Design for Attendance System with the Direction Identification Based on RFID

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Abstract. A direction recognition attendance system based on RFID (Radio Frequency Identification) is designed in the paper. Using multiple card readers (a master and more slave), the system can recognize the direction of the card-holders effectively. Firstly, to read the RFID cards held by passersby and vehicles, multiple card readers must be installed in the region. Secondly, according to reading the difference of recorded time by multiple card readers, the direction of passage can be decided. Synchronism of the master-slave card readers are achieved using the time hack command, which ensure the accuracy of the decided direction. Finally, the access records will be packaged and transmitted to the server by the mobile network from the master card reader. The system can decide the direction of passage and calculate the passing time of the passersby and vehicles, making it a highly intelligent and efficient attendance management system.

Keywords: RFID · Card reader · Direction of passage · Attendance system

1 Introduction

Personnel attendance is one of the most important parts of the Enterprise Management System, and how to fulfill attendance in an easy but efficient way is what the company cares. In previous, staffs were asked to clock in and out or recording manually by the companies. It was inefficient and error-prone. Now, with the development of RFID tech and the enterprises informatization construction, it is being a trend for a company using the RFID tech to deal with the personnel attendance work [1, 2].

RFID is a kind of non-contact, automatic identification technology [3]. It has some advantages, such as lower cost, more stable signals and longer distance for reading. RFID is widely applied in areas such as industrial automation, communication and transportation, etc. [4]. For example, traffic monitoring, item management and checking in/out as well as attendance system are using RFID technology [5, 6].

As we all know, it is common to use RFID in personnel attendance system. Personnel attendance can be completed via a card reader reading a RFID card [7]. But some problems might be occurred in certain occasions like large-scale mine factories. For instance, most systems are using proximity card-reading devices which request our

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staffs to check manually and closely, causing inefficiency if high pass rate needed in the factory. Another instance is that although system of large-scale mine factories can recognize a target, while they cannot tell which direction the target's heading. Thus, the system cannot monitor or manage the staff's clock-in or clock-out automatically. And people need to do statistics and manage the condition of passersby [8].

In order to enhance the efficiency of personnel attendance and solve the problem that the attendance system cannot decide the direction of the passage, a RFID-based direction identification system is designed. We need to install a few of card readers to read the RFID cards on the passersby or vehicles in areas which needed to be decided in this system. According to reading the difference of recorded time by multiple card readers, the direction of passage can be decided. Then the data by the card readers will be transmitted to the server for storage and recording via mobile communication networks. In this system, we adopt the active RFID technology, which is stable with signal and can be read in a long distance with little interference [9]. This design for personnel attendance system based-on RFID technology can tell the direction that people or vehicles are heading. And can calculate the passing time and working time information and so on, which will contribute to more intelligent personnel attendance system for large-scale mine factories.

2 Composition of the System

Figure 1 shows an installation diagram for a large-scale mine factory's personnel attendance system. The volume of the card readers installation is up to the reading distance and the width of the gate of the factory (If the width of the gate is shorter than the distance which the readers can cover, we need a pair of card readers. Otherwise, we need several pairs.). One is the master card reader, others are slave readers. To elaborate easily, 2 pairs of card readers are installed in the paper. The master card reader 1 and the slave card reader 3 are in the front of the gate. Slave card reader 2 and 4 are behind the gate. The master card reader 1 and slave card reader 2 constitute a pair of card readers, slave card reader 3 and 4 become the other pair. With the help of cards working in pairs installed in the front door and back door, the system can calculate the time difference. Card readers are connected with wired Ethernet and data are transmitted by it. The master card reader is connected to the remote servers via mobile communication base station and Internet, then it will send card-reading records and access records to the remote servers.

Slave card readers read RFID information in their covering ranges, then pack the data and transmit it to the master card reader. The master card reader also reads RFID information in its own covering range. At the same time, it accepts information from the slave card readers and analyses them. The system can decide the directions of the RFID cardholders by calculating the time difference from the front/back card readers, the system can decide the directions of the RFID cardholders. And it is requested the master-slave card readers must keep time synchronous.

