Framework Design of Internet of Things Fusion Perception Application System Based on BeiDou

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Abstract

Aiming at the access problem of BeiDou spatio-temporal information in the Internet of Things (IoT), the application system framework of "BeiDou + Intelligent Sensor" is put forward according to the characteristics of high-precision positioning, timing and short message communication of BDS by integrating IoT multi-sensor sensing technology with ubiquitous IoT communication technology. It includes "BeiDou + Intelligent Sensor" fusion sensing platform, chips and modules, which realizes the fusion of BeiDou spatio-temporal information and intelligent sensing information, solves the industrial shortcomings in the application of "BeiDou + IoT", and provides rich IoT sensing data sources and business application exports for central processing nodes such as smart city brains, data centers and supercomputing centers.

Keywords

BeiDou. IoT. Multi-source perception fusion

1. Introduction

The origin of the IoT can be traced back to 1993. After a long time of brewing, the International Telecommunication Union formally put forward the concept of the IoT in Internet Re. Ports 2005: The IoT in 2005, that is, "the interconnection between any object at any time, any place, ubiquitous network and ubiquitous computing" [1]. The IoT technology has made great progress and development up to now, and the broad application prospects have been highly concerned by countries all over the world. IoT in China has a good technical, industrial and application foundation, and the development of the IoT has achieved remarkable results. In 2020, the scale of IoT industry exceeded 1.7 trillion yuan. It is estimated that by the end of 2022, the industrial scale will exceed 2 trillion yuan. It is predicted that by 2025, the number of mobile IoT connections in China will reach 8.01 billion with a compound annual growth rate of 14.1% [2]. With the development of economy, the application of IoT industry is growing steadily, and the application of public market is beginning to appear. In the future, the global IoT still has huge market potential.

BeiDou Navigation Satellite System (hereinafter referred to as BeiDou or BDS) is a global satellite navigation system independently built and operated by China with an eye to the needs of national security and economic and social development. It is an important national spatio-temporal infrastructure that provides all-weather, all-day and high-precision positioning, navigation and timing services for global users. Since BDS provided services, it has been widely used in transportation, agriculture, forestry and fishery, hydrological monitoring, meteorological forecasting, communication timing, power dispatching, disaster relief and mitigation, public safety and other fields, which serves the important national infrastructure and produces remarkable economic and social benefits [3].

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One of the core technologies of IoT application is location service, and the foundation of location service is the core equipment upstream of the industrial chain. The integrated module with communication and navigation function has become the neck link of the whole application field. "BeiDou + IoT" is to provide colorful intelligent services for the industry and the public by combining the positioning service of BDS with the low-power IoT communication mode. BeiDou and IoT have penetrated into every corner of human social production and people's life, and their fusion will inject new vitality into the economic and social development of China and even the whole world.

2. Fusion perception demand analysis

Spatio-temporal location service is the rigid demand of intelligent perception and the core technology of intelligent service development in the future. Integrated innovation is the inevitable choice of industrial development. Satellite navigation and location service industry in China is moving towards a new stage of technique fusion and industrial fusion [4]. The fusion of BeiDou technology with advanced technologies such as IoT and big data would present a new form of innovative development by integrated application of terminal products and system services. All links of the industrial chain would be integrated with high-end manufacturing, advanced software industry, integrated data industry and modern service industry to form a new format of integrated development. This new form and format of technique fusion and industrial fusion can realize the orderly flow of people, money and materials under BeiDou Spatio-temporal intelligent linkage, and the civil market would have explosive growth [5].

After years of construction and application, BDS-related products are widely used in domestic transportation, marine fishery, emergency disaster reduction and other fields. However, its application in IoT has just started. With the rapid development of the globalization of BDS in China, "BeiDou Globalization + IoT" products have become an important extension of BeiDou industrial chain. It is also an important breakthrough to greatly enhance the core competitiveness of BeiDou products in the world and promote the large-scale application of BeiDou application industry. As a link in BeiDou industrial chain, IoT technology can not only directly form navigation application products to serve users, but also promote the emergence of new industries and the development of information technology industry [6]. During the "14th Five-Year Plan" period, the state will vigorously promote the construction of the IoT in China, promote the technological innovation of the IoT, and implement major application demonstration projects.

