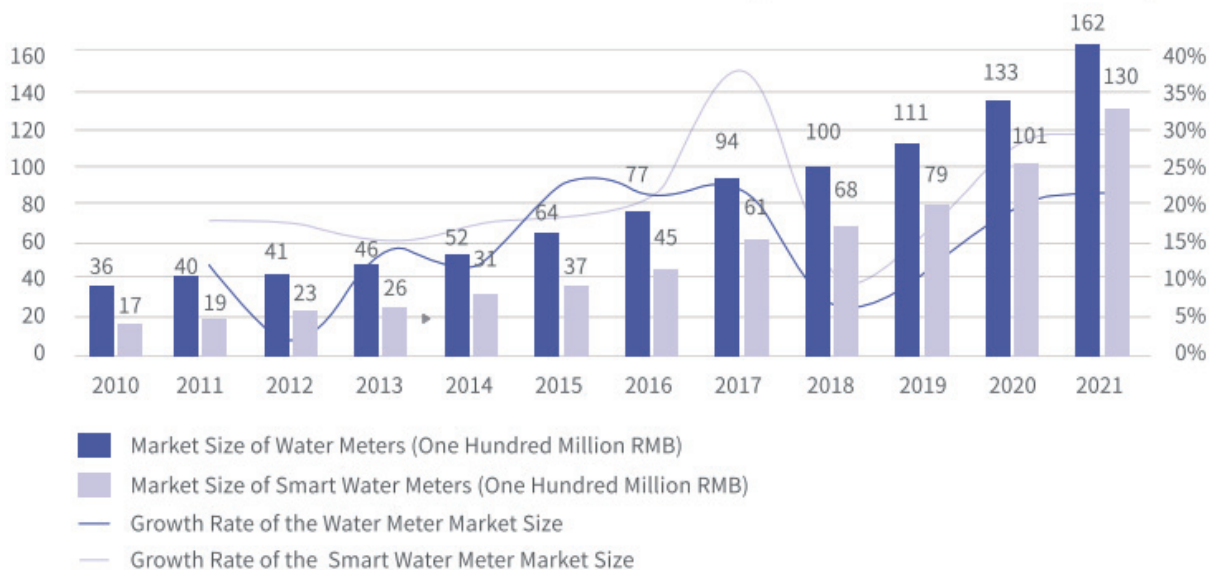


Diagram1: Progress of Newly-built 3G/4G Base Stations by China's Three
Source: Wind, Guosen Securities Economic Research Institute

Taking the smart water meter industry as an example that has been rapidly promoted in recent years. According to calculation, the costs of manual water

meter reading in many regions including Shenzhen are lower than that of full application of smart water meters. There is a negative correlation between

Calculation of The Market Size of Water Meters in China (Unit: One Hundred Million RMB)



Growth Rate of the Smart Water Meter Market Size
Diagram Source: Special Report on the IoT Industry: Competing Tracks for the IoT Industry Can be Reallocated

costs of manual water meter reading and population density. Instead, in some remote mountainous areas with low population density, the IoT generates more direct economic values. Taking the project of “Internet Plus Village Water Supply” in Pengyang County in Ningxia as an example in 2018, it has built around 40,000 IoT testing devices through three years, covering 7000 km of water supply networks in the whole county. Finally, this project has achieved a reduction of 50% in management, a decline of 1.2 million yuan in annual costs of human labor, a drop of 50% in operation and maintenance costs, and a decrease in the county pipe network leakage rate from 40% to 20%.

2. The Willingness of Paying for IoT Services: Compliance > Risk Avoidance > Increased Efficiency > Cost Reduction

In recent years, many IoT application cases take “cost reduction and efficiency improvement” and “income increasing and expenditure decreasing” as their marketing points. However, in practical applications, the payment for compliance and risk avoidance is likely to be generally higher than that for cost reduction and efficiency improvement. Compliance includes direct or indirect compliance with government regulations and internal rules of organizations. It is easier to understand the direct obedience. For example, some government agencies require smoke detectors to be internet-linked. Also, in some big companies, only some senior staff have the access to designated servers. As for the indirect obedience, it can be commonly seen that some companies in the industry manage themselves through some IoT technologies, and other companies have to follow the compliance. Risk avoidance mainly includes liability hedging and asset hedging. As for liability hedging, for example, shopping malls need to make sure that water and air are not poisonous and electric power and heating companies need to guarantee people’s safety when people use their services. Generally speaking, these accidents are often caused by external reasons. As for asset hedging, for example, companies need to

prevent the theft from their important assets and protect their IT systems. Costs caused by these accidents are usually higher than those of using a new technology or service. Also, these accidents will have a significantly negative impact on the career of the responsible person.

In the practical business environment, compliance and risk avoidance can be converted. Risk avoidance driven by negative incidents, will be required to convert into compliance when negative impact becomes large enough.

“Income increasing and expenditure decreasing” and “cost reduction and efficiency improvement” can only be achieved after completing the application of the IoT, therefore, it takes a relatively high amount of time and energy to persuade customers to accept the IoT. On the whole, clients in a mature, large and price insensitive market, are more willing to use the IoT to increase revenue, decrease expenditure, and improve efficiency. As mentioned above, in low population density areas or scenarios, the IoT is more likely to play the role of “reducing costs and increasing efficiency”, especially the latter role. According to actual orders, most of big companies have urgent demands in risk avoidance and internal compliance and they prefer to pay for the customized solutions in the current Chinese market. It is possible to increase revenue, decrease expenditure, and improve efficiency through customized products and services, or through relatively standard industry solutions.

3. Several Fields of the Widespread Commercial Application of the IoT in Vertical Markets

From an abstract perspective, the application fields of the IoT include asset management, remote management and predictive maintenance.

Asset Management

Assets consist of tangible and intangible possessions and resources that are important to the business development, including large-

scale engineering equipment in construction, fleets of the logistics companies, pipelines of oil and gas companies, transmission lines of electric companies, server chips of operators rooms and goods of retail companies. Almost all companies will invest a certain amount of human, material and financial resources in asset management, but through the IoT, they can achieve more efficient inspections of safety and compliance, improve management efficiency and reduce management expenses. Generally speaking, there appears to be a close relation between the payment ability of customers and the prices of assets.

Remote Management

The objects of remote management include both assets and personnel. In the movement scenario is the remote management for personnel required and in low population density areas is the remote management for assets necessary. For example, it is necessary for the logistics industry to use remote management of drivers to avoid driving fatigue and traffic accidents. Taking the IoT solutions to power distribution as an example, managing equipment remotely with the IoT approach can accurately locate malfunctions in the first time without requiring repairs.

Predictive Maintenance

The shutdown of important equipment can cause huge economic losses to enterprises. Therefore, predictive maintenance technology has been used in these industries and scenarios for a long time by using relevant sensors, which aims at examining the real-time performance and status of equipment and understanding the functions of equipment so as to offer corresponding maintenance solutions in time. In recent years, predictive maintenance systems have been adopted in more fields apart from aviation and rail traffic.

4. Exploration of the Widespread Commercial Application by the IoT in Vertical Markets

As for the actual payment capacity, industries such as government affair management, energy (including electricity and fossil fuels), traffic-related fields (including vehicles, transportation and logistics), infrastructure and real estate, communications (including communication devices and operators) have the stronger ability to pay and serve as an important driving force in the innovation and application of the IoT.