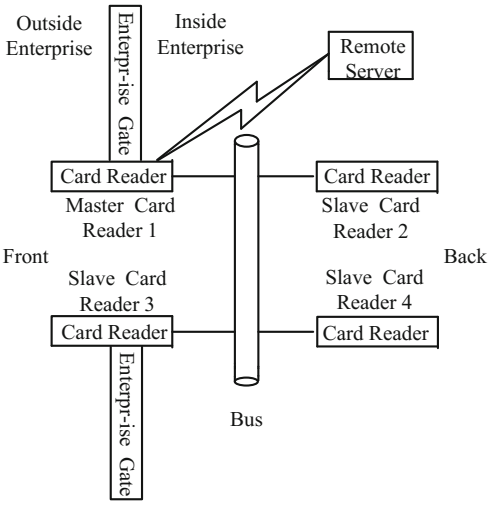

Fig. 1. The installation instruction of attendance system

3 Design of Card Readers

3.1 Composition of a Card Reader

As shown in Fig. 2, the constitution of the card reader includes: power module, MCU, RAM, FLASH, clock module, Long-wave-time-service module, acousto-optic indicating unit, RFID card-reading module, configuration interface, Ethernet interface module, and mobile communication module.

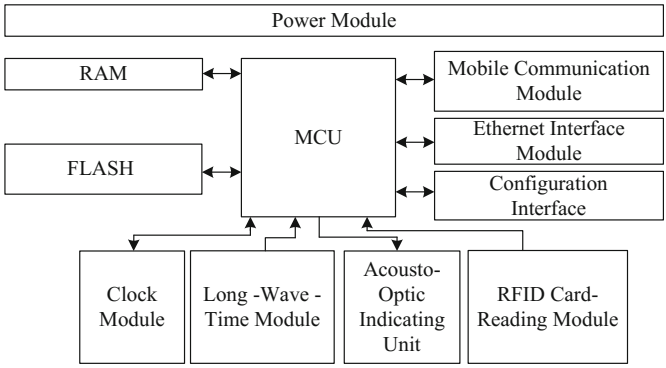

Fig. 2. Circuit diagram of the card reader

Power module: to supply other modules with power.

MCU: control other modules, process data, decide the direction, upload information and other secondary functions.

RAM: cache the to-be-processed data.

FLASH: to preserve data that mustn't be lost when the power is being cut-off, including configuration figures of the card-reader, unsent reading records, unsent access records.

Clock module: to provide card readers standard time, produce card-reading records and access records timestamp. Slave card readers preferentially adopt the clock time from the master card reader to keep in time synchronization.

Long-wave-time-service module: to proofread the clock module of the card readers. Adopting BPL time service [10], this module receives standard signals from long-wave-time-service launcher, then demodulates the time-serving signals, via electric level signals output by the timers' pins. The MCU can synchronize the system clock according to the electric level time periods, then provide card readers with relatively accurate time, thus realizing time synchronization with the master-slave card readers. The key of direction recognizing is to synchronize the time of every card reader, adopting long-wave-time-serving module preferentially [11]. When long wave time serving signal can be received, this system can use the time service to synchronize time of every card reader. When interference appears or owing to the restrictions the environment, the card readers cannot receive the time-serving signals, this system can use the clock module to synchronize time of every card reader by networking synchronization. The master card reader can obtain the standard time by connecting time-serving servers via mobile communication base stations. Then, via Ethernet, the master card reader can give instructions to slave card readers, the slave card readers can keep in time synchronization with the master card reader.

Acousto-optic indicating unit: to indicate the working status of the card reader via LED and buzzers.

RFID card-reading module: to complete reading information of the RFID cards.

Configuration interface: providing standard interface to deploy the working parameters for card readers.

Ethernet interface module: to provide data communication between the master-slave card readers.

Mobile communication module: process the aerial interface between remote servers and card readers, fulfill the data uploading tasks.

3.2 Programming Flow of the Card Reader

The working process of a slave card reader is showed as Fig. 3. Once electrified, this system will decide the current device is a slave card reader from the systematic configuration, then start up the overtime timer.

The processing flow of the slave card reader: the card reader will go to interrupt if it gets data. The serial port will save the data in the UART (Universal Asynchronous Receiver/Transmitter). Then the main loop of the card reader could read and analyze data in the UART queue. If analyzed successfully, the data will be transferred into records by reading the current time using the time module, then the records will be saved in the RAM. If the records fulfill a page of FLASH, it will be saved in the FLASH. And overtime timer will be reset every time the reading record is generated. When the data in the UART queue is finished and no new card-reading data arrival, the

