The structure of computer-based system of industrial railway traffic scheduling

Tatiana Balitskaya, Gennadij Korop, Dmitrij Marchenko, Vladimir Kuchma

Volodymyr Dahl East-Ukrainian National University
Molodizhny bl., 20a, Lugansk, 91034, Ukraine, e-mail: tfreyamail@gmail.com
Received June 05.2013: accepted July 12.2013

S u m m a r y. A structure of computer-based system of industrial railway traffic scheduling has been developed. Presented are: a range of tasks to be solved by the scheduler, processing car traffic volumes, and operating principle of the system.
K e y w o r d s. Car traffic volume, ergatic system, scheduling (operational planning), scheduler (system of operational planning), industrial railway traffic, daily schedule (time-table).

INTRODUCTION

Current requirements towards arrangement and quality of transportation demand new organizational and technological solutions in transportation (traffic) management, based on a broad implementation of integrated data systems. Development and implementation of the data systems is aimed to improve industrial railway traffic and to reduce operating costs.

One of the ways to develop an enterprise in market economy conditions is to increase the competitiveness of products and services. From economics point of view the liquidity of goods (the ability of goods to be sold quickly) is affected by several factors: quality, cost, delivery time and quality, business terms and conditions, etc. High product quality is achieved by development and accurate meeting the production technology. And if this factor is affected by the production technology choice and compliance, the level of the remaining factors is significantly affected by forwarding services. Delivery time of both raw materials and goods, depends on the level of the forwarding services at all stages. Delivery time plays an important role in modern economic conditions. All these facts point to the necessity of improving forwarding services. Railway transport (traffic) is the main carrier of both raw materials and finished goods for big enterprises with annual turnover exceeding 2 million tons/year.

At present, tasks associated with the scheduling process of car traffic volume are still being solved manually, without considering possible influencing factors in the operational environment. It is not possible to solve the problems of modern industrial railway traffic in an integrated setting without information technology and computers. Current information systems are still operating as I&R (information and reference) systems.

Consequently, it is necessary to automate the control of industrial railway traffic operation. The purpose of computer-based system of industrial railway traffic scheduling is to satisfy the needs of enterprise production and marketing units with timely, qualitative and complete services [16,18].

The purpose of the scheduling of a railway station operation is to carry out assignments for reception, connecting, disconnecting and departure of trains and railcars (including empty railcars for repositioning), loading, unloading, as well as meeting the timetable, train formation plan and established performance specifications [15].

The enterprise planning tasks, supervisory control, as well as assessment and control are carried out by a train dispatcher.

The dispatcher's duties are:

- to establish the efficacy of the order of priority of disconnecting and transmission of trains taking into consideration loading and unloading at railway loading complex and shunting areas;
- to carry out the plan of connecting the trains and in-plant transmissions;
- to carry out the plan of loading-unloading by timely filing of railcars to the railway loading complexes, controlling loading at railway loading complexes and loading-unloading mechanisms and machines;
- to distribute work between shunting locomotives based on the best usage of their power and time between shunting zones and sorting devices;
- to provide smooth operation of all parts of transportation department and minimum downtime based on dispatcher scheduling;
- to provide full and timely transportation for all shops and enterprise sectors on the basis of work process and transportation requirements estimate;
- to provide quantitative and qualitative performance in accordance with established timetable standards, minimizing inter-operational downtime; to use the equipment and labor in the best way, minimizing costs, to ensure safe and trouble-free operation and to avoid technical and commercial rejects.

OBJECTS AND PROBLEMS

In terms of general systems theory - the system of industrial railway traffic is structured, that is represents a set of input systems, which are called its elements. The elements of a structured system will be interpreted as a subsystem corresponding to the complete system.

We describe the interaction of the system elements of the industrial railway traffic of a conditional enterprise. On the basis of the described process we construct a model of computer-based system of industrial railway traffic scheduler. Simulation allows studying the essence of complex processes and phenomena with the help of experiments not with the real system but with its model. We know that it is not necessary to know all characteristics of the system to make reasonable decisions on system operation, - analysis of its simplified, approximate representation is always sufficient.

