ARCHITECTURE FOR OPERATION MANAGEMENT IN URBAN RAIL TRAFFIC

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Abstract: It is conspicuously to announce that China has already become the country with the largest-scale market as well as the fastest growing urban rail transit in the world. This article, from the perspective of production and operations, has described the status quo of the informationization of rail transit enterprises and analyzed the demand for functions of production and operations management of these enterprises, aiming at the improvement of current delicacy management. Meanwhile, we have put forward the general framework of the system of operations management and discussed the system's key functions to clarify its significance to rail transit enterprises and recommend certain effective methods to enhance the informationization of the production and operations management of rail transit enterprises.

1 INTRODUCTION

With the rapid development of cities around China, rail transit has already become a fundamental project of infrastructure to optimize the public transportation and make the cities' development sustainable (LiBo, 2008). China is presently enjoying a boom in constructing the rail transit and has become the biggest market for the construction of rail transit (Liu R. F., Guan C. Q., 2005). As an expression of advanced transportation technology and a desirable way of transportation, rail transit surely depends on informationization, which is a necessary means to the prevention of safety accidents in rail transit and delicacy management (LiBo, 2008). Although China's rail transit has entered the period of informationization, there are still plenty of problems in its information system.

From the perspective of production and operations (Bai, Ma, 2010), there are problems like low rate of integration (Martinez MJ, 2009) of such subsystems as rails, vehicles, power supply, signal and so on, lack of composite application, inadequate arrangements for information resources, poor sharing rate and insufficient extension of the coverage of informationization (ZhouXiaoqi, ZhengJian, 2005). What's more, with the increase of volumes of passengers (Aftabuzzaman M (Aftabuzzaman, Md), Currie G (Currie, Graham), Sarvi M (Sarvi, Majid), 2010), the current situation of operations become increasingly poor, which has been severely affecting the rail transit's traffic functions.

In order to address the issues mentioned above, this article analyzes and discuss the general framework (Koutsopoulos, Harls N., Wang, Zhigao, 2009) and key functions of the information system of production and operations management of rail transit (Holmstrom J, Framling K, Ala-Risku T, 2010). The system begins with the rail transit's technological features and aims at the improvement of delicacy management. It also intends to combine the various technology systems and business management system together organically, and achieve prediction and analysis to the volume, organizations of traffic, directions of manoeuvre, management of passenger transportation and the informationization of alert and exigent directions to enhance the rail transit enterprises' construction of informationization under the three main subjects of rail transit's production and operation-safety, service, efficiency (Song Y, Wang ZC, Wang MS, Huang S. G, 2010).

2 TRANSACTION REQUIREMENT ANALYSES

As we all know, safety, effective operations and serving societies are the primary goals of rail transit. From the perspective of production of transportation, rail transit is a huge and complex technology system

made of such subsystems like rails, locomotives, power supply, telecommunications and signals. And it is also a system of unity of people and machines

(Shinya Kikuchi1, Nopadon Kronprasert, 2011) The management core of rail transit enterprises is to get the sectors in the production of transportation linked organically, so that the whole system's safety and efficiency can be assured. Therefore, the daily operation put emphasis on organizations of transportation, service to passenger transportation and safety management. A management information system (MIS), with advanced technology, legitimate structure, and synchronized functions, provides powerful technological support to reach effective operations, excellent services, safe motions and scientific management. To achieve these goals, the practice demand for functions of this system is as follows:

- Management of transportation. Transportation organization includes equipment for operations, staff, operation plans and the work of direction. Good transportation management is instrumental to optimize the system's efficiency, magnify the capacity of traffic, meet passengers' and owners of cargo's diverse needs, and provide more convenient, faster and more comfortable services. Thus, it is of great importance.

- Management of passenger services. It includes services to passengers, ticketing, tickets funds, platform services and complaints settlement. The agents should conform to the principle of "focus on people", and advocate high-efficiency and high-quality services. At the same time, due to the differences of the cost of investment to subway routes in different cities, the income from ticketing should be distributed to respective companies, so that managers can master the operation situation of every unit.

- Safety management. The system has to guarantee the safety of the operating vehicles (Ding Lieyun, Jia L, Fu Feifei, Luo Hanbin, Wu Xianguo, 2009). During the process of informationization, the selected equipment and adopted technology must ensure the safely running. Meanwhile, the adoption of mature technology can make the system run smoothly and avoid the risks brought by preliminary trial operations. Making good use of sophisticated technologies that already existed from domestic and overseas will shorten the construction period substantially, and reinforce the system's stability so that we can see the benefits from informationization sooner.

- Integrated management (Stella F, Vigano V, Bogni D, Benzoni M, 2006) with advanced information technologies. The information system should set out from the whole entity, design systematically and implement universally, so that the construction of the system can be carried out organically and orderly. Each subsystem should not be systems isolated from the outside, and should be closely connected with other systems in order to achieve the information sharing within the system and among other practice systems, as well as the related units of government and local communities.

