Design and Application of IoT based Intelligent Logistics Monitoring System

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Abstract: This paper describes an intelligent system for real-time item status monitoring in the logistics process. By installing the logistics monitoring device and binding the monitoring device and the item information, the user can know the status of the item in real time. The main components of the system include: power module, main control module, communication module, status sensor, terminal electronic device and data center. The relationship between them is as follows: the power modules are respectively powered by the main control module, the communication module and the status sensor; The status sensor is responsible for detecting the status of the item and transmitting the status information to the main control module, and then the main control module transmits the information directly or indirectly to the data center via the communication module, and then the data center distributes the information to the terminal, and finally the terminal electronic device displays the real-time. Item monitoring information, and the monitoring information is analyzed by the data center. The system has the characteristics of monitoring device recycling, miniaturization, and monitoring systemization etc. The signal processing and processing of the terminal electronic device or the data center reduces the additional burden of the underlying hardware such as the main control module and improves the efficiency.

1. Introduction

With the rapid development of the Internet economy, express logistics has a close relationship with people's work and life. The state of the goods in the process of logistics, such as vibration, tilt, temperature, humidity, etc., will have an impact on the quality and service life of the goods. In recent years, due to the increasing number of disputes over goods caused by logistics, the state of goods in the process of logistics has not only become the focus point of buyers, but also the pain point of sellers and producers. It is also the key point for logistics companies to improve service quality. [1]

The traditional monitoring of the state of the logistics process uses a mechanical vibration monitoring label and a tilt monitoring label. The principle is that the label is subject to irreversible recording such as discoloration after a condition exceeding the set threshold. Such mechanical monitoring labels can’t be recycled and reused, which will lead to an increase in logistics costs, and only high-value goods can be used; in addition, other important logistics status information, such as time of occurrence, degree of failure, and occurrence frequency is not available. [2] Moreover, the verification of such mechanical monitoring labels can only be performed manually, and automatic collection of large-scale status data cannot be performed.

With the rapid development of electronic information technology, the accuracy, power consumption and price of the monitoring sensors in the state (such as vibration, tilt, temperature, humidity, etc.) have fully met the state monitoring requirement in the logistics process, so the electronic condition monitoring device can be used to achieve Monitoring of logistics status. [3] The popularity of terminal electronic devices (especially terminal electronic devices such as smart phones) and the increasing maturity of narrowband communication technologies; the logistics status data monitored by electronic condition monitoring devices can be conveniently displayed on terminal electronic devices such as smart phones. [4] To allow users to fully understand the real logistics status; and these logistics status data can also be quickly and efficiently aggregated in the data center for use by logistics companies, vendors, and resolve disputes or improve management. At the same

time, such an electronic condition monitoring device can be completely reused without burdening the logistics enterprise. [5]

Therefore, there is an urgent need in the market for a monitoring system that intelligently monitors the status of items in the logistics process, thereby enabling automatic data collection and transmission, facilitating dispute resolution and improving management.

2. System Design

The article provides a status monitoring system for the goods in the logistics process, including a power module, a main control module, a communication module, a status sensor, a terminal electronic device, and a data center. The user binds the cargo information to the monitoring device through the main control module, the status sensor detects the item status information and transmits it to the main control module, then the main control module directly or indirectly transmits to the data center via the communication module, and then the data center transmits to the terminal. [6] The user can finally directly monitor the impact of the cargo, the number of tilts, and the temperature and humidity in the terminal electronics. [7] Moreover, through the analysis of the data center, the user can access the level of damage of the goods and the time of damage, thereby determine the responsibility of logistics and transportation.

2.1 Power Module

The power modules supply power to the main control module, the communication module, and the status sensor. The power modules described in this document are on-board power modules, solar modules, or battery modules. [8] The battery module is a portable battery, preferably a button battery. The advantage of the button battery is that it realizes the miniaturization of the logistics monitoring device while being durable and replaceable.

