Research on Data Collection System of smart meters Based on RFID Communication Technology

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Abstract. In order to meet the intelligent trend of electric energy meters, to solve the bad management problem of smart meters. First, the RFID chip integrated into the smart meter circuit board so that RFID read-write device and smart meter can achieve mutual communication through the wireless communication, and on this basis by combining UHF RFID communication technology, WIFI/3G/4G, cloud platform and other technologies, an smart meter data collection system based on RFID communication technology has been developed, which is used in smart meter information query, warehouse management, on-site reading smart meter and data transmission. The system Significantly reducing the time to track and find and has Realized the smart meter information real-time query and warehouse accurate inventory, improve the efficiency of the smart meter management by taking advantage of RFID Technology without contact, passive, and can be instantaneous long-distance bulk reading smart meter data information. In addition, the use of hand-held RFID read-write device for on-site smart meter reading, making the meter reading process more efficient, intelligent and convenient, which effectively solve the problem of the common electronic energy meter function single, Meter reading method lags behind and so on.

1. Introduction
With the development of national power system, the rapid growth of electricity demand, the number of smart meter is growing. For the year ended 2016, the country's total Smart meter users nearly 400 million, How to achieve rapid and efficient management of the power companies need to solve the problem [1]. Therefore, in the face of a large number of smart meter data, how to achieve rapid and efficient management [2] is a problem that power companies need to solve. The traditional smart meter data information management chaos, inefficient, can not achieve paperless operation at each stage lead to smart meter data tracking management is not in place, real-time update is slow, prone to data errors, can not accurately query and locate the meter data. In addition, the way of on-site meter reading lags behind, time-consuming and laborious, has been unable to meet the requirements of [3] intelligence.

At the same time, RFID represented by the Internet of Things industry is rising rapidly. China and the world of Internet of things is still in the initial stage of development, with a certain initial technology, industry and application base, Showing a good development situation. RFID industry begun to take shape, the size of the industrial market more than 10 billion, in which low-frequency and high-frequency RFID is relatively mature, the application effect is remarkable. At present, China's Internet of Things in the security, electricity, transportation, logistics, health care, environmental protection and other fields have been applied, and the application [4] model is maturing.
Therefore, the paper combines UHF RFID technology, WiFi / 3G / 4G, cloud platform [5] and other technologies with the Android operating system to study a smart meter data collection system for the current watt-hour meter industry is still common problems. This system can overcome many defects in the existence of the common electronic energy meter management, has the function of secure login, scan code, wireless upload reading smart meter data[6] to the cloud platform and so on, which has achieved paperless operation and real-time tracking in all stages of smart meter management, Better reflect the RFID technology does not need to contact, passive, information security advantages.

2. RFID communication technology and working principle

RFID [7] (Radio Frequency Identification) communication technology is an automatic identification technology based on wireless communication, which can identify automatically the target and obtain the relevant data through the RF signal without human intervention, and can identify high-speed moving objects and simultaneously identify multiple tags. The RFID system is generally composed of application system, reader, electronic tag and other components, the relationship between the three has shown in Figure 1.

RFID system basic working principle: the reader sends a specific frequency radio frequency signal through the launch antenna, the electronic tags will generate induced current and be activated when they enters the effective work area, so that their own encoded information is sent out through the built-in RF antenna. Then, the reader’s receiving antenna receives modulation signals sent by the tags and sends it to the reader signal processing module by the antenna regulator. After demodulation and decoding, the valid information is sent to the background host system for related processing. The host system identifies the tag’s identity according to logical operation and takes corresponding measure and control for the different settings, and finally sends the instruction signal to control the reader to complete corresponding read and write operation.

3. Smart meter data collection system

3.1. RFID smart meter design

In order to provide support for subsequent system development, increase the RFID communication module on the basis of the existing smart meter, make it has the function of RFID communication. So that RFID read and write devices can communicate with smart meter through wireless communication, this will further promote the intelligence of smart meter storage management, achieve accurate positioning and real-time query smart meter information, greatly improve the efficiency and quality of management. At the same time, we can use hand-held RFID read and write devices for on-site reading meter after the use of smart meter, make meter reading [8] more convenient and accurate. RFID smart meter main structure shown in Figure 2.
3.2. RFID data collection system function design

Research and Development of android-based smart meter data collection system, using the Java language and Eclipse development environment. This system has an interactive interface, can use meter reading client to upload smart meter data information collected by RFID read and write modules to the cloud platform system through 4G network or WIFI and other communication methods, as shown in Figure 3.

As the smart meter data collection system, the system provides users with an easy, convenient operating interface to facilitate the user's operation, quickly and accurately query all aspects of smart meter data; guide meter reading staff to collect the standard data, and real-time communication with the background server to ensure reliable and smooth communication. Therefore, this system has a high practicality, reliability, security, system function block diagram shown in Figure 4.

The smart meter data collection system has the following main functions:
(1) Registration/Login: smart meter reading client has stored a large number of user’s electricity information, including table address, power consumption, voltage, current, power and other information. Therefore, in order to protect customer privacy, the client needs to have login authentication function, at the same time the client should have a faster login system to facilitate the use of meter reading staff, for this the module has designed to remember the account and password function to choose, that account login successfully once, then do not have to re-enter the account password information.

