Design on Emergency Dispatch and Command System of Urban Rail Transit[1]

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Abstract

Urban rail transit brings huge economic and social benefits to the society, however, the event of accidents and breakdown of subway can cause a wide range of traffic impact, significant personal and economic losses and even cause traffic paralysis. Current domestic emergency dispatch and command model is basically "man-based", therefore the validity and effectiveness of emergency scheduling decisions of vehicle dispatcher is directly related to the efficiency of emergency disposal and operation safety during the emergency events. For the realization of the emergency dispatch control mode from the current "man-based" to "automation" in the near future, this paper designed an urban rail transit emergency dispatch and command system with the functions such as fault time warning, emergency events disposal and fault information management. This paper also designs the background support system and the software framework to realize the functions.

Key Words: Urban rail transit; Emergency dispatch and command system; The hardware and software framework; The system function module

Urban rail transit system involves a body of departments, complex professional technology and high operation ability, while it's vulnerable to large passenger flow, natural disasters, self-failure and man-made destruction in the daily operation. The occurrence of such emergency events is characterized by randomness, transitivity and diffusivity. At the same time, urban rail transit is characterized by narrow space, compact structure, intensive passenger flow and high running speed. All the factors mentioned above lead to the fact that, in case of emergencies, it will bring significant difficulties to carry out the personnel evacuation, rescue work and work related to emergency disposal as soon as possible.

The dispatch and command system stand in the central command position of urban rail transit system, therefore the increasingly development and progress of dispatch and system improvement and progress will greatly improve the efficiency and brings higher safety rate; On the other hand, if any mistake lies behind the scheduling information distribution channels or scheduling system, serious accidents may take place beyond the urban rail transit system. Accidents occur frequently as a result of scheduling problem in the process of urban rail transit operation around the world. As a result, it has become a focus of scholars to improve the capacity of urban rail transit emergency scheduling command, make it sooner to dispose the emergency events, maintain safety during the operation period, and minimize the loss after the emergency events.

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1 The Current Urban Rail Transit Emergency Dispatch Mode

Urban rail transit operation management aims to ensure safety operation on the basis of efficiency operation and service quality improvement, therefore the centralized control and unified command is the imperative principle of urban rail transit operation.

At the same time, driver dispatcher is the main executor of the principle. Dispatching work mainly reflects on the role of the "central nervous", which embodies their supervision, control, coordination and command functions. Dispatching ability directly affects the safety and efficiency of urban rail transit operation. The particularity of the working process is mainly manifested in the operation characteristics of the remote monitoring and control, and also in the way of command information distribution to which communication tools must be put through. From the perspective of operating production, urban rail transit train dispatcher's main responsibility includes two aspects of content: In normal circumstances, they should ensure the train runs safely according to operation plan; Under the condition of abnormal state ,such as emergency occurs, they have to coordinate the command handling of emergencies, ensure safety, and to resume normal operations as soon as possible. The current manual emergency scheduling problems existing in the command mode is mainly manifested in the following two aspects.

There is a high request of man-based emergency dispatch ability of professional strain capacity, physical quality, and psychological quality for train dispatching individuals under the emergency events. The professional strain capacity refers to the knowledge or experience of emergency disposal, physical quality refers to fatigue, concentration ability and distribution ability, and psychological quality refers to the ability to handle emotional tension. All the factors mentioned above make the labor intensity and mental pressure is too large of the individuals of the dispatchers group, which are also vulnerable to the influence of human factors and the external environment. These factors will lead to their low efficiency, unreasonable emergency decision-making, and even blindness in the emergency events disposition.

On the other hand, under the emergency, the emergency disposition of train dispatcher in order to obtain the information they need to make decisions, the need for frequent and complex multi-level and the exchange of information flow and information, and in exchange has strict requirements on time and way. Current dispatching personnel rely mainly on intercom communications tools, such as dispatching telephones and intercoms, to distribute scheduling command or collect the information. Information interaction in this way leads to huge dispatching working strength of dispatchers on the other hand, puts it into risks such as information omission or misjudgment, thus emergency scheduling decision is unreliable or mistakes on the other hand.