2.2 Main Control Module

The main control module accepts the status information of the item detected by the status sensor, and then transmits the item status information to the data center via the communication module. Moreover, the main control module further includes a power management module, an alarm feedback module, a real-time clock module, a data storage module, a sleep wake-up module, and a positioning module.

Through the power management module, the main control module controls the output of the power module, which is beneficial to improving the utilization of the power supply and reducing the power consumption of the system, thereby saving costs. The warning feedback module can directly or indirectly issue a warning signal to the abnormal data detected by the state sensor: directly issue a warning signal, including setting an alarm light, an alarm horn or an audible and visual alarm at a position that can cause the transportation personnel to pay attention, and a warning, and connected to the feedback module; the warning signal is indirectly sent, and the warning feedback module transmits the detected abnormal data to the data center through the communication module, and pushes the prompt information to the relevant APP software or the logistics transport personnel through the data center or make warning call from the data center to the logistics transport personnel. In addition, the real-time clock module is used to obtain an accurate real-time time signal and transmit it to the main control module to ensure the real-time and accuracy of the monitoring data. The sleep wake-up module is configured to detect the use state of the terminal and issue a sleep signal or a wake-up signal to the main control module, and then the main control module sends a power control signal to the power management module according to the sleep signal or the wake-up signal, which is beneficial to ensure low power consumption.

2.3 Communication Module

The communication module is responsible for transmitting the status information of the items collected by the main control module to the data center for analysis. Transmission methods include

direct transmission and indirect transmission. Direct transmission refers to the directly transmitting of collected item status information to the data center through narrowband communication technologies (such as NB-loT or LoRa, etc.). Indirect transmission refers to the collection of monitored item status information to the data center through forwarding by the terminal electronic device. Moreover, the indirect transmission reduces the configuration requirements of the communication module and the main control module, and further realizes the miniaturization of the logistics monitoring device. In addition, abnormal data can be used by logistics companies, vendors or manufacturers to resolve disputes or improve management levels.

2.4 State Sensor

The state sensor includes a temperature and humidity measurement module and an impact tilt measurement module. For example, gyroscopes and accelerometers collect vehicle speed, acceleration, angular velocity information, and so on. The temperature and humidity measurement module is used to collect the temperature and humidity signals in the environment in real time and transmit them to the main control module. The impact tilt measurement module includes an impact force measurement module and a tilt measurement module. The impact force measurement module is configured to collect the external impact force signal and transmit it to the main control module; the inclination measurement module is installed on the monitored object, and monitors the tilt angle signal of the monitored object in real time, and then transmits the tilt angle signal to the main control module.

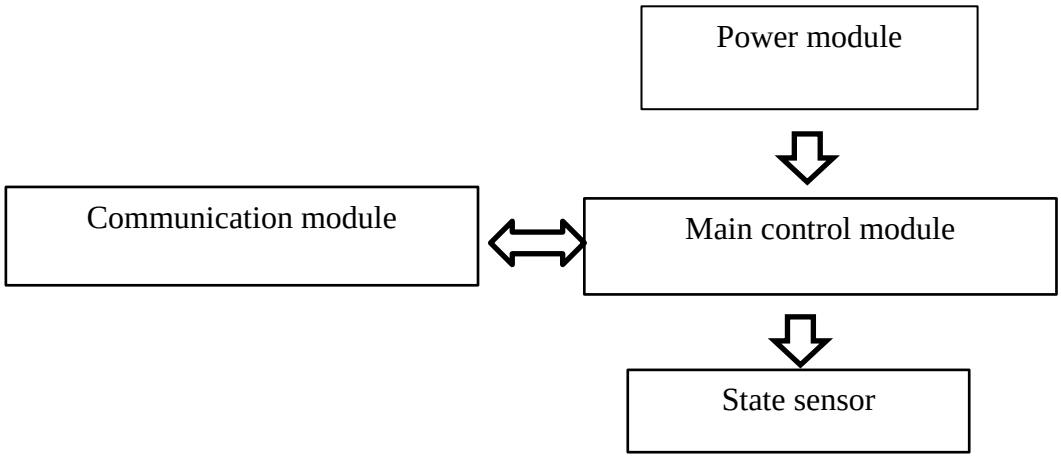

Fig 1. Schematic diagram of the item status monitoring system in the logistics process

