Design of unified rail traffic management system architecture in Republic of Bulgaria

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The rail traffic management systems have to meet requirements of high responsibility and fail-safe behaviour. It is expected that these systems will give a possibility of real-time rail traffic monitoring and ensure information for all parties interested in this business. The paper examines an architecture capable to implement a system providing such a possibility. The solution proposed is in compliance with communications currently available in the Bulgarian railway infrastructure and the problems arising from their condition.

***Условия за изграждане на архитектура на единна система за управление на влаковото движение в Република България (Венцислав Г. Трифонов)**. Към системите за управление на влаковото движение се предявяват изисквания за висока надеждност и безопасно след отказ поведение. Очаква се тези системи за дадат възможност за следене на движението на влаковете в реално време и да осигуряват информационно всички заинтересувани от този бизнес процес страни. В статията се разглежда възможна архитектура за реализиране на система, осигуряваща тази възможност те. Предложеното решение е съобразено със съществуващата към момента комуникационна осигуреност на железопътната инфраструктура в България и произтичащите от това проблеми.*

Problem definition

The current train control systems in the Republic of Bulgaria function on the basis of:

- Availability of train control systems at stations (interlocking)
- Train control systems between stations (ETCS 1/2/3)
- Level-crossing control systems (automated level-crossing devices);
- Systems of ensuring rail traffic management authorities: dispatching connections for different authorities: (train, electrical, power supply), train dispatching radio connection, etc.

Despite the type of different systems, the human factor is the one to mainly participate in traffic. The rail traffic is controlled by traffic managers on duty who command entrance, exit and marshalling routes at the stations they are responsible of. At the moment the traffic between stations is implemented both automatically and by using telephones.

Currently there is no unified train traffic system in Bulgaria. The data of real train location are not received by an objective system of train location control but are input by the dispatchers of individual dispatching circles.

The lack of high-level data acquisition automation affects the process of rail traffic management by overloading the dispatcher and duty traffic manager with performing lots of administrative activities.

According to the Regulations of Rail Traffic Management, the traffic control is mainly of two types:

- Train control by using telephones;
- Train control by using interlocking.

The process of management is reduced to filling in telephonograms by duty traffic managers on one the hand, and on the other hand, “manual” input of train location in the common train control system by the dispatcher.

The advanced solutions for implementation of train traffic management systems are based on:

- Availability of a common communication system to ensure train traffic needs;

- Availability of dispatching systems for train control in individual dispatching sections.

The equipment of tracks with ETCS 1/2/3 provides real information where the train is (within a block section).

Unfortunately, the Bulgarian conditions show that none of the above mentioned three systems has been implemented. There are individual sections equipped with one or another of these systems but they are not connected to each other.

On the other hand, being member of the united European railway area, the Republic of Bulgaria has to implement a system of data exchange on freight and passengers thus joining the unified common system [1].

From this point of view it is necessary to find out a working solution to guarantee:

- Meeting the European requirements [2];
- Data acquisition of the rail vehicles position within the Bulgarian railways and ensuring automatic data exchange with similar European railway administrations;
- Providing objective management of the duties of traffic managers and dispatchers by automation of their work;
- Discharging traffic managers and dispatchers from routine duties (filling in books, etc.) giving them opportunities to focus on their main activities.

The implementation of an additional network to perform real-time risk monitoring and assessment is aimed at avoiding occurrence of situations and failures that could result in incidents and accidents [3].

The paper examines the possibility to implement a system architecture defining functionalities and interfaces on different levels in order to involve the network of National Railway Infrastructure Company (NRIC) and guarantee receiving real-time information related to rail vehicles at stations and traffic between stations.

Architecture of data transmission for traffic management

The system of data transmission for traffic management is aimed to provide the following functions:

- Electronization of the forms filled in by duty traffic managers;
- Providing a unified communication environment to perform operational train work;
- Introduction of objective management for monitoring on the each locomotive location within the railway network;
- Introduction of objective management for availability of rail vehicles in the sections between two stations (marking the end train car electronically);
- Introduction of a video connection between the dispatcher and traffic manager.
- Providing a unified safety communication environment for data transmission (based on GSM, GSM-R or fixed communication environment).

To implement the system of data transmission, it is necessary to introduce a possibility to transmit the same information through:

- NRIC trunk cables;
- Train dispatching radio system;
- Construction of optical routes;
- Leased optical services;
- IP mobile channels provided by mobile operators.

