浦发银行 SPD BANK HUAWEI

Bank of Things White Paper

— Next-Generation Financial Infrastructure

(2020)

Contents

1 Background

1.1 Digital Economy, Renovating the Social Production Paradigm

With the wide-scale adoption of information and communications technology (ICT) and the emergence of new modes and business practices, the mode of production in society is undergoing profound transformation. Similarly, the economic operation mode is facing significant reconstruction. As a new socio-economic paradigm, digital economy has become an important driver of global economic growth. In the digital economy, people identify, select, filter, store, and use data (digital knowledge and information) to guide and optimize resource allocation. Data assets will become a new factor of production. Digital technologies enable high-quality economic development, marking a mature digital economy.

In the digital economy era, supply and demand markets are facing major reconstruction. The digital economy is direct, fast, and highly penetrated. Search, replication, transportation, tracking, and verification are performed at lower costs. New models of consumer and enterprise behavior have already emerged, or will emerge in the near future. From the demand perspective, consumers will compare goods and services using multi-dimensional information; the consumer market will see diversification, differentiation, and personalization trends; the "long tail" and "superstar" effects will emerge at the same time. Lower search and verification costs effectively increase sales of personalized and less popular products. In the meantime, consumers can quickly find similar offerings, increasing demand for already popular, high-quality products. Higher consumer goods transaction efficiency indicates platform-based and scenario-specific consumption trends. Such changes in the consumer demand structure call for a quick and efficient response from the supply side. To achieve optimal resource allocation, changes in business operations, organization, and management are necessary. On the supply side, rapid market changes require enterprises to effectively integrate resources through cooperation and build an ecosystem to enhance their core strengths. The development of IT and non-exclusive digital production materials will reduce organization costs, industry barriers, and information asymmetry. Vertical integration of traditional supply chain finance will expand into network-based industry finance both vertically and horizontally. In other words, the competition between different enterprises and industries will be a case of "winner takes all".

The digital economy provides powerful technical means for economic entities to reduce losses caused by irrational decisions. With the rapid development of both the economy and society, external environments have become increasingly complex. Facing greater uncertainties and limited capabilities (time, resources, and computing), economic entities show bounded rationality in economic decisions. By contrast, the digital economy allows economic entities to obtain all relevant information, thereby improving decision-making through increased data processing capacities. This also leads to a marginal decrease in losses caused by irrational decisions.

To restructure the economic structure and improve decision-making, the financial resources transmission mechanism and financial institutions' service modes will be transformed, with digital technologies playing a key role in enhancing service quality and financial resource allocation. As a new type of production material, data will be key to financial institutions' customer acquisition, understanding customer values and requirements, and managing credit risks.

1.2 5G Era, Promoting Intelligent Connectivity of Everything

The Internet of Things (IoT) is a network where things are interconnected. The International Telecommunication Union (ITU) defines the IoT as a network that connects all objects to the Internet by using sensing devices for information exchange and communication according to the agreed protocols, thereby implementing intelligent identification, location, tracking, monitoring, and management. The sensing devices include QR code reading devices, radio frequency identification (RFID) devices, infrared sensors, global positioning systems, and laser scanners.

5G technology has become a hot spot for global communications development. Using new network architecture, 5G provides increased network performance with peak bandwidth of over 10 Gbit/s, millisecond-level latency, and ultra-high-density connections. The 5G era will significantly enhance the connectivity of everything. The IoT will develop rapidly and be widely used in society.

- **5G substantially improves key network capabilities.** Enhanced Mobile Broadband (eMBB) increases the user experienced data rate to 0.1–1 Gbit/s, mobility speed to 500+ km/h, and greatly increases the peak data rate. Massive Machine-Type Communications (mMTC) supports higher network connection and traffic density. Ultra-reliable low-latency communication (URLLC) enables ultra-low latency.
- **5G network capabilities promote data diversification, high-speed processing, and in-depth value mining, facilitating IoT development.** The 5G network makes data collection easier and more diversified. In terms of data processing, 5G enables edge and cloud computing to support high-speed data flows and maximize data circulation. Through 5G's increased device connection capacity, a greater number of sensors can be used on the network. These sensors provide significantly more data, helping to generate different applications.
- **The convergence of 5G and IoT will accelerate the connectivity of everything.** 5G + IoT do not require separate network construction, greatly reducing construction costs. The emergence and comprehensive coverage of 5G help solve IoT implementation difficulties and meet IoT's requirements for high reliability, high speed, and low power consumption. As a result, IoT will expand from the infrastructure to the application layer, supporting large-scale adoption in various scenarios. Hundreds of billions of IoT terminals can be connected at the same time, assisting in the interaction between people and things, enhancing people's lifestyles.

In the 5G era, rapidly advancing cloud computing, big data, and artificial intelligence (AI) will trigger global IoT growth. According to GSMA, the number of connected IoT devices (including cellular and non-cellular devices) will reach 25.2 billion in 2025, far exceeding that in 2017 (6.3 billion). In the meantime, the IoT market scale will be four times that of the current market. Furthermore, the number of connected industrial Internet devices will increase to 13.8 billion in 2025, a five-fold increase from 2016 (2.4 billion). There will be more connected industrial Internet devices than connected consumer IoT devices by 2023.

China has preliminarily established an IoT system with solid industry and application basis. According to CCID, China's IoT market will continue to grow by 20% from 2019 to 2021, reaching CNY2.62513 trillion by 2021. From specifying its status to supporting industry development through capital and technology, China has also successfully developed a number of key policies regarding the IoT. In 2010, China proposed to accelerate the development of the IoT as one of the seven strategic emerging industries. In 2012, the government issued a policy to provide financial and taxation support for the IoT industry in demonstration areas. In 2017, a policy was launched to improve the technical innovation system and construct a standards system. In 2020, government policies proposed dedicated number allocation for the IoT, use of licenses, and accelerated NB-IoT development, fast tracking the development of IoT (see Table 1-1).

Table 1-1 Major Chinese policies on IoT development

Time	Policy	Contents
October 2010	Decision on Accelerating the Cultivation and Development of Strategic Emerging Industries	As an important part of next-generation IT, IoT becomes one of the first seven strategic emerging industries that would be promoted in China.

Time	Policy	Contents
May 2011	China IoT White Paper (2011)	Systematically analyze the IoT architecture, key elements, technical system, industry system, and resource system.
December 2012	12th Five-Year IoT Development Plan	Remarkable achievements should be made in core technology R&D and industrialization, key standards research and formulation, industry chain establishment and improvement, as well as major application demonstration and promotion.
September 2013	Action Plan for IoT Development	Master IoT core technologies to form a secure, controllable, and globally competitive IoT industry system.
April 2014	Key IoT Work of MIIT in 2014	Promote the R&D of sensors, chips, transmission, information processing technologies, and study the service-oriented IoT transmission architecture.
January 2017	13th Five-Year IoT Development Plan (2016-2020)	Improve the technological innovation system, build a standards system, and promote the large-scale application of the IoT industry.
May 2020	Notice on Promoting the All-Round Development of Mobile IoT	Recommend the migration of 2G/3G IoT services and establish a mobile IoT ecosystem for coordinated development of NB-IoT, 4G (including LTE-Cat 1), and 5G.

Against this backdrop, IoT will gradually become intelligent, IoT ecosystem will grow, and "things" will become important carriers of data. With intelligent connectivity of everything, diversified, real-time, dynamic, and associated data will serve as an important production factor, boosting high-quality economic development. 6G will enable full coverage of the sky, sea, and ground to build a fully connected planet, integrate the physical and virtual worlds, and accelerate digital economy development.

1.3 Reshaping Financial Services with Two Drivers

Technological innovation and the digital economy are the two driving forces behind banking development. Innovative financial services have become a mega-trend. With increasing industry convergence and head effects, financial services will focus on customer experience, expanding the institutions' business scope based on customer resources. Previously, financial services centered on products, and their efficiency has reached the boundary optimum due to the optimal division of labor. Structural changes in the consumer and production markets, and the implied requirement to improve economic efficiency will therefore drive financial institutions to seek disruptive changes in order to improve service quality.

Technical means help to reduce losses caused by information asymmetry in financial services. Due to information asymmetry, financial institutions would historically choose "high-quality" customer groups with assets available for mortgages in order to reduce adverse selection and moral hazards. This approach could lead to financial exclusion. The advent of digital technologies like big data, IoT, AI and cloud computing, can address this imbalance by allowing financial institutions to generate accurate financial profiles of diverse customers. This approach provides the opportunity for financial inclusion and the betterment of social welfare overall.

FinTech allows the financial services industry to facilitate modern economic system development and better serve the real economy. National and local policies have been established to advocate FinTech development. These policies aim to improve the quality and efficiency of financial services, optimize financial development modes, and enhance financial core competitiveness (see Table 1-2).

Table 1-2 Key policies on FinTech development

Time	Policy	Contents
September 2016	G20 Advanced Principles of Digital Financial Inclusion	Put forward the concept of digital financial inclusion and eight main principles. Digital technology becomes the key to advancing financial inclusion.
September 2019	FinTech Development Plan (2019–2021) by the People's Bank of China	Propose "four beams and eight pillars" for China's FinTech development to give full play to FinTech while enhancing technical defense against and regulation on financial risks.
January 2020	Implementation Plan for Accelerating Shanghai FinTech Center Construction by Shanghai	State the goal of building Shanghai into a FinTech center with global competitiveness in five years. Advocate to better serve the real economy, promote smart banking, and enrich financial services.

