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Analysis and Adoption of the Internet of Things in Life Cycle Management of Electric Energy Meters

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Abstract: *Objective: this research aims to design and implement the whole life cycle management system of electric energy meters based on the Internet of Things. Methods: first, the current development status of power asset management and the Internet of Things industry in China is studied and analyzed, and the existing problems of power asset management are pointed out. Then, the radio frequency identification (RFID) technology used in system design is introduced in detail. After that, the design scheme of the system is introduced from the aspects of the overall design structure of the system and the development and operation environment. Finally, the concrete implementation and research results of the system are introduced and analyzed. Results: the results of actual investigation and analysis show that the system proposed in this research has good practical application value, realizing the full life cycle management of electric energy meters, shortening the time of each stage of asset management, and greatly improving the work efficiency of managers. Conclusion: the Internet of Things technology has high application value and prospects in electric energy meter life cycle management.*

Keywords: *Internet of Things; electric energy meter; life cycle management; RFID*

1. Introduction

The concept of the Internet of Things was first proposed in 1990. At that time, the definition was connecting all objects with the Internet through radio frequency identification (RFID) equipment, thereby realizing management and intelligent identification [1]. In 2005, the definition of this technology was updated, and the new definition notes that Internet of Things technology realizes information exchange and communication through the connection of any article and network through two-dimensional code reading equipment, RFID technology, and other equipment based on the agreed grid and protocol to realize intelligent identification, tracking, monitoring, management, and other functions [2]. This technology generally has the three characteristics of special Internet recognition, communication, and intelligence [3].

Asset life safety cycle management is an advanced management method that attracts more attention at present [4]. It carries out unified management and planning for design, inspection, purchase, operation, maintenance, and scrap cleaning through the system. In the case that the demand and safe operation are guaranteed, the safety, energy efficiency, and cost control within the whole life cycle of the asset should be optimized [5].

In recent years, China's economy and science and technology have developed rapidly. The power economy has become an integral and important part of the national economy [6]. For a long time, power grid enterprises have been characterized by multifarious equipment assets, large quantities, and fast renewal. This leads to very difficult equipment management of power enterprises [7]. Incomplete statistics show that State Grid has been bidding for smart meters for many years. From 2017 to 2020 alone, The State Grid invited 16 tenders to purchase smart meters and purchased 233 million smart meters. Moreover, the brands of these meters are different. In addition to the large number, electric energy meter realization is characterized by dispersion and complexity [8]. Therefore, it has been a difficult and weak link in power enterprise asset management. The electric energy meter asset management of electric power enterprises mainly includes daily operation and maintenance management and fixed assets stock and distribution management. Its management level directly affects or even decides the daily operation and future development of the enterprise. With the arrival of the information age, it has become a development trend to apply information technology to the daily operation and management of enterprises. Automatic management identification technology has been widely considered and supported [9]. The application of information technology to the management of electric power enterprises plays a great role in promoting

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their intelligence and information construction. China's Internet of Things technology development started late and is still in a relatively backward state. Most of the technology is still in the adoption stage. In recent years, China has been paying increasing attention to this technology, which is both an opportunity and a challenge [10].

The main research purpose of this research is to analyze the whole life safety cycle management system of electric energy meter assets based on the Internet of Things and its application based on RFID radio frequency identification, wireless network communication, and other technologies. It is hoped to improve electric energy meter management and staff efficiency to further promote the information construction of electric power enterprises.

2. MethodS

2.1. Problems in electric energy meter system management

The following problems exist in the electric energy meter management system. First, there are many types of electric energy meters, and their distribution is scattered. electric energy meters are mostly distributed in substations, special power rooms, and users. If the equipment status cannot be accurately tracked and mastered, it will bring great difficulties and problems to the asset inventory. Figure 1 shows the detailed electric energy meter classification diagram. Second, asset inventory needs to be counted and recorded gradually, which is a huge consumption of manpower and material resources and is prone to human error. Third, it takes a long time for an electric energy meter to be taken out and used, which increases the risk of electric energy meter damage and reduces the efficiency of use. Fourth, asset information is scattered, and the relevant information cannot be systematically centralized management. In addition, these materials and management need to be collected by special personnel, and manual errors easily occur, which increases the cost of management and supervision.

