Research and Application of Intelligent Emergency Call Terminal for Elevators

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Abstract. Aiming at the difficulties and pain points of external distress calls after elevator entrapment, the low-cost, and highly reliable new rescue terminal technology solution was researched and proposed. Based on the Internet of Things (IoT) technology, this solution provides a real-time emergency call and handling method.

Keywords: Elevator Safety; Internet of Things; Emergency Rescue

1 INTRODUCTION

In recent years, elevators have become modern industrial equipment closely related to people's lives. As the number of elevators increases, the number of elevator trapped faults is also constantly increasing. The most important issue is how to actively take remedial and emergency measures to reduce the harm and avoid unnecessary casualties[1-6].

Currently many elevator manufacturers have adopted a three-party or five-party elevator intercom system. But this system's role is limited. The first reason is the gradual failure of the cable carriers laid in cable trays and trenches; the second reason is the lack of self-help capability when the trapped passengers are the elderly or children; the third reason is the rescue timing delays because many trapped individuals are unable to accurately describe the elevator location to the rescue party[7-11].

Aiming at the above problems, a low-cost and highly reliable intelligent emergency call terminal for elevators has been studied and proposed. This terminal is connected to the existing elevator intercom system of the elevator, monitors the call for help voice of the elevator intercom, identifies the rescue status, and automatically transfers the unanswered call for help to the elevator emergency response service platform. The solution provides rescue services for trapped personnel, and greatly avoids the limitations and defects of various existing elevator rescue solutions[12-14].

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2 TERMINAL FUNCTIONAL FRAMEWORK

The functional framework of the elevator intelligent emergency call terminal is illustrated in Fig.1.

The system adopts the three-layer IOT(Internet of Things) architecture. The intercom system of the elevator car, as the perception layer of IOT, is responsible for the perception of the voice signal of the call for help, the acquisition of the sound signal and the conversion of the electrical signal, and the internal transmission. On the transmission layer of IOT architecture, the elevator intelligent call terminal plays its roles on the information transmission of voice call for help through the collecting, logically converting, calculating and judgement of the electrical signals from the perception layer. The rescue cloud platform belongs to the application layer of IOT, and realizes multiple functions including voice intercom appeasement, emergency personnel and material scheduling to data statistics, big data services and so on.

When an entrapment incident occurs, the terminal will instantly communicate with the elevator intercom system or the control room host. Simultaneously, the terminal communicates with the elevator emergency response service platform. It handles voice communication functions such as outgoing calls, incoming calls, call transfers, and platform data push for different rescue parties. It also supports third-party emergency response and data recording.

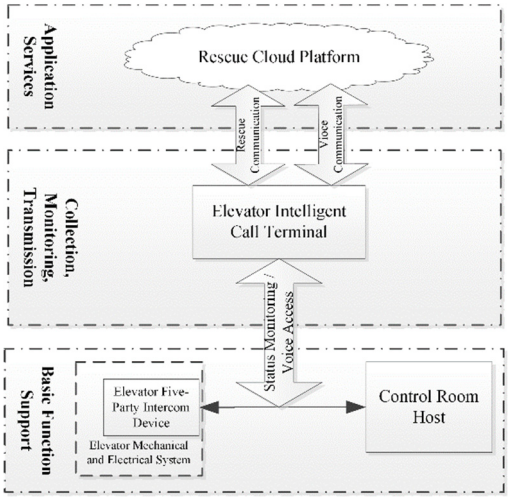

Fig.1. System functional diagram

The elevator intelligent call terminal operates with the existing elevator intercom system. Without affecting the original functionality of the elevator intercom, the terminal can quickly and stably access the voice signal of the elevator intercom system through convenient construction methods. It enables the internal voice distress signal detection within the elevator intercom system. When the call from the elevator was not promptly responded by the control room personnel, the terminal automatically connected with the internal voice of the elevator intercom system and dials pre-setting emergency rescue telephone numbers. This allows real-time voice communication between the trapped passengers inside the elevator and the rescue personnel. By pre-setting multiple phone numbers, the terminal can start different levels of rescue personnel, including local property duty staff, elevator maintenance personnel, and local public rescue forces.

