Determination of the influence degree of technologies for issuing train traffic safety warnings

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Abstract. This article focuses on assessing the quality of information based on the Bayes network to justify the effectiveness of internet technology in providing traffic safety in rail transport, while issuing speed reduction alerts. To achieve this goal, the following tasks were completed: technological schemes of data transmission and reception systems “P”, “Sh”, “E”, “L”, “D” of rail transport network enterprise were presented; a Bayes network was formed, the probabilities of events were determined; conditional probabilities of control phenomena were determined. An existing and proposed system of issuing and cancelling warnings on Uzbekistan Railways has been studied. An evaluation based on the Bayes network has been carried out to justify efficiency in terms of data quality. One plot with a train serving intermediate stations was chosen conditionally. The transmission of alerts to these trains was carried out with two different systems. Technological operations are reduced to probabilistic relations. The model identifies a control event in four for comparison. The results showed the reliability of existing monitoring system data lower than suggested. This is due to the connection of the existing transmission system with each other, which allows the OBAUT system to control that all data is simultaneously transmitted and the transmitted data is received, regardless of the previous data. In addition, the level of subjective interventions for information transmission is also significantly reduced. OBAUT capabilities are considered much more efficient in terms of data quality, reliability and timely transmission. The widespread use of Information Technology in the network helps to improve the quality of data, and the addition allows you to make quick decisions in the organization of train traffic.

1 Introduction

In the process of making quick decisions in the safe organization of train traffic, the technical condition of the road or sections and peregons is the object, quality information about the condition of the devices plays a huge roll. In the rapid management of transportation in rail transport, information about the location status of the detected failures of the traffic composition and the speed of movement requires high accuracy. The correct distribution of...
rolling stock when organizing cargo transportation increases the cost of transportation by reducing the cost of transportation.

The existing system of transmitting and receiving alerts is based on the manual preparation of preliminary information about issuing alerts, an automated system of train traffic control in the CIS countries. Fault detection is determined by road masters, SCB (signalling center blocking) electromechanics, and electrical network enterprise electromechanics based on daily, weekly, monthly, annual plans, and departmental dispatchers are notified. Telephone transmissions of these aircraft to The telegraph were marked after the department dispatchers were registered in the relevant journals.

The reliability and timeliness of messages depends on department dispatchers and telegraph personnel. The human factor, including subjective intervention, raises some doubt on the output data of the system. After receiving the information, it is necessary to further check the information. Nevertheless, the system has a significant impact on the organization of train traffic.

From the above, it can be seen that the qualitative and timely transmission and reception of data, a new technology of processing is offered. research has led to the development of a system known as the train traffic safety enhancement data quality and concurrent automatic transmission system (OBAUT). The system automatically processes data processing to the necessary stations and participants in the action, reduced and works without the direct participation of a person.

To justify the advantages of the proposed OBAUT technology in ensuring the safety of train traffic, it is recommended to use the criteria of data quality and timely arrival.

The quality of the data reflects their suitability for decision making and planning. The main norms of data quality include: completeness, reliability, accuracy and timely reach.

The considered methods are more suitable for specific areas of the process and solve very narrow problems for assessing the quality of data. The current and OBAUT systems of warning issuance and cancellation do not meet the considered capability requirements of the methods considered to address the problem of data quality assessment.

Bayes network method is proposed to study data quality assessment[1-11]. This method is made up of conditional probabilities, which implies a graphical probabilistic model.

Since the current and OBAUT’s primary outcome of issuing and cancelling alerts is outgoing data, it is recommended to assess their effectiveness according to the data quality criterion. The purpose of the study is to assess the quality of data based on the Bayes network to justify the effectiveness of rail transport in train traffic using speed limit warnings in internet technologies.

Achieving this goal involves solving the following tasks:

1. Description of technological schemes for reaching the desired destination at the point of detection of alerts;
2. Bayes network formation;
3. Determination of a priori probabilities of events;
4. Determination of conditional probabilities of data reaching a specified destination.