1. BeiDou + IoT mutual empowerment is the development direction of technique fusion

With the in-depth development and application of IoT, cloud computing, artificial intelligence, etc., ubiquitous positioning technology will further develop towards multi-source fusion, high precision, large coverage, high real-time, high reliability, low cost and scalability, and realize mature application.

2. BeiDou + IoT technique fusion is the foundation of new spatio-temporal service system in China

In the new stage of development, the industrial chain demand of satellite navigation application and location service application is quietly changing, and the core direction of industrial development is gradually changing from the previous location service to a more perfect accurate spatio-temporal service. Focusing on building a new time-space service system in China that is more ubiquitous, more integrated, smarter and safer, efforts will be made to promote systematic integrated innovation, realize the wider application of PNT technology in the IoT, greatly expand the current satellite navigation and location service industry ecosystem, and form a larger output value scale, which is the future general line of industrial development [7].

3. BeiDou + IoT promotes the layout of new infrastructure and builds BeiDou application industry ecosystem

Facing the demands of high-quality development, the "new infrastructure" is an information infrastructure system guided by new development concepts driven by technological innovation, centered on data and based on information networks, which provides services such as digital transformation, intelligent upgrading, integrated innovation [8]. The implementation of "new infrastructure" has brought more vast fields for the development of satellite navigation and location service industry. Among them, the high-precision spatio-temporal information based on BeiDou is the

foundation, which can combine, integrate and integrate various information infrastructures (5G/big data/IoT, etc.) to form a win-win platform for intelligent information gathering, and finally realize the development of intelligent information industry clusters.

3. Design and analysis of system framework

The application system framework of IoT fusion perception based on BeiDou adopts 2 +1 +1 +5 +1 framework design. Based on two key technologies of BeiDou+IoT fusion and supported by a set of BeiDou+IoT fusion standard specification system, a BeiDou+IoT fusion sensing chip and five modules are developed, and a new spatio-temporal big data application promotion platform is constructed to realize the application and development of BeiDou in IoT.

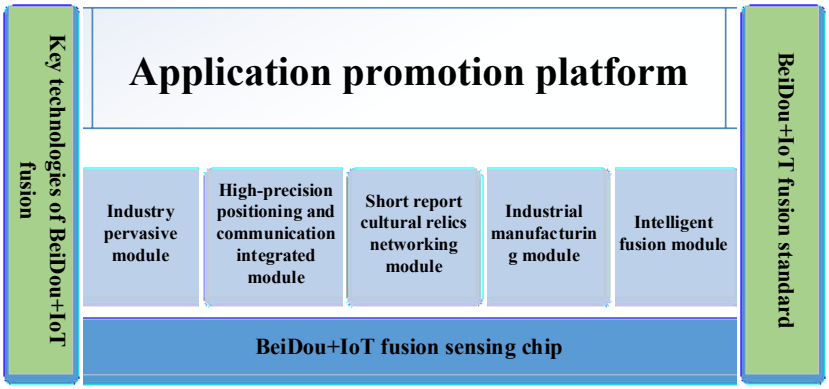

Figure 1: Framework diagram of IoT fusion perception application system based on BeiDou

BeiDou+IoT fusion sensing chip. A BeiDou+IoT fusion sensing chip is designed, which supports BDS/ GPS/ GLONASS/ Galileo four systems, SBAS/ PPP/ GAS high-precision positioning, NB-IoT and LTECat.1 IoT technology, and adopts special technology to realize ultra-low power consumption design. The power consumption in PSM mode is as low as μA, and that in DRX mode is as low as mA.

Five-type serialization module. Five-type BeiDou+IoT series modules are developed, which are industry universal module, vehicle gauge high-precision module, short message cultural relics association module, industrial IoT module and intelligent fusion module. It covers three major scenarios——industry application, industrial manufacturing and high-end application.

Application promotion platform. An application promotion platform is built. Based on big data architecture, superimpose PNT spatio-temporal service layer and IoT layer, typical industry scenarios are and expanded including vehicle supervision, manual inspection, factory intelligent manufacturing, emergency command, mobile office and other common basic functions of industries. Typical business scenarios are selected and promoted for most industries.