Government Affair Management

As for smart government affair management, the commercial scale of internet-linked cameras has been developing fastest. According to Sunrise Big Data, in 2019, the number of global security cameras reached to 400 million, which is expected to be 550 million in 2020 and 800 million in 2021. As for intelligent fire protection, smoke alarms need to be internet-linked. In May 2017, the Fire Department of the Ministry of Public Safety and Security proposed that “If the automatic fire alarm system is installed, it shall be connected with the remote monitoring system of urban fire protection”. In cities with relatively high GDP, there are other typical IoT projects such as intelligent traffic (intelligent parking lots and smart traffic management), public utilities (intelligent lighting) and environmental surveillance.

Energy

The energy field is one of the main forces to explore the large-scale application of the IoT, which is applied in almost all business links. With regard to the electricity generation, some companies has been trying to realize predictive maintenance by means of the IoT in recent years and several projects concerning has been launched in 2020. As for the electricity transmission, smart cameras have been widely used in the power system, such as real-time monitoring and alarm for pipeline leakage. As for the electricity consumption, it has been showed that 490 million smart electricity meters have been installed in current electricity grids and some of them can interact with the external devices.

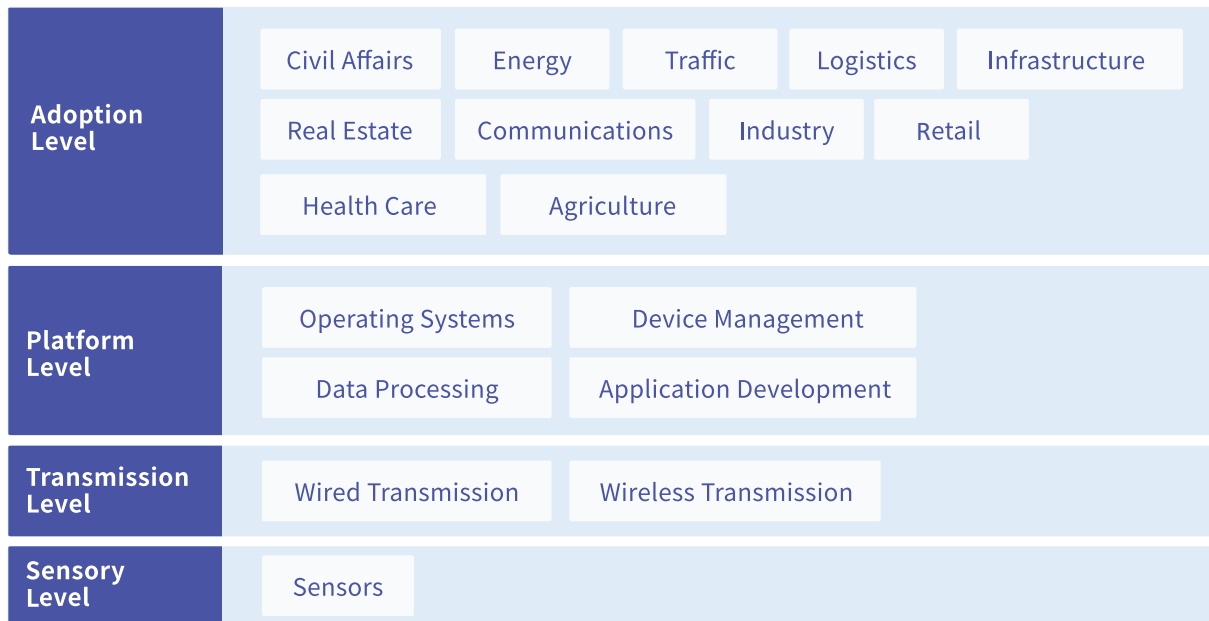
The new energy charging pile will also be equipped with the communication function, which will be the main force of application increment in the IoT in the future.

Traffic-related Fields

In the traffic-related fields, the IoT is typically applied in asset management and remote management. Asset management focuses on managing the operation status of transportation vehicles and remote management focuses on monitoring and providing services for drivers, together to achieve the risk avoidance for both asset and personnel, efficiency improvement, cost reduction, etc. The IoT has been used for asset management for

a long time. For example, predictive maintenance is typically used for airplane engines and the high-speed railway.

Freight is a typical example of the remote management application. Data shows that there are more than 10 million freight vehicles and 30 million transporters in China. The number of accidents in the Chinese road freight industry is 3.7 per million km, which is around 37 times that of the United States. With the application of the IoT, the traffic on the road can be monitored by ADAS cameras, which can detect the dangerous driving behavior of drivers. In future, with the widespread use of V2X Internet of vehicles (IoV), traffic-related fields will be the most potential market of the IoT.



Infrastructure and Real Estate

The IoT has been applied in the infrastructure field for many years. For example, there are 200 to 300 bridges in China equipped with IoT sensors to monitor their conditions, with costs ranging from 1 million to 10 million yuan. The Humen Pearl River Bridge has attracted much attention this year. At the beginning of its design, GPS displacement, strain real-time, long-term deformation, overload and other monitoring systems have been added to monitor the bridge safety.

As for real estate construction, in 2018, the number of functional elevators in China reached to 6.2783 million. More elevators have been linked to the IoT, which has laid a foundation for businesses such as elevator media and advertisement, indoor delivery by robots and elevator insurance. Meanwhile, the number of smart community has been 164,400 with 790 million urban population in China. In 2020, the bidding and procurement of smart communities are gradually increasing with the joint promotion of local governments, developers and properties. In the

field of commercial real estate, IoT companies offer energy-saving solutions to keep winning clients.

Industry

In fact, In addition to the above fields, the IoT has been used most widely in the industrial field. The field hopes that the detection and control solutions based on the IoT can further strengthen predictive maintenance to improve machine operation efficiency and reduce operation downtime, so as to reduce costs and increase efficiency. However, startups in the IoT field usually get revenues of around tens of millions yuan and the growth rate of the annual revenues is 2-3 times. Many enterprises are still in the loss, and a few companies' income level is more than 100 million yuan. The Textile IoT has attracted lots of investment in recent years, but it is not sure the amount of return investors can get from their investment.

Retail

The retail sector, being highly expected by the IoT, hope to improve the cost-effectiveness and customer experience in stores by means of the IoT. Lots of large major chain supermarkets have used digital labels. Although vending machines are popular as the new retail, few companies in the industry chain are making money. The retail

industry has low profit rate, so it is relatively sensitive to prices. That means it is not easy to achieve a wide application of the IoT in a short term. With the IoT, the retail companies can record customers' preference and create a data funnel similar to online shopping, which depends on optimizing the input-output ratio of products and services of the IoT.

The IIoT is definitely valuable. Over the past several years, the application of RFID and digital labels have gained the real intelligentization in the retail industry for the first time.

However, the wide application of the IIoT still faces some challenges. There is a negative correlation between the cost efficiency of the IIoT and population density. The IIoT is not cost-effective in the areas with low population density and in this case, governments and non-profit organizations will pay for IIoT services. In the unmanned or less humanized scenarios, the marketing points of cost reduction and efficiency improvement are not attractive to clients because low-cost human labor is sufficient in labor markets under the background of global migration. Therefore, IIoT companies need to discover more application scenarios with client' willingness and capacity in payment into consideration.