Process car traffic volume is transmitted between different levels; we call these levels - the levels of interaction.

Objects of industrial traffic, in which car traffic volumes are changed (the order of cars in the train, the size of the train, specification of goods and condition of railcars are changed), are meant under the selected levels. For example, *a connecting station* extracts to a separate level, because it has a number of distinct qualities, which significantly distinguish it from other objects of industrial transport. These qualities include, first and foremost, the fact that the connecting station belongs to the main-line traffic system and not to the railway traffic of the industrial enterprise.

Second, the following can be performed at the station: accumulation, generation and re-organization of car traffic volumes of adjacent enterprises that are being served.

Factory railway station should be allocated at the next level. Both levels are necessarily interconnected, but, unlike the connecting station, the factory railway station processes (generates, reorganizes, accumulates) the car traffic volumes of the enterprise only. *Special dead end tracks* for sorting, waiting, accumulation and other operations can be located in the loading and unloading areas of the enterprise. This element should be allocated in a separate level of interaction. The elements of this level can directly interact with the connecting station, bypassing the factory railway station.

Railway loading complex (RLC) can be selected as the next level that is specialized in loading and unloading of goods. All levels interact alternately with each other, but on a number of occasions some of the levels can be excluded.

The structure of the described system is determined by regular monitoring of engineering communications between the selected levels of interaction. These communications are described in detail by the process of industrial traffic system. Process is defined as total combination of operations on railcars processing (operations of acceptance, delivery of trains to the spur tracks; rebuilding trains, weighing, supply to the railway loading complex, cargo operations, taking from the railway loading complex, generation of supply to the station or dead end tracks, technological permutations of railcars or groups of cars; accumulation and weighting, minor repairs, cleaning, washing, cargo heating or other operations to restore looseness or flowability of cargo, collection of supplies to the connecting station) [9, 10].

All railcars involved in the calculation of the current period can be divided into three basic groups:

- wagons to be transported for unloading and loading within scheduling period;

-wagons to be collected and administrated within scheduling period;

- wagons to be transported under the dual operations and to be collected within scheduling period.

Imagine scheme of engineering communications in scheduling of shunting operations on the industrial railway transport (fig. 1).

It should be noted that the above process operations are conducted on specialized railway lines and certain enterprise points, so they correlate accurately with the selected levels of interaction.

The wagons received by the company, pass the following cycle [14]:

1) Acceptance procedures;

2) Rebuilding the train;

3) Distribution and delivery of wagons to the purpose fronts;

4) loading and/or unloading of wagons;

5) Removal of wagons from the spur tracks.

Sometimes some other operations are added to the above, such as weighing, but their structure resembles one of these operations.

All transactions are reflected in a daily timetable. Time for acceptance procedures is normalized and is in specific formulas, so computer-based scheduling of acceptance operations presents no difficulty.

Most of the railways loading complexes are equipped with shunting means, therefore, loading or unloading of railcars is not particularly difficult. But often it is not possible at big enterprises. The railcars should be pushed by the locomotive to be loaded or unloaded.

Let us consider process operations with car traffic volumes as some service requests for the purpose of subsequent implementation of the proposed model and based on it computer-aided generation of daily timetables for the industrial railway traffic. Imagine an interaction scheme of service requests for conditional industrial enterprise (fig. 2). For the block "Queuing service requests → Finding solutions → Generation of service requests" the service requests are organized on the following principle: incoming - from the connecting station, from the locomotive depot after having received a request from the factory station, the factory station, from the railway loading complexes, after submitting an request to the locomotive depot. After Finding Solutions block the generated service requests return to be fulfilled at: factory station, railway loading complexes and locomotive depot [1-3, 11].

In turn, the model presented is an element of the block 3 ergatic system (fig. 3). It consists of a plurality of different elements, which during operation is closely interact and affect one another.

In our case, this process control system of automatic construction of the daily schedule of the train station in an industrial plant, and the person who interacts with the system decision maker (DM) [4-7, 12, 13].