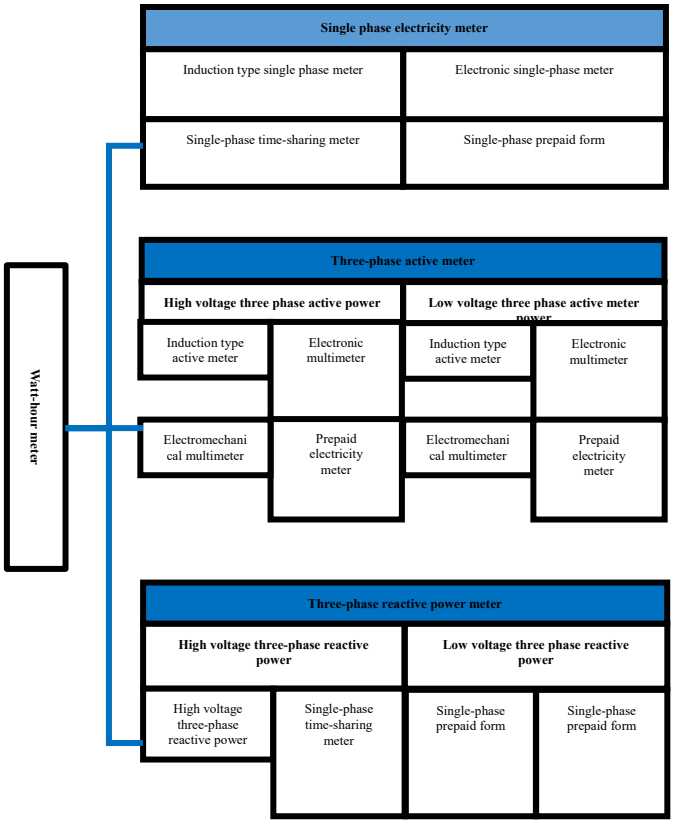

Figure 1: Electric energy meter classification diagram.

2.2. Introduction of key system technologies

RFID technology is radio frequency identification technology, which is a noncontact automatic identification technology. The RFID system mainly includes the RFID hardware domain (tag, antenna,

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and reader), RFID middleware, and commercial application domain. The specific system composition and functions are shown in Figure 2.