3 TERMINAL RESEARCH AND DESIGN

The hardware functional modules of the intelligent elevator emergency call terminal include:

core processing module, power management module, mobile communication module, intercom call processing module, data processing module, and user interface (UI) module. The structural diagram of the terminal is shown in Fig.2.

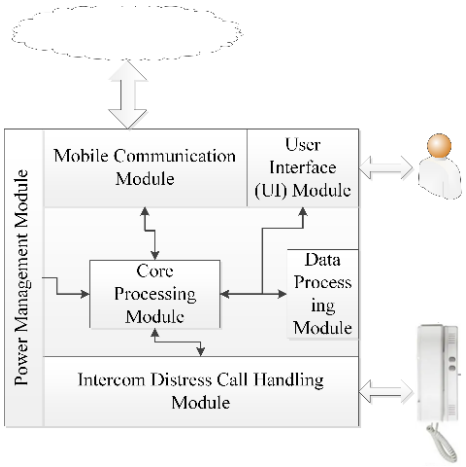

Fig.2. Terminal structural diagram

3.1 Core Processing Module and Data Processing Module

The core processor is responsible for coordinating and processing data operations and exchanges between various modules of the intelligent emergency call terminal. It performs basic logical judgments and data calculations.

The data processing module is responsible for storing, querying, and extracting various data of the intelligent emergency call terminal, such as the operational history data, elevator basic information configured within the terminal, configuration information required during the startup process, and connection keys assigned by the cloud service platform.

3.2 Power Management Module

The power management module provides a stable and reliable working power environment. It includes a main power supply, backup power supply, and dynamic power switching circuit. When the module is functioning normally, the main power supply module works and provides the required power to various functional modules of the terminal. In the event of a power outage or abnormal conditions like unplugging the power plug from the socket, the dynamic power switching circuit detects the abnormal status of the main power supply in real time and switches the power supply circuit to the backup power supply. The stored power in the backup power supply is provided to the terminal through a voltage boosting circuit to ensure that the intelligent emergency call terminal has sufficient time to complete necessary tasks such as data processing, peripheral device support, and external rescue calls.

3.3 Intercom Call Processing Module

The intercom call processing module is responsible for accessing and detecting emergency signals in the elevator intercom system. It processing module integrates into the signal bus of the original elevator intercom system in a simple manner. It detects and determines the emergency voice signals in the original intercom system through various methods such as voltage signal detection, digital signal decoding, and analog voice recognition. If the emergency voice is not responded by other parties within the intercom system, the voice channel will be switched to the external voice channel of the mobile communication module to make emergency calls.

The intercom call processing module has multiple interfaces for the elevator intercom bus. Each interface can connect to a set of elevator intercom devices, allowing it to support the simultaneous connection, detection, and determination of multiple channels of elevator intercom signals.

3.4 Mobile Communication Module

The mobile communication module is responsible for external telephone calls and data exchange with the cloud service platform. It uses an IoT card with voice and data capabilities to connect to the network of the service provider. The IoT card is bound and authenticated with the core processor during the production process.

The mobile communication module supports various network protocols such as SOCKET, MQTT, HTTP for data exchange with the platform. When the intelligent emergency call terminal forwards the emergency voice to the maintenance personnel's mobile phone number or the telephone operator of the cloud service platform through the voice communication function, it also pushes the corresponding elevator related information to the emergency voice as an alarm message to the cloud service platform. This enables the platform to automatically match the voice with the basic information and location of the alarmed elevator for remote rescue dispatch. The communication between the mobile communication module and the platform is encrypted, supporting not only data upload to the platform but also the bidirectional transmission of terminal configuration information and software upgrades.

3.5 User Interface (UI) Module

The user interface module has a wireless network configuration interface that allows users to initialize and set up the intelligent emergency call terminal through wireless networks such as Bluetooth, Wi-Fi, and 4G networks. Through the UI module, users can preconfigure basic settings, software logic, elevator basic information, terminal interface connection status, basic rescue information, and outbound numbers for the terminal.

4 Terminal Applications

4.1 Terminal Deployment

Before the terminal operates normally, it needs to be associated with the specific monitored elevator through on-site installation and deployment, software configuration and binding process.

The terminal should be arranged in a location that does not affect the normal use of other equipment in the elevator room, where there is a suitable temperature and is not easily affected by moisture.

For inorganic room elevators, the possible place arranging the equipment is above the roof of elevator car.