Key technologies of BeiDou+IoT fusion. Two key technologies, multi-source and multi-mode inductance fusion and on-demand dynamic power consumption control, are tackled. Five fusion innovations are realized including indoor and outdoor seamless positioning fusion, high-precision positioning fusion, multi-mode transmission fusion, multi-source navigation fusion and AI application fusion.

BeiDou+IoT fusion standard. BeiDou+IoT standards and specifications are formulated including common standards such as chip and module standards, platform standards, interface and communication protocol standards.

3.1. BeiDou+IoT fusion sensing chip

The fusion sensing chip is mainly composed of SOC subsystem, GNSS IP, NB-IoT IP and LTECAT.1 IP. Among them, SOC subsystem is composed of multi-core embedded CPU, which mainly completes the control, scheduling and information sending and receiving functions of each IP subsystem on the chip. GNSS IP to complete the GNSS signal receiving and sending, for part of the

RNSS frequency points to do receiving, RDSS frequency points to do receiving and sending. NB-IoT IP completes the narrowband IoT function, which enables the chip to have the ability of Internet of Everything. LTECAT.1 IP expands the ability of NB-IoT in medium speed and mobility, and makes the chip have wider adaptability to the Internet of Everything.

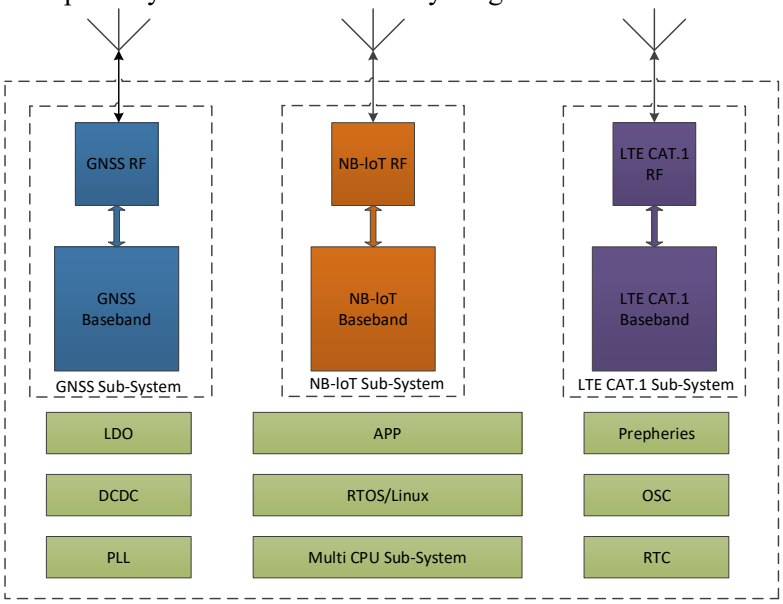

Figure 2: Architecture diagram of BeiDou+IoT fusion sensing chip

3.2. Five-type serialization module

3.2.1. Industry pervasive module

The module is positioned to meet the core positioning characteristics, which is characterized by low price, universality, low power consumption and small size, and meets the needs of BeiDou and IoT for location-aware information. The industry universal module is intended to integrate interfaces with rich functions, including but not limited to LCM, camera, touch screen, microphone, speaker, UART, USB, I2C interfaces, etc. It supports multi-network SmartLTECat1 module and is equipped with Android operating system. The module is oriented to M2M fields, such as MID, PND, POS, router, data card, vehicle terminal, smart phone, digital billboard, security and industrial PDA. The potential customers that can be tapped by the module include public security, emergency, water conservancy, oil, electric power, railway, transportation, water transport and so on.