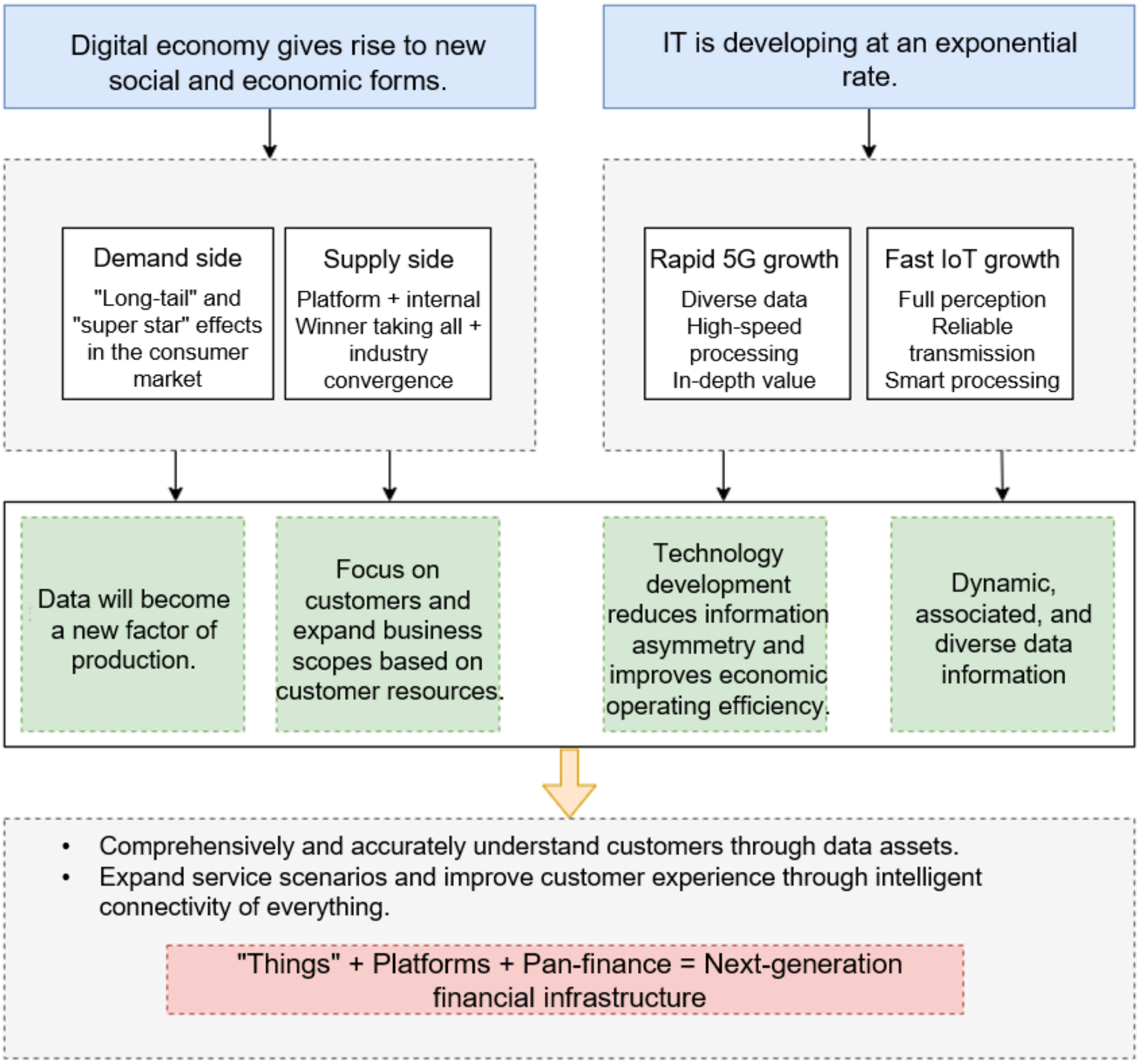
Data is the only non-exclusive production material. This differentiates it from traditional production materials such as labor, raw materials, and capital. This means that data can provide continuous value, facilitating cross-domain capability supply. Strongly associated, dynamic, and multi-dimensional data is important for banks to accurately understand customers and enhance customer service capabilities. In the Internet era, online data can be easily obtained, but only limited offline data is acquired. Rapidly developing IoT supports both online and offline data acquisition.

In the digital economy era, commercial banks are facing multiple challenges. Changing the traditional operating mode and transforming technologies have become an industry consensus.

From the perspective of customers, the rapid development of mobile Internet allows individual users to access financial products and services faster and more conveniently. This in turn enhances financial behavior frequency and transaction workloads. Furthermore, as society becomes more digital, micro-, small-, and medium-sized enterprises (MSMEs) have greatly enhanced their economic operating efficiency and consequently require greater financial support. Traditional banks, however, cannot fulfill such needs due to financial exclusion as mentioned above.

From the perspective of the banking industry, Internet companies such as Ant Financial and Tencent have quickly grasped pitfalls and occupied these spaces using their platform-based products. This accelerates the disintermediation of traditional financial institutions, including banks. These online platforms also eliminate information asymmetry and intensify homogeneous competition among financial institutions. In addition, a more digital society brings about reforms across various industries. Traditional financial institutions, however, fail to provide targeted financial services due to their limited understanding of other industries, which can weaken their customer relationships. Facing the preceding challenges, commercial banks need to proactively carry out digital transformation: migrating offline services online, and more importantly, transforming customer interaction modes and credit systems. It is therefore necessary for banks to explore new customer engagement modes and establish a credit risk system using scenario-specific, platform-based service models and "things". This approach can help banks provide comprehensive financial services. In a fully connected society, building next-generation financial infrastructure with pan-financial service capabilities — bank of things (BoT) — is a bold attempt to of FinTech transformation.

Figure 1-1 Reshaping financial services in the digital economy and society



2 BoT

2.1 Definition and Connotation

Definition: BoT is a business form in which "things" become one of the core production materials of future banks, and a component of the next-generation financial infrastructure with pan-financial service capabilities.

Connotation: "Things" here refer to physical entities that directly engage in financial activities. By connecting physical and digital spaces, "things" become business data, intelligence, scenarios, and customers. Information of "things" is the increment of data elements; intelligence of "things" is the increment of technical elements; interaction of "things" is the increment of scenario elements. By improving these three key elements, BoT can discover more financial and non-financial requirements of enterprises and individuals, thereby generating customer profiles with greater accuracy. This can expand service receivers, enrich business models, and enhance risk management capabilities.

2.2 Features

1. **Directly serving intelligent "things", not just people**

   With AI development, "things" will become more intelligent. They will obtain autonomous decision-making capabilities and participate more in the social activities of humans. In the future, "things" will help people process a large number of common and financial affairs, serving as important carriers of all human activities. Therefore, this paper defines "things" as "**intelligent things"** that are capable of environment awareness (sensing), information interaction (expression), information processing (thinking), information storage (memory), and ownership proving (identity). "Things" can independently own bank accounts and become direct banking service receivers, i.e. customers. For example, with an independent account, a self-driving car is capable of autonomous refueling/charging, maintenance, parking, repair, and insurance services, as well as processing all corresponding financial activities. Similarly, an unstaffed factory can independently perform financial and non-financial activities such as raw material purchase, processing, manufacturing, logistics, sales, financing and loans.

2. **Scenario-centered business model**

   Scenario-specific universal financial services are a key developmental direction of commercial banks. BoT proactively builds scenario-centered business models.

   Proactive services: BoT identifies scenarios for customers, analyzes customer requirements in specific scenarios based on mass external IoT data, and recommends faster, more proactive financial services.

   Personalized services: The most significant feature of scenario-specific business models is exploring personalized demands based on scenario requirements. BoT's customers cover both people and "intelligent things". By embedding services into production and real-life scenarios, BoT interacts with customers, detects customer experience, and knows customer requirements. Consequently, BoT can quickly respond to customers' personalized demands and improve service accuracy.

   Continuous services: The demand from social and economic activities is ever-changing and the boundary of demand gets blurring and integrated. With smart devices, BoT provides 24/7 services. For example, chattel mortgage funds are granted immediately, delivering continuous services from goods moved into the warehouse, to automatic review, and funds receiving

   With scenario-specific business models, BoT detects real-time customer behavior in specific scenarios using IoT devices. Technologies such as big data analysis and associated analysis enable BoT to deliver integrated pan-financial services anytime, anywhere, creating customer experience-centric service capabilities.

3. **Risk management model based on the objective data credit system**

   Fundamentally, credit represents mutually trusted production and social relationships between individuals, organizations, and commodity transactions. Theoretically, credit is value movement in which a financial institution, on the basis of fully trusting that a customer can fulfill its commitment, lends money to the customer by means of contract, seeking return and appreciation of the principal. A core element of bank operations is risk management and the identification of credit ratings, that is, credit pricing. Douglas Merrill, Google's former CIO, says "all data is credit data." Data lies at the core of credit pricing. In the past, due to limited data acquisition channels, conventional credit assessment systems mainly used the subject's credit rating, such as a FICO score. In the Internet era, human transaction data is quickly moved online, enriching data sources. The credit assessment system has gradually shifted towards subject credit + transaction credit, such as Zhima Credit. In the era of everything connected, data sources will be significantly developed, and the credit assessment system will transform accordingly into an objective system of subject credit + transaction credit + entity credit (real credit of individuals/legal persons reflected by objective data).

   Objective data in the IoT era reflects the relationships between people, people and things, and things themselves. This far exceeds the Internet era in terms of data sources and dimensions. Multi-dimensional data in the IoT era is closer to that of the physical world, supporting effective assessments of credit ratings. Using advanced technologies such as big data, cloud computing, mobile Internet, and IoT, BoT develops a risk management toolbox based on objective data. Under intelligent connectivity of everything, the toolbox dynamically depicts customers' basic information, production and operations processes, as well as collateral status to support decision-making and services. This new risk management model enriches credit data sources, improves data credibility, and allows more natural and legal persons to enjoy financial rights, facilitating financial inclusion.

2.3 Development and Evolution Phases

History shows that technological transformations bring about significant social, cultural, and economic changes, as well as major adjustments to society's industrial structure, operational system, and interest distribution. BoT's emergence and development come from multiple technological transformations, such as 5G, IoT, AI, and big data. However, technological transformation does not happen overnight. It is a gradual process. With the development of peripheral technologies and banking services, BoT's form and service model will undergo three evolution phases: "twins of things", "thing services", and "serving things". In each phase, "intelligent things" play different roles. In the "twins of things" phase, "intelligent things" are data touch points, enriching data sources and allowing BoT to better understand customers and their requirements. In the "thing services" phase, "intelligent things" are expanded into service touch points, enriching service channels and enabling better serves. In the "serving things" phase, "intelligent things" will become the agents of customers. Banks will directly serve "things" to deliver the ultimate customer experience.

2.3.1 Twins of Things Phase

"Twins of things" refer to simulation processes that use physical models, sensors, and real-time and historical data, covering multiple disciplines, physical quantities, scales, and probabilities. A simulation process maps physical things in the virtual space and reflects the entire life cycle of the corresponding entities. The digitalization of the physical world means building a virtual model that simulates real world behaviors, thereby improving product innovation and production efficiency.

In a society with "twins of things" at its core, existing banking business model are due to change. BoT will grasp and describe customers' behavioral features, explore their financial requirements to provide suitable financial and non-financial services, and avoid the mismatch of financial resources while enhancing risk management.

2.3.2 Thing Services Phase

"Thing services" refer to pan-financial services provided by BoT using various smart devices. In this phase, BoT focuses on establishing a platform-based business model. It exchanges information with customers through smart devices and combines payment, financing, leasing, investment, and wealth management activities with work and lifestyle scenarios such as shopping, travel, manufacturing, procurement, healthcare, and sales. By doing this, it can deliver integrated product services.

BoT regards "things" as the medium of financial services and matches product services with financial requirements of "things". The aim is to extend the user service medium in smartphones to other smart devices. For example, a self-service coffee machine is used as a transaction payment medium for coffee sales. Alternatively, a smart factory's production system could be the service medium used to provide integrated pan-financial solutions such as procurement, settlement, marketing, and logistics.

2.3.3 Serving Things Phase

"Serving things" means that BoT offers financial and non-financial services to intelligent IoT devices. In this phase, BoT directly serves smart devices with independent decision-making capabilities. The aim is to provide suitable financial services that meet the financial requirements of "intelligent things". The "thing" itself becomes the customer, which greatly expands banks' business forms.