Therefore, it has been increasingly difficult for this kind of pure manual emergency dispatch and command mode to handle emergency events under high operating safety and efficient emergency disposal of urban rail transit. There’s an urgent need to design and develop a set of automatic emergency dispatch and command system to assist the dispatchers to make manage fault information and make emergency-handling decisions under emergency events.

2 Research Status of Urban Rail Transit Emergency Dispatch and Command System

Urban rail transit emergency dispatch and command automation system should include the following functions as to support to make emergency dispatching decisions. That is the function of fault classification and accident risk grade identification based on the characteristic data, the function of time and space warning under emergency accidents based on the statistics of history accident or on-hand data, the function of information storage and management of Emergency scheduling plans and the function of emergency scheduling information visual collection and release. The related research contents can be summarized into three aspects as system background technology, software platform and dispatch information terminal [2].

1) Background Technology of Urban Rail Transit Emergency Dispatch and Command System

The main functions of urban rail transit emergency dispatch and command background system should include fault classification and accident risk grade identification based on the characteristic data by the use of data mining method. At present, the classification of operational safety accidents and hazards analysis focused on major accidents [1].

The analytical methods such as preliminary hazard analysis (PHA), fault tree analysis (FTA), event tree analysis (ETA), cause and effect analysis diagram method, operation risk analysis, sneak circuit analysis (SCA), dynamic event tree method, dynamic fault tree method, Petri net method analysis always be used to make a risk rating. Some focus on the methods such vehicle reliability test, maintenance and risk evaluation, the driver operating safety assessment, hazard assessment, the risk assessment for underground structure [3-7]. The research on accident early warning still stay in the stage of theoretical analysis, however, few can be really combined with the rail transit operational data to come true the warning and prevention function of the system.

2) The Logic Framework of Urban Rail Transit Emergency Dispatch System

Rail transit operation enterprises gradually realized the importance of emergency management and carried out to establish professional departments, formulated emergency disposal plans and developed emergency management system. A series of other positive and effective work also have started to be implemented. Literature[8] studied abroad on railway emergency management system, points out that emergency rescue command system should become one of the important supporting systems to maintain railway management; Literature [9] put forward the comprehensive construction of contractor's operational control center (COCC) and emergency treating center (ETC), to make sure operation management and coordination under various operating conditions; Literature [10] introduces the structure of the urban rail transit emergency command system and the process of emergency disposal work and puts forward the framework of urban rail transit emergency disposal and auxiliary decision system. There're problems such as fuzzy job responsibilities, however, in existing systems.

3) Terminal Equipment Research and Development for Dispatch Information Distribution

Literature [11] pays much attention to the construction of urban rail transit passenger information system (PIS). Literature[12] pointed out that PIS subsystem is responsible for many main functions such as information collection, receipt, handling, distribution of the control center; Network subsystem is responsible for network connectivity among the control centers, stations, tunnel APs(wireless network connect point), and the trains; The station servers process and send the multimedia information to the terminal controllers after the station subsystem receives that [13]. Notably, the R&D of terminal equipment of current urban rail traffic information distribution mainly focuses on the needs of passengers without that of dispatchers.

3 Design on the Framework of Urban Rail Transit Emergency Dispatch and Command System

The framework of urban rail transit emergency dispatch and command system can be showed in figure 1. The system can realize fault type classification, risk range automatic identification, fault time and space warning, emergency dispatch plan information management and other functions through the design.[2]