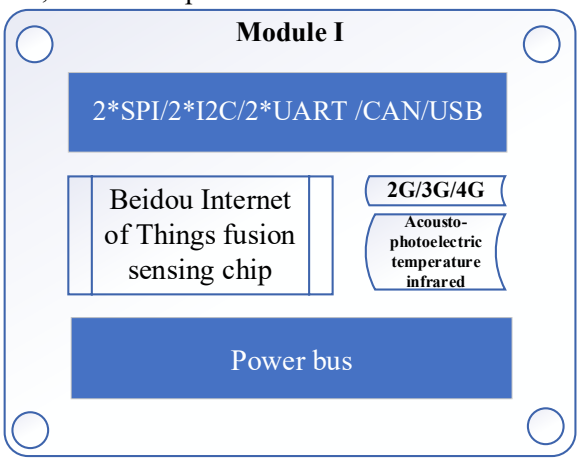

Figure 3: Framework diagram of industry pervasive module

3.2.2. High-precision positioning and communication integrated module

For high-end industry applications, it is mainly aimed at applications with high-precision requirements for position positioning. The high-precision positioning module has the core characteristics of high positioning accuracy, strong environmental adaptability (which can be applied to harsh environment), strong anti-static and anti-electromagnetic interference capabilities. The module uses multi-constellation high-precision GNSS (GPS/ GLONASS/ BeiDou/ Galileo/ QZSS) receiver, RTK high-precision positioning technology, DR inertial navigation technology and gpsOneXTRA auxiliary technology. The RTK accuracy can meet the centimeter-level positioning requirements in open environment, and it relies on inertial navigation to position in non-signal areas and multipath interference areas, which improves the positioning accuracy and speed of the module and has centimeter-level positioning capability at lane level. The module is embedded with rich network protocols, integrates multiple industry standard interfaces and supports a variety of drivers and software functions (such as USB drivers under Windows XP, Windows Vista, Windows 7/8/8.1/10, Windows CE, Linux and Android systems, eCall, etc.). The main application scenarios are located in transportation, logistics, railway, petroleum, public security, emergency and other industries.

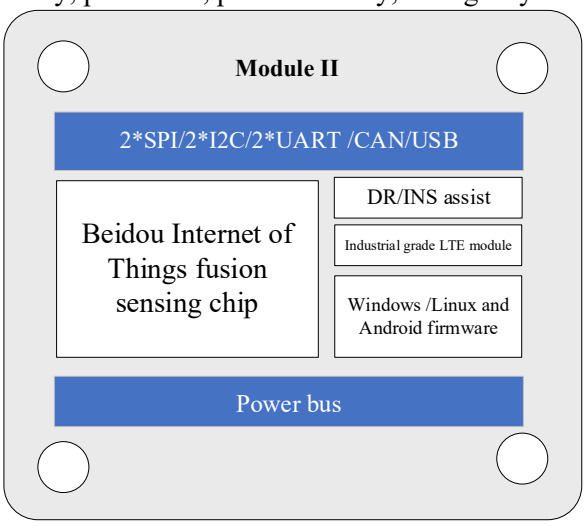

Figure 4: Frame diagram of high-precision positioning and communication integrated module

3.2.3. Short message cultural relics networking module

It has BeiDou-3 positioning function, BeiDou-3 RDSS function, cat.1 and nb-iot communication function. It can realize the global data transmission without blind spots of the IoT, and has great application potential in marine supervision, meteorological supervision, power grid, railway, public security, emergency and other fields. The concrete manifestation is ocean buoy observation data transmission, specific application scenarios such as remote data transmission of wind power generation equipment, field environmental observation data transmission, emergency rescue handheld terminal, public security handheld law enforcement terminal, position monitoring of ships and special vehicles, hydropower station monitoring, electric meter data collection and transmission, hydrometeorological data collection and monitoring, border emergency communication and field operation.