2 Methods

The system of issuing and cancelling alerts to trains operates on the basis of sections and telegraph method (Figure 1). Initial information about alerts is sent to The Telegraph by department dispatchers. The telegraph lists the information received in the appropriate journal and inserts it into the computer and sends it to the designated addresses [15-18].
Fig. 1. Current technological scheme for issuing and canceling alerts

The automated notification transmission system (OBAUT) works on the basis of the application of internet technologies. The study developed the OBAUT system during the performance of the work. The purpose of the system is to ensure timely, reliable and high-quality transmission of detected alerts, as well as the storage of data in the base processing aimed at shaping statistical data[11-21]. Department dispatchers enter detected alerts to the common base via commuters installed in the room, and the information entered sends speed limit warning information to Station, Yard, train locomotives. (Figure 2)

Fig. 2. OBAUT technology scheme

Bayes network formation

Comparison is made under the same conditions of data quality in the two systems. The object of the study serves as a railway peregons and sections with a train.

Stages of performing train operations:

Stage 1. The train at Station “A”, which delimited the area where the warning was detected from the odd side, reached the DU-61 warning letter in time and in full.

Stage 2. The warning telegram to station watch “C”, which delimited passage from the odd side where the warning was detected, reached in time and in full.

Stage 3. The train at Station “B”, which delimited passage from the pair of sides where the warning was detected, reached the DU-61 warning letter in time and in full.

Stage 4. Warning telegram to the station watch “P”, which delimits the area where the warning was detected from the paired side, reached in time and in full.

Stage 5. The warning telegram to the dispatcher to the site where the warning was detected reached in time and in full.
The Bayes network method was used to compare the quality of data in these systems. Formally, a Bayes network is a directed acyclic graph whose vertices correspond to a random variable, and whose graph arc encodes the conditional independence relations between these variables. Nodes can represent variables of any type, and can be parameters, hidden variables, or hypotheses.

If the structure of connections in the network is determined, the study will consist in choosing free parameters of the conditional probability distribution \[1-10].

A fully integrated probability distribution for a Bayes network:

\[ P(V_{1:n}) = \prod_j P(V_j | pa(V_j)) \]

For the train information and cancellation system, the Bayes network consists of gathering three of the variables \( A', B, S \): \( A' \) set of operations related to shaping data on train warnings for transmission to stations, measures to take security measures and plan further work after receiving warnings to package \( B \), issuing DU-61 blanks to train machinists on the basis of data set \( S \). Variables include control events to assess the quality of data.

\[ A = \{ A, A, A, A \} \]
\[ B = \{ B, B, B, B, B, B, B, B, B \} \]
\[ S = \{ S, S, S, S \} \]

For OBAUT, the Bayes network also consists of three sets of variables. \( A', B, S \) because the same operations are studied. \( A' \) set of operations related to the shaping of warnings issued to trains, \( B \) includes security measures after receiving e-mails of warnings, planning further work, measures to electronically deliver DU-61 blanks to train machinists, and a set of \( S \) variables, control events to assess the quality of data.

\[ A = \{ A, A, A, A \} \]
\[ B = \{ B, B, B, B, B, B, B, B, B \} \]
\[ S = \{ S, S, S, S, S, S, S, S, S \} \]
Based on the operations of transmitting detected alerts on the plot, a working network of Bayes monitoring systems is formed. We can see in Figure 4 that the messages sent from the issuance and cancellation of alerts are logically interconnected.

Fig. 4. The present day Bayes work network to issue alerts.

In Figure 5, we can see an automated transmission system for issuing alerts.

Fig. 5. OBAUT Bayes work network.
Figure 6. The probability table of the Bayes network of the current system of issuing warnings.

Figure 7. The probability table of the OBAUT Bayes network.
Let's draw up the full probability of events for each system separately. The full probability of transmitting alerts based on the current system of issuing and canceling alerts is expressed as follows:

\begin{equation}
P(B, A, P, B, A, P, B, A, P, B, B) \\
P(B, B, P, B, S, B, B, S, B, B)
\end{equation}

All alerts on the plot are collected after the OBAUT enters the data directly into the base by the PCHD. Therefore, the information that comes to the server simultaneously reaches all stations "A and B" were reached in time and in full by the DU warning letter. Warning telegrams to "DNTS" and Station C arrived in time and in full under conditions 3, the probability of elements of set \(S\) is determined as follows:

\begin{equation}
P(S, A, A, A, A) = \frac{P(S)}{P(A, A, A, A)} = \frac{A^2 = A^2 = A^2 = A^2 = 1}{A^2 = A^2 = A^2 = A^2 = 1}
\end{equation}

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\end{equation}
3 Results and discussion

Using the GeNie program, the current system of issuing and canceling alerts can determine the probability of all events (Figure 8) according to the given conditions.