2.5 Terminal Electronic Device

The terminal electronic device is responsible for presenting the user with real-time monitoring information of the analyzed items in the data center. The terminal electronic device is a mobile terminal or a fixed terminal having a screen display function, and can display monitoring information on the spot to facilitate the on-site inspection of the consignee. The mobile terminal is a mobile smart device with communication function, such as a smart phone, a courier scanning mobile terminal, a tablet computer or a notebook computer. Fixed terminals are computers, mainframe computers, courier display devices, and other fixed electronic devices that can be used to display and analyze data. Compared with the fixed terminal, the mobile terminal can display the item status information remotely, so that the user can more easily access the status of the item.

In addition, the status abnormal data recorded by the data center can be provided to the user's mobile terminal (such as a smart phone), for the recipient user to check the goods. The recipient user makes a decision on whether to sign the goods by checking the status monitoring data of the goods in the logistics process on the smartphone. Moreover, the smart phone can obtain the monitored abnormal state data from the logistics state monitoring device through the short-range communication technology (such as Bluetooth), or download the monitored state abnormal data through the Internet connection data center. Based on this, the mobile terminal is suitable for use by

logistics couriers, senders and recipients. The fixed terminal is suitable for logistics companies, vendors or manufacturers to resolve disputes or improve management level, because it has strong computing power and can perform big data analysis.

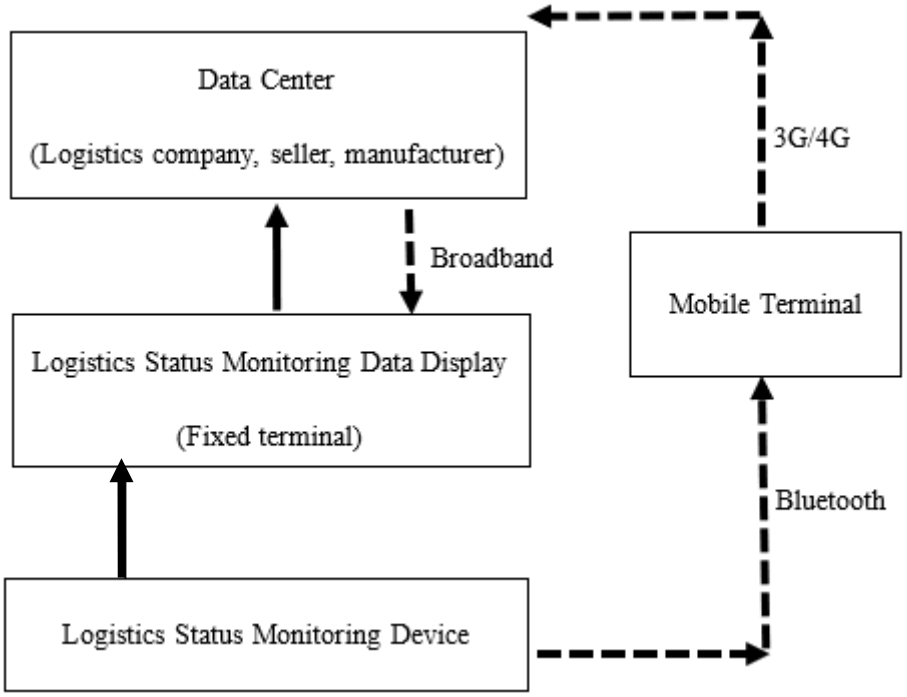

Fig 2. Schematic diagram of indirect exchange of monitoring system data

2.6 Data Center

The data center is a cloud server. The cloud server is more powerful in computing or storage than the data storage device of the local physical server, and is simple, efficient, secure, and flexible in processing capability. It is also simpler and more efficient to manage. Users can quickly create or release any number of cloud servers without having to purchase hardware in advance. Moreover, cloud servers can quickly build more stable and secure applications, reducing the difficulty of development and operation and overall IT costs.