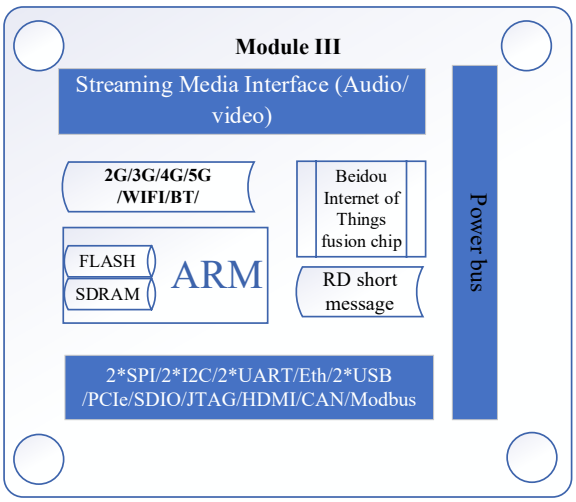

Figure 5: Framework diagram of short message cultural relics networking module

3.2.4. Industrial manufacturing module

Based on the industrial intelligent manufacturing site sensing and control, the core function is to realize the collection, calculation, comprehensive perception and wireless communication uploading of information facing industrial intelligent management, informationization and intelligent production. For example, the position and status of man-machine material ring information in the industrial field. It helps the informationization and intelligent upgrading in the industrial field, and promotes the realization and development of digital factories. The module focuses on the fusion of indoor and outdoor people, vehicles and materials with high-precision positioning features, which is applied to intelligent manufacturing, intelligent scheduling and production of intelligent construction sites, etc. According to different manufacturing factories and application fields, BeiDou+IoT sensors and intelligent sensing modules are integrated, and standard industrial interface protocols are used to help factories realize intelligent and automatic transformation and intelligent manufacturing.

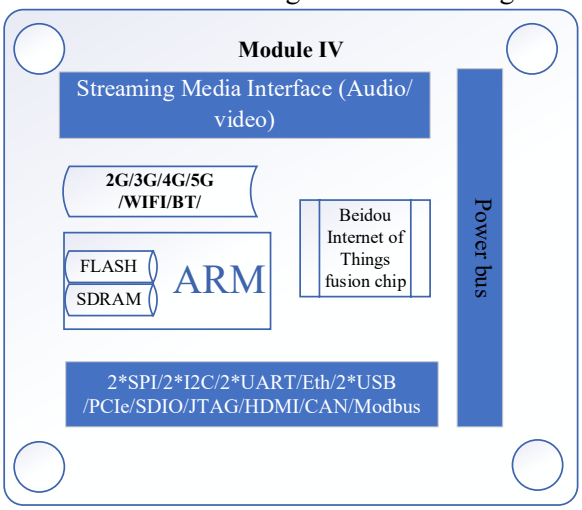

Figure 6: Frame drawing of industrial manufacturing module

According to different application scenarios, industrial manufacturing modules can be divided into low-profile industrial manufacturing modules and high-profile industrial manufacturing modules. The low-profile industrial manufacturing module is mainly used to meet the needs of industrial field data acquisition and high-precision positioning in the whole industrial production process, and has the functions of sensor data acquisition, industrial fieldbus communication, wireless information transmission, fieldbus command issuing and so on. On the basis of the above functions, the high-profile

industrial manufacturing module adds audio and video communication, security control gateway access, and intelligent analysis of data edge calculation.

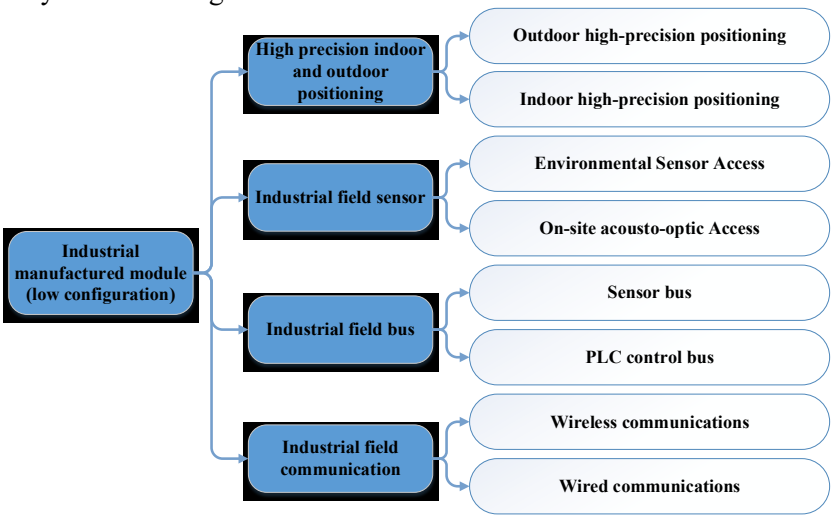

Figure 7: Industrial manufacturing module (low configuration)