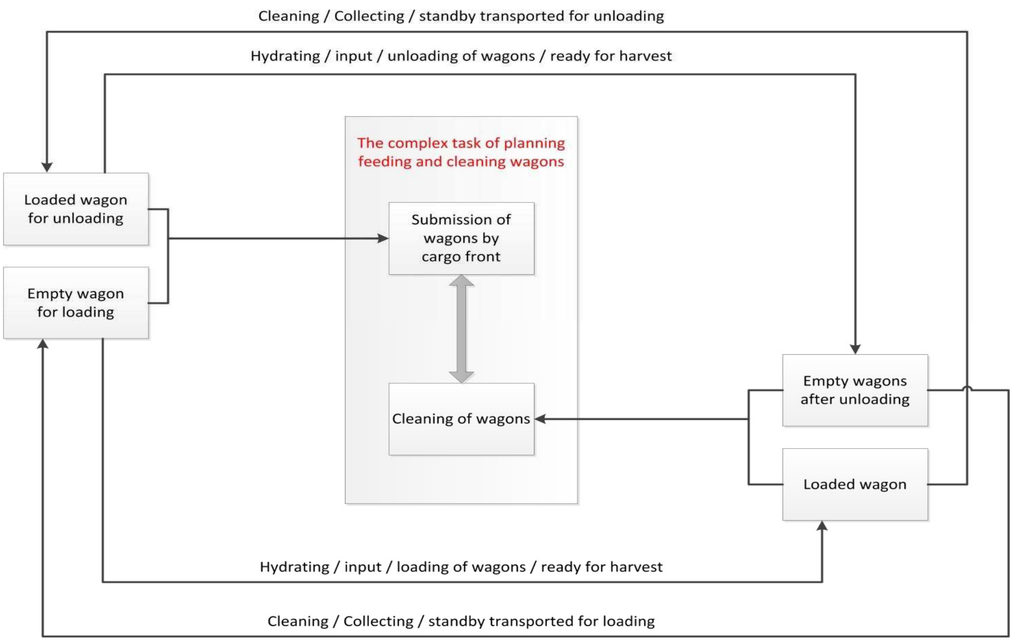

Fig. 1. Engineering communications in scheduling of shunting operations on industrial railway transport

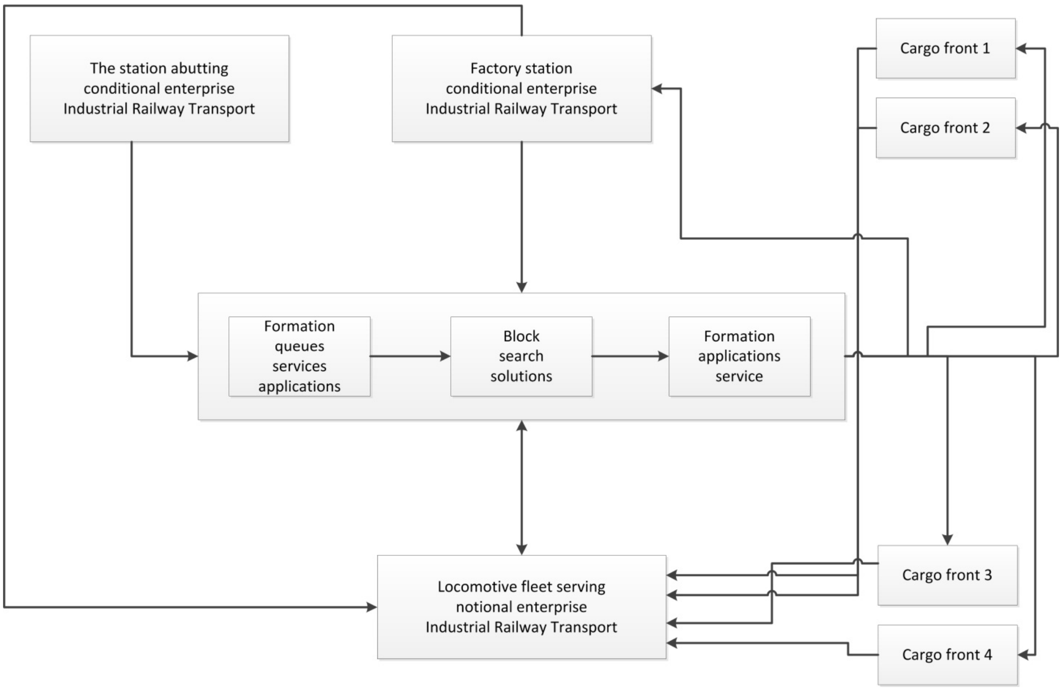

Fig. 2. The scheme of interaction between service requests for conventional industrial enterprise