When using the first two lines, it is necessary to proceed to filtering the signals of Layer 1. Due to large variations of operational parameters in various technology sections, it is necessary to use algorithms of adaptive filtering. Similar methods are given in [4] and [5].

The computerization of Rail Traffic Management Forms is the basis of traffic safety increase by discharging duty traffic managers from routine administrative duties. A process of possible "virtualization" is described in [6].

The introduction of a unified system of data exchange between duty traffic managers will result in:

- Automated receiving information related to the exact data and departure hour of a certain train or marshalling train from a certain station;
- Receiving information about the occupation of a certain section between two stations or a track;
- Possibility to connect the data from duty traffic managers with GIS system.

The necessary telecommunication structure is based on two types of data channels:

- channels of minimal bandwidth;
- channels of bandwidth providing data transmission at minimum 9600 Kbps.

It is provided to implement the channels of minimal bandwidth on the current trunk channel thus ensuring quality connection between the duty traffic manager and dispatcher.

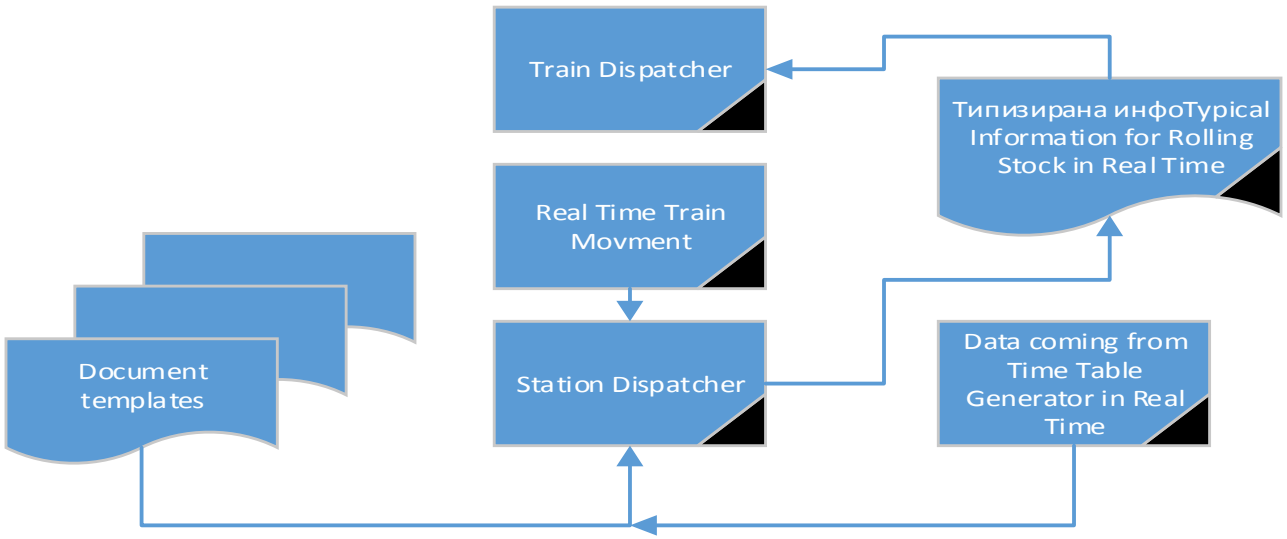

Fig.1. Document turnover architecture to the unified traffic management system using a telephone method.

Architecture of high-responsible commands management

At the moment the devices mostly operated in the National Railway Infrastructure Company (NRIC) are electrical interlocking and systems with relay-key dependencies. This type of interlocking guarantees train traffic safety achieving traffic safety in an objective way. The specific situations occurring in the process of railway operation impose the necessity on traffic managers to take responsibility and give commands that are out of the objective safety control of respective interlocking. This type of commands is called "high-responsible" and is given by using different mechanisms that require unambiguous command input. Most often they are given by using sealed buttons. To this moment these actions are achieved by writing down (creating a paper document) in compliance with the regulations of National Railway Infrastructure Company (NRIC). The development of controllers to regulate these manipulations would increase the level of operation safety. The development of controllers for data acquisition of the given high-responsible commands could result in:

- Data acquisition of all high-responsible commands given by duty traffic managers;
- Data acquisition of all commands given by duty traffic managers;
- Creation of unified database of commands given in the National Railway Infrastructure Company (NRIC) network thus making possible to analyze the risk on certain tracks or sections;
- Analysis of the staff safety work level and the quality of their training;
- Analysis of risk level in the whole network and individual sections and possibility to forecast the probabilities of emergency occurrence.