The data center is used for analyzing and processing the received temperature and humidity signals, real-time time signals, geographic coordinate signals, impact force signals and tilt angle signals, respectively, and then forming monitoring data including temperature values, humidity values, real-time time, geography, impact force, and tilt angle values. After the monitoring data is generated, it is sent by the data center to the terminal electronic device, such as the mobile terminal for display. Through the data center for signal storage and analysis processing, on the one hand, the additional burden of the underlying hardware such as the main control module is reduced, miniaturization is realized, and on the other hand, the signal transmission and processing capability of the access data center is correspondingly improved. In addition, the data center can perform subsequent analysis such as statistical analysis and classification of large-scale monitoring information, and monitor and manage the whole process of logistics, to facilitate dispute resolution and improve management level.

3. Hardware Design

The main control module uses the nRF52810QCAA Bluetooth chip and integrates the ARM® Cortex-M4 core with rich FLASH and RAM space. The nRF52810QCAA Bluetooth chip is selected as the main control module, which achieves the advantages of low cost, high calculation rate and easy debugging. In addition, the hardware settings of the real-time clock module and the data storage module included in the main control module contribute to the low energy consumption and high

efficiency of the system as a whole. The 32K768 clock chip is used as the real-time clock module, which is beneficial to meet the requirements of low power consumption, low cost and small volume of the system. The data storage module uses the FLASH memory chip of the model W25Q80 to ensure enough storage space. In addition, the ADXL375 large-range sensor is used as the impact tilt measurement module in the state sensor to facilitate accurate measurement and reduce power consumption. The DHT11 digital temperature and humidity sensor is used to improve the accuracy of the temperature and humidity measurement module.

4. System Operation Flow

First, the logistics personnel install the logistics monitoring device on the outside of the cargo or its packaging.

Secondly, the logistics personnel or consignors scan the QR code on the logistics monitoring device through WeChat “sweep” or use the logistics monitoring device “QR code scanning function of APP software” to complete the binding of the logistics monitoring device to the goods. At the same time, the logistics monitoring device is activated to enter the state monitoring mode, and the binding and activation information is reported to the data center.

During the transportation of goods, the logistics monitoring device automatically records the abnormal data of the state, such as the abnormal mode, intensity and time of occurrence; when the abnormal state is recorded, the device will emit a light.

Subsequently, the consignee can scan the QR code on the logistics monitoring device through WeChat “sweep” or use the logistics monitoring device “QR code scanning function of APP software” to obtain the state abnormal data in the logistics process. After checking on the mobile phone, decide whether to sign the goods.

Finally, after the recipient confirms the receipt, the logistics personnel will use the logistics monitoring device to remove and recycle from the package. The logistics personnel and the recipients confirm the item information by applying the intelligent terminal equipment, and transmit the information to the data center, real-time monitoring of the information of the item status in the logistics process, improving the monitoring level of the logistics information, and ensuring the goods security.