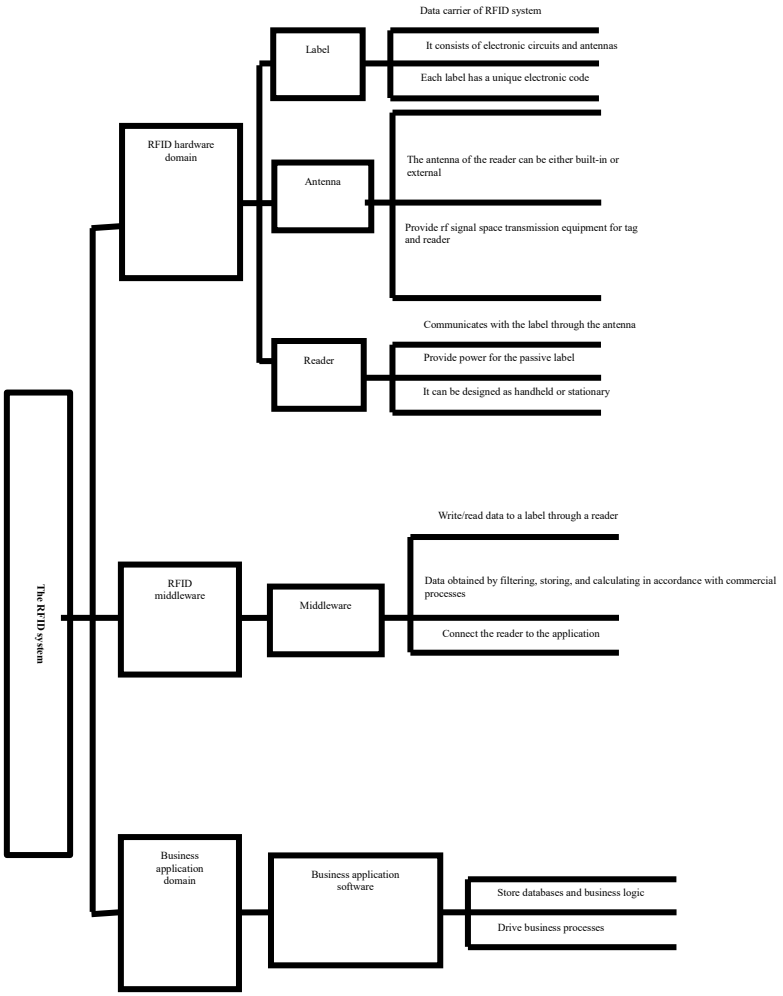

Figure 2: Composition and function of RFID system.

2.3. Design of an electric energy meter life cycle management system based on the Internet of Things

System development platform:

The system design uses the C/S+B/S structure design, and the system internal uses the TCP/IP protocol. The development platform of this system is Windows 2010 and Visual Studio 2010, and the backstage database development platform is JAVA, NET, Noka tag library, SQL Server 2008, etc.

Runtime environment:

The operating environment is mainly composed of a server, client, and handheld terminal. The server side is mainly used to deploy Web services and database services. A client is a PC terminal used by users to access and manage the system. Handheld terminals refer to smart mobile terminals used for asset inventory and inspection.

Overall system structure design:

1). Physical structure design. The physical structure of the system is mainly composed of the following four parts. A: asset safety life cycle management system platform. The client is the dominant, and it is a platform for staff to manage and access the system and for asset information recording, analysis, processing, and monitoring. B: various servers: card issuing server, application server, data server, etc. Its function is centralized management data to help users achieve the purpose of accessing system data easily through the network. C: communication transmission network and RFID middleware network. The communication transmission of the system adopts the combination of wired and wireless communication. D: RFID terminals and electronic tags, which mainly include readers, card issuers, and antennas.

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2). Logical structure design. The logical structure design mainly includes the following three parts. A: data acquisition layer, in which data mainly include electric energy meter asset information, image shooting information, and alarm information. B: information transmission layer. Based on mobile communication networks and power private networks, electric energy meter asset information, image shooting information, and alarm information of RFID tags are connected to the transmission layer through the communication network and uploaded to the asset management center database. C: application platform layer: This layer mainly uses the processed and analyzed data to query, maintain, and manage the equipment information in various regions and realizes joint data processing and comprehensive judgment by using data mining, information fusion, and other technologies. The detailed system software structure is shown in Figure 3.