4.5

Industrial Internet Platform Empowers Manufacturing Upgrading

Overall Situation of Industrial Internet Platform

In the past three decades, the global Internet industry has been growing exponentially, giving rise to a number of tech giants with high market value, such as Microsoft, Amazon, Facebook, Google, Alibaba, and Tencent. Currently, as traditional industrial manufacturing is plagued by rising costs and diminishing margins which calls for urgent transformation of the entire industry, the development of Internet is entering a new stage - the industrial Internet.

International giants led by GE, Siemens, SAP, PTC have joined the race with different strategies, using their edges in technology and products to capture territory in the battle of industrial transformation. Chinese companies such as Haier, Sany Heavy Industry, China Aerospace Science and Industry Corporation, Foxconn, Xuzhou Construction Machinery Group are also taking actions to follow the trend, embarking on a new journey of industrial digitalization and intellectualization. Ten “cross-industry and cross-sector” platforms have emerged

as a result of their efforts.

Under the leadership of these leading companies, the main forces of various subdivision fields also continuously participate in the transformation process, playing a part as the precious “third pole” in industrial Internet.

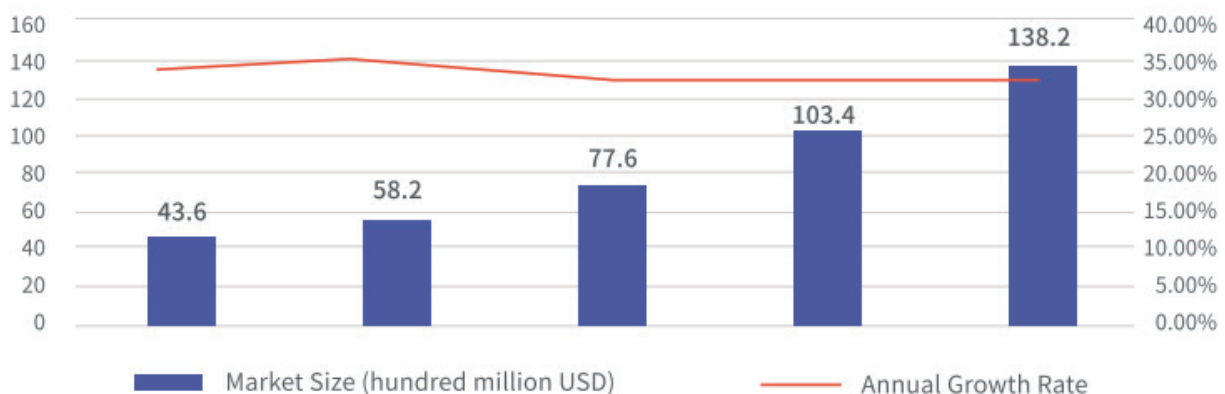
The global industrial Internet platform market continues to show rapid growth. According to MarketsandMarkets, the world's second largest market research institution, the global industrial Internet platform was valued at over USD 4.36 billion in 2019. Driven by preferential policies and market forces that accelerate materializing application scenarios of industrial Internet platform, its market value is expected to reach USD 13.82 billion in 2023, with a compound annual growth rate of 33.4% from 2019 to 2023.

Nevertheless, right now, industrial internet platform is still in the early stage of development, and it has a long way to go before it reaches maturity.

Such considerable market size and opportunities will definitely attract more players from various industries. As the bond among industrial total factors, total value chain and total life cycle, how does industrial Internet coordinate industrial chains, allocate resources, reduce costs, and predict future changes through insight?

As a “new industrial base”, the industrial Internet platform is the top priority of the industrial Internet

Figure 1. Market Size and Annual Growth Rate of Global Industrial Internet Platform



Source: Compiled by Chinese Institute of Electronics

industry by connecting equipment and applications. According to the latest data of 2020 from China Academy of Industrial Internet, by June 2020, China has over 70 industrial Internet platforms with industrial and regional influence, with 40 million sets of equipment connected to the network; the number of industrial APPs has exceeded 250,000; in total, industrial Internet platforms have served nearly 400,000 industrial enterprises.

At the same time, China's "new infrastructure" projects also add momentum to the development of industrial Internet, making it a popular field for innovation and entrepreneurship, and promoting its in-depth integration with various industries. So far, industrial Internet has been applied in multiple industries such as home appliance and 3C, automobile, petrochemical, iron and steel, clothing, machinery, etc. New models and forms of business are constantly coming up, including network-based collaborative manufacturing, management and decision optimization, remote O&M, mass customization, with the goal of cutting costs, improving efficiency and optimizing industrial chain. When we trace its origin, we can find that the idea of industrial Internet originally originated in the United States, Germany and other western countries, where it is more often known as the Industrial Internet of Things, and the connectivity of devices and equipment is emphasized.

What's different is that in the Chinese context, "industrial Internet" has wider connotations. It includes industrial mechanism and knowledge graph, focuses more on the service side of industry, and sets the collaboration of industrial chains and the creation of industrial ecosystem as the goal. At present, it is thriving in China with the nation's unique institutional advantages. Moreover, the COVID-19 epidemic in 2020 has inspired more enterprises to explore new paths of promoting digitalization, networking and intellectualization. In addition, the complexity of the industrial Internet platform's technology system, the diversity of application scenarios, and the variety of user needs indicate that the transformation and

upgrading of industrial manufacturing can never be accomplished by a single enterprise alone, nor by a few enterprises together. For application in each industrial scenario, it requires the transformation and upgrading of the entire industrial ecosystem.

Four Types of Participants in Industrial Internet

Home to many well-known industrial Internet platform providers, Europe, America and Asia are the focal areas for the development of industrial Internet platforms. In general, there are four main types of participants, namely manufacturing enterprises, industrial equipment providers, industrial software and service providers and information and communication enterprises. In Europe and the United States, most industrial Internet platforms are developed by industrial equipment providers and industrial software and service providers.

For example, industrial equipment providers mainly include GE, Honeywell, Cisco, ABB, Siemens, Schneider Electric, and Rockwell, etc. GE created the Predix platform, and in 2018, it expanded its digital business with launch of USD 1.2 billion industrial Internet software company, setting Predix, asset management, manufacturing execution systems and other digital business as an independent division; during Hannover Messe 2016, Siemens launched the open IoT operating system MindSphere; ABB Group launched ABB Ability, an industrial IoT platform offering integrated solutions for industry, electricity, transportation and other vertical markets.