BoT will design core services for "intelligent things", such as value storage, fund transfer, and credit authorization. This means that in the future, "intelligent things" can independently perform financial activities such as deposits, remittance, insurance and loans based on big data, AI, and IoT. This scenario will free people from complex social and financial affairs. The owner of an "intelligent thing" needs only to authorize its financial behavior within a certain scope. The BoT would then independently open a bank account for the "intelligent thing" and provide financial and non-financial services. This will enrich banking service scenarios. Intelligent refrigerators can independently do the shopping; vending machines could independently buy and sell goods; smart cars could independently pay for refueling and insurance and apply for maintenance. Banks will enable, manage, and constrain financial behaviors in these autonomous activities through the things' accounts. By serving "things", banks will be serving enterprises or persons behind "things".

In summary, the three evolution phases represent exploration of financial service forms in the future digital economy era. The three phases are interwoven: "thing services" may appear in the "twins of things" phase and are built on the "twins of things". The two phases ultimately culminate in the "serving things" phase, where "intelligent things" become agents. As our requirements are reflected in these "intelligent things", their experience and services are passed directly onto us.

3 Driving Transformation

3.1 Service Transformation

As a financial infrastructure in future society, BoT will expand direct service receivers from people to "intelligent things". This brings significant innovations in service experience, customer engagement, as well as personalized and diversified services.

Directly serve "intelligent things" and create new customer experiences. As the digital society advances, virtual and physical worlds will continue to converge at faster speeds. The social experience of people will include the social experience of "things", whereby the latter's rational experiences are based on objective data, using indicators such as response time, transaction cost, deployment location, and system robustness. BoT will build a systematic, structured, and logical framework to reconstruct thing-centered customer experience and meet things' requirements in real time. This will be one of the key service areas of BoT.

Table 3-1 Customer experience indicators for "things"

Type	Indicator
Speed	• Task time (e.g. time to confirm, accept, and deliver an order) • Response time of a single task
Efficiency	• Transaction volume improvement • Process of a single transaction • Transaction frequency
Precision	• Order correctness/failure rate • Order acceptance/rejection rate
All established goals	• Total revenue • Total profit
Autonomy level	• Owner's engagement • System running robustness • Total amount involved in autonomous transactions

With the emergence of digital twins and agents, customer experience will become more rational. As this cannot be accurately assessed through qualitative analysis, we propose a group-based customer experience assessment model. The formula is as follows:

$$C=\begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ x_{31} & x_{32} & \cdots & x_{3n} \\ x_{41} & x_{42} & \cdots & x_{4n} \\ x_{51} & x_{52} & \cdots & x_{5n} \\ x_{61} & x_{62} & \cdots & x_{6n} \\ x_{71} & x_{72} & \cdots & x_{7n} \\ x_{81} & x_{82} & \cdots & x_{8n} \\ x_{91} & x_{92} & \cdots & x_{9n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \begin{bmatrix} w_{1<resource\ involved>} \\ w_{2<product\ price>} \\ w_{3<business\ flow>} \\ w_{4<sevice\ period>} \\ w_{5<service\ quality>} \\ w_{6<function\ relalized>} \\ w_{7<speed>} \\ w_{8<interaction>} \\ w_{9<marketing>} \\ \vdots \\ w_{n<operation>} \end{bmatrix}$$

$$Z_i = \frac{C_i}{\max\limits_{1\le j\le m}\{C_j\}}$$

$$EI_i = 2sigmoid(10Z_i) - 1$$

Customer experience model: Multiply n customer experience factors (such as <resource-involved>, <product-price>, <service-period>, <function realized>, <speed>, and <marketing>) by the corresponding weight y to calculate the initial group customer experience value C of m customers. Then normalize the value linearly to obtain the normalized customer experience discount Z_i, where the numerator C_i indicates the individual customer experience value and the denominator $\max_{1 \le j \le n}\{C_j\}$ indicates the optimal customer experience value in ideal conditions (theoretical ideal value) with a value range of [0,1]. Then, use the sigmoid function to convert the customer experience discount Z_i into the final customer experience value EI_i. When the initial customer experience value C is higher, the customer experience discount decreases. When Z is closer to 1, services provided are better. However, with the increase of the initial customer experience value C, the marginal increase of the final customer experience value EI_i is decreasing, that is, the marginal effect of customer experience is decreasing. In other words, the product optimization cost is not in proportion to customer experience improvement. For different customers and business scenarios, factor weights can be adjusted to generate an optimal model, cost curve, and benefit curve for evaluating customer experience. Using this model, BoT can perform quantitative analysis on the experience of future customers' digital twin/agent devices and optimize business products to improve both customer service quality and efficiency.

Quickly respond to requirements when customer reach moves downwards. Thanks to a variety of "intelligent things" in the IoT functioning as service touch points, BoT remains closer to customers and obtains multi-dimensional, trustworthy data in real time. These boundless service touch points help BoT reach different aspects of the customers' work and life through ubiquitous connected networks, and deliver intelligent, and immersive experiences. In doing so, BoT goes beyond traditional online and offline service channels, quickly responds to customers' financial requirements, and win customer loyalty.

Deliver personalized and diversified services through multi-dimensional information awareness. BoT performs intelligent analysis and makes decisions based on the large amount of real-time data collected by IoT terminals. It proactively matches customers' scenario-specific requirements, and provides feedback-based, personalized, and diversified services. This enhances targeted service provisioning, product customization, and dynamic risk management to reduce communication friction and supply-demand mismatch. With the development of industrial digitalization, the large-scale industrial Internet ecosystem will become the trend for the real economy and industries. Equipped with large amounts of industrial sensor data, the manufacturing industry will transition from large-scale manufacturing to customization on an individual basis. BoT can sense the actual requirements of physical enterprises through platform data, provide personalized pan-financial solutions, and offer diversified services for MSMEs, thereby achieving financial inclusion.

3.2 Business Transformation

BoT embodies an advanced development phase of embedded and scenario-specific banking, the application of digital twins in banking, and banking innovation and development by learning from Internet finance. Traditional and digital banks are collaborators in industry convergence, while BoT is the integrator, enabler, and leader of industry finance. Industry 4.0's informatization and automation capabilities, along with Bank 4.0's service openness, move banking services to the left. Taking "things" as a core production factor, BoT closely combines economic and financial activities which were once separate.

Build intelligent space scenarios and define products for "thing" customers. Traditional banks are divided based on customers or business processes, such as corporate and retail businesses, and financial markets. Specific business products are designed for each phase of the traditional financial process. In the BoT era, many products are designed according to the requirements of "thing" customers in intelligent space scenarios, removing the limitations of financial and non-financial products. To achieve this objective, BoT builds a new platform-based, modular, scenario-specific, and personalized service model using smart devices and data. The model covers the business logic of objective data acquisition, online data processing, platform requirement analysis, personalized product design, and modular products. In doing so, it can generate scenario-specific product services.

Build a new profit-making model through win-win cooperation. The core feature of the digital economy is to provide customized products and services at a low marginal cost. Data, a non-exclusive production material, will promote cross-industry cooperation. In the digital economy era, BoT deeply integrates with industries, removing barriers of information asymmetry through an industry interconnection platform, reducing channel communication costs, and benefiting all enterprises on the industry chain.

Focus on customer experience and reengineer business processes. Centering on customer experience, BoT uses reliably objective data from many IoT devices. It then integrates online and offline processes and builds a new paradigm of platform-based, integrated, and modular business processes. This consequently simplifies business processes, shortens the process cycle, and reduces costs caused by process friction.

As industries are converging and boundaries are blurring, giant enterprises are becoming platform-based while surrounding enterprises are becoming functional and modular. Personalized requirements on the demand side can be promptly sent to the supply side through intelligent platforms. This minimizes information asymmetry and matches resources more accurately. Facing new requirements emerging from social and economic changes, commercial banks will need to reconstruct their business logic. By adhering to its scenario-specific and ecosystem-based concepts, BoT integrates with industries, deeply understands pain points in each industry scenario mode, and designs more personalized pan-financial products and services through big data analysis and prediction. BoT will integrate the capabilities and data of open banking and data-based banking, and leverage IoT, AI, blockchain, and big data to build an all-round financial supermarket, driving technological monetization.

3.3 Risk Management Transformation

Expand data sources and perceive the physical world. "Data is value" has become a popular concept across various fields. Data is valued and pursued like a currency that flows. The commercial use of 5G will accelerate the development of the IoT industry. Sensors are connected to various physical devices, greatly enriching data sources. The IoT is a perception and interaction system oriented towards the future physical world. It will become a new structure for social attributes and bring significant changes to the production and lifestyle modes of the physical world. The IoT constructs digital twins for the real world after perceiving it through mass terminals and platform architecture.

Develop a new risk assessment model, pricing real credit. At present, banks prefer modeling, rating, and classification based on the subject credit data. This risk management model has two major disadvantages. First, subjective data may be forged, and comprehensive data cross-verification is expensive. As a result, many credit services cannot be carried out, such as loans for SMEs and long-tail individuals. Second is credit delay. A model based on static data cannot reflect real-time credit status. In view of these issues, BoT devises a new risk assessment model based on objective data. It uses IoT hardware to obtain a large amount of credible data, such as industrial enterprises' production activity data, people's behavior data, and smart cities' operational data. BoT can then establish a new risk assessment model for banks using technologies such as neural networks.

Value timeliness and build a dynamic risk view. Traditional risk control models experience time delays. By using legacy data, a quarterly or annual report can only reflect previous operating status. In the digital economy era where economic activities are accelerating, real-time data is required to better evaluate risks and issue warnings. The intelligent risk assessment model, based on real-time, reliable, and objective data, transforms the traditional risk control model into a new risk control service model featuring asset data visualization, management, and control.

Perform remote supervision and optimize the post-loan management mode. Traditional post-loan management modes experience several problems such as high supervision costs, low work efficiency, slow speeds, and information asymmetry. These issues create vulnerabilities for internal management. Based on the intelligent connectivity of everything, BoT uses various sensors to detect the operating status of enterprises and pledges in real time. Greater risk assessment accuracy improves post-loan management, reduces bad debt rates, and lowers risk management costs. Mass IoT data is used to assess the production and operating status of enterprises, warehouses, on-site offices, logistics, and energy consumption indicators such as water, electricity, and coal.