A typical elevator intelligent call terminal installation and wiring schematic is shown in Fig. 3. The elevator intelligent call terminal is connected to the communication cable between the elevator intercom through the form of wired cable, and collects the electrical signal of the elevator intercom. Considering the convenience of cable connection, the wiring position of the terminal is generally at the phone cable connection of the elevator machine room. Every terminal has an QR code and unique IMEI code. Usually, one terminal will control multiple elevators.

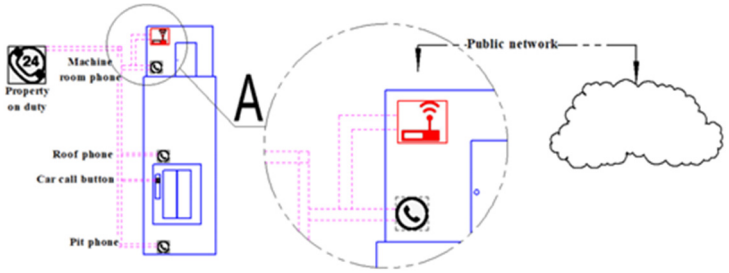

Fig.3. Terminal deployment diagram

4.2 Data Exchange Between Terminal and Platform

The terminal communicates with the cloud platform through a user UI module using a certain protocol. When the terminal is powered on and connected to the platform, the platform can configure data and issue instructions to the terminal through the data communication format and network protocol formulated by the program. Based on the operations the remote operation and maintenance of the terminal will be achieved. The following examples are several instructions of the network protocol.

(1) Device registration

{"imei":"9999999999999","iccid":"8888888888888888","cmd":"reg","num":”123456"}

(2) Read parameters

{"imei":"9999999999999","cmd":"read"}

(3) Upload heartbeat packet

{"imei":"9999999999999","cmd":"heart","csq":"31"}

(4)Upload call record

{"imei":"9999999999999","elevator":"123456","cmd":"record","calltime":"2021-12-10 08:23:30","answernum":"96333","starttime":"2021-12-10 08:23:42","stoptime":"2021-12-10 08:23:45","duration":"3"}

4.3 Terminal-Based Platform Management Functions

The functions of the platform cloud service were shown in Fig.4, including agent service console, Geographic information Management, terminal management, data management, rescue disposal management etc.

(1) Agent Service Console. The agent service console unit includes basic functions of a general call center, such as call answering, outbound calls, busy indication, available indication, three-way calling, call hold, call resume, etc.

(2) Geographic information Management. The function of geographic information management provides geographic information services to the agent service console unit, assisting the responders in quickly identifying the geographical location of distress calls and providing support for timely and accurate rescue dispatch.

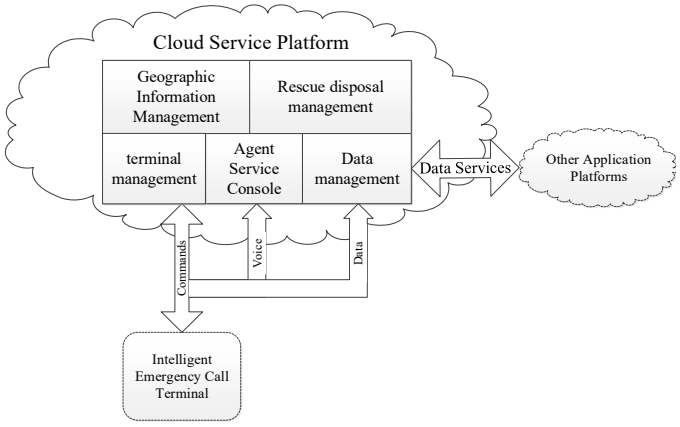

Fig.4. Cloud platform architecture diagram

(3) Data Management. The data management unit provides storage, management, and query services for massive elevator information, property information, maintenance unit and personnel information, rescue resource information, etc., supporting the fundamental data requirements for the effective rescue of trapped individuals.

(4) Terminal Management. This includes tasks such as terminal distribution, access, authorization, and maintenance. It also handles the reception, parsing, storage management, data source matching, and information retrieval and display of information uploaded by the intelligent emergency call terminal.