In terms of industrial software and service providers, major players include SAP, PTC, Amazon and Microsoft. SAP's Leonardo IoT is "a key and comprehensive technology enabler for industrial IoT and Industry 4.0 by facilitating digital transformation", which allows its customers to collect information from machines, products, supply chain, consumers and other sources; since 2013, through a series of strategic M&A, PTC has gradually built up an end-to-end industrial Internet

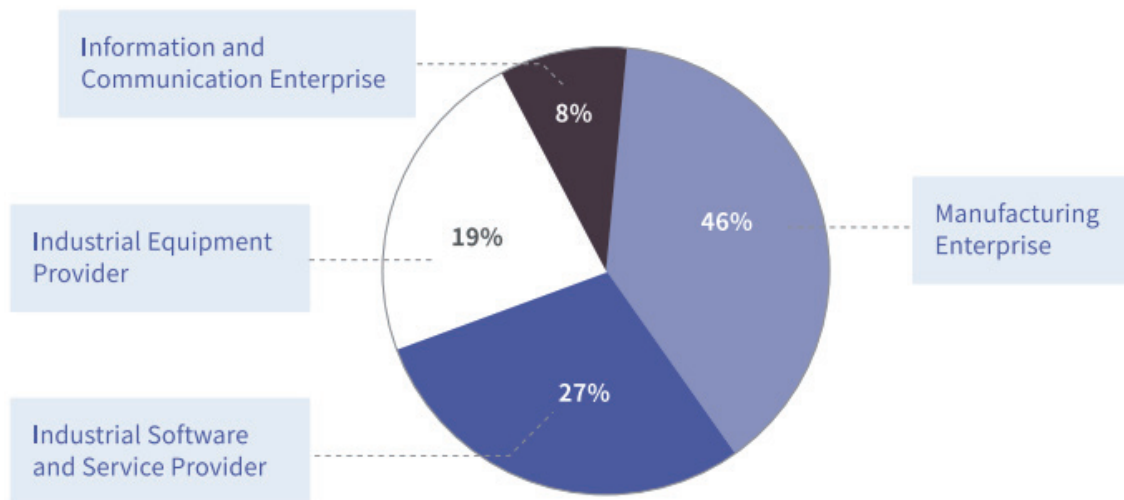
platform, integrating Axeda, ColdLight, Vuforia and Kepware and other products into ThingWorx platform.

In China, however, nearly half of the local industrial internet platforms are developed by manufacturing companies. According to China Academy of Information and Communication Technology and other publicly available data, in 2018, 46% of domestic industrial internet platform providers were manufacturing companies, 19% were industrial equipment providers, 27% were industrial software and service providers, and the remaining 8% were information and communication companies.

Inspur has created Yunzhou Industrial Internet, with Inspur Cloud ERP and Quality Code as its core competency. UFIDA developed Smart Industrial Internet Platform in 2017 to help industrial enterprises achieve lean manufacturing and smart manufacturing.

Among Chinese industrial equipment providers, Sany Heavy Industry incubated IRootech Technology, the entity behind ROOTCLOUD industrial IoT platform. China Aerospace Science and Industry Corporation founded CASI Cloud in 2015 as the division for industrial Internet platform, which developed INDICS, an industrial Internet

Categories of Chinese Industrial Internet Platform Provider (2018)



Source: China Academy of Information and Communication Technology and publicly available information

Among industrial internet platforms developed by manufacturing enterprises, Haier's COSMOPlat features the mass customization model, and the platform completed two rounds of funding in 2020, raising tens of millions of RMB in each round. Foxconn Industrial Internet Co., Ltd., a subsidiary of Foxconn, introduced Fii Cloud. PCITC launched ProMACE, an industrial Internet platform that expands the group's business from petrochemical and coal-based chemical to salt-based chemical, fine chemical, biochemical and other segments. As for industrial software and service providers,

platform featuring cloud manufacturing. XCMG Information, a spin-off of Xuzhou Construction Machinery Group founded in 2014, independently developed the Hanyun Platform in 2016. Meanwhile, information and communication enterprises such as Huawei, Alibaba, Tencent, Tuya Smart are behind some of the industrial Internet platforms on the market. Tencent Cloud's WeMake, for instance, covers the whole business lifecycle from research, production, supply, sales to service, combines their own industrial know-how with that of other partners within the ecosystem, and offers

customized solutions for industrial enterprises. Among industrial internet platforms developed by manufacturing enterprises, Haier's COSMOPlat features the mass customization model, and the platform completed two rounds of funding in 2020, raising tens of millions of RMB in each round. Foxconn Industrial Internet Co., Ltd., a subsidiary of Foxconn, introduced Fii Cloud. PCITC launched ProMACE, an industrial Internet platform that expands the group's business from petrochemical and coal-based chemical to salt-based chemical, fine chemical, biochemical and other segments. As for industrial software and service providers, Inspur has created Yunzhou Industrial Internet, with Inspur Cloud ERP and Quality Code as its core competency. UFIDA developed Smart Industrial Internet Platform in 2017 to help industrial enterprises achieve lean manufacturing and smart manufacturing. Among Chinese industrial equipment providers, Sany Heavy Industry incubated IRootech Technology, the entity behind ROOTCLOUD industrial IoT platform. China Aerospace Science and Industry Corporation founded CASI Cloud in 2015 as the division for industrial Internet platform, which developed INDICS, an industrial Internet platform featuring cloud manufacturing. XCMG Information, a spin-off of Xuzhou Construction Machinery Group founded in 2014, independently developed the Hanyun Platform in 2016. Meanwhile, information and communication enterprises such as Huawei, Alibaba, Tencent, Tuya Smart are behind some of the industrial Internet platforms on the market. Tencent Cloud's WeMake, for instance, covers the whole business lifecycle from research, production, supply, sales to service, combines their own industrial know-how with that of other partners within the ecosystem, and offers customized solutions for industrial enterprises.

Application Practice of Industrial Internet Platform

Compared to the traditional Internet, industrial Internet is more reliant on a particular industry, and

only when the platform is closely coupled with the specific manufacturing process, can it generate more value and serve all aspects of industrial manufacturing.

In general, manufacturing process can be divided into two categories: discrete manufacturing and process manufacturing.

Discrete manufacturing, which mainly includes 3C home appliances, automobile transportation, clothing manufacturing, etc., are all done at one station before the next station is connected through a series of interruptible processes to finally realize the output of the product.

In process manufacturing, such as the production of iron and steel, petrochemicals, coal-based chemicals, salt-based chemical, pharmaceutical, electricity, and cement, raw materials are subject to a series of physical and chemical reactions and converted into finished product, and the process is irreversible and continuous.

The application practice of industrial internet platforms in production process is mainly concentrated in industries with higher level of underlying digital technology and more emphasis on quality, energy efficiency and environmental protection. Through effective management of various production factors including equipment, production lines, workshops, as well as various functional departments, the on-site response time and productivity are improved, quality is raised, and costs are reduced.

(1) Discrete Manufacturing

At present, the application of industrial Internet platform in discrete manufacturing industry is mainly concentrated in vertical markets such as 3C home appliance, automobile, and food and beverage. Industrial Internet platform is used to pool the resources of various players in the industrial chain and value chain, promote transformation in business and innovation in business model, optimize resource allocation, create synergy through collaboration, and ensure the rapid update and iteration of products.

3C Home Appliance

China's Midea, Haier, Hisense, Changhong, TCL, Fotile, Gree and other Chinese enterprises have successively become the "Smart Manufacturing Comprehensive Pilot" Projects of the Ministry of industry and Information Technology of China. Among them, more enterprises have been selected for demonstration programs at provincial and municipal level. Meanwhile, based on extensive expertise and rich experience in the appliance manufacturing industry, Haier, Midea and Siemens have incubated their own industrial Internet platforms respectively, which offer integrated solutions covering the whole process from user interaction, module procurement, smart production, precision marketing, smart logistics, and smart services to end users' smart life.

At present, Haier's COSMOPlat has built 15 smart interconnected factories around the world, covering the production of air conditioners, refrigerators, washing machines, water heaters, dishwashers, range hoods and other products. Midea Group established a subsidiary Midea Cloud as the entity for its industrial Internet platform M.IoT and IoT services. TCL set up Getech, providing external smart manufacturing services. IoT platforms specialized in smart home also began to set foot in industrial Internet. In the first half of 2020, Tuya Smart launched an industrial Internet platform "Cloud Manufacturing" that is specially designed for the manufacturing industry, with the aim of helping IoT factories to reduce failure rate of equipment, and raise yield and productivity. So far, the platform has been adopted by over 5,000 manufacturing enterprises.