Table 3-2 Comparison between traditional credit assessment and objective credit assessment

	Traditional Credit Assessment	Objective Credit Assessment
Data source	Mainly credit investigation data from banks	IoT device data, platform transaction data, and user behavior data
Data timeliness	Low data collection efficiency	Real-time and dynamic
Object for evaluation	Uses credit history to reflect future credit status.	Combines mass IoT objective data with an entity's credit records.
Analysis method	On-site due diligence, scorecard, etc.	Data mining and machine learning
Service receiver	Entities that meet strict credit standards	All entities in the society
Usage scenario	Mainly in the credit financing field	Various social production and life activities such as consumption and lending

4 Architecture Design

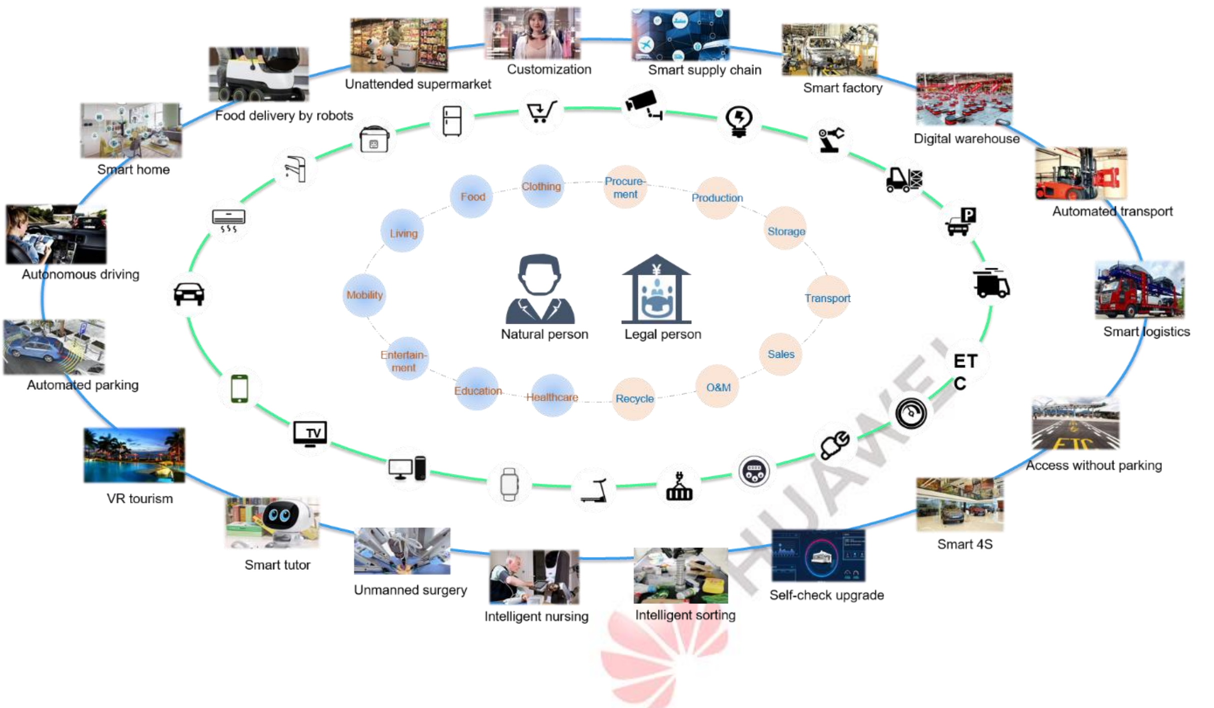
4.1 Business Architecture

4.1.1 Business Vision

Economic development leads to an abundance of commodities. This also makes people vulnerable to goods and services fatigue where they are tired of dealing with affairs in work and life. BoT frees people from such financial activities. Nowadays, an increasing number of "intelligent things" develop scenario-specific services, freeing us from unnecessary common affairs. However, a lot of financial affairs still require manual intervention. For example, self-driving cars offer convenient mobility services that may be affected if parking, charging, maintenance, and other activities still require our presence. In the "thing services" and "serving things" phases, cars, upon limited authorization from their owners, will independently complete routine actions like parking, charging, and maintenance. This allows everyone to focus on creative activities which can enhance their life experience.

Economic development brings abundant capital which does not flow into MSMEs with limited informatization. To solve this problem, BoT will advance financial inclusion and make financial services available and accessible. Capital is crucial to an enterprise. Due to information asymmetry, MSMEs must go through long and difficult processes to lend from banks. BoT can directly provide loans and even embed them into each operational phase of enterprises based on their production status, product sales status, and market demands. For example, BoT can exchange data with processing machine tools to determine the credit limit for purchasing raw materials and paying for electricity fees. It can also exchange data with vehicles for transportation to determine the credit limit for paying charging fees and tolls, and with warehouses for storage to determine the financing amount available for inventory. Through this system, many MSMEs can obtain timely credit services.

Figure 4-1 Bank service ecosystem



In the future, the new financial business form of "things as the medium and scenarios as the core" will help achieve the preceding business vision, helping to serve enterprises and individuals.

4.1.2 Element Forms

In the new financial business form of "things as the medium and scenarios as the core", "things" are the key element. After "things" obtain more authorization from people and become more intelligent, they can engage more extensively in social life and production. The focus of banking will gradually expand from people to people and things, including a large number of intelligent credit and financial services.

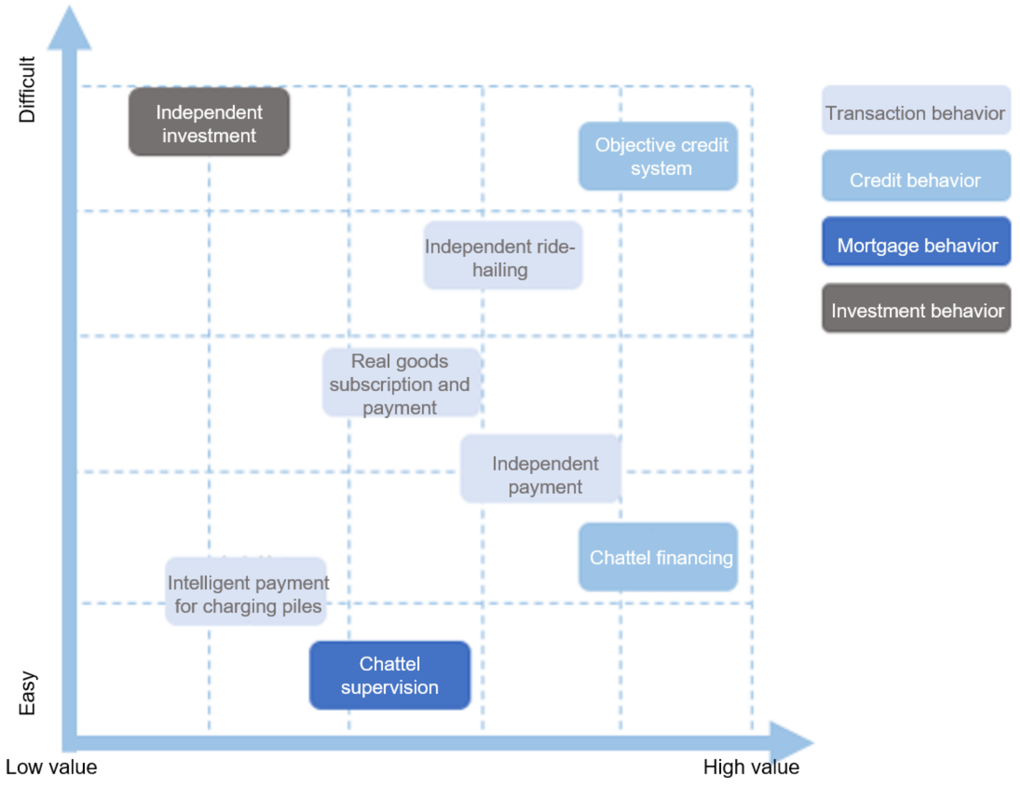
As a value carrier, "things" represent important forms of value storage. Homes, cars, jewelry, factories, equipment, and vehicles are valuables and important collateral for financing. However, restricted by technology and information asymmetry, banks remain cautious when it comes to lending. Additionally, only certain valuables can be used in mortgages and the discount is unsatisfactory. As a result, the wealth of society does not flow well.

As a data carrier, "things" serve as important tools for value discovery. With the development of IoT and AI, sensors are emerging, helping to explore more financial scenarios. For example, more car financing options are available in wholesale, retail, and use phases using technologies such as OBD, BeiDou positioning and geo-fencing; commodity financing based on digital, standard asset inventory is supported through RFID tags, positioning, tracking, and intelligent monitoring technologies. As tools, "things" not only enhance production and social life, they also collect behavioral data and generate new assets accordingly. For example, a car can provide navigational services for users whilst also recording their daily itinerary, frequently visited places and business. A machine tool supports programmable automatic processing and records working duration and output. "Things" collect, store, and analyze objective, real-time data in work and social scenarios, helping to establish objective banking credit systems. They play an increasingly important role in modern banking as data assets.

As an intelligent carrier, "things" are powerful assistants in the work and life of people. "Intelligent things" directly participate in financial activities as our digital agents. The main financial activities of the banking industry include transactions, credit, mortgage, and investments. "Intelligent things", as financial customers, also have the following behavior:

- Transaction: initiated or participated in by "intelligent things", such as shopping and payment. Examples include seamless payment and independent shopping by "things".
- Credit: As a credit derivative of a natural or legal person, an "intelligent thing" can apply for a certain credit limit from a bank and receive refined management from the credit subject with an independent account. In addition, an "intelligent thing" is also an asset, which supports credit assessment of an individual or enterprise and can be used for credit applications.
- Mortgage: "Intelligent things" are valuables and their worth is assessed based on market conditions. "Intelligent things" can be mortgaged to banks for financing applications, such as auto financing.
- Investment: "Intelligent things" have asset attributes and independent accounts. When independent shopping of "intelligent things" is possible, they can invest using funds in their accounts, such as buying wealth management products, securities, stocks, and funds. For example, an intelligent refrigerator buys wealth management products and uses earnings for replenishment, which directly benefits the owner. This is similar with investment losses.

Figure 4-2 Difficulty and value distribution of BoT financial services



As shown above, BoT services vary by difficulty and value. We perform a qualitative analysis on the difficulty and value of each type of business. On this basis, we will gradually build a comprehensive BoT business ecosystem extending from easy services to difficult services and from high-value services to low-value services.

There are four prerequisites for "things" to participate in financial services as transaction entities:

- **Clear ownership between people and "things":** It does not matter how valuable an "intelligent thing" is, whether it is owned by a person for a period of time, or whether it is free to use or not. Instead, ownership of the "intelligent thing" at a specific time should be clear and traceable. For example, the smart shopping cart owned by an unmanned supermarket can be used by a shopper for free, but it can be a banking customer if who uses it at what time is clear.
- **Clear authorization from people:** "Thing" customers are extensions of people. Intelligent "things", as our agents, must have a clear scope of authorization such as objects, content, time, means, amount, and frequency. By controlling, auditing and reauthorizing "things", risks can be avoided.
- **A trusted transaction environment between "things", platforms, and people:** BoT breakthrough lies in interaction between "intelligent things", and between "intelligent things" and platforms, as well as independent financial transactions. This not only expands transaction objects, time, and areas, but also accelerates transaction processes, especially the decision-making process. In doing so, banks will gain more customers, perform more transactions and improve economic efficiency.
- **Standardized "thing" identity:** As a bank customer, an "intelligent thing" needs to have a standardized identity definition. This can be achieved by a unified encoding rule and a standardized identification and verification method. This guarantees and recognizes the unique identity of a "thing" so that its transactions can be regarded as credible.