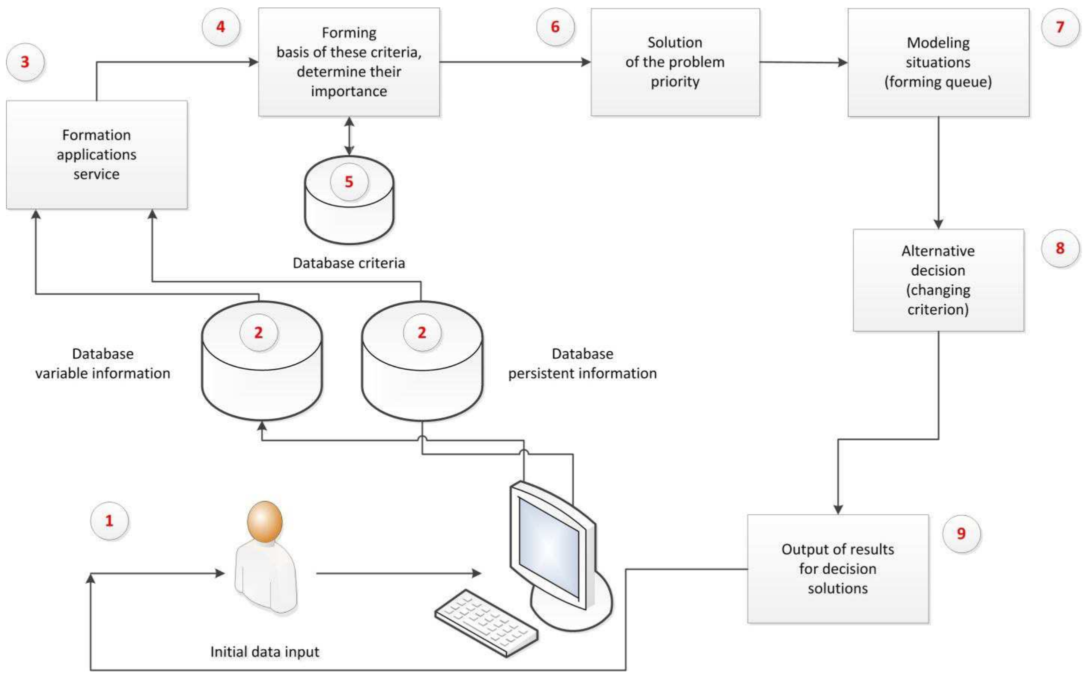

Fig. 3. The structure of functional ergatic system

The system includes the following elements:

1. Dispatcher, who acts as a decision-maker.

2. Databases containing: 1) constant information 2) variable information.

To constant information we refer information about the development structure of the enterprise railroads, tracking characteristics, normal position of shunts, traffic routes, etc.

To variable information - starting letter and transactions register.

The starting letter indicates freight end-station, date dispatched, registrar's name and a list of railcars. Each car has its serial number and type, freight name and railcar weight.

The transaction register contains information about the operation name, registrar's name, locomotive number, operation path number, start time, end time and a list of railcars with their registration number, type of car and type of cargo.

3. Service requests are generated in the developed system of codification based on the constant and received data.

4. To select a service application (to meet the requirements) we shall create a database of criteria that then will be used to solve the problems of priority.

5. Criteria Database. By criteria we shall understand some certain conditions, subject to which simulation takes place:

- to rebuilt or not the train;
- to take into account the priority of railcars (own, someone else's);
- to cluster railcars in one group when supplying them to the station;
- to consider the minimum of locomotive operation;
- minimum running time at the railway loading complex;
- capacity of program execution at railway loading complex within time "window", etc.