Automobile Traffic

The automobile industry presents a scenario where resource matching and collaboration involve more data and require more complex analysis. Volkswagen, BMW, Toyota, Ford and other well-known international auto companies, have been combining their own advantages in auto

manufacturing, parts and components, automation and IoT with platforms developed by Siemens, Bosch and ABB, so as to fully integrate and better manage the data and businesses on the automobile industry chain and value chain.

Meanwhile, Chinese automakers such as SAIC, Dongfeng and FAW have also entered into partnership with platform providers such as XCMG Information, CASICloud, Inspur and UFIDA to build platform-based ecosystem around leading enterprises, linking upstream and downstream players, and actively exploring innovative application of industrial Internet platform in auto manufacturing.

Volkswagen uses Siemens' MindSphere platform to connect and integrate the data from mechanical equipment and production systems of 122 factories, and to improve and standardize production systems and processes based on the platform's big data analysis. On July 9, 2020, Beijing New Energy Automotive Co., Ltd. and Siemens signed a framework agreement for cooperation, joining hands to build a high-end smart manufacturing base and smart innovation studio, and exploring the application of industrial big data and cloud applications based on Siemens' MindSphere platform.

(2) Process Manufacturing

For the process manufacturing industry with large production scale and heavy asset equipment, such as steel, petrochemical and so on, the industrial Internet platform offers equipment and product management services throughout the entire life cycle and makes online status monitoring, fault detection and diagnosis and predictive maintenance of industrial equipment and product status.

Steel

In recent years, application of industrial Internet platform in the steel industry has gradually materialized. Siemens, Schneider Electric, IBM, Microsoft and other platform providers have formed industry-specific knowledge base and model library, and partially applied industrial Internet platform

in single aspect such as equipment condition monitoring and optimization, and fault detection and diagnosis. In China, HBIS, Baosteel and JISCO have been actively experimenting with remote O&M based on industrial Internet platform. By working with platform providers such as Inspur, Huawei and Bonc, they have preliminarily realized remote monitoring, fault diagnosis and gained support in other services.

In order to detect and report equipment failure in real-time and minimize downtime, JFE Steel introduced the recovery support system to its production lines in all six steel production bases in China. Based on IBM's Watson, the system is specially designed for steel plant, enabling maintenance personnel for quickly and effectively search for the previous cases and relevant information needed for recovery and speed up repair.

Development Prospects of Industrial Internet

Currently, industrial Internet is rapidly penetrating into various industry segments. Meanwhile, it is noteworthy that industrial Internet platform is a complex with both industrial technology and information technology, and therefore building a platform requires solid support in basic technology. As few companies reside at the intersection of key technology and the targeted industry, collaboration with different platforms has become the dominant trends.

For instance, ABB Ability works with Microsoft's Azure to leverage the latter's capacity in cloud and big data for cloud storage, centralized management and rapid processing of ABB's data in equipment O&M. ABB Ability also adopts IBM Watson's AI function to analyze real-time images captured in the manufacturing process to identify defects.

The extensive participation of enterprises across the world has accelerated the development of the entire industry and ecosystem of industrial Internet, but the uneven quality of technological innovation has brought new problems.

European and US's enterprises have been leading the world in graphical modeling of thing model, highly available and scalable architecture, machine learning modeling, new AR/VR with human-machine interaction, etc., while China is still in want of breakthroughs in indigenous core technologies. The gap in technological capability and efficiency between enterprises from different parts of the world is even wider when it comes to a particular scenario.

The integrity of developer community and ecosystem built by various platforms around the core of industrial Internet also varies, so does the training system for interdisciplinary talent. The development of industrial Internet platform is iterative and incremental. It is also a long-term process that requires constant and considerable investment for both preliminary platform building and later promotion. In China, expenditure for platform building is covered mainly by the enterprise itself or government subsidies, and as a large number of small and medium-sized enterprises face financial pressure, the critical task of platform building is far from accomplished.

In terms of application, right now, industrial Internet is mainly adopted for equipment condition monitoring. However, the core of the manufacturing industry lies in the innovation of the value chain, which takes shape along the product's life cycle. Industrial Internet should be made full use of to connect different links on the value chain, including "research, production, supply, sales, and service", and to realize the fundamental business goals of improving quality, reducing cost, and increasing efficiency.

In terms of business, platform enterprises should take into consideration not only the technology evolution and product generalization, but also how to delve into the field based on the different characteristics of vertical industries, and they also need to think how to build and promote a cross-industry and cross-sector ecosystem, and whether to convert to the business model of "software as a service".

With stronger foundation of equipment, production lines, factories and digital capability, leading enterprises in various subdivisions are dominating the application scenarios of platforms, while small and medium-sized enterprises are still exploring. As platforms grow rapidly and are used in more industries and scenarios, the existing academic qualifications and vocational education system cannot meet the personnel demand from platforms, and countries across the world will be confronted with the severe challenge of the lack of

interdisciplinary talent.

As industrial Internet platform quickly evolves from an abstract idea to materialized projects, innovation and competition around these platforms will intensify. In 2021, based on actual demand, all kinds of platform providers will promote ongoing innovation in platform technology, functional iteration and business model, and eventually, a few will stand out as the leader, guiding the future development of the industry.

4.6

New Infrastructure Will Accelerate the Development of AIoT Industry

During the outbreak of COVID-19 pandemic which began in early 2020, new products and technologies, such as AI infrared temperature measurement equipment, smart positioning, smart mask and smart community have emerged rapidly. The demands for smart devices that are intelligent, contact-free, remote-controlled, and interconnected from the government, enterprises and consumers have been growing explosively. Obviously, under the New Normal, “new infrastructure” is going to become the mainstream of 2021.

1. “New Infrastructure” Will Transform the Technological Advances into Productivity

In the past decade, China has made digital economy as a national strategic priority by putting forward a series of significant development plans including the Outline for the National IT Application Development Strategy, the National Information Technology Plan and the Guideline on Emerging Sectors of Strategic Importance during the “13th Five-Year Plan”. The construction of new infrastructure, represented by 5G, IoT, industrial internet and new energy, has been highlighted. From this year’s Report on the Work of the Government, the construction of new infrastructure is an important strategy to expand domestic demand and promote accelerated transformation of the economic growth model, aiming to transform technological advances into productivity, then into economic growth, so as to boost consumption, improve people’s livelihood and adjust structure.

The digital economy has become an important way to release the new economic energy, increase effective investment and stimulate new consumer demand.

In the first quarter of 2020, the value added of

information transmission, software and IT services increased by 13.2% year on year. The new forms of business bucked the trend with growth, which shows that the digital infrastructure is urgently needed to increase economic growth.

On the March 4th, 2020, at a meeting of the Standing Committee of the Political Bureau of the CPC Central Committee, decision-makers stressed that the government will speed up the construction of major projects and infrastructure that have previously been planned, and will accelerate the construction of new infrastructure projects related to 5G networks, data centers and AI. By that date, 13 provinces and regions, including Beijing, Hebei, Shanxi, Shanghai, Heilongjiang, Jiangsu and Fujian published their 2020 investment list with plans for prioritized projects, of which 8 provinces announced the planned investment budget, a total of 33.83 trillion yuan (about 4.85 trillion U.S. dollars.)