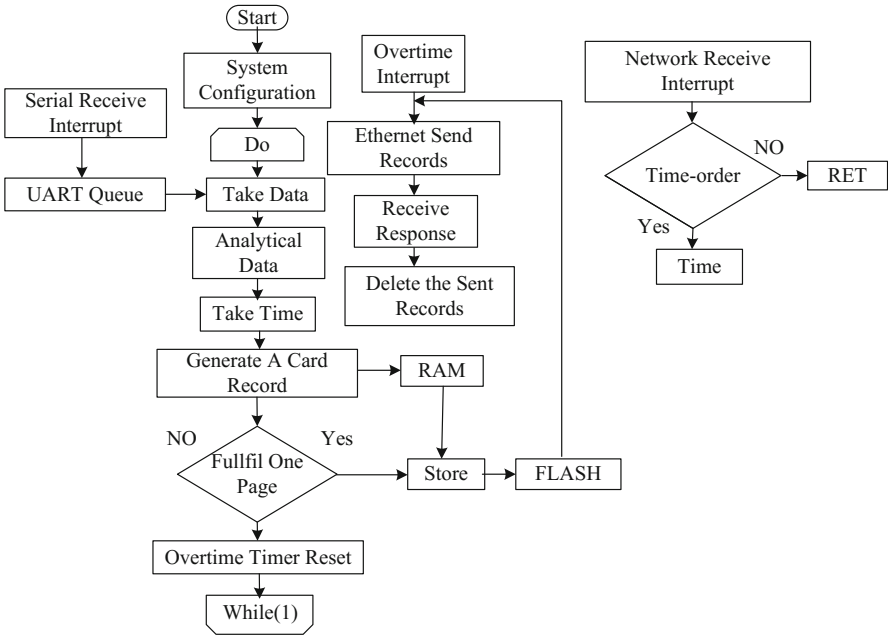

Fig. 3. Program flowchart of a slave card reader

overtime timer will run over because of no reset, then the procedure will jump into the timeout interrupt, timeout interrupt reads card-reading records from the FLASH and sent the records via Ethernet to the master card reader, at the same time, receiving the response from it. If the master card reader receives rightly, the record will be removed from the slave card readers.

During the slave readers working period, if the network receives the interrupt which is the time order from the master card reader, the time checking operation is triggered. If not, the procedure will return to the main loop to continue.

The processing flow of the master card reader is showed as Fig. 4. Once electrified, this system will decide the current device is a master card reader and start the timeout timer.

The working process of the master card reader: it is similar to the slave card readers, the difference is that the program will jump to timeout interrupt to execute, when the overtime timer overflow. The timeout interrupt read the access records from FLASH and send them to server via Mobile communication network, at the same time it will receive the server's response, if the server receives the records of the master card reader rightly, the master card reader should delete the transmitted records.

In the working process of the master card reader, if the network receives an interrupt which is the record of transportation from the slave card readers to the master card reader, the master card reader will receive records and store in the FLASH, otherwise, it will return to the main loop to continue.

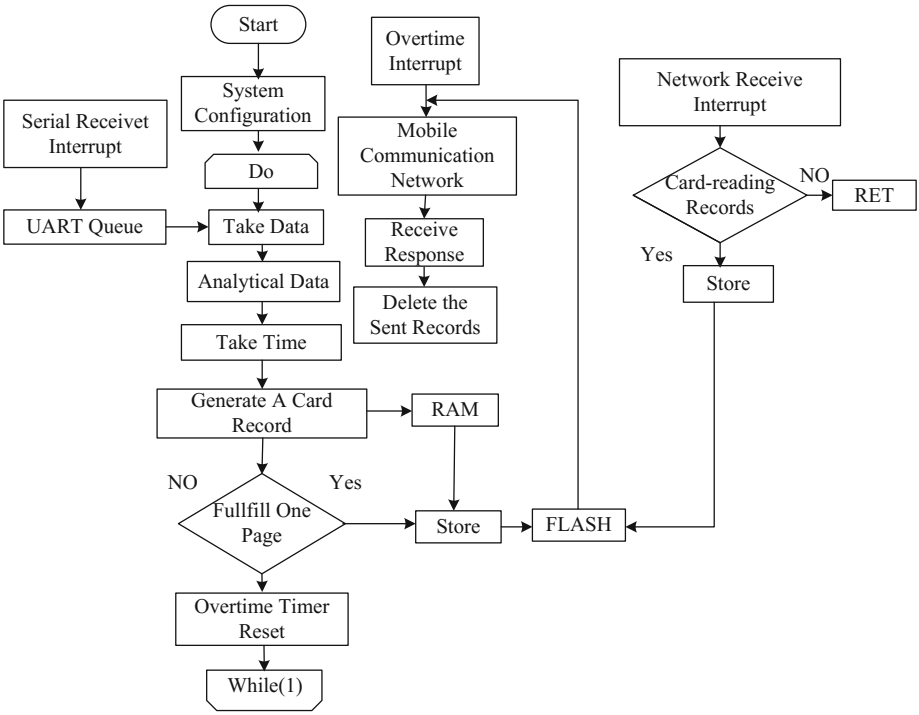

Fig. 4. Program flowchart of the master card reader

4 Direction Recognition Algorithm

In order to decide the direction of the passersby and vehicles, this paper proposed the algorithm of the direction recognition. As shown in Fig. 5.