Fig.3. Cargo binding main page

Fig.4. Information entry page

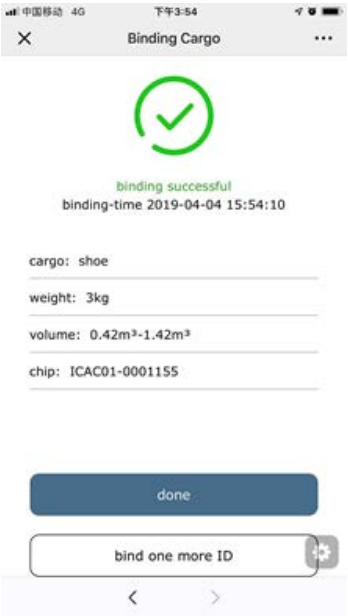

Fig.5. Binding success page

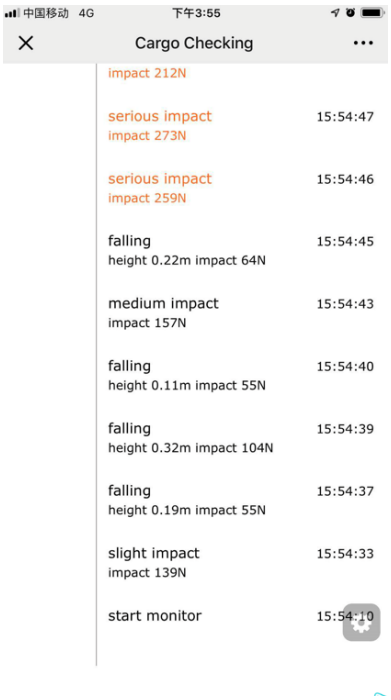

Fig.6. Real-time monitoring page

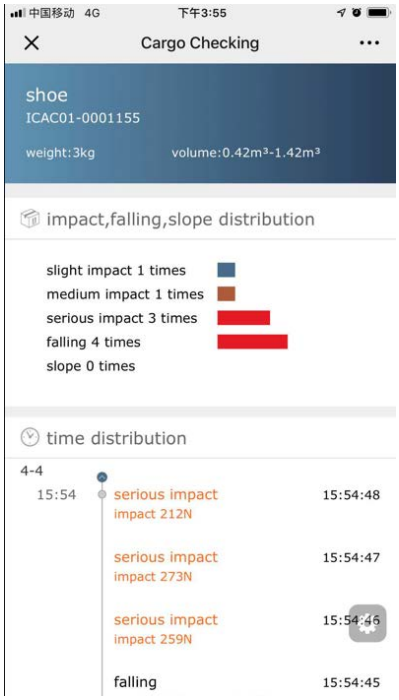

Fig.7. Information summary page

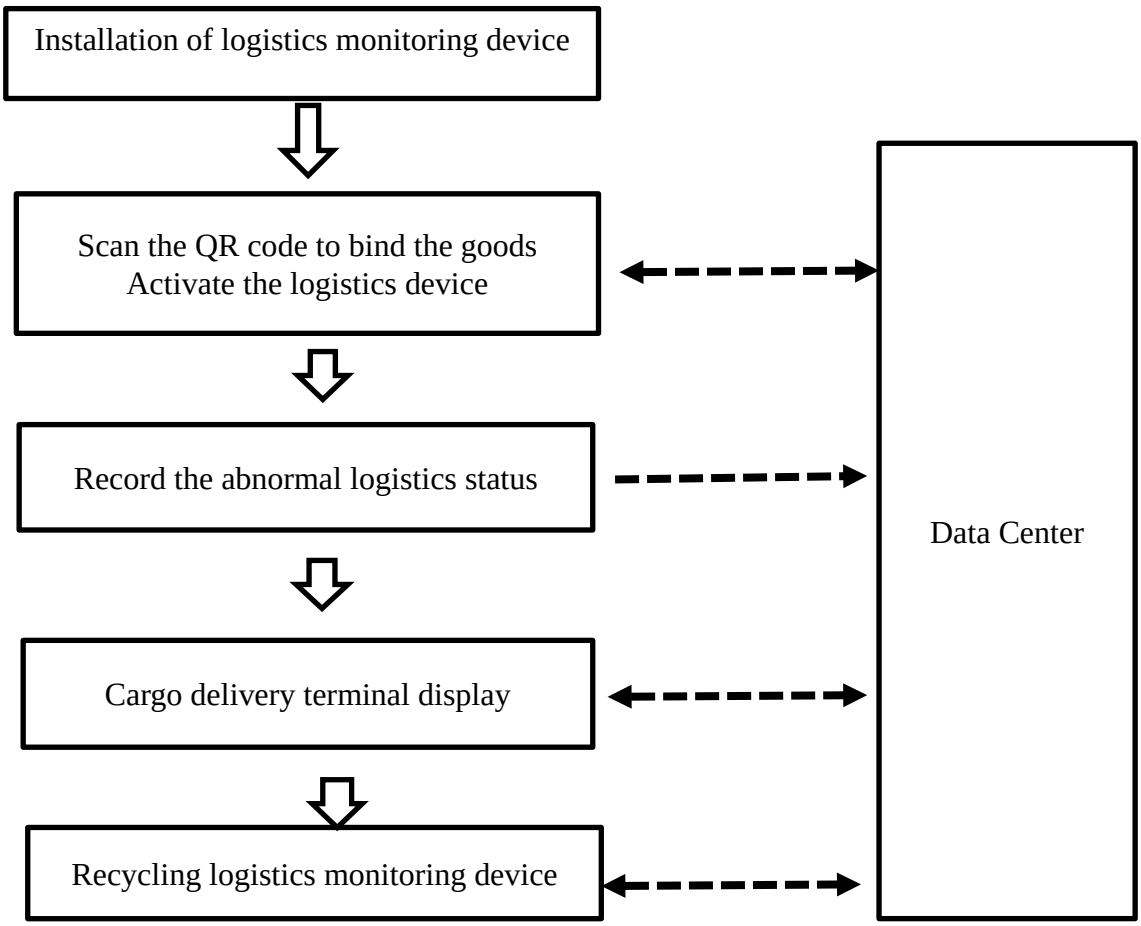

Fig. 8 System operation flow

5. Conclusion

The system adopts modular design of the collection terminal, and the functions of each module are relatively independent, and are controlled by the main control module, which is beneficial to improve the working efficiency and reliability of the collection terminal, and is convenient for debugging and maintenance. The intelligent logistics monitoring system performs signal storage and analysis processing through the data center. On the one hand, it reduces the additional burden of the underlying hardware such as the main control module, realizes miniaturization of the monitoring device, and on the other hand, improves the signal transmission of the access data center. The system can effectively solve disputes and improve management level for logistics companies and sellers.

References

[1] Xu Z, He J, Chen Z. Design and actualization of IoT-based intelligent logistics system[C]// IEEE International Conference on Industrial Engineering & Engineering Management. 2014.