(2) RFID scanning: before the meter reading, firstly we must set the hand-held RFID function parameters, including antenna power, regional frequency, inventory parameters, and then through the RFID scan for the corresponding connection. The traditional meter reading mode is very time-consuming due to need to find constantly the corresponding table number, user number and other information in the thick meter reading card. For improving the query speed, the meter reading machine has designed RFID fast query and positioning technology, only swept away can quickly query and locate the power meter attribution, from a certain distance from the energy meter to use RF technology to quickly query and locate the power Table related information, only need to sweep away can quickly query and locate the power meter attribution and related information even a certain distance from the power meter.

(3) Meter reading function module: meter reading staff not only on-site reading data displayed by smart meter, but also recording the working state of smart meter, and collected information will be saved and uploaded to the cloud platform. Second, the meter reading module can single copy and group copy smart meter, and has the smart meter maintenance function.

(4) Warehouse management module: In the smart meter warehouse management work, the system also has a warehouse management functions that record the smart meter entry, delivery, inventory and location in the Treasury and other information.

(5) Data transfer module: intelligent hand-held terminal is no longer a traditional meter reading terminal only has a single meter reading function, but with more intelligent features, such as real-time interaction with the server. Above functions need to use the wireless network, so the meter reading terminal equipped with WIFI and 4G two wireless communication to ensure that it can be online in real time. For saving more traffic, two communication modes should be able to automatically switch, when the meter reading terminal searched WIFI signal automatically connected to the WIFI mode, disconnect 4G signal; when the WIFI signal disappears automatically switch to 4G connection mode to ensure real-time online.

(6) System settings module: the module is mainly used for system settings, making the system matches the RFID communication function, so it needs to have certain permissions to access the system to modify the relevant information.

4. Research on Multi-block meters remote Operation at the same time

To solve the problem of multi-label collision When multiple smart meters at the same time on-site operations, the reader uses a specific and efficient electronic tag collision processing algorithm, which is based on the adaptive binary tree search (ABS) algorithm. This algorithm is simple to operate, the recognition time is shorter, there is no case that the tag is not responding for a long time.

Assuming that the number of tags in the system is \( N \), the number of branches allocated by the system is \( M \), and when the system search depth is 1, the recognition probability is:

\[
p(l) = \left[ 1 - \frac{1}{M} \right]^{N-1}
\]  

When the search depth is \( d \), the probability of system identification is:

\[
p(d) = \left[ 1 - p(l) \right]^{d-1}
\]

The average depth of the search for \( N \) tags during a complete identification process is:
\[ E(d) = \sum_{d=1}^{N} p(d) = \sum_{d=1}^{N} dp(1)[1 - p(1)]^{d-1} \]

The above formula has been simplified, sorted, and according to the ratio of the sum formula can get formula:

\[ E(d) = \frac{1}{(1 - \frac{1}{M})^{N-1}} \]

In the above formula, \( M \) is the common ratio, that is the number of branches assigned by the system. So that we can get the system search process required for the average number of time slot:

\[ T = E(d)M = \frac{M}{(1 - \frac{1}{M})^{N-1}} \]

When the search algorithm has two branches, the average number of time slot required is \( T_2 = 2/(1-1/2)^{N-1} \). When the search algorithm has four branches, the average number of time slot required is \( T_4 = 4/(1-1/4)^{N-1} \).

Compared with the above two formulas, we can see that when \( N>3 \), the average time slot used in the four-branch search algorithm is less, the system performance is better than the two branches search algorithm. When \( N \leq 3 \), the two branches search algorithm uses less average time slot, the system performance is better than the four branch search algorithm.

Therefore, the process of adaptive binary search algorithm is shown in Fig 6, and on the basis of this algorithm, configure appropriate inventory cycle, dwell time, power, Q value and other parameters set, so that it can not only maintain high read rate, but also to achieve the rapid reading and writing of electronic tags.

In the binary search algorithm, the algorithm encoding using Manchester encoding which can identify the collision by bit, the specific diagram shown in Figure 5.

![Figure 5 collision situation of Manchester encoding](image)

When the number of bits sent by two (or more) tags is different, the received rising and falling edges canceled each other out, so that the receiver will receive an uninterrupted carrier signal over the duration of the entire bit window. this state will cause an error because it is not specified in the Manchester encoding, so that this method can be used to track the occurrence of collision by bit backtrack to find out the specific bit of the collision. At this time the reader can identify all the collision bit information.
5. Conclusion

For the smart meter information management, warehouse management, on-site meter reading, data transmission and other issues, RFID communication module is integrated into existing smart meter, which is applied to all aspects of management of the smart meter, and on this basis, a smart meter data collection system based on RFID communication technology has been studied and developed, this system has the following advantages:

- The system can use RFID reading and writing device to achieve mutual communication with smart meters through wireless communication technology, read-write and store data, record all aspects of the smart meter information at any time.

- Through RFID reading and writing device to manage smart meter storage warehouse, has achieved smart meter real-time query and inventory, and improved management efficiency.

- Hand-held RFID reading and writing device is used for on-site meter reading, making the meter reading process more intelligent, convenient, data collection more accurate, greatly improving the efficiency of manual meter reading.

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