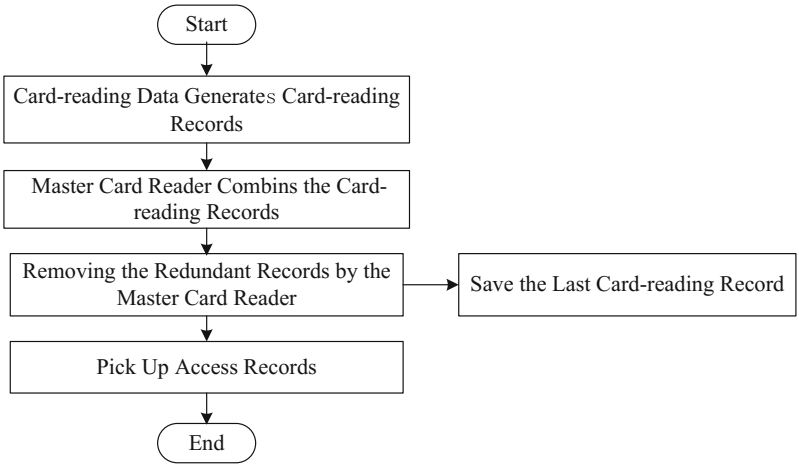

Fig. 5. The flowchart of direction recognition

(1) Card-reading data generates card-reading records

All card readers get data from reading the RFID cards, then sort the data based on the ascending array in the same RFID card. The card-reading data timestamp is the timing of the reader read RFID cards. Because of passersby or vehicles take time to go through a single card-reader area, the same RFID card will be read repeatedly, which will cause the data redundancy, so, the redundancy need to be removed to generate new records.

The redundant data will be processed as below: for the same card (identified with card ID), the first time the card is read, record the card-reading time as t_1, when read the I times, record as t_i. The system will set a overtime as TOT, which should be designed less than the passing time from the front/back (or back/front) card-reader. Then combine the data with this RFID card, if:

$$t_i - t_1 > TOT\,. \tag{1}$$

The card-reading records will be recorded and saved as t_i, if not, the card-reading data will be considered as redundant data and it will be deleted. The procedure will cycle like this until the card-reading records generated. As shown in Fig. 6.

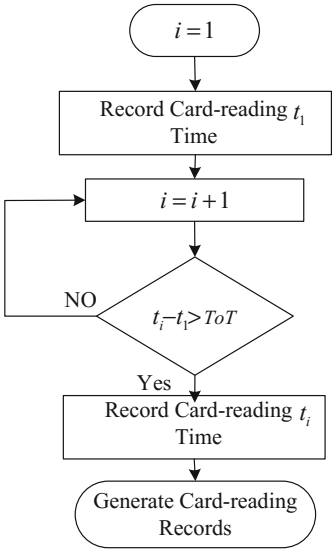

Fig. 6. Flowchart of card reader removing redundant data

(2) Master card reader assembles the card-reading records.

The slave card readers transport the card-reading records via LAN to the master card reader. The master card reader will assemble the records, then assort them based on the card ID and order the records in the ascending rule of timestamp in each part.

(3) Removing the redundant records by the master card reader

For the generation of card-reading records is independent between card readers, one RFID card may be read by different card readers at the same time and saved as card-reading records, so once the records were combined together, there will be repeat records, which should be processed as below: compare every item after summary and make a decision according to the different card readers but with the same RFID card: compare the absolute D-value of the first record with second record, if the D-value is smaller the *TOT*, delete the second record, then compare the third record with the first one, looping like this to remove the redundant records in the same RFID card. This procedure is the same with data redundancy removing, just the difference of data and records.

(4) Pick up access records

Search the trip point (from the front to the back/from the back to the front) according to the ID of RFID card after processing the redundant records. Pick up the records before and after the trip point as one piece of access records, so will decide the direction of accessing. After picking up the position of readers in couple, mark the record in position of "front-back" as "enter", and mark the record in position of "back-front" as "leave".

(5) Save the last card-reading record

Removing the redundant records in the master card reader, pick up and save the last one to be used as accessing records in the next implement.

5 Conclusion

A direction recognition attendance system based on RFID is designed in the paper. Multiple card readers must be installed in the region. With the cooperation of master-slave card readers, the system can decide the direction of the card holders by the time difference from a pair of card-readers. Also calculate the access time and working time. The information by card readers will be recorded and saved in the server via mobile communication module. Compared to the traditional attendance system, this paper can decide the direction of accessing people, increase the efficiency and shorten the passing time.

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