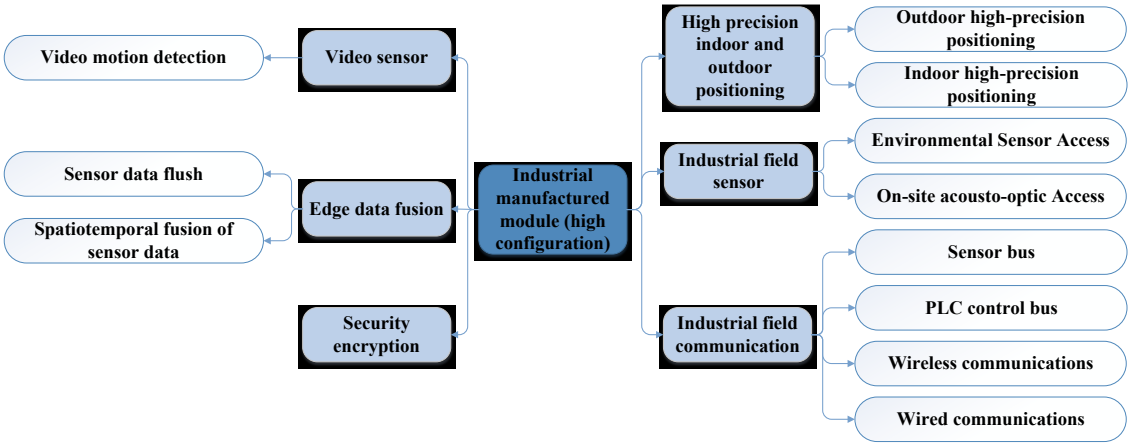

Figure 8: Industrial manufacturing module (high configuration)

3.2.5. Intelligent fusion module

Located in the application requirements of AI edge computing fusion computing in complex multi-dimensional perception environment, the target market is the information processing and core control of automatic driving complex systems. The core feature of the intelligent fusion module is that it integrates complex sensor information and complex sensors of vision, 3D LIDAR and high-speed signal lamp, and has the function of edge calculation of sensor information. The module has multi-core heterogeneous processors such as CPU, NPU and GPU. Intelligent fusion module mainly fuses multi-sensor information in spatio-temporal, extracts complex semantic information, integrates with cloud platform and big data technology, and completes complex field data analysis functions. The main application scenarios are vehicle automatic driving, robot automatic control, smart city, smart transportation, general aviation, railway train control and other fields, providing information resources for vehicles, robots and aviation aircraft, and providing information decision-making basis for subsequent complex control.