4.1.3 Business Architecture

BoT operates largely as a regular bank, and its core business is substantially similar in this regard; traditional financial services such as deposits, loans, investments, payments, and settlements are all available to customers. With the business element increment from "things", BoT effectively serves natural person customers, legal person customers, and "thing" customers. Pan-financial services become scenario-specific and ecosystem-based. These changes come from BoT businesses.

BoT businesses include the following:

- **"Thing" information access service:** manages devices and collects "thing" information, which is the basis for the data element increment. Information about "things" can be directly obtained from the life IoT environment on the consumer side and the production IoT environment on the supply side, or indirectly obtained from ecosystem partners.
- **"Thing" information processing service:** implements "thing" information cleaning, organization, association, trustworthiness assurance, and real-time processing, adding a data increment to "thing" information. Deeply perceiving the physical world requires huge amounts of multi-source multi-dimensional data. In addition, the data of different subjects and objects should be flexibly associated and organized. When "thing" information is indirectly obtained from partners, data trustworthiness assurance is also one of the key capabilities required by the "thing" information processing service.
- **Objective information analysis service:** obtains detailed raw data from the "thing" information access service, metadata, intermediate data, and associated data from the "thing" information processing service, transaction data and customer data (natural and legal persons) from core business systems, as well as business information flow data and "thing" customer data from scenario and BoT services. This integrates logistics, information flow, and

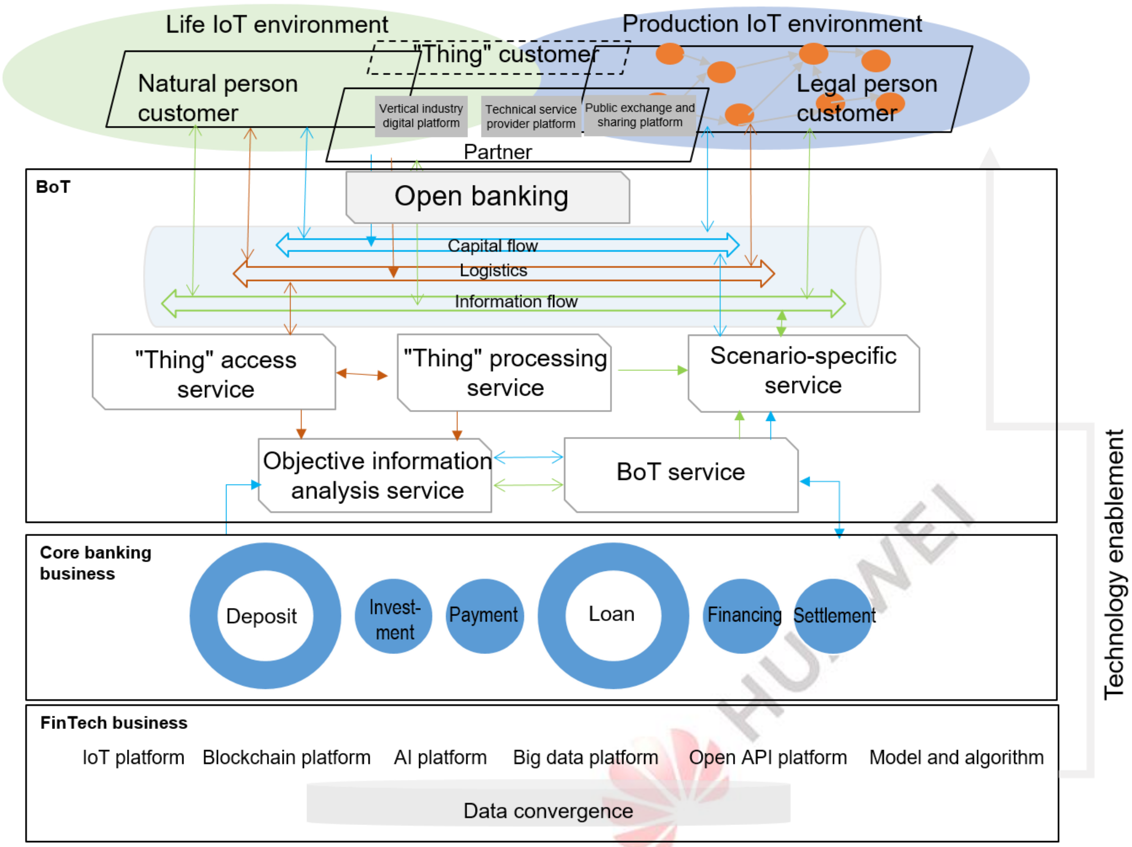
capital flow, and connects physical and digital spaces. The objective credit analysis service enables objective, dynamic, and accurate risk assessment using subject credit, transaction credit, entity credit, and technologies such as data mining and AI. Customer profiles and status awareness are also supported, in which customers involve natural persons, legal persons, and "things". Associations are established between "things" and natural persons or legal persons to detect the status of customers in the physical world at different times and in different scenarios. The objective information analysis service is embedded into core business services, BoT services, and scenario-specific service processes as required.

- **Scenario-specific service:** adds an increment to scenario elements. To meet financial service requirements in a person's social life and production activities, BoT adds "things" as customers, apart from natural and legal persons. This brings an increment to scenario-specific businesses which are integrated product and service solutions built on actual actions and scenarios of "things". These scenario-specific services are personalized, fragmented, automated, and high-frequency. They help to refine and enhance services for individuals and enterprises.
- **BoT service:** offers business data and takes "things" as customers, acting as a financial service module. One or more core banking businesses, plus BoT attributes or features such as transaction channels, objects, limits, and frequencies, will generate financial services tailored for "things". The BoT service obtains objective credit, customer profiles, and status profiles from the objective information analysis service and embeds them into scenario-specific services through open capabilities. The BoT service supports "thing" accounts, independent payment of "things", token-based assets, and "thing" credit ratings.

BoT's technical basis lies in rich and expanded FinTech service capabilities. As BoT raises higher requirements on data convergence and openness, IoT becomes one of the new core capabilities in addition to big data, AI, and blockchain. Banks not only embed core financial service APIs into customers' or partners' business applications, and more importantly, they deeply integrate with consumption and supply scenarios. Banks need to enable customers and partners through FinTech, which provides interface standards and helps to develop a secure, trustworthy IoT environment for financial transactions. Banks should also build their own ecosystems and integrate these ecosystems with other ecosystems.

BoT has diversified partners covering vertical industries, public services, and technical platforms, such as the industrial Internet platform and the IoT platform of public cloud service providers.

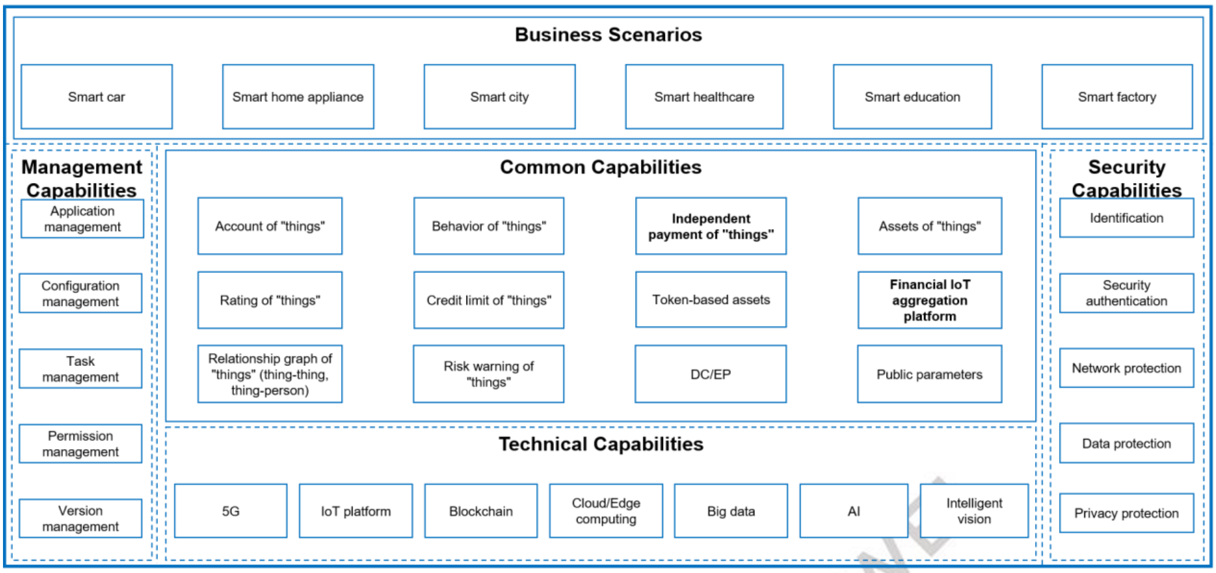
Figure 4-3 BoT business architecture



4.2 Application Capability Reference Framework

BoT requires a 4+1 application capability architecture: that is, common, technical, management, and security capabilities to support application scenarios. Common capabilities are the core, technical capabilities are the foundation, and management and security capabilities underpin all processes.

Figure 4-4 BoT application capability reference framework

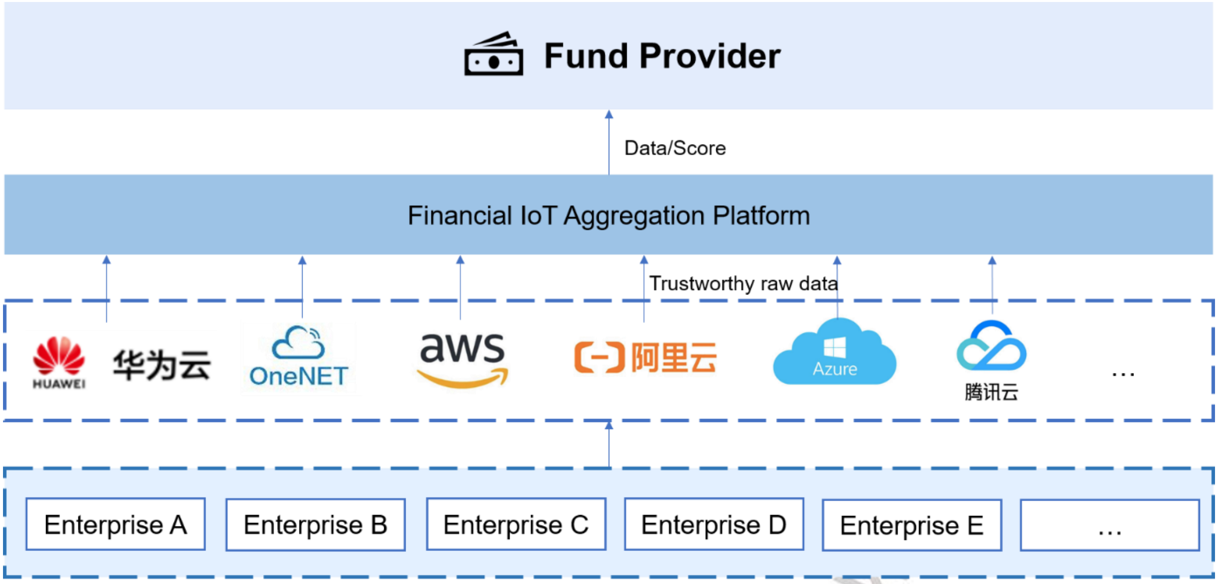


4.2.1 Common Capabilities

To provide financial services for "intelligent things", BoT needs to have basic common capabilities such as things' virtual accounts, behavior, and payments. This improves payment, financing, investment, asset management, and information intermediary services, and empowers a new financial business form which controls risks and eliminates information asymmetry through data. IoT finance integrates business and service networks at the financial level to deliver automated, intelligent financial services and create multiple business models.