At the press conference held on April 20, 2020, for the first time, Wu Hao, the head of the department of high-tech industry of the National Development and Reform Commission (NDRC), clarified the three aspects of “new infrastructure”

The first aspect is information-based infrastructure

on new generation information technology, such as telecommunication infrastructure exemplified by 5G, IoT, industrial internet and satellite internet; new technological infrastructure exemplified by AI, cloud computing and blockchain; computing infrastructure exemplified by data centers and intelligent computing centers.

The second aspect is converged infrastructure, referring to the deep application of technologies including internet, big data and AI to support the transformation and upgrading of traditional infrastructure, such as intelligent transportation infrastructure and smart energy infrastructure. The third aspect is innovation infrastructure that supports scientific research, technology development and product development and serves for the public good. It includes key infrastructure projects for scientific technology, science and education and product innovation. With technological innovation and industrial transformation, the meaning of the new infrastructure will be broadening.

In China, in order to thoroughly implement the plan of building the new infrastructure and speed up the development of the mobile IoT, the Ministry of Industry and Information Technology (MIIT) issued Notice by the General Office of the Ministry of Industry and Information Technology of Furthering Advancing the Comprehensive Development of the Mobile Internet of Things (hereinafter referred to as the Notice), clarifying the requirements from the perspectives of network building, its scale, module price, data migration and application development. According to the Notice, The evolution trend of the technical standards and industrial pattern of global mobile IoT shall be accurately grasped, the migration and network switching of 2G/3G IoT business shall be promoted, an integrated ecosystem of mobile IoT in which NB-IoT (narrow-band IoT), 4G (including LTE-Cat1, i.e. 4G networks of Speed Category 1) and 5G develop in a coordinated manner shall be established, and on the basis of deepening coverage of 4G network and accelerating the construction of 5G networks, NB-

IoT shall be used to meet the needs of most low-speed scenarios, LTE-Cat1 (hereinafter referred to as “Cat1”) shall be used to meet the needs of medium-speed networking of things and voice, and 5G technology shall be used to meet the networking needs of higher speed and low delay.

By the end of 2020, general coverage of NB-IoT networks in main urban areas of cities above the county level and in-depth coverage in key areas shall be realized; the number of mobile IoT connections shall reach 1.2 billion; the convergence of prices of NB-IoT modules and 2G modules shall be promoted, and new IoT terminals shall be directed to migrate to NB-IoT and Cat1; a group of NB-IoT application benchmarking projects and NB-IoT application scenarios of million-level connections shall be created as well.

2. “New Infrastructure” Cannot Be Built Without the IoT

The seven areas of new infrastructure are 5G networks, ultra-high voltage, inter-city transportation and inner-city rail systems, new energy vehicle charging stations, big data centers, artificial intelligence, and the industrial internet, all of which cannot be developed without the IoT technology. Among them, 5G-enabled IoT is expected be with low latency, high speed and connectivity. In this way, the IoT could evolve together with the 5G network; the deployment and operation of ultra-high voltage and new energy vehicle charging stations requires the distributed IoT monitoring and management. As for the railway system and big data centers, data collection, real-time monitoring and dispatch can only be done on the interconnected IoT devices. The AIoT (AI+IoT) is going to improve application layer technologies, perfect user experience and increase efficiency in data collection and analysis. The building of industrial internet industry platforms also relies on the “connectivity” of the IoT. Energy and transportation infrastructure also needs the IoT empowerment.

New infrastructure construction and goals

Project	Content Description	Objective
5G	1. Upgrading, retrofitting, and building up reserve capacity in machine rooms, power supply, power transmission towers, pipelines, etc. 2. R&D and deployment of 5G base stations, core networks, transmissions, and other infrastructure equipment. 3. Deployment of new types of 5G cloud service application platforms, coordinating utilization with new types of businesses and industry in various vertical markets. 4. Networked environment of new types of advanced manufacturing in Industrial Internet of Things surrounding 5G. For example, New Infrastructure such as IoT clouds, networks, terminals, etc., and infrastructure for vehicles, roads, and networks for an Internet of Vehicles, etc.	Three major operators expect to build more than 550,000 5G base stations over the course of the year ¹ . From 2020 to 2022, investment will gradually increase. By 2025, finish building a 5G network that essentially covers the entire country. For this, it is estimated that 5 to 5.5 million 5G base stations are needed, at an average cost of 500,000 RMB per base station, meaning direct investment for base stations will be circa 2.5 trillion RMB.
Big Data Center	1. Basic supporting facilities for data centers such as machine room buildings and production control rooms. 2. Optical transmission fiber, internet exchange point centers, data service platforms, and other network and service facilities that may support the development of data centers. 3. Balanced deployment and utilization of Internet data centers. 4. Big data R&D and industrialization projects in vertical fields such as connected vehicle networks and satellite big data.	The development of data centers grows to a large scale both in terms of individual centers as well as on a sectoral level, capable of meeting China's rapidly developing data storage needs. By 2025, build a number of large and super large data centers and edge computing data centers.
AI	1. Development of underlying hardware such as AI chips. 2. Construction of a universal intelligent computing platform. 3. Basic R&D centers for Intelligent perception and processing, intelligent interaction etc.. 4. Construction of pilot zones for innovation & development of artificial intelligence.	By 2023, construct about 20 pilot zones for innovation & development of next generation artificial intelligence.

5G network is a solid foundation of the development of “new infrastructure” and the IoT. The date, June 6, 2020, is the first anniversary for the Ministry of Industry and Information Technology to issue 5G business licenses to 4 major operators in China. According to Lu Chuncong, deputy director of the Information and Communications Administration of the MIIT, the basic telecommunications companies in China have built more than 250,000 5G base stations, with over 36 million 5G users. By the date of September 17th, the number of 5G base stations has exceeded 500,000 with approximately 100 million devices connected to 5G networks. China is expected to build more than 600,000 5G base stations by the end of the year, covering cities above the prefecture level in the country. By the end of August, China has more than 110 million users having already signed up for 5G plans. The gradual rollout of 5G technology provides huge space for the AIoT industry to grow. Those associated industries, including smart living, smart city, car networking, telemedicine, big data and smart factory will make smart devices omnipresent. According to the statistics issued by the MIIT, by the end of February, the number of IoT end users has exceeded 1.04 billion, increasing by 15.54 million compared with the end of last year. “5G+IoT” model played an important role in fighting against the pandemic. With the 5G-enabled online healthcare system, hospitals across the country could provide medical services such as remote group consultations, radiology diagnosis remotely, remote diagnosis, and fever consultation, allowing medical experts in Beijing to give guidance on treating the patients to doctors in Wuhan “face to face” but with an actual distance of 1200 kilometers; “5G+unmanned vehicles for helping with COVID emergency”, adopting the information technologies such as the IoT, machine learning, biometric identification and clouding, can be brought to key places and units including stations, hospitals, schools and communities to disinfect the streets or provide healthcare services; China Electronics Technology Group Corporation, together with SF

Express, successfully delivered valuable medical supplies to doctors and nurses in Wuhan Jinyintan Hospital with drones.