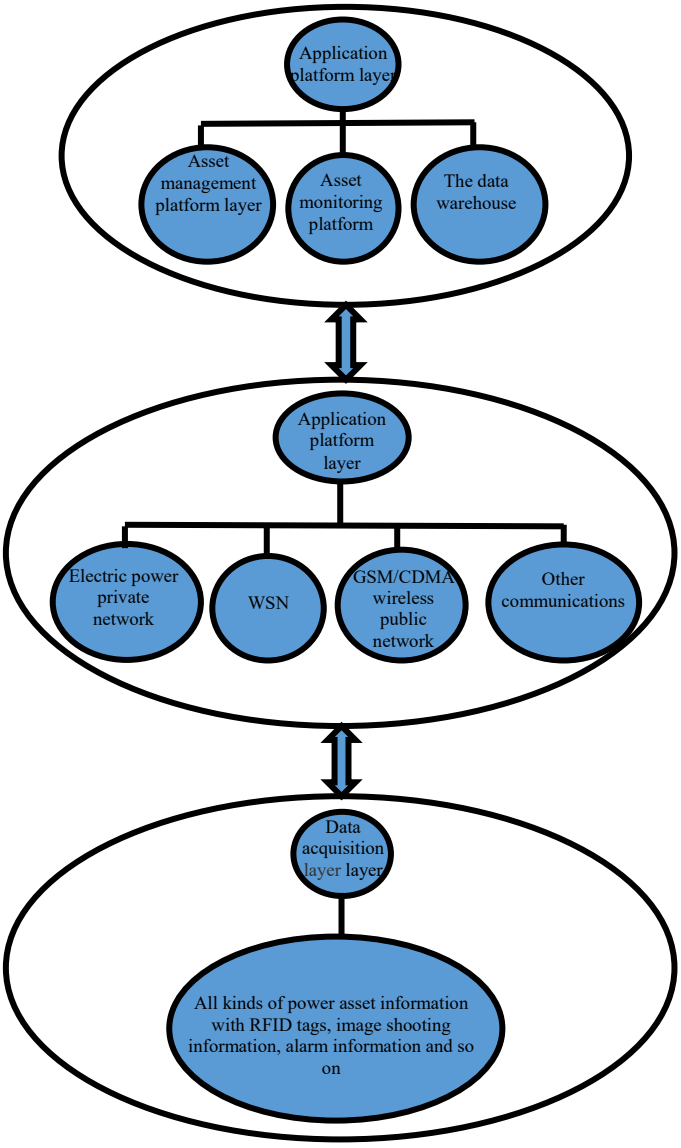

Figure 3: System software structure diagram.

3). Functional module design. In this research, according to the actual situation and needs of the functional module, a systematic design is implemented. The functional modules mainly include the following aspects. A: asset management, which mainly records the life cycle management of assets from purchase to scrapping. It is generally divided into assets increase, take, lend, return, inventory, depreciation, allocation, clearing, change, and scrap. B: basic data management, which mainly implements data management such as input, query, and modification of asset-related information, including asset file management, usage part management, employee information management, and supplier information management. C: statistical query: query and manage asset-related management information, personnel and department information, operating status, data reports, etc. D: alarm display: video linkage and shooting of abnormal situations such as asset loss and unauthorized disassembly within the supervision area and

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timely alarm display. E: system management, which can ensure system security, including password setting, permission setting, and parameter setting (Figure 4).

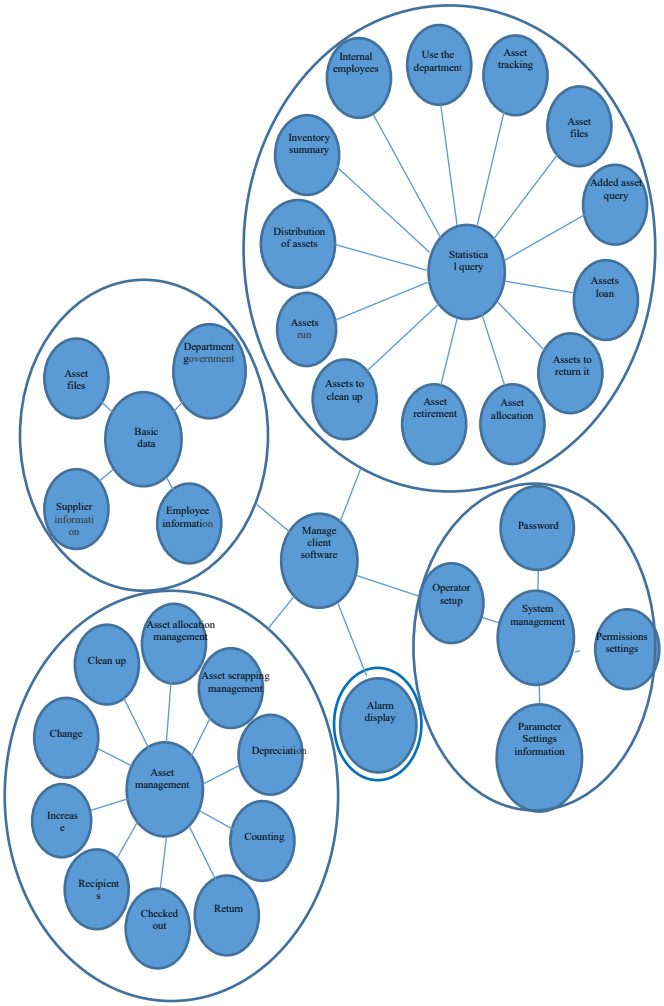

Figure 4: System function module design diagram.