6. Applying fuzzy multi-criterion analysis of alternatives with paired comparisons, based on experts' knowledge, we solve the problem of priority. Problem solution is prioritization of the generated requirements.

7. We create a queue for servicing based on solution of prioritization problem. We have a block of situation simulation.

8. By changing the criteria we shall get a set of alternative solutions.

9. The received results are provided to the decision-makers in the form of several daily schedules for the industrial railway traffic, which are accompanied with comments and are evaluated with time or monetary units to make final decision.

CONCLUSIONS

The following conclusion can be drawn out from the above stated. The range of tasks associated with the process of scheduling of car traffic volumes is very diverse and broad. Using information technology and computers in our model, we propose to design a computer-based system of scheduling of industrial railway traffic at the enterprise, center of which is the ergatic system. The basic idea of which is as follows: on the basis of information provided by the Dispatcher (DM), the system generates service requests using interconnections shown in Figure 1. Then some criteria are introduced for consideration through direct participation of decision-makers and their importance is determined. Based on the importance of criteria we use methods of fuzzy multi-criterion analysis of alternatives with paired comparisons to solve the problem of priority. The problem solution is sorting of computer-generated service requests in the order of criteria importance. Then queuing of the service requirements generates, based on system-assigned priority. We can change one of the paired comparisons, suggested by DM, to get alternative solutions. Then a conclusion of the obtained results is drawn up to make the final decision and to build daily schedule for operation of the industrial railway traffic at the enterprise [8, 17, 19, 20].

Java object-oriented programming language is selected for implementation of the software package. Cross-platform, initially incorporated into the language, provided its popularity in programming for a wide range of devices, from personal computers with different operating systems, and to mobile phones and other gadgets. It is considerably easier to create reliable software with this programming language. Since Java programs are interpreted rather than compiled, their execution on different platforms is much simpler. In this case it is sufficient to create a platform-runtime Java-system. If such system exists for this operating system, any Java-program can be executed in the environment without additional compiling on this platform.

DBMS Firebird - a compact, cross-platform, free database management system – is used to develop a database. Its capabilities are virtually no way inferior to other database capabilities, and would be enough to do the job. In addition, it uses SQL dialect, which is very easy to learn. Other advantages of this database are resources simplicity, good-enough performance for high volumes of data, easy to install and fairly easy administration.

REFERENCES

1. **Abrahamsson** Lars Railway Power Supply Models and Methods for Long-term Investment Analysis, tech. rep., Royal Institute of Technology (KTH) / Lars Abrahamsson. Stockholm, Sweden. – 2008.
2. **Akulinichev V. M., 1981.:** Matematicheskie metody v jekspluatacii zheleznyh dorog : uchebnoe posobie dlja vuzov zh.d. transp / V. M. Akulinichev i dr.. – M.: Transport, – 223.
3. **Cruz-Rodrgues R.D., Latorre-Bayona G., 2000.:** Interactive Tool for Mid-Term Transmission Expansion Planning in a Deregulated Environment /