3 THE ARCHITECTURE OF OPERATION MANAGEMENT INFORMATION SYSTEM

In order to fulfill the enterprises' demand for operation management, the application structures of MIS are illustrated as figure 1.

As is shown in figure 1, the system has two hierarchies. The bottom layer serves to monitor comprehensively, belonging to the technology system; the upper layer is a platform for production, belonging to management system. The respective functions and contents of each hierarchy are as follows.

3.1 Comprehensive Monitoring -- Technology System

This hierarchy is closely connected to hardware. It controls the hardware and collects and analyze the signals of the equipment's status though telecommunication system. This layer mainly embraces SCADA, AFC, FAS, BAS, PIS and other systems, which can monitor the power supply, locomotives, the risk of fire, environmental disasters, the mechanical and electrical equipment at the station, the automatic tickets-checking devices, and the equipment for guiding the passengers. The subsystems mentioned above finally unify together through the comprehensive monitoring system, and offer a way for the staff to master the situation of operations. Theoretically, the comprehensive monitoring system is able to combine all the technology subsystems together, and make suggestions for the comprehensive manoeuvre decisions by gathering signals, analyzing universally, and translating the information for the administrative.
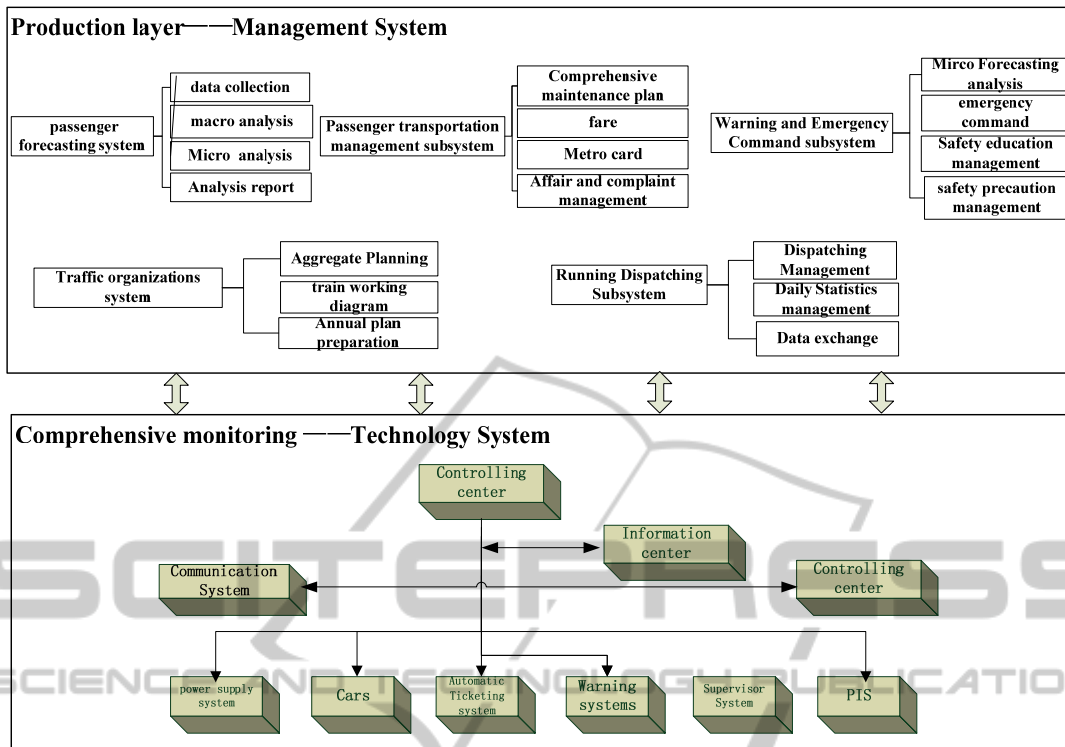
Figure 1: The architecture of operation management system.

However, we must note that the current comprehensive surveillance systems in the field of rail transportation both domestically and abroad, are still developed from the perspective of technology. Consequently, the functions of practice management of these systems are relatively weak, and they cannot entirely cover the requirements of production and operations of rail transit. Therefore, it is necessary to expand the functions of the comprehensive monitoring system and integrate with the system of practice management of production by data connection with the guidance of the universal arrangements of production and operations system.

3.2 Transaction Layer-management System

Transaction layer is the counterpart of technology system, belonging to the realm of management system. However, it is organically linked with the technology system, and needs the help of comprehensive monitoring system to gather data from respective technology systems, and to analyze and transform the information to understandable information for the administration.

According to the general rules of operations management of rail transit, this layer primarily implements the task of informationization of prediction and analysis to the volume, organizations of traffic, management of passenger transportation and the informationization of alert and exigent directions. The systems mentioned above need to exchange data with the technology systems. For example, the volume prediction system need to be connected with AFC to collect the information of passenger volume; the system of organizations of traffic needs to convey the locomotives' operation plans to the commanding center; the system of scheduling command needs to receive various data from comprehensive monitoring system and translate them into the proper forms to the officials; the system of alert and exigent directions needs to further analyze the data from the comprehensive monitoring system from the perspective of safety and emergencies, and to start the counter plans to tackle the certain situation.