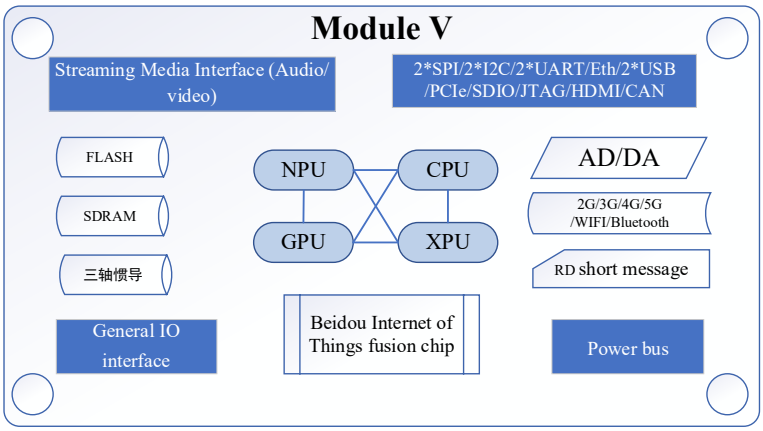

Figure 9: Framework diagram of intelligent fusion module

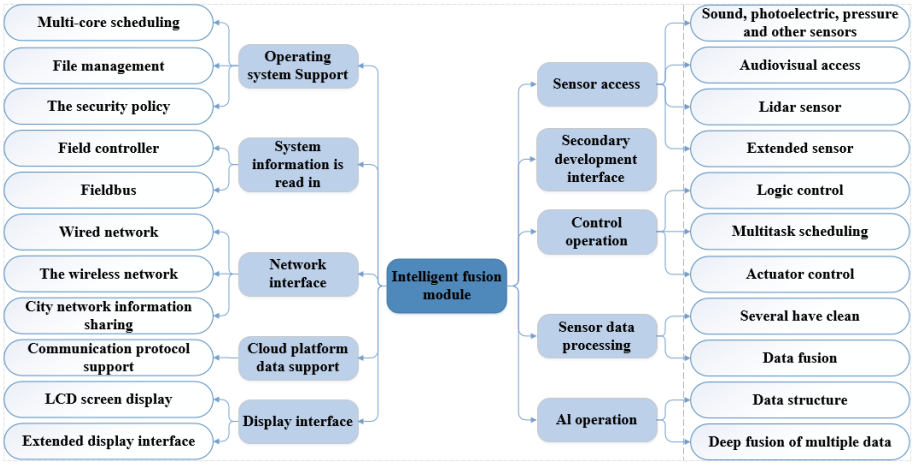

Figure 10: Framework diagram of intelligent fusion module

3.3. Application promotion platform

BeiDou+IoT fusion support platform includes a series of functions such as sensor data collection, cleaning, analysis and disposal, which provides multidimensional data sets and tool environment for the application system of urban brain. It includes sensor equipment layer, gateway edge layer, general platform layer, application platform layer and business layer. The sensing equipment layer is the basis of realizing the comprehensive perception of the IoT. Using sensors to collect equipment information is mainly to identify objects through sensors to collect data information. The gateway edge layer is mainly responsible for analyzing and mapping the information collected by sensors, and transmitting the collected information to the general platform layer. The general platform layer completes the equipment management and rule engine processing. The application platform layer completes the aggregation of data information and forms a data management platform for similar equipment. The business layer forms a user-oriented business management platform for specific business applications.

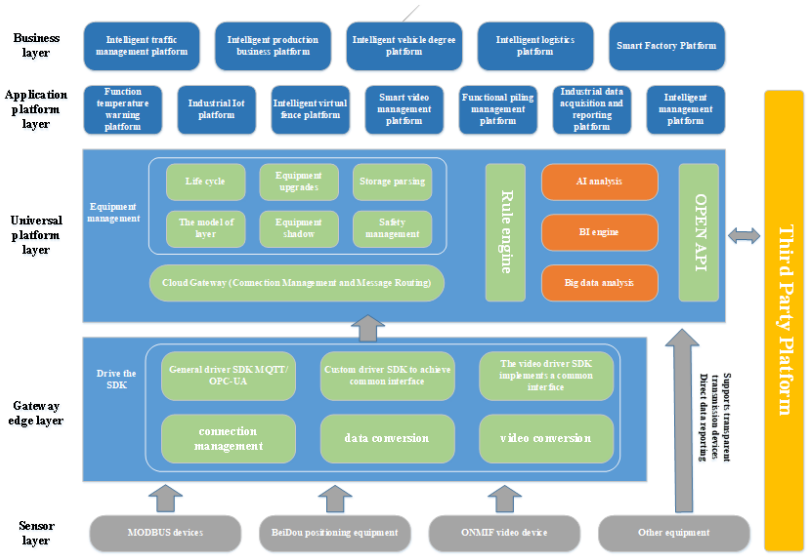

Figure 11: Framework design of application promotion platform

3.4. Key technologies of BeiDou+IoT fusion

3.4.1. Multi-source and multi-mode sensing fusion technology

Multi-source and multi-mode sensing fusion involves indoor and outdoor seamless fusion, high-precision heaven and earth fusion, multi-constellation positioning fusion, multi-mode transmission fusion, GNSS/IMU multi-source navigation fusion, communication and guidance fusion design fusion, and AI application fusion of BeiDou+IoT.