Requirements to Architecture of automation rail devices management in the sections between stations

Uniting all level-crossings in a unified system for control on their functionality;

Creating a common radio network for data exchange of different level-crossing devices;

Providing optical link between the level-crossing devices and the sections between stations next to them;

Implementing a new type of level-crossing devices giving a possibility of remote diagnostics.

Design of Architecture of rolling stock management

The Architecture of management is based on introduction of the following systems:

- Introduction of a locomotive positioning system in the sections between stations and at stations;
- Introduction of a train-end monitoring system in the sections between stations;
- Introduction of a video track recording system during the train movement;
- Introduction of a system recording the conversations between engine drivers related to their duties in the cab;
- Introduction of video connection between engine drivers and the corresponding carrier's dispatcher.

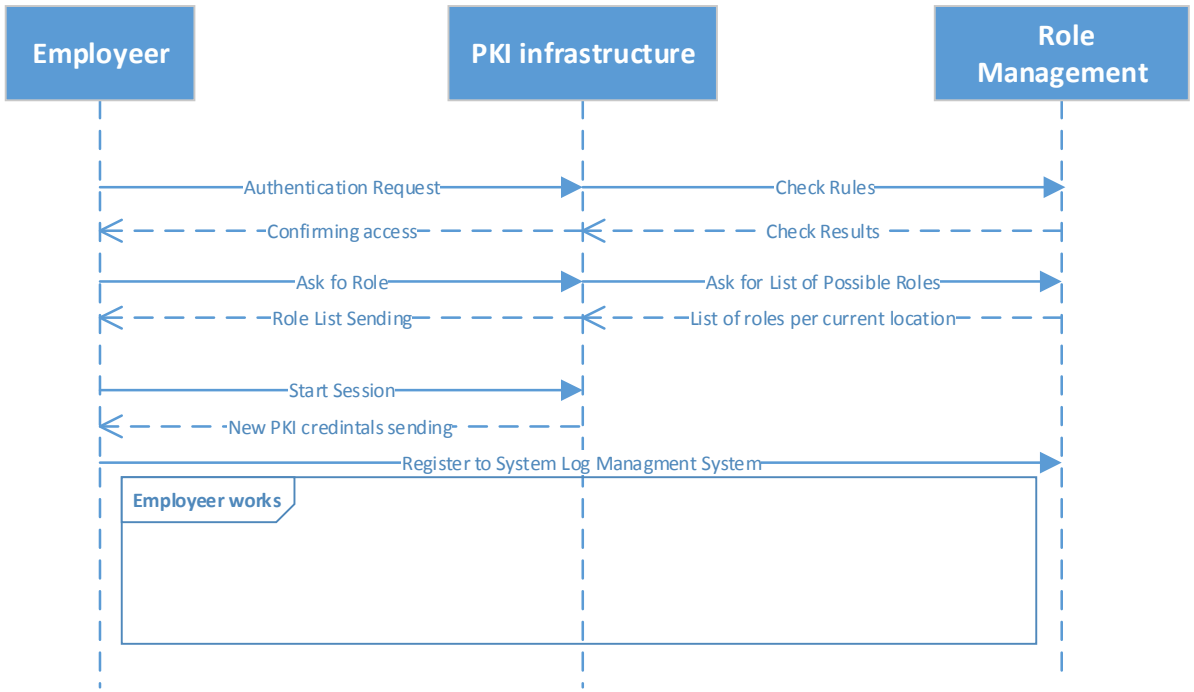

Fig.2. Method of employee's role verification.

Common solution for system safety.

When system users enter the system, they have to get a possibility of receiving relevant roles in a reliable way. The role indication is mandatory in order to guarantee receiving different class of services at different points of the system. Thus it guarantees achievement of operativeness of staff activities on different positions in the National Railway Infrastructure Company (NRIC) and business establishments. Fig.2 presents the method of how a role is joined to a certain employee. The specific feature in this process is the necessity to build a link to the service through PKI and the change of keys while working.

Conclusion

The paper presents the problem of designing a unified network of the National Railway Infrastructure Company (NRIC) to receive real-time train traffic data. For that purpose a strategy of data exchange through using different forms of communication connectivity is proposed. Some problems and requirements to different architectures for implementation of document turnover connected with filling in train traffic forms applied with using telephones are analyzed. A principal architecture of role authorization providing mobility of the whole NRIC staff is proposed.

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