3. “New Infrastructure” Boosts the Development and Application of AIoT

Some experts summarized that the demands and requirements of the “new infrastructure” would push the improvement of the IoT in several ways as follows:

Continuous Improvement of AIoT Capabilities

Improve the foundation network construction of 5G, industry-specialized network setting, MEC and other related capacities construction, full network control and the supply of 5G chip modules; improve the underlying infrastructure of the industrial internet, including identify resolution platform, Edge Network and industrial platform; improve the construction of data center or application platform; improve the operation efficiency and data analysis ability combined with AI technology, and solve trust problems and improve data security with block chain.

Promote the Transformation of Traditional Facilities and Development of New Ones by AIoT

IoT can be applied to transform the traditional facilities. Smart city, smart healthcare, smart transportation, smart park, smart agriculture, smart policing and smart retail requires intelligent upgrading traditional infrastructure, fix the weak links in rail transportation and cold chain logistics; strengthen weak areas in the industries of nuclear power, UHV, charging stations, hydrogen fueling station and lithium battery innovation; strengthen the weak points in sewage and garbage treatment; management of the old park and upgrade its system. As for developing new facilities, contact-free supporting facilities such as drones, unmanned distribution system, unmanned factory, unmanned system in prevention and control of COVID-19,

supporting facilities for the newly emerging industries such as photovoltaics, biomass energy, green heating,

Promote the Establishment of AIoT Educational Institutes and R&D Institutes

Looking at all links on AIoT, from the practical applications of the sensor, the chip to the IoT, and the convergence of IoT and AI, a lot of R&D institutes, educational institutes, innovative organizations and centers for talent development

have been founded. Many enterprises also set up their own R&D centers to overcome the hurdles limiting IoT, develop chips, sensors and networking modules. The favorable government policies on the new infrastructure will provide more incentives for companies to invest in research to a certain extent. At present, under the stimulation of the COVID-19, and on the basis of increasingly innovative policies, technologies and business models, 2020 has become the first year of IoT Era, and the market for AIoT also continues to grow.

Comments

1

"This research will definitely provide a better understanding of the sector and its perspectives, discussing the most challenging issues of the industry, specifically in this critical moment in which everybody is wondering how the pandemic will affect the future of the world, including the application of new technologies that is increasingly accelerating in our lives. "

Luis Diego Monsalve Hoyos, Ambassador of Columbia to China

2

"IoT security is valued by the consumer and now more than ever. The strength of the Alliance is drawn from leading members like Tuya, who provide world class security at the scale needed for the consumer and the commercial IoT industry. Regulations are coming to clear the noise out of the market but by working together now, ioXt and Tuya improve consumer confidence, increase adoption, and guide global regulators."

Brad Ree, CTO of ioXt

3

"There is a new word that has been born for about 1-2 years, that is, AIoT is a combination of two core technologies: IoT and AI, many key developers are interested in developing products and services. Collaboration with companies that have solutions are the choices - IoT and AI technologies to achieve country development in all dimensions, such as talent and manpower skills enhancement, and development of digital infrastructure."

Niti Mekmok, President of Thailand IoT Association

4

"With the convergence of technologies, adding intelligence to edge devices is the most logical step forward – APARA compliments Tuya Smart in taking the lead to postulate the next chapter of Smart City architecture."

Ms. Shanlynn Lee, APARA President

5

"Related to the Internet of Things (IoT), there are significant advances that will enhance productivity, standards of living and will open new avenues for business and interactions all over the world. I was very impressed by the technology displayed by Tuya and developers will contribute to enhance the trade and commerce between countries. "

Amb. Carlos Giralt Cabrales, Consul General of Mexico(Guangzhou)

6

"As the Representative of Singapore's manufacturing sector, the SMF is happy that Tuya is producing a White Paper on AIoT which will enhance SMEs worldwide towards preparing for challenges and achieving sustainable growth in a competitive environment. SMF looks forward to a rewarding partnership with Tuya Smart and to collaborate together to drive growth for businesses worldwide."

Mr. Douglas Foo, President of Singapore Manufacturing Federation.

7

"As the Sino-EU Technology Innovation Cooperation platform, we are pleased to see that Tuya is taking lead on the global AIoT ecosystem building. IoT is no longer a new word to us, however, how to build the real connected ecosystem, integrate all those different parties globally, and be intelligent is still something we are exploring. This White Paper on Global AIoT Developers Ecosystem is no doubt inspiring and insightful that we can find answers to some critical questions."

Athena Wang, Operation Director of ENRICH, Asia Pacific Region

8

"Chile's National Policy on Science, Technology, Knowledge and Innovation intends to enhance the scientific- technological ecosystem by adopting advanced digital technologies. InvestChile welcomes top foreign AIoT companies, like Tuya

Smart, whose purpose and solutions are aligned with our national aspiration. ”

Juan Pablo Garnica, Investment Promotion Director of Invest Chile

9

“The Internet of Things (IoT) creates completely new business potentials by networking products of an increasingly smart nature. Whole industries including mobility, health and manufacturing are being fundamentally altered.

By enabling newly emerging business models and the development of disruptive IoT solutions, Tuya Smart is a true global leader and shaper of the ongoing digital transformation.”

Lukas Huber, Deputy CEO & Executive Director China; Greater Zurich Area AG Switzerland

10

“This white paper illustrated the clear trends of IoT development and consequent massive opportunities coming along with this new AIoT era. Sweden, together with other Nordic countries, is the pioneer both concerning AIoT innovation capability and market readiness. As the world leading player, Tuya Smart has already been active in Swedish market, and playing a critical role in its transformation.”

Dr. Bin Zhu, Investment Director, Business Sweden

11

“Japan is currently accelerating its digitalization, Connected Industry, and other areas, and various technology accelerators are being used throughout Japan to promote the integration of foreign companies, Japanese companies, and Japanese R&D institutions, including in the AIoT field. Companies like Tuya are welcome in Japan to bring new energy and potential to the Japanese AIoT industry. The white paper provides a wealth of information on usage scenarios, security, and unified standards that will be of great value to both Chinese and Japanese companies working to transform and upgrade their manufacturing industries.”

Kyungho Jin, Investment Director of Japan External

Trade Organization(Beijing) (JETRO)

12

“As China enters the digital era, the digitalization process across the country and in various industries is in full swing, but it also faces many confusions and problems. To solve these problems, enterprises and society need to work together to create a suitable environment for development. Tuya is taking the lead, innovating in the field of IoT, and creating the right environment for the industry at the same time. This white paper not only introduces the detailed status of AIoT industry development, but also analyzes the common problems and discusses the ways to solve them, providing inspirational guidance and practical suggestions for CIOs working on the front line. We look forward to the facts, perspectives, and working paths contributed in this white paper becoming a magic bullet for all CEOs, CIOs, and CXOs on their way to innovation!”

Xingguo Zhang, COO of China Hospitality Technology Alliance (CHTA)

13

“With the rapid development of AI and the IoT as well as the integration of AIoT into various industries, this is an important change and opportunity for the fiercely competitive lighting industry, which will also provide more industrial added value and development space for the lighting industry caught in involution. The future has come, we need to focus on the lighting industry, and actively embrace change. There is a poem: With the wheel of history passing, there will always be a lush new green grass next to the grass.”