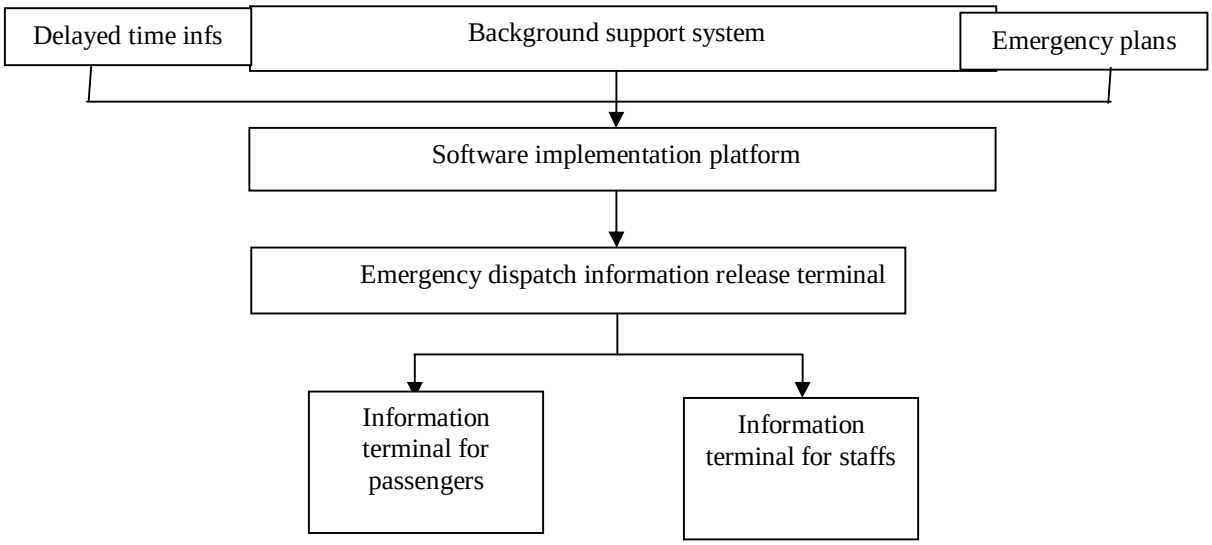

Figure 1The Basic Framework of Urban Rail Transit Emergency Dispatch and Command System

3.1 Urban Rail Transit Emergency Dispatch Background Research

Research on urban rail transit emergency dispatch background system is based on urban rail traffic accident and fault log data, by using the theory of data mining algorithm such as association rules and clustering analysis algorithm.

The research focuses on urban rail traffic accident fault classification and risk grade intelligent decision method. Identifying failures of high frequency and risk level to establish database of high frequency at high risk of failure based on the fault occurrence frequency and all kinds of accidents probability and statistics becomes one of the passing way. By studying different types of information management technology of urban rail transit emergency plans and fault time-space warning technology oriented to dispatchers, our design engages in the two aspects of prior control and afterward disposal to improve the safety and efficiency of urban rail transit emergency dispatch. The framework of the background system is shown in figure 2.