Power Engineering Review, IEEE.- vol. 20. - Nov. 2000. – 61–62.
4. **Degtjarenko V.N., Lazarev E.G., 1990.:** Avtomatizirovannye sistemy upravlenija promyshlennym transportom : uchebnoe posobie / V.N. Degtjarenko, E.G. Lazarev. Rostov n/D: Rost, inzh, - stroit, in-t, 64.
5. **Gapanovich V.A., Grachev A.A., 2006.:** Sistemy avtomatizacii i informacionnye tehnologii upravlenija perevozkami na zheleznyh dorogah / M. : "Marshrut", – 544.
6. **Gruntova P.S., 1988.:** Avtomatizirovannye sistemy upravlenija na zheleznodorozhnom transporte: ucheb. posobie / Belorus. in-t inzhenerov zh.-d. transp.. — Gomel' : BelIIZhT, Ch. 3. – 279.
7. **Horstman K., 2007.:** Java 2: v 2 t. / Kornell Horstman. – 7-e izd., – T. 1. – 1000 p. – T. 2. – 1049.
8. **Jari Stern, 2006.:** TracFeed Simulation, Reference Manual. Technical Report BBSE951112-BNA, Balfour Beatty Rail / Jari Stern. - March 2006.
9. **Korop G., 2010.:** Development of procedure of search of rational variant of technological treatment of incoming car traffic volume / Korop G., Zaverkin A., Shikun O. // Commission of mototorization and power industry in agriculture Lublin university of texnology, Volodimir Dal East-Ukranian national universiti of Lugansk. – Lublin, volume XA. – 276-284.
10. **Korop G.V., 2011.:** Creating a software system for construction of the daily schedule for railway industrial enterprise / G.V. Korop, S.V. Stepanchenko, D.V. Morgachev, S.O. Titakov, V.P. Parhomenko // TEKA / Polska Akademia nauk. – Lublin, – Vol. XI B. – 48-53.
11. **Kraft E.R., 2002.:** Priority-based classification for improving connection reliability in railroad yards – Part II: Dynamic block to track assignment, Journal of the Transportation Research Forum 56. – 107-119.
12. **Lentink R.M., 2006.:** Algorithmic Decision Support for Shunt Planning, PhD thesis, Erasmus Research Institute of Management, Erasmus University Rotterdam.
13. **Men'kov A.V., 2005.:** Teoreticheskie osnovy avtomatizirovannogo upravlenija : uchebnik dlja vuzov / A.V. Men'kov, V.A. Ostrejkoiskij. — M.: Izdatel'stvo Oniks, — 640. Zdes' eshhe byl ISBN,no t.k. on bol'she nigde ne ukazyvaetsja, to net smysla ego i zdes' ukazyvat'.
14. **Nechaev G., 2009.:** Automation of classification work planning at rail mode / G. Nechaev, G. Korop, M. Slobodyanyuk // Transport Problems` 2009: Materials I International Scientific Conference 2009, Transport Problems International Scientific Journal. – The Silesian University of Technology, Faculty of Transport: Poland. – 283–287.
15. **Nechaev G.I., 1999.:** Tehnologija i organizacija raboty transportno-skladskih sistem / G.N. Nechaev. – Lugansk: Izdatel'stvo SNU, 230.
16. **Pilo E., 2006.:** Catenary and autotransformer coupled optimization for 2x 25kV systems planning. I n Computers in Railways X : Computer System Design and Operation in the Railway and Other Transit Systems, Prague, The Czech Republic / E. Pilo, L. Ruoco, A. Fernandez.
17. **Railway Simulation**, April 2008. - URL http://www.opentrack.ch/
18. **Shafit E.M., 1986.:** Avtomatizirovannye informacionnye sistemy na zheleznodorozhnyh stancijah : mezhvuz. sb. nauch. tr. / Dnepropetr. in-t inzhenerov zh.-d. transp. im. M.I. Kalinina, Kaf. "Jelektron. vychisl. mashiny". — Dnepropetrovsk: DIIT, — 119.
19. **Stephan Arnd, 2008.:** Arnd Stephan Open Power Net – Simulation of Railway Power Sup –ply Systems / April 2008. - URL http://www.iaror.org/sessions/ stephan.pdf. Slides for presentation.
20. **Tulupov L.P., Leckij Je. K., Shapkin, 2005.:** Upravlenie i informacionnye tehnologii na zheleznodorozhnom transporte : uchebnik dlja vuzov zh.-d. transporta / pod red. L.P. Tulupova. — M.: Marshrut. — 467.

СТРУКТУРА АВТОМАТИЗИРОВАННОЙ СИСТЕМЫ ОПЕРАТИВНОГО ПЛАНИРОВАНИЯ РАБОТЫ ПРОМЫШЛЕННОГО ЖЕЛЕЗНОДОРОЖНОГО ТРАНСПОРТА

Татьяна Балицкая, Геннадий Короп,
Дмитрий Марченко, Владимир Кучма

Аннотация. Разработана структура автоматизированной системы оперативного планирования работы промышленного железнодорожного транспорта. Представлены задачи, которые будет решать предложенная система оперативного планирования переработки вагонопотоков и принцип действия системы.
Ключевые слова. Вагонопоток, эргатическая система, оперативное планирование, промышленный железнодорожный транспорт, суточный план-график.