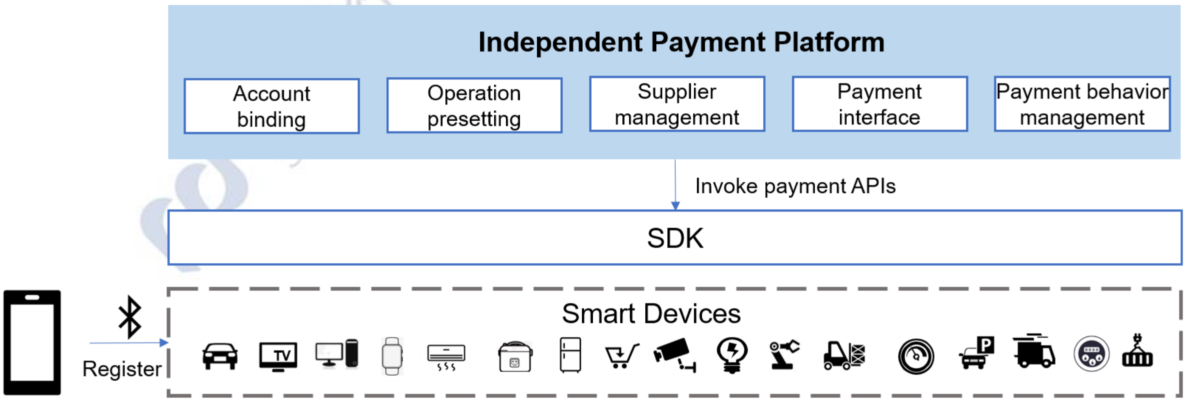
Financial IoT aggregation platform: BoT will build an IoT aggregation platform for the finance sector. The financial IoT aggregation platform is a platform for IoT platforms of major cloud service providers (CSPs). Through data interfaces of these IoT platforms, the financial IoT platform receives specific device set data from IoT platforms, after simple configuration and end user authorization (for data compliance). The aggregation platform then sends IoT data through unified service interfaces to financial institutions which utilize the data to deliver financial services. This is a type of data supply chain finance based on CSPs' data credit.

Figure 4-5 IoT aggregation platform



Independent payment platform for "things": BoT will provide an independent payment platform, as well as payment Software Development Kits (SDKs) and development frameworks applicable to various terminal systems, to enable device manufacturers. No matter which IoT platform a smart device is connected to or which IoT ecosystem the device belongs to, the device can utilize the payment interface through the platform and framework, enabling independent payments. This does not involve adaptation to card organizations and third-party payment platforms, or binding logic between devices and bank cards. This independent payment platform enables unified and open payments.

Figure 4-6 Independent payment platform



Virtual account for "things": refers to a bank settlement account opened to provide consumption, payment, and other services for "things" in the BoT era. The virtual account must be bound to a type-I account of a natural or legal person, and shared with the natural or legal person. In addition, the account relationship graphs between "things", and between "things" and people, should be constructed.

Behavior module: records and analyzes the status and behavior of "things", to analyze behavior of natural or legal persons, thereby offering enhanced services.

Payment module: processes transaction requests sent by "things" and connects to the corresponding supermarket systems.

Asset module: manages all the assets connected to the bank's IoT platform.

Rating module: supplements the objective credit system and manages things' ratings based on a person's rating. To control customers' credit risks and enable fund security, liquidity, and profitability, banks comprehensively evaluate customers and determine their credit ratings from the following aspects: customers' operating capability, profitability, repayment capability, development capability, personal quality, and credit status.

Credit limit module: sets the upper credit limit of virtual accounts for risk restriction, dispersion, and warning. The credit limit management system involves credit limit application, validation, modification, and freezing.

Asset token module: introduces asset accounts of "things" into the token accounting model. In this model, "things" are stored and operated in token mode to support asset-centered dynamic pricing, transfer, disassembling, and trading. This module links "things" and people across multiple departments, services, and channels, and provides unified services and marketing, including asset monetization, circulation, mortgage, and pledging.

Risk warning: If fraud occurs or the amount exceeds the applied credit limit, a warning is promptly sent, and a message is pushed to the natural person to check the "thing" status and transaction order validity.

4.2.2 Management Capabilities

Basic BoT management capabilities involve access management, basic management, provisioning, modeling, and O&M. BoT supports connections to the cloud, bidirectional message communication between devices and the cloud, batch device management, remote control and monitoring, OTA upgrades, and device linkage rules. Device data can be flexibly transferred to other services on the cloud, helping IoT industry users quickly connect devices and integrate industry applications. The functional modules are as follows:

"Thing" access: BoT supports multi-mode, multi-network, and multi-protocol access and provides IoT device SDKs in multiple scenarios and languages to resolve IoT fragmentation issues and quickly access devices.

"Thing" management: BoT offers rich device management capabilities. A unique identifier is created for a device so that the BoT can obtain online behavior information about the IoT device, including online status and business access, and remotely manage the device without connecting to its serial ports. Moreover, device grouping and labeling are supported.

"Thing" provisioning: BoT automatically delivers device information by utilizing the unified device provisioning service and in-depth IoT platform integration across regions. Devices can go online securely and reliably based on service objectives, minimizing the possibility of human intervention errors.

"Thing" model: refers to a unified model of physical devices of the same type. Devices and applications operate according to data and commands defined by the "thing" model, decoupling devices and applications. Message communication is designed based on the "thing" model. In the uplink direction, attributes and messages are reported. In the downlink direction, commands and messages are delivered, and attributes are modified.

"Thing" O&M: BoT supports batch operation, simplifies device management, and provides functions such as remote configuration, OTA upgrade, and device fault alarms.

4.2.3 Security Capabilities

As IoT is advancing, security protection is vital to the IoT era, and this involves BoT's security capabilities. Each link of BoT may have security vulnerabilities and become the target of cyber-attacks. Therefore, each layer should have a security solution to protect business systems, including terminal security, access security, platform data security, and application security. In addition, BoT inevitably involves personal data when processing user device data, and should comply with local laws and regulations.

Terminal security: includes the security of chips, embedded operating systems, coding specifications, third-party applications, and functions. Security challenges exist, such as vulnerabilities, defects, specification use, and backdoors. Modules and SDKs with integrated security capabilities can be added to devices or gateways which then receive and execute security policies and report access behavior data.

Access security: A large number of IoT devices and cloud servers are directly exposed to the Internet. Once their vulnerabilities are exploited, security risks such as device control, user privacy leakage, and cloud server data theft may occur, and even basic communication networks may be severely affected. To prevent these risks, gateways and platforms should be authenticated through trusted connections. Also, ensure data is sent to correct terminals or platforms, to prevent data from being intercepted, eavesdropped, or tampered with during transmission.

Platform data security: When sensitive data is transmitted between IoT devices and IoT platforms, IoT network adapters and security service platforms can encrypt and transmit the sensitive data in two directions to ensure that the data is not stolen or tampered with. The IoT card can securely store sensitive data to prevent sensitive data leakage and tampering.

Application security: The application layer is easy to access and has the most external contact points, thereby facing various attacks, such as unauthorized user/device access. IoT network adapters can be used to authenticate IoT devices, ensuring that authorized IoT devices only receive data and instructions from authorized platforms.

Data compliance: Private personal or enterprise data is used in BoT services. Therefore, national laws or industry user privacy policies should be obeyed and sufficient measures should be conducted to ensure that various data is used in compliance with regulations.

4.2.4 Technical Capabilities

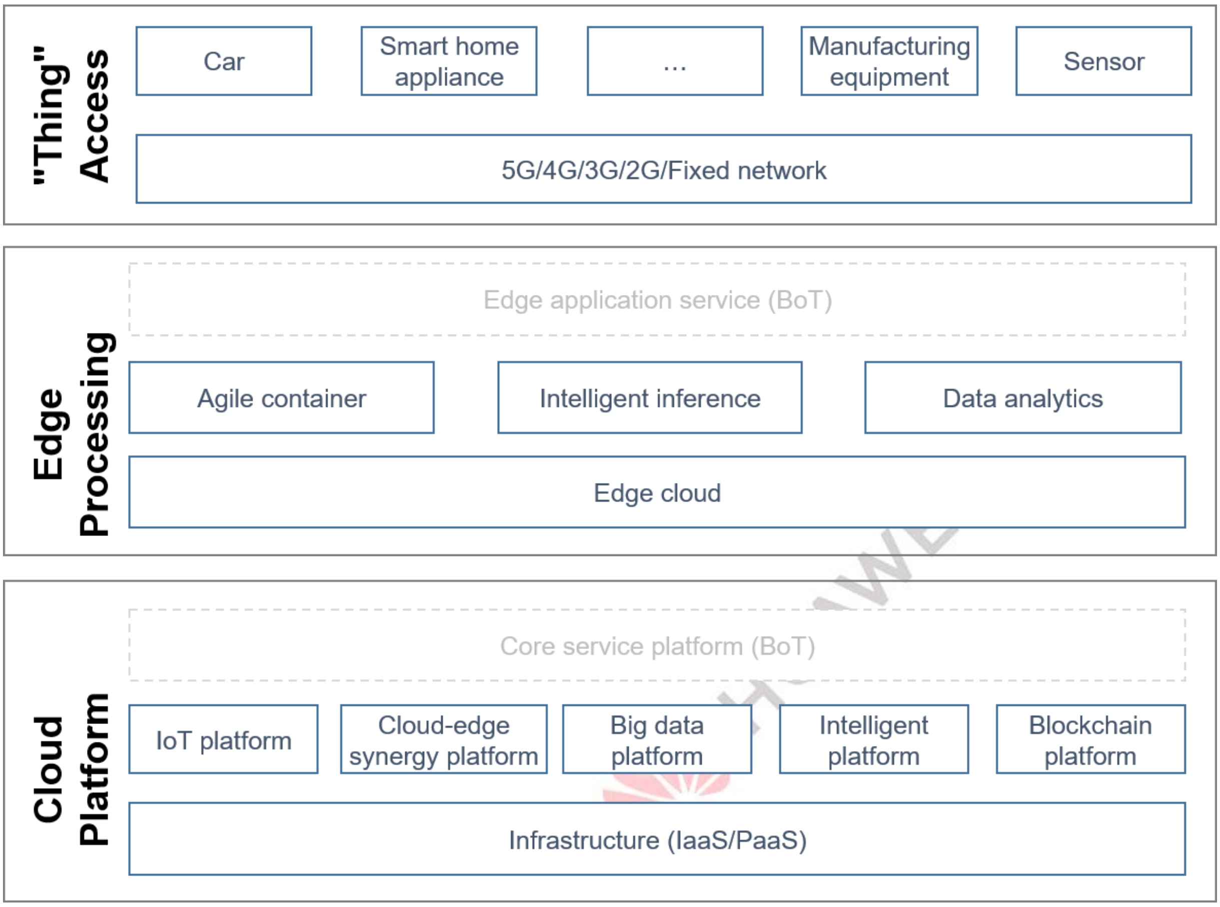
BoT is built on the three-layer architecture: "thing" access, edge computing, and cloud platforms. This architecture is underpinned by emerging technologies such as 5G, IoT, and AI.