4). Database design. The background database server is the Windows 2010 operating system, SQL Server 2008 database software. The database storage table is designed according to each function module. Each table is named according to its function. For example, the user account table is defined as NK_SYS_USERINFO, and the role table is defined as NK_SYS_ROLE.

3. Functions of the electric energy meter life cycle management system based on Internet of Things technology

3.1. Warehouse management

Server-based storage management is realized. In the first step, the server sends labels to electric energy meter assets. In the second step, the server establishes an asset information database and associates it with the labels. In the third step, the database time is recorded. In the fourth step, the handheld device is employed to obtain the label position and transfer to the server to complete the record.

3.2. Outbound management of electric energy meters

Electric energy meter outbound management is classified into two methods. The first method is using the server to issue the electric energy meter asset table, then transferring it to the handheld device and completing the outbound, and using the server to record the outbound record. The second is that the staff carries out the warehouse operation directly through the hand-held machine and reads the product information while using the server records.

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3.3. Electric energy meter inventory management

Electric energy meter inventory management also has two approaches. The first way is making an inventory list through the server and transferring it to the hand-held machine, and then manual inventory is performed by the hand-held machine. At the same time, the data are transmitted to the server, and the asset inventory report is issued. The second method is for the staff to conduct inventory operations directly through a hand-held machine and then transfer the label information support of the inventory to the server.

3.4. Electric energy meter status monitoring

The electric energy meter lifecycle management system automatically monitors electric energy meter exceptions.

1). It should inform the staff in advance when an electric energy meter is about to be effective.

2). It should inform the staff in advance when the inventory of electric energy meters is nearly insufficient.

3). It should inform the staff in advance when electric energy meter assets are close to the maintenance time.

4). It should inform the staff in advance when the lease term of electric energy assets is approaching.

3.5. Electric energy meter asset maintenance management

The system can record electric energy meter maintenance information in real time. The personnel can modify, delete, and add the information according to the actual situation and save the information to the database. At the same time, the system can remind regular maintenance and submit to business approval.

3.6. Electric energy meter asset query and statistics management

In the query function, the system can support associative query and fuzzy query. In the statistical function, the system can output more statistical statements, including asset statements, inventory loss and profit statements, asset types, and inspection reports.

4. Discussion

At present, we have fully entered an information age. Internationally, developed countries such as Europe and the United States attach great importance to the Internet of Things and have conducted massive studies and achieved corresponding results [11]. RFID technology has been widely used in transportation, industrial automation control, commercial retail, and other fields in the United States. Japan also started an extensive Internet of Things infrastructure in 2004. China also attaches great importance to the construction of the Internet of Things. At present, relevant enterprises in China are also actively promoting Internet of Things-related construction and have achieved certain results [12].

At present, the traditional electric power asset management method is generally based on paper documents to record tracking management. Then, the asset is managed in the form of a bar code. In addition, with the continuous expansion of the scale of electric power enterprises, the traditional management mode will not only increase the workload of staff but also lead to many problems, such as delayed management data and increased management difficulty [13]. Generally, the management of power systems lacks effective real-time supervision and management with an effective computer system. Compared with traditional electric energy meter management systems, the Internet of Things-based electric energy meter lifecycle management system has the following advantages. It can read data from far and near and observe objects in time that are not visible. It can be seen inside data from the outside. It can still operate normally and play a role in harsh environments. It can be carried out in parallel in multiple jobs, with a large storage space for information. It can realize the location of the object through the tag. In general, it is a general trend to apply the Internet of Things to electric energy meter lifecycle management [14].

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5. Conclusion

Taking an electric energy meter as an example, this research is developed to discuss the Internet of Things, RFID, and other technologies, and an electric energy meter life-cycle management system based on Internet of Things technology is designed. Moreover, the actual investigation and analysis are implemented. The practical application effect of the designed system is ideal, and it can effectively solve the problems of fixed assets management chaos and that records and reality do not conform. This system improves the automation level of electric power asset management, improves management efficiency and quality, and makes electric power management enter a new era.

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