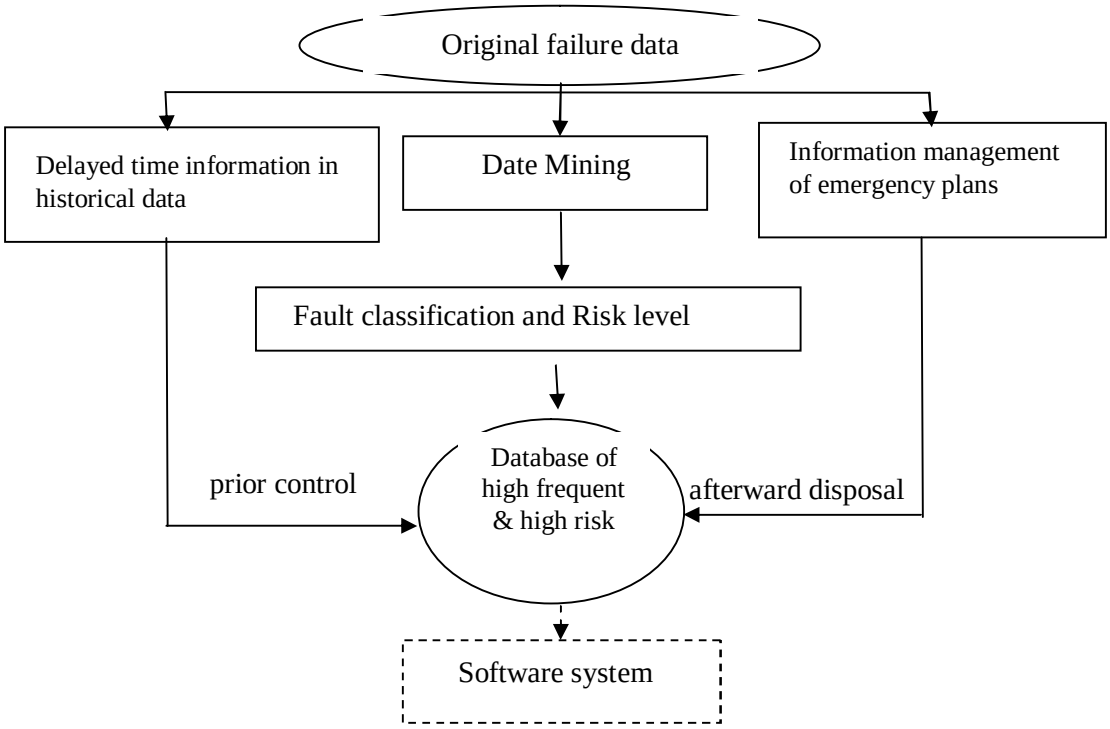

Figure 2The Framework of Background System

3.2 Design on Urban Rail Transit Emergency Dispatch Software System

Guided by technical system of the background theory, the use of the design on the software platform of the system integrated the platforms including fault time and space warning subsystem, expert system of emergency disposal, fault information management subsystem and fault classification management subsystem. The structure of the software platform is shown in figure 3. SCADA system and GIS system which have been used widely in urban rail transit are also designed to access into the software platform to reinforce its functions. The software platform can make full use of information of different lines and stations supported by SCADA and GIS, combining the data of fault data classification and risk level offered by background technology system and, at the same time, the contingency plans stored in the software. Thus the system can help make the urban rail transit emergency dispatch and management to realize intelligent operation by offering particular measures for emergency events and early warning for the fault time and space.

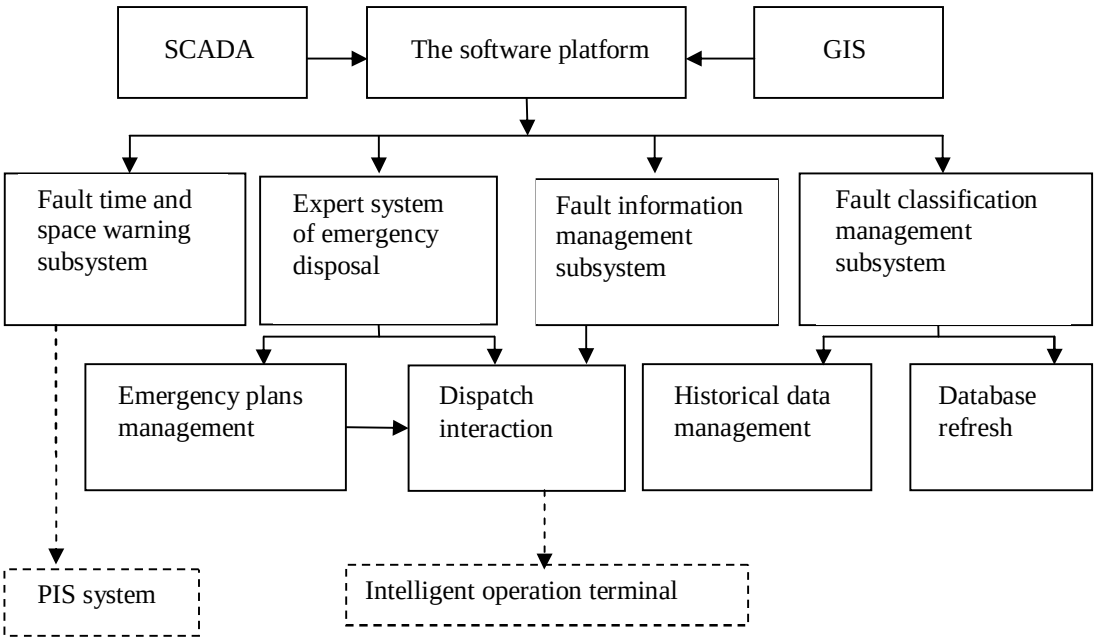

Figure 3The Structure of the Software Platform

3.2.1 The Role of SCADA System and GIS System in the Software Platform

SCADA system is one of the most effective computer systems in the process of automatic production and transaction management. One function of SCADA system is to collect information of the stations, lines, and vehicle bases and other on-site locations. SCADA system can make automatic control to scenes by the way of local control or remote control and, at the same time, conduct comprehensive and real-time monitoring and implement the failure effect analysis, fault alarm trigger linkage mechanism and the road network planning analysis. Therefore SCADA system can provide necessary reference for emergency dispatch management.