The "thing" access layer accesses a large number of "intelligent things" and collects their data, marking the first step in mapping the physical world to the virtual world.

The edge computing layer distributes central computing power to each edge and offers real-time secure services in the near field.

The cloud platforms layer provides basic service cloud platforms such as IaaS and PaaS, and more importantly, management and processing platforms. The AI platform builds intelligent marketing and risk control models for "things", facilitating BoT. The blockchain platform protects identity authentication and transaction behavior privacy of "intelligent things", and offers trusted transactions and value discovery to "things" and data. The big data platform supports unified data storage and analysis, and accelerates BoT development through data. The IoT platform unifies connections between "things", manages "things" throughout the lifecycle, and enables BoT applications.

Figure 4-7 BoT technical capability architecture



5 Key Technical Challenges

5.1 Information Processing for Tens of Billions of IoT Devices

5G supports the access of 1 million devices per square kilometer. With BoT development, banks will connect to tens of billions of devices. Accessing diverse devices, and processing and analyzing device information require capacity expansion, flexible business scenario support, and real-time response in low-latency scenarios. This poses huge challenges to device access management, information transmission, information processing, and architecture cost.

Fully automated device access management: As the number of devices increases, manual functions such as boot programs, software and security configurations, device registrations, and device upgrades are no longer feasible; any mechanism involving human interaction becomes outdated and impractical. Therefore, all these processes must be automated to save time and improve efficiency. Devices should be equipped with built-in facilities, boot programs, security keys, and other necessary functions to facilitate the automation of the first startup.

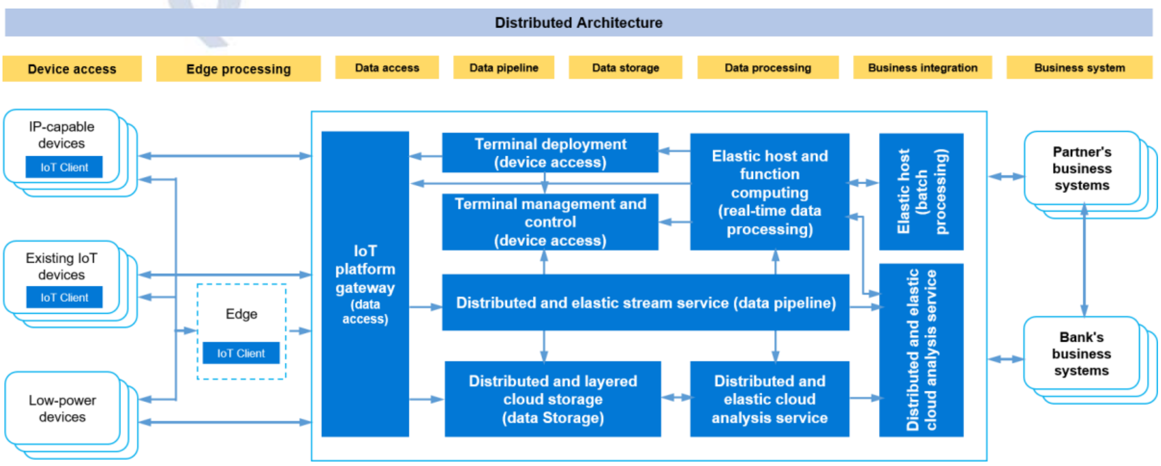
Message queues that support mass connections: The number of IoT sensor connections increases by 10 to 1000 times. IoT sensor communication features high frequency and small message volume, and negates the need for real-time response. Traditional web services, file transfer, and simple message queues are not applicable. Instead, information should be transferred to a collection cluster using message queues that support scale-out and time sequences. Message queues can be segmented by source, destination, and topic. The collection nodes are stateless and separated from the business layer and even the data analysis layer, enabling nearly linear horizontal expansion of the cluster.

Device-edge-cloud elastic polymorphic processing architecture: BoT's financial services are embedded into various industries and daily life. The device-cloud two-layer architecture of the mobile Internet cannot deal with billions of connections and responses. Scenario-specific hierarchical processing is the prerequisite for million-level processing. Simple scenarios, such as water, electricity, and gas meter data collection, have low frequency, small message volume, unidirectional information upload, and do not require low latency. Devices can be directly connected to the IoT platform on the cloud. For a single intelligent application, such as warehouse camera monitoring, real-time video streams are directly transmitted to the cloud for intelligent identification, which results in high bandwidth costs and slow response. To solve these issues, edge devices are deployed nearby and run intelligent vision algorithms to identify exceptions at the edge. The edge can trigger alarms, such as warnings broadcasted through speakers. In addition, video clips and events related to exceptions are synchronized to the cloud for archiving and in-depth analysis. In a comprehensive analysis scenario, such as a smart home procurement plan, refrigerator inventory, family diet, health information, family schedule, local weather, local market price, local delivery, and procurement history are analyzed. Due to data privacy regulations, the preceding data cannot be processed centrally on the cloud; instead, edge computing at home is more suitable. Edge processing features front-end services, local decision-making, security, flexibility, and cloud-edge synergy. This device-edge-cloud distributed processing architecture can better support scenarios involving mass connections, complexity, and low latency requirements. Both the edge and cloud have strong distributed elastic scaling capabilities, and support different deployment modes. Reference standards can be generated from continuous practices.

Economical architecture: The economical architecture is the prerequisite for banks to quickly develop tens of billions of "thing" customers. Software replication ensures that the marginal cost is almost zero in large-scale scenarios where banks' cost challenges come from infrastructure such as computing, storage, and network resources. Elastic cloud computing, tiered storage, and slicing networks provide resources based on service values and requirements, improving resource utilization while reducing construction and usage costs. Elastic cloud computing includes elastic cloud servers, function computing, message queues, and analysis; these cloud services can be scaled in or out as required. Tiered data storage stores data by layer based on functions and purposes, such as processing performance, storage capacity, and use frequency, to reduce storage costs. 5G network slices can be used to build networks with different costs based on different purposes, values, and SLA requirements.

The following figure shows the reference architecture.

Figure 5-1 BoT distributed processing architecture



5.2 Mass, Diversified Data Storage and Organization

BoT provides data-driven financial services with "things" as the medium and scenarios as the core. Data generated by "intelligent things" is classified into static data and dynamic data. Static data is mostly tag data, such as data generated by RFID tags. Dynamic data is time-sequenced: each piece of data corresponds to a time and grows with time. Data of things has features of **HEART**:

Huge: In the mobile Internet era, mass data is generated from human manipulation. In the era with intelligent connectivity of everything, data is generated by "intelligent things" and data volume grows by several orders of magnitude. For example, a processing machine running for 24 hours produces dozens of TB of data. A 1080p camera collects more than 80 GB of data per day.

Edge-preprocessing: Mass data generated by things has low value density and not all data is valuable enough to save. If a factory does not work at night and no exceptions occur, each frame of data remains unchanged. Only the latest frame is retained at the edge and saved with the start time and end time.

Archival: "Things" generate data rapidly, indicating that the value of data also decreases fast. The data is not directly referenced and only data summary is sufficient. Operating data of a high-end manufacturing device is only valuable when a fault occurs. Generally, data is summarized several days later into whether its status is normal and how many goods are processed. The detailed data is directly archived for reference.

Rarely-editable: Data generated by smart devices is the result of objective description or rational reasoning. In the mobile Internet era, data is subjective, easy to change, and prone to human errors. In the era of everything connected, data is quickly generated (written) by "things" and does not require modification (not recommended either).

Time-sequential: Data of a specific IoT device, regardless of real-time video stream data or structured data of periodical sensing, carries timestamps naturally. Generally, data access also carries timestamps for retrieval.

The HEART features pose new challenges to mainstream technologies. Therefore, new technologies and policies need to be introduced.

Hierarchical policy: Given the data value density, access frequencies (hot, warm, and cold), and bandwidth costs for storing mass data on the cloud, the device-edge-cloud synergy architecture is recommended. Typically, hot data that has been recently generated or frequently accessed, is pre-processed and filtered by the time series database, and then stored in the local hard disk of an edge server. Warm data or cold data is compressed and sent to the cloud, and then backed up and archived using OBS. In this way, data transmission bandwidth costs and storage costs are effectively reduced.

Storage-compute separation technology: The Hadoop platform uses the distributed technology to process mass IoT data on the cloud. The advantage is that a distributed storage resource pool is constructed based on common servers. However, it also has an obvious disadvantage: in the case of rapid data growth and three copies of Hadoop, many computing CPU resources are wasted during node capacity expansion. The separation of storage and compute can improve storage efficiency and reduce costs. Compute nodes use high-performance servers to build clusters, and storage arrays use large-capacity storage servers to form clusters. The capacity of compute nodes and storage nodes can be expanded based on data storage and processing requirements. A time series database is used to store and analyze a large amount of dynamic data, effectively saving storage space and reducing I/O overheads.

Graph database: BoT needs not only asset and identity information of "things", but also their status information, production data, and data associated with their time, space, and owners. BoT analyzes and predicts relationships between "things" and their owners to provide payment, financing, risk control, and other pan-financial services. In this process, graph databases are used for relationship analysis. Graph databases have various issues, such as compatibility with new hardware (VNM, RDMA, FPGA, and GPU), immature interface language (GQL), and lack of domain knowledge for data modeling. These issues should be addressed in banks' business practices.

As for the development trend of storage technology, spintronics-based magnetic random-access memory is worth tracking.

5.3 Perception Data Authenticity Assurance

As a new production factor in the IoT era, data will drive BoT business development and this role of data depends on its authenticity and trustworthiness. Sensing devices ensure data authenticity and trustworthiness by means of a built-in security environment, data encryption, network transmission encryption, and the like. However, such data security protection methods based on a single sensing device cannot meet BoT's data authenticity and trustworthiness requirements on a large number of devices. This issue should be addressed through the IoT architecture.

BoT uses a group architecture for device data collection, that is, a collaborative, division-based, and organized system with group attributes formed by independent smart devices. The group system flexibly organizes functions and roles of smart devices based on different service scenarios, targets, people, and events. The group architecture is closely related to and coupled with monitoring targets, environments, and events. This highly self-organized, self-adaptive architecture greatly increases the probability of perceiving real events through multi-source data cross-verification and interaction with service events.