Qidong Wen, Deputy Secretary of China Association of Lighting Industry

14

“2021 White Paper on Global AI+IoT Developers Ecosystem presents the current status and development trends of the global AIoT market with a large amount of detailed data, provides specific analysis and case studies for each major industry

segment, and accurately describes the application features of the Zigbee Interoperability Standard in door locks, lighting, electricians, and other scenarios.”

Ruiyun Shang, representative of Zigbee Alliance China

15

“We believe that the future development trend of the IoT industry is to move from the current fragmented and closed model to a borderless and open ecological model. In the future, we hope to sincerely cooperate with all partners on the Tuya platform to build a more open and intelligent ecological environment.”

Chunlei Zhuo, General Manager of Consumer Eco-Device BU, Lenovo China

16

“In the AIoT era, Tuya provides a stable, efficient, and intelligent platform for smart homes in the Japanese real estate market. We believe that together we can create a new era for Japan's smart industry.”

Taiko Ogawa, Chairman of the Board, Okura Co., Ltd.

17

“It is expected that this white paper will not only provide guidelines for technology transformation and upgrading for enterprises, but also promote excellent AIoT projects so that more enterprises will have a model to follow in their technological innovation and practice.”

Hantao Ge, Chief Researcher of IoT Industry, Deputy Director of Strategic Planning and Research Department, Telecommunication Technology Labs, China Academy of Information and Communications Technology (CAICT)

18

“In the era of Internet of Everything, AI+IoT has brought infinite possibilities for industry development. 2021 White Paper on Global AIoT

Developers Ecosystem is a highly recommended book that clearly describes the development of the industry and fully analyzes the current dilemma.

With the push of various new technologies and policies, the industry will take a new leap forward, let's wait and see.”

Jincai Yang, Honorary Member of the European Academy of Sciences, Arts and Humanities, President of Shenzhen Security Industry Association

19

“The development of the AIoT industry requires a diversified, abundant and stable developer ecosystem, a neutral and open development platform also required. Haier is willing to work with partners in the industry to build an interoperable development ecosystem, create a seamless interactive all-scene smart home and a better future together.”

Ye Wang, Haier Smart Home Vice President

20

“Bluetooth has always focused on providing developers with full-stack, fit-for-purpose wireless solutions in all key areas, so as to enable simple and secure device connectivity. We believe that only with a large, mature, and innovative development ecosystem could ensure commercial availability of connectivity in the future. We are looking forward to it with the whole industry together.”

Lori Lee, Bluetooth SIG APAC Senior Marketing Manager

Producers

Tuya Smart, Gartner, Global Intelligent Business,
AI+IoT Business Vantage

Co-Producers

Asia-Pacific AI Business Alliance, Intelligence Business
Academy

Special Thanks to

Asia Pacific Assistive Robotics Association
Bluetooth SIG
Broadband Capital
Business Sweden
China Association of Lighting Industry
China Chamber of Commerce for Mechanical and
Electrical Equipment
China Household Electrical Appliances Association
China Smart Home Industry Alliance
Consulate General of Mexico in Guangzhou
CTTL
Embassy of Columbia to China
Greater Zurich Area AG Switzerland
Invest Chile
ioXt Alliance
Japan External Trade Organization(Beijing)
SGS
Shanghai Pudong Intelligent lighting Association
Shenzhen Association of Internet of Things
Shenzhen Security and Protection Industry Association

Singapore Manufacturing Federation
ENRICH(Hangzhou)

Thai IoT Association

Wi-Fi Alliance

Zhejiang Digital Economy Society

Zigbee Alliance

Netherlands Foreign Investment Agency

Editor in Chief

Eva Na

Chief Editor

Holmes Chen

Deputy Editors

Cindy Lee, Gloria Yuan, Jean Zhao

Editorial Board Members

Alan Ren, Ann Marie Olivo-Shaw, Barry Guo, Doris
Chen, Gagan Kohli, Geralt Kong, Jia Chaopeng, Julia
Soens, July Lee, Lauren Xia, Li Yike, Lisa Gu, Mona
Xiong, Riva Huang, Tanya Tan, Teresa Tao, Wesley Wei

Special Thanks to

Hou Menglin, Hu Anlun, Jia Wanneng, Liu Jiwu,
Liu Yawen, Tang Jiaoli, Wang Han, Wang Hanqin,
Wangying, Wu Yinglei, Wu Yujie, Yang Qinghui, Yu
Weijing, Zheng Xiangwei, Zhou Junhao

About Us

Tuya Smart Intro

Tuya Smart is a global Cloud Development Platform and a leading AI+IoT Developer Platform that connects the intelligent need of consumers, manufacturers, brands, OEMs, and retail chains. The platform provides developers with a one-stop AI and IoT PaaS-level solution that contains hardware development tools, global cloud services, and smart business platform development, offering comprehensive ecosystem empowerment from technology to marketing channels to build the world's leading IoT OS.

By the end of October 2020, the Tuya IoT Development Platform served over 230,000 developers around the world and generated over 81 million AI voice interactions daily. The "AI+IoT" platform has smart-enabled more than 200,000 products. Now, Powered by Tuya products can be found in more than 190 countries in over 100,000 online and offline sales channels globally. Tuya Smart: <https://www.tuya.com/cn/>

Co Producers Intro

Intelligence Business Academy (IBA) is a comprehensive communication and content generating platform in the field of intelligent business. IBA alumni networks include global technology leaders, renowned investors and industry experts all over the world. IBA brings inspiring technology innovative business model, global vision, cutting-edge awareness and Intelligent transformation insights.

The AIBA (Asia-Pacific AI Business Alliance) is a non-profit organization initiated by Tuya Smart and the Hong Kong Trade Development Council. It aims to increase communication opportunities in the AIoT industry and accelerate the development of artificial intelligence and IoT technologies in various fields. It currently has more than 100 members, covering lighting, electrical, large and small home appliances, security, agriculture, health, energy-saving, education and entertainment industries.

AIoT Business Vantage (ABV) reflects industry experts' opinions on global artificial intelligence and the Internet of Things. We provide an in-depth assessment of the global AIoT market, including business cases, new products and technologies, and value chain analysis.

Global Intelligent Business is an industry media and exchange platform focusing on Artificial Intelligence and Internet of Things. It tracks the frontier information of artificial intelligence, analyzes intelligent business cases, invites entrepreneurs and investors to analyze industry trends, and is committed to providing professional and comprehensive information and multi-channel support for global intelligent business ecosystem. As the most in-depth professional media of No.1 AIoT, Global Intelligent Business has attracted the attention of more than 100,000 AIoT industry players and investors. Over 90% contents are original and have been read for more than 10 million times. It provides fresh, in-depth and informative industry reports and observations, and pushes valuable information of global intelligent industry.

Copyright Notice

All content in this white paper, including but not limited to text, graphics, logos, trademarks, etc., is the property of the authors and protected by applicable law. Some of the content in this report is from public sources, and the source has been acknowledged.

You may use the contents of this report for your personal study, research, or enjoyment, or for other non-commercial or non-profit purposes, provided that you comply with the Copyright Law and other relevant laws and do not infringe upon the legal rights of the report or the rights holders. In addition, any use of the contents of this report for any other purpose requires the written permission of the owner of this report and the related rights, and payment of remuneration. Unauthorized use of this report will violate the Copyright Law and other relevant laws. The contents of this report may not be modified or reproduced in any form without the written permission of the right holder.