As an emerging discipline which assembly covered the disciplines of computer science, geography, surveying and mapping of remote sensing science, environmental science, urban science and space science, GIS can be used to do scientific analysis such as spatial query statistics, spatial analysis and 3D model analysis, offering a variety of methods of spatial data input and output. A transaction processing system can be formed through the combination of GIS and real-time system, which is the best implementation platform of decision support system. GIS system can display information about the monitoring devices conveniently, clearly and accurately when urban rail transit emergency event occurs, thus provide the support of geographic information and route guidance for the comprehensive coordination and senior management group.

3.2.2 The Fault Time and Space Warning Subsystem

Realize the function of fault time and space warming is one of the corn functions of emergency dispatch and command system by the use of historical fault data and expert experience. The subsystem will conduct precious fault classification management of historical fault data and fault of delay time and space analysis, and combine the research of operational individuals and urban rail operation expert. Thus the subsystem can offer a specific time and space warning with the judgment of the occurrence of operation failures. The warning content can be displayed by terminal channels such as PIS system, broadcast, LED and so on.

3.2.3 The Expert System of Emergency Disposal

Outputting the corresponding emergency measures of certain faults is another corn function of urban rail transit dispatch and command system. The subsystem makes full use of historical fault information, expert experience and contingency plans for a particular operation failure, thus the system could search emergency plans and specific cause of the historical faults with the judgment of certain failures to offer solution measures. Emergency measures will be displayed to station dispatcher, train attendant, train operator, maintenance and repair personnel and other staffs by hand-held electronic terminals.

Dispatch interaction under the emergency events is another important function of emergency system, which could conduct instant communication, information feedback and phonetic interaction among the coordinate and management group, station dispatcher, train attendant, train drivers and maintenance and repair personnel. Therefore expert system of emergency disposal ensures sufficient knowledge of emergency fault among related individuals and offers solid support for the quick resolve to the failure on the foundation of safety. The implementation of this function is under the support of fault classification subsystem and fault information management subsystem. The principle is to guarantee information communication will be unobstructed under emergency events, otherwise it leads to a disorderly management.

3.2.4 Fault Information Management Subsystem

The storage, management and analysis of fault information, including historical fault information and real-time fault information, is the main functions of fault information management subsystem. There are two important ways to realize the two functions, one method including is to import the existing fault data directly through the background support system, another is to put it into the system by dispatchers when events happens. The first method can avoid the cumbersome of single-by-single data input by the way of mass-data upload. Differently, the second method can collect and store the information of the cause, demonstration, and the disposal process of the emergency events at the right time they occur. Good man-machine interface should be fine designed to make sure the quickness and comprehensive guarantee input of the key information.

3.2.5 Fault Classification Subsystem

Fault classification subsystem achieve to realize the intelligent decision of emergency incident risk grade, and provide the information to the staffs with the help of the analysis from the background technical support system when emergency events occur.

Therefore, the subsystem can help to assist emergency personnel to release information of emergency events of different grade and develop different emergency measures. The realization of the function of the subsystem mainly lies in the function of the other subsystems.

3.3 Urban Rail Transit Emergency Dispatching Terminal Hardware Subsystem

The network layer, line layer and station layer are designed to be the framework of urban rail transit emergency dispatching terminal hardware subsystem for the final realization of the functions of the urban rail transit emergency dispatch system. The terminal hardware subsystem is mainly derived from the functions of emergency dispatch and command system. The subsystem includes passenger-oriented emergency information distribution terminal and staff-oriented hand-held intelligent dispatch terminals. PIS, LED display and broadcast are parts of the former terminals, and used for guidance to help the passengers out of accident and emergency events, help accident evacuation order, and failure under the condition of passenger travel choice better planning.

4. Conclusions

As the "brain center" of the emergency disposal system, urban rail transit dispatch and command system is increasing important to the emergency management, whose accuracy and efficiency in the emergency dispatching decision directly affect the efficiency of emergency disposal and operation security during emergency events. Therefore, it is inevitable for the emergency dispatch control mode to change from "man-based" to "automatic". This paper, from the aspects of theory and practice, summarizes and analyses the process, problems and development needs of urban rail transit emergency dispatch and command system and further more designs the framework of urban rail transit emergency dispatch and command system, providing an theoretical idea and method for further study and application.

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