4 KEY FUNCTIONS AND THE FULFILLMENT OF MIS

For this part, we are going to discuss the most important functions for production and operation management in rail transit industy.

4.1 Subsystem for Predicting and Analyzing of Passengers

This subsystem conducts the predictions of volume of passengers and many kinds of statistical analyses at both macro and micro levels to provide justifications to routes operation plan, organization management and program management, which is the origin of the management information system of production and operations. It mainly includes such key functions like collecting fundamental data, predicting and analyzing the passenger volume at macro level, predicting and analyzing the passenger volume at micro level, statistically analyzing reports and so on. The fundamental data are classified into four categories. The first kind of data is those statistics from the authority, including population, economy, traffic and city planning. The second kind is the collected data about the passenger volume, including the information about passengers' needs for going out, the information on passengers' ways of transportation, passengers' starting and finishing points, their ages, incomes, and psychology. The third category of data is the real figures of AFC. According to the current technological means of AFC, there are starting and finishing points and tickets funds. The last kind of data is synthesis of survey on volume and samples of AFC data. The macro prediction and analysis are mainly based on the first, second and fourth categories of data, specifically including such functions like management of repertoire of predicting models, generating plans for out-going, distribution of traffic, division of means and allocation of traffic volume. The micro prediction and analysis are mainly based on the last two kinds of data, including functions like the management of past volume statistics, the regular patterns of the distribution of passengers volume (trend, fluctuations among seasons, and recurring fluctuations). The report involving analyzing the macro and micro prediction results jointly, showing the results of analyses in the forms of graphs using GIS. The results include analyses of density, distribution, fluctuating patterns of passengers.

4.2 Subsystem for Traffic Organizations

This system is actually one of the subsystems of plan management for operations, which primarily works on the codification of the business' yearly plan, the train operation diagram and other kinds of plans. The yearly plan is a kind of macro and directive program. This plan can be further into quarterly, monthly and ten-day basis plans, and it has a function of adjustment of plans. The main tasks of the codification system are to codify the regular train operation graphs and the ones on weekends and holidays, in order to adjust to the fluctuations of volume. Besides, this system some subsidiary functions like intersections management, indicators management and simulation of operations. Comprehensive planning mainly includes compartment attendant planning, plan for vehicles use. These auxiliary plans are supplements to the train operation diagram and intend to ensure the appropriate implementation of the train operation diagram.

4.3 Running Dispatching Subsystem

This subsystem is used to undertake the specific works of daily operations. It is a collective and management on the basis of comprehensive monitoring, which is directed by organizations of traffic plan and mainly embraces traffic scheduling, power dispatch, loop control scheduling and comprehensive fixing scheduling.

From the management level, this subsystem includes data exchange, scheduling log management, daily statistical management and the comprehensive fixing plans. Data exchange involves gathering information from kinds of technology systems and translating them to the understandable jargons with the help of the comprehensive monitoring system. Scheduling log management is a comprehensive record of the certain shift, primarily recoding the shifting of duty, the operation situation of each technology system and indicators and the abnormal condition handling. A further classification can be power, traffic and loop control in light of specialty, and comprehensive scheduling and scheduling on station basis according to certain posts. Daily statistical management produces various immediate statistical reports according to the requirements and provides materials to the leaders of the enterprise and each operating department to ensure their knowledge of the situation of production and operations. "Accurate statistics" can be finished at the ends of months. Comprehensive fixing plan serves to conduct plan scheduling, which principally involves formulating the daytime shift work plans including personnel on duty and plan scheduling and other scheduling functions. The main function of it is the fulfillment of the formulation and issuing of the day time shift plan and the arrangements of comprehensive fixing plans.

4.4 Passenger Transportation Management Subsystem

The subsystem has many functions such as fare, metro card, complaints and some other passenger service administrations (Ulusoy, 2010). Fare statistical work is to help the corporation has an understanding of incomes. According to customer relationship management theory, the subway company should feed back information in time, and can improve the service quality of company finally.

4.5 Warning and Emergency Command Subsystem

According to precautionary theory, this subsystem mainly involves emergency command, safety precaution and education management. Also, it concludes circumstance, equipment, administration, and other factors. To be specific, safety precaution management has the features of safety architecture management and monitor information collection; emergency management mainly includes security pre-proposal on railway accidents.

5 CONCLUSIONS

This article analyzes the requirements of operation management, from the angel of urban rail transit business. Through the analysis, we propose a framework for operation management information system. Further more, we analyze the key functions of the system in detail. However, the rail transit has the characteristics of complexity, more intermediate links and strong ties. Therefore, the fine-grained management should, based on advanced management system, make full use of information technology. In the end, the purpose of this article is to offer a model for operation management in rail transit industry, and expect the industry to achieve the goal of modernization and informationization finally.

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