[2] Tao B, Yi L. Upgraded Application of Intelligent Environment Monitoring System in IOT Smart Home[C]// Sixth International Conference on Intelligent Systems Design & Engineering Applications. 2016.

[3] Feng C, Wu H R, Zhu H J, et al. The Design and Realization of Apple Orchard Intelligent Monitoring System Based on Internet of Things Technology[J]. Advanced Materials Research, 2012, 546-547:5.

[4] Lee J, Seo S, Choi M I, et al. Design and Implementation of IoT-Based Intelligent Condition Management System for the Industrial Facilities[M]// Internet of Things. User-Centric IoT. 2014.

[5] Lin N, Yu H L. Vegetable Intelligent Monitoring System Database Design Based on the Internet of Things[J]. Advanced Materials Research, 2013, 655-657:1423-1426.

[6] Zu Q, Zhang H, Xu X, et al. The Design and Implement of Bridge Health Monitoring System Based on Internet of Things[J]. Journal of Graphics, 2013.

[7] Kao K C, Chieng W H, Jeng S L. Design and development of an IoT-based web application for an intelligent remote SCADA system[J]. IOP Conference Series Materials Science and Engineering, 2018, 323.

[8] Zhang C, Zhang X, Wang D, et al. Design and implementation of cloud service system for cold chain logistics of fresh agricultural products based on component integration[J]. Transactions of the Chinese Society of Agricultural Engineering, 2016.