Using the GeNie program, the OBAUT system can determine the probability of all events (Figure 9) according to the given conditions.

Fig. 8.
The probability of events in the OBAUT Bayesian network under given conditions. The sensitivity results of control events for a fully probable Bayes network are shown in Figure 10. GeNIe implements an algorithm proposed by Kjaerulff and van der Gaag (2000) that performs simple sensitivity analysis in Bayes networks. Roughly speaking, given a set of target nodes, the algorithm efficiently computes a complete set of derivatives of reliable probability distributions across target nodes for each numerical parameter of the Bayes network. To calculate the probability of reliability of these goals, the accuracy of the digital parameters of the network shows the importance. 

Fig. 9.

Fig. 10.
Fig. 11. S

Fig. 12. S
Fig. 13. $S$

Fig. 14. $S$
Fig. 15. S

Fig. 16. S
4 Discussion

Under a given condition, the control event takes the value Θ. For the current system and

\[
\Theta^1 = P(S_1 | A_1 A_2 A_3 A_4)
\]

\[
\Theta^2 = P(S_2 | A_1 A_2 A_3 A_4)
\]

\[
\Theta^3 = P(S_3 | A_1 A_2 A_3 A_4)
\]

\[
\Theta^4 = P(S_4 | A_1 A_2 A_3 A_4)
\]
\[ \theta_1 = P[S A A A A A], \quad \theta_2 = P[S A A A A A], \quad \theta_3 = P[S A A A A A] \]

Table 1. Probability of control events

<table>
<thead>
<tr>
<th>№</th>
<th>Events</th>
<th>Current system</th>
<th>OBAUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The train at Station &quot;A&quot; reached the DU-61 station just in time and completely.</td>
<td>( \theta_1 = \ldots )</td>
<td>( \theta_1 = \ldots )</td>
</tr>
<tr>
<td>2</td>
<td>A warning telegram reached station “C” in time and in full.</td>
<td>( \theta_2 = \ldots )</td>
<td>( \theta_2 = \ldots )</td>
</tr>
<tr>
<td>3</td>
<td>The train at Station “B” reached the DU-61 station just in time and completely.</td>
<td>( \theta_3 = \ldots )</td>
<td>( \theta_3 = \ldots )</td>
</tr>
<tr>
<td>4</td>
<td>The warning telegram to DNTS reached in time and in full.</td>
<td>( \theta_4 = \ldots )</td>
<td>( \theta_4 = \ldots )</td>
</tr>
</tbody>
</table>

5 Conclusions

6 Summary
We can get

\[ \mu_j \] values from Figure 8 and compare them with each other. As the number of contacts increases, the likelihood of sending messages in quality decreases. Failure to send a message on time reduces the quality of the data.

\[
\mu_j > \mu_j' > \mu_j'' > \mu_j'''
\]

We can take

\[ \mu_j \] values from Figure 9 and compare them with each other. Since the correlations between the sent data are reduced, the likelihood of the data reaching qualitatively and on time depends on the execution of the operations. Showed the stability of data transfer results in OBAUT.

Figures 10-17 show the sensitivity of \[ S_j \] and \[ S_j' \] events under full probability Bayesian networks. This figure shows the sensitivity of control phenomena to changes in other network phenomena. The \[ S_j \] event is more sensitive to events than \[ S_j' \], which indicate a higher level of OBAUT data quality when transmitting alerts compared to the current operating system.

OBAUT excludes the human factor, including subjective interference with the quality of the data and its transmission at speed, and thus bypasses the quality of the output data. By having information reach everyone at the same time when organizing train traffic through an automated system of alerts, the loss that trains will have on the road; reducing them and economic efficiency will be achieved.

References