The advantage of this new architecture is that it makes single-point data modification invalid. This is ensured through cross-verification of multi-dimensional data collected at multiple points, thereby increasing data forging cost. IoT application scenarios focus on events after multi-source data encapsulation and weaken the function of single-point data. Decisions are made based on events. Therefore, BoT uses the group collaboration architecture on the perception side to prevent single-point data tampering and ensures decision-making effectiveness. Importantly, BoT needs to define "social function attributes" of different sensing devices to generate group collaboration models applicable to different scenarios.

5.4 Unification and Openness in the Multi-ecosystem IoT Environment

The IoT ecosystem remains highly fragmented. The terminal systems, transmission protocols, and IoT platforms are not unified. Based on the current ecosystem status, BoT will build an IoT financial platform with unified integration capabilities and open capabilities. With this platform, sensing devices of production enterprises can provide trustworthy, objective data for multiple banks. "Intelligent things" capable of independent payments can be bound to different bank accounts.

A large number of manufacturing enterprises rely on professional industry solutions for digital transformation to reduce costs and improve efficiency. In this case, if an enterprise has financial service requirements, a bank needs to know the enterprise's production and operating status data from digital sensing devices, so as to better control risks. The enterprise may falsify data, creating uncertainty for the bank: whether data directly obtained from the enterprise's digital platform is authenticated or reliable. If the bank directly provides a digital solution that covers devices, it will suffer from heavy-asset operations and insufficient industry understanding. Therefore, banks need to find a way to obtain real data while maintaining light-asset operations. Considering that most IoT solutions rely on CSPs' IoT platforms, banks can build a financial IoT aggregation platform to access these IoT platforms and obtain trusted data at low cost, enabling data unification and openness. Consumers' smart devices will see surges in payment demands; to this end, BoT will build an independent payment platform to enable payment unification and openness.

By building the two platforms (financial IoT aggregation platform and independent payment platform), BoT can implement unified data development and payment openness in compliance with data usage regulations in the multi-IoT ecosystem scenario, without affecting the current IoT ecosystem.

5.5 Open IoT Security

BoT aggregates a large amount of industry chain and personal data, so it needs to protect networks from malicious behavior. In a centralized environment with a single security management domain, security issues are easily resolvable. However, in a distributed environment with multiple security management domains, resolving security issues becomes more challenging.

BoT's aggregation platform integrates various IoT platforms. From the perspective of security, open IoT security involves the direct IoT domain (from devices to direct IoT platforms), the interconnection domain (from direct IoT platforms to the BoT aggregation platform), and the data domain (data exchange and end-to-end business transactions between platforms).

Direct IoT domain: The domain is relatively mature and usually managed by IoT platform service providers or solution vendors. The security factors are as follows:

- IoT protocol security: Identifies MQTT/COAP packets and defends against malformed packet attacks and malicious threat traffic to ensure IoT protocol security.
- Terminal and device management security: The network enablement platform works with access authentication devices to implement terminal identity authentication and management, authentication control, and secure Firmware-Over-The-Air (FOTA).
- Data isolation and storage security: Terminal PKI certificates, OS packages, configuration files and logs are logically isolated and stored after encryption to ensure security.
- Encrypted data transmission: Traffic is transmitted in end-to-end encryption mode based on TLS/DTLS, preventing data theft and replay attacks on the entire network.
- Terminal and network bidirectional authentication: The network applies two authentications to mid-range and high-end scenarios. The first authentication uses PEAPv0 (EAP-MSCHAPv2) where terminals and network access devices use bidirectional authentication. The second authentication uses certificate-based EAP-TLS to ensure that terminals are not spoofed or deceived.

Interconnection domain: The connection from direct IoT platforms to the BoT aggregation platform is a semi-trusted system interconnection. **The BoT aggregation platform proposes binding standards for direct IoT platforms and provides auditable check and warning.** The BoT platform should monitor the login, working status, data collection period, security events, and encrypted communication of physical devices, and manage some devices or some configurations of devices. **An independent secondary identification and encryption mode is used for devices when high trustworthiness is required.** For example, independent hardware security chips are deployed in physical devices or physical unclonable functions (PUFs) are used for "thing" customers' self-service payment and investment. Encryption keys and identities can be derived from unclonable material properties, allowing PUFs to work with classic cryptography of secret keys. The only difference is that keys are bound to each component and cannot be separated. In this way, financial transactions enjoy higher security without considering security issues when physical devices collect other information (handled by the direct IoT domain).

Data domain: One of the important security issues in the data domain is how to protect customer privacy and remove customers' concerns about BoT access. In data exchange or collaborative analysis scenarios with data privacy protection, BoT does not need detailed real data of customers, and only analysis results are required. In this case, **homomorphic encryption and federal computing technologies** can be used. The homomorphic encryption technology enables mathematical operation in a ciphertext condition. The result is converted into plaintext through a separate decryption process and consistent with the result of mathematical operation in a plaintext condition. Federal computing technology is used in AI analysis so participants only exchange intermediate computing data instead of raw data. In this way, an IoT platform or edge transmits encrypted data or intermediate data for AI inference to the BoT aggregation platform which cannot decrypt the data, fully protecting customer privacy.

Another significant research in the data domain relates to transactions that can be verified by third parties, applicable to multi-party transactions or transaction environments with low credibility. IoT devices, direct IoT platforms, and the BoT aggregation platform or business systems, can directly use blockchain-based smart contracts for accounting. This highly trustworthy mechanism is necessary because BoT's core business interaction between devices is performed without manual intervention. However, the current blockchain-based solutions, such as Bitcoin, Namecoin, and Ethereum, still require core IoT security applications. Unbound storage requirements, large amounts of data transmission involving network entities, trusted decentralized peer-to-peer infrastructure's degradation into central entities which dominate networks, and unproven security protocols are likely to overturn the current blockchain foundation. A feasible solution is to customize and optimize the blockchain protocol for IoT applications with limited storage and bandwidth to provide provable security for specific transactions.

6 Scenario Design

Technology changes life, and scenarios drive services. With the help of "things" as value, data, and service carriers in social and economic activities, BoT delivers ultimate pan-financial service experiences (timely, personalized, dynamic, and comprehensive) in smart spaces. Scenario-driven services are the core of future banking. No matter how technologies develop, the ultimate service receivers are natural or legal persons and meeting their requirements is key to optimal customer experiences. BoT makes full use of IoT, big data, AI, 5G, and cloud/edge computing technologies, and combines them with financial scenarios to serve customers with technologies and reach scenarios through "things".

6.1 Life Scenarios

6.1.1 Car Ecosystem

Build a future car into the third space of smart life and redefine the way we live. Cars are not only a means of transportation, but also a smart mobile space, the third space outside of home and the workplace. Upon leaving the office, a smart car can meet the user in a designated pick-up location. On the road, the car obtains traffic information and tells smart home appliances when to activate. We do not need to find gas stations, parking lots, and car washes by ourselves, which greatly facilitates mobility. Based on big data analysis, smart cars proceed to the most economical gas station, charging station, and car wash. All the financial behavior is based on its own accounts. Moreover, a future car will be built into a comfortable smart space which better understands and meets people's needs. For example, it adjusts temperature and brightness based on a drivers' typical behavior and preferences, and offers health service suggestions. Through data analysis, BoT enables the "intelligent thing" — car — to develop into an intelligent, user-friendly space. It finally serves the user with a personalized, scenario-specific, and feedback-based experience.

6.1.2 Home Ecosystem

Smart home appliances learn to think. Technologies such as 5G, AI, IoT, and big data are helping smart home appliances develop thinking capabilities to build an efficient, convenient, and smart home space. This makes life more secure, convenient, and comfortable, and changes the way people live. An air conditioner works based on our preferences, a refrigerator buys food based on our preferences and body conditions, and a TV provides information and service channels as well as entertainment services. We can buy anything we like when watching a TV show. A kitchen will connect to a variety of home appliances to learn about our health and plan recipes and cooking methods, and a smart mirror buys skincare and cosmetics according to the user's skin condition and preferences.

In the future, home will be a smart space composed of smart home appliances. Based on scenario-specific service capabilities, BoT directly connects to smart home appliances to provide personalized, comfortable, and warm home service experiences based on different requirements.

6.2 Production Scenarios

6.2.1 Smart Factory

When everything is intelligently connected, factories will adopt digital twins for design and manufacturing, a platform-based supply chain, automated quality control, and smart energy efficiency management. Driven by data, smart factories can greatly improve working conditions, reduce manual intervention in production lines, and improve production process control. More importantly, digital twins are built through informatization to streamline design, production, and sales processes, integrate and optimize resources, and enhance production efficiency and product quality.

Based on the digital twins of smart factories, BoT can better understand the real-time operating status of enterprises, dynamically rate enterprises based on the objective credit assessment system, and determine what credit limit is appropriate. BoT regards a production line or workshop as a set of "intelligent things", opens independent accounts for them, and offers financial services during procurement, production, and sales. This new model makes financial services accessible to MSMEs, achieving financial inclusion.

6.2.2 Smart Logistics

Technology empowers smart logistics. The production, transportation, and labor costs of the traditional logistics industry are high. In addition, a multitude of goods maybe overstocked and damaged, which causes losses to logistics enterprises and increases the risk of banks' lending to these logistics enterprises. With 5G and IoT, the logistics ecosystem will undergo tremendous transformation. An interconnected network system is formed between all commodities, and factories perform automatic virtual production. BoT evaluates factory equipment and commodities, and reports alarms or applies for maintenance when authorized. It also tracks high-priced goods throughout the process and presents real-time logistics and commodity information. Distribution device data is uploaded to the cloud in real time for 24/7 continuous monitoring and analysis, allowing for more accurate and faster goods receiving and distribution. This improves operating efficiency of logistics enterprises, strengthens banks' post-loan risk management, and lowers loan thresholds.

China has high logistics costs; to solve this issue, BoT provides pure credit loans based on mass data generated by smart logistics. This greatly alleviates logistics enterprises' capital pressure and improves their operating efficiency. In the future, each truck may open a bank account based on its own logistics credit and apply for a logistics financing loan to pay for its own operating costs.

7 Future Prospects

The era with intelligent connectivity of everything sees infinite possibilities. Through a large number of "intelligent things", the IoT integrates the virtual and physical worlds, and promotes the in-depth integration and interaction between information systems in the virtual world and physical systems in the physical world. IoT reconstructs economic forms where the supply-driven or demand-driven mode is changing towards a new economic operation mode that features supply-demand collaboration and in-depth integration of R&D, products, financial institutions, and commerce. IoT will also reshape the future financial service system and transform the subjective credit system into an objective system. "Intelligent things" connected to the IoT will generate an unprecedented amount of data where this data depicts city operations, business operations, and personal lives. For banks, this means wider customer reach, more personalized financial services, and more effective risk control. In addition, "intelligent things" can better represent their owners in economic activities, driving radical changes in banks' service receivers and business models. At that time, "intelligent things" will initiate more transactions than people. Pan-financial service capabilities will become the core competitiveness of banks. BoT — a new financial infrastructure tailed for economic operating mode in the digital society — is around the corner.

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