3.4.2. Dynamic power consumption control and energy saving technology.

The fusion sensing chip at the sensing end of the IoT requires high power consumption, and the low power consumption design of the chip is very important. With the progress of technology, the density of integrated circuits in the chip is getting higher, the running speed is getting faster, and the connections on the chip are getting thinner. The power supply network on the chip must send power to each unit with less connection resources, which requires the chip designer to reduce the power consumption in the design stage. The low power design is poor, the system calorific value increases, and the heat dissipation cost of chip packaging also increases accordingly. The higher the power consumption of the chip, the more energy the portable equipment consumes, and then the more heat it generates, which leads to the increase of thermal noise, which would affect the normal operation of the equipment and lead to the slower running speed of the equipment. When it comes to portable equipment, the greater the power consumption of the chip, the shorter the service time under the same battery capacity. Therefore, it is very important to break through the key technologies of low power consumption of chips.

3.5. BeiDou+IoT fusion standard

Four types of standards related to the IoT security platform based on BeiDou spatio-temporal benchmark service is prepared. It includes BeiDou spatio-temporal benchmark class specification, platform access equipment class specification, data transmission protocol class specification and software interface standard class specification. The research provides standardized technical support and lays the foundation for the fusion and application of BeiDou and IoT.

3.5.1. BeiDou spatio-temporal reference class specification

It mainly defines the architectural relationship among demonstration services, navigation/timing terminals, service platforms, etc. in the IoT platform of BeiDou+IoT fusion benchmark service, and supports IPv6 and IoT connection. It aims to guide the application of BeiDou+IoT security platform in a certain。 area. On the basis of BeiDou benchmark service IoT platform, a demonstration application business system is developed, and all kinds of BeiDou terminal equipment required are comprehensively summarized in each business system.

3.5.2. Specification for platform access equipment class

The sensor types connected to the platform can include pressure sensor and force sensor, position sensor, liquid level sensor, energy consumption sensor, speed sensor, acceleration sensor, radiation sensor, heat sensor, etc. [9].

3.5.3. Data transmission protocol class specification

BeiDou+IoT fusion equipment carries out long-distance two-way communication between terminals and between terminals and IoT platforms through mobile base stations, and defines and standardizes data transmission formats, such as error checking methods, data comparison methods and file end definitions.

3.5.4. Software interface standard class specification

BeiDou+IoT industry application software interface standard mainly specifies the following parts:

1. Interface standard between application software: Application software includes business system application software and navigation terminal application software, and interaction between application software includes interaction between business system application software and interaction between navigation terminal application software and business application software.
2. Interactive interface standard between software and users: Standardize the system platform, main functions, software input and other contents of the interactive interface between software and users.

4. Conclusion

According to the characteristics of the IoT, this paper proposes a new fusion sensing application architecture framework combined with the application of BDS, so as to accelerate the application and development of BeiDou in IoT. The framework is based on two core key technologies, namely, multi-source and multi-mode sensing fusion technology and on-demand dynamic power consumption control, and leads the whole BeiDou industrialization from both technology and products. Through six integrated innovation measures, namely, compatibility and interoperability fusion of four systems, high-precision fusion of heaven and earth, seamless fusion of indoor and outdoor, multi-source navigation fusion, AI spatio-temporal dynamic fusion and multi-mode transmission fusion, it has achieved cutting-edge leading from the perspective of industrialization, realized a highly integrated chip and serialized module, which occupies the market with low cost, low power consumption and convenience, thus driving the development of industrialization. The fusion of multiple technologies is also conducive to the development of innovative application modes, thus catalyzing the promotion of industrial scale.

The establishment and promotion of BeiDou+IoT fusion perception application architecture will drive the technique fusion in 5G, BeiDou navigation, Internet of Vehicles, mobile phone field, industrial Internet and other fields. It promotes a unified spatio-temporal benchmark based on BeiDou, deeply integrates, processes and relates all kinds of industrial manufacturing information. It not only promotes the upgrading of related industries such as data collection, processing, software development and platform operation, but also drives related industrial manufacturing enterprises to make strategic adjustments. Focusing on high-precision location service of BeiDou, it gives full play to its core

competitive advantages, promotes the organic fusion of BeiDou industry and industrial informatization construction, and better develops the transformation and upgrading of manufacturing enterprises. All these will play a decisive role in the overall strength of IoT and BeiDou industrial chain in China.

Identification of funding sources and other support, and thanks to individuals and groups that assisted in the research and the preparation of the work should be included in an acknowledgment section, which is placed just before the reference section in your document.

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