(5) Rescue Disposal Management. The function is responsible for handling rescue operations for incoming distress calls. It provides reasonable disposal plans for the manual operators and record key milestones in the disposal process. Based on the real-time situation of rescue dispatch the three-level rescue system will be realized as shown in Fig.5.

The first level rescue is maintenance organization. When the cloud platform receives a call from a passenger trapped in the elevator, the command center will notice the maintenance organization

to implement rescue in accordance with the elevator emergency rescue response procedures and time limit requirements.

The second level rescue is public rescue station. When the maintenance organization doesn't response within the specified time, the nearest public rescue station for rescue will be started.

The third level rescue is public security and firefighting rescue forces. When the above two levels rescues didn't work, the public security and firefighting rescue forces will implement the rescue. Thus, the linkage mechanism between elevator safety and public safety through has been constructed.

In the rescue process, the platform will play the assist roles by providing relevant information such as the geographical location of the elevator, the elevator's installation time, years of service, maintenance records, the traffic condition around the faulty elevator, the surrounding rescue force distribution, and so on.

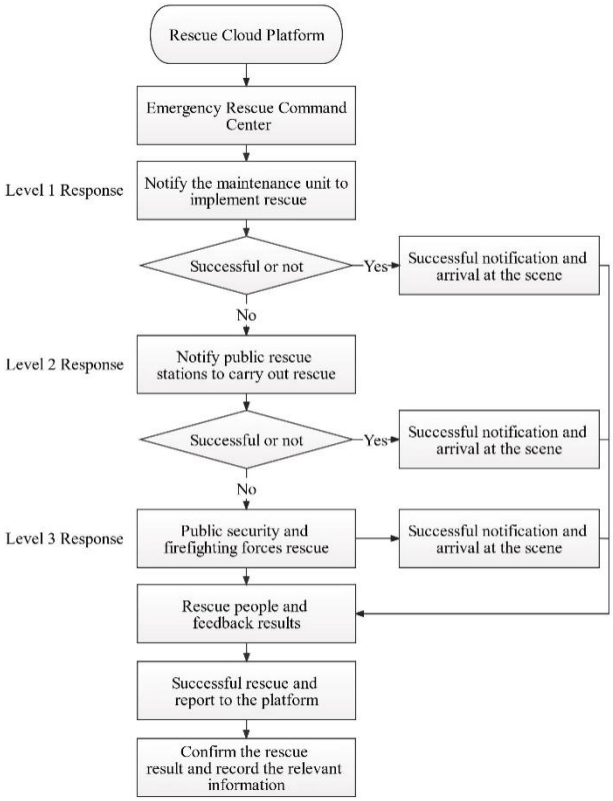

Fig.5. Remote rescue dispatch process

4.4 Application Effectiveness

This system solution and terminals had been successfully applied on 15,000 elevators in a city of Shandong Province. Through the terminal 13,425 times calls were successfully answered and

transferred. Within them, emergency disposal was carried out for 241 elevator entrapment incidents, and 496 trapped passengers were rescued.

The application demonstrates the effects of elevator rescue mechanism based on the terminal and platform. In addition, the platform also records the related information about the rescue affairs. Through the analysis of the rescue data, the prevention capability of elevator safety accidents will be improved.

5 CONCLUSIONS

By leveraging the data integration between the terminal and the platform, the system effectively solves the problems of functional deficiencies in previous elevator intercom devices and signal loss inside the elevator. It enables configurable outbound calls, thereby enhancing the utilization of the cloud service platform. Furthermore, relying on the platform's functional advantages, the overall emergency response capabilities of the rescue system is significantly improved.

The system achieves real-time and accurate positioning by binding critical elevator information to the terminal. The situations where individuals, such as the elderly, children, and people with disabilities, have limited abilities to accurately describe the condition and location of the faulty elevator during distress calls has been effectively solved. The overall capacity for elevator emergency disposal has significantly improved.

But at the same time, it should also be noted that the existing terminals rely on existing elevator intercom equipment to achieve intercom external calls and mutual intercom functions. Once the elevator intercom equipment itself malfunctions, there is a certain possibility that the emergency intelligent call terminal may not work properly. This also brings certain difficulties and significant workload to the installation, functional acceptance, and subsequent long-term maintenance of the terminals. This will be the area that needs further consideration and improvement in the subsequent terminal design and development process.

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