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REMOTE MONITORING AND DIAGNOSTICS OF DEVICES BASED ON DISTRIBUTED DATABASE SYSTEM

Summary. The paper provides an overview of the problems connected with remote monitoring and diagnostics of rail signalling devices which are both distributed over a large area as well as highly diversified in terms of scope and format of the information that is made available. A diagnostic system, based on a distributed, relational database and a wireless data transmission system, has been presented in this paper as a solution to these problems. Moreover, the paper provides a description of the advantages of the solution in question that manifest themselves in the data collection, transmission, processing and presentation.

ZDALNE MONITOROWANIE I DIAGNOZOWANIE URZĄDZEŃ W OPARCIU O ROZPROSZONĄ BAZĘ DANYCH

Steszczenie. Referat nakreśla problemy związane ze zdalnym monitorowaniem i diagnozowaniem urządzeń automatyki kolejowej rozproszonych na dużym obszarze i jednocześnie silnie zróżnicowanych pod względem zakresu i formatu udostępnianej informacji. Jako rozwiązanie przedstawiony jest system diagnostyki oparty o rozproszoną, relacyjną bazę danych i bezprzewodowy system transmisji. Prezentowane są zalety rozwiązania ujawniające się w obszarach gromadzenia, przesyłania, przetwarzania i prezentacji danych.

1. INTRODUCTION

Nowadays, the technical progress enables collecting a growing amount of diagnostic information from signalling devices. Still, the transmission of growing amount of data from devices distributed over a large area, collection of the data in an organized way and effective processing and user-friendly presentation of the data present challenges.

These challenges can be met by a system which is based on a relational database, in which distribution of devices is accompanied by distribution of the database itself. Collection of information with the use of available relational database management systems (RDBMS) allows for clear organization of data which is practically unlimited in terms of diversity and volume. A distributed structure enables local data processing, thereby reducing the volume of diagnostic data that is required to be transmitted. Such reduced volume of data significantly facilitates the use of wireless data transmission methods, GPRS in particular.

Use of a relational database, thanks to standardized structures and interfaces, allows for application of standard data access and analysis technologies. In particular, it was possible to develop an expert system, allowing for prediction of failures in monitored devices and for undertaking preventive actions (preventive maintenance).

2. PROBLEMS

2.1. Data acquisition

When collecting data from devices of one type it is mainly necessary for acquiring data to design a relevant interface that will interface data transmission devices with data receiving devices. The degree of difficulty increases significantly if a number of various types of devices, from different producers and manufactured at different points in time is involved and – first of all, when devices which perform different functions are involved. It makes it necessary to apply interfaces of many types simultaneously and to handle different communication protocols.

On the one hand, a reliable acquisition requires providing protection against disruption of the data collection process and, on the other hand, detecting possible breaks and disturbances, as well as reporting them to the data collection system.

SOLUTION:

The types of interfaces and protocols used can be stored in the database. Owing to that it is possible to create software for data acquisition handling that is based on the self-configuring modules. Any change in data acquisition parameters requires the revision of entries in the database only.

Any disruption of the data acquisition process is registered in the database in parallel with the received data thus making it possible to evaluate whether the results are complete and reliable.

2.2. Data storing

A high amount of monitored devices and systems results in a high volume of data that has to be stored. In particular, it happens in the case of up-to-date equipment which generates an extensive spectrum of diagnostic data. If the monitoring takes long, the volume of data goes up so much that difficulties with finding effective archiving methods arises – methods which would at the same time ensure quick access to the data collected.

SOLUTION:

Database management systems offer ready, highly effective solutions for managing high volume data.

2.3. Data arrangement and organization

Apart from the problems connected with the data volume, problems arising from the data diversity occur. The scope and format of information usually differs depending on the device as well as on the duration and frequency of monitoring. In consequence, it is highly difficult to process and interpret the data, especially if it is necessary to compare the data coming from different devices.

The information on device and equipment performance is not only obtained by means of automatic receipt of diagnostic data but also through monitoring and measurements made during maintenance and repair. It is often difficult to link the service-related data with the information that is collected automatically as the data formats differ or even because of the informal character of the service-related data.

SOLUTION:

Thanks to the ability to define multilevel relations, the hierarchical and recursive ones in particular, the relational databases allow for creating both transparent and precise data models of almost any complexity. Diverse models can exist without any conflict in one database.

The database can also be used for providing service and maintenance support for devices. Owing to that, an additional source of diagnostic data is obtained in which data is available in the form allowing for further processing and comparative analysis in relation to automatically collected data, in particular.

2.4. Distribution of devices and data transmission

A high volume of data translates into difficulties in effective transmission of the data over long distances whereas it is essential for remote monitoring and diagnostics of pieces of equipment which are distributed over a large area. These difficulties become bigger if such wireless transmission systems as GSM (GPRS) are used and it often happens that they are the only transmission media available for devices installed in the field.

Interference and transmission breaks, poses another problem because they, like in the case of data acquisition, must be detected and interpreted in order to achieve the required level of reliability of the data collected.

SOLUTION:

The distribution of database allows for the application of local, preliminary processing of the diagnostic data that is being received. It contributes to the significant reduction of data volume and to increasing the computing power of the whole diagnostic system at the same time.

Any transmission interference and disruption can be registered at the database parallel to the received data and in a similar way as it happens in the case of data acquisition process interference.

2.5. Data processing and presentation

The diversity of formats and meanings of information collected hinders developing tools for data analysis and presentation. As a rule, it is necessary to use separate and highly specialized applications for each device and system.

SOLUTION:

Since a uniform model of diverse diagnostic data has been developed, it is possible to develop universal analytical tools, starting from simple filtration and retrieval mechanisms up to expert systems for which the databases represent a natural source of information.

Data – either raw or processed via analytical systems – can be presented in a unified form thus contributing to the clarity of the presentation and the user-friendliness of the system.

2.6. Making the data available

If the diagnostic data is to be used by a wide range of users, the problem with determining the scopes of information available for the users of respective systems and devices arises. It is necessary to diversify the authority of the users and to protect against both unauthorized access as well as unauthorized data modification.

It is necessary to provide each user with appropriate equipment and software that will allow for accessing, analyzing and reviewing the data concerning selected groups of devices.

SOLUTION:

Relational database allows for creating well organized, hierarchical user structures and authority frameworks as well as for linking them with device structures and diagnostic data structures. Thanks to that it is easy to define user groups, give the relevant authority and control the packages of authorization.

The widespread availability of ready-made components for accessing databases with use of popular programming languages, tied in with a standardized model of data in the database significantly facilitates the development of a standardized user interface. In particular, it is possible to use an internet browser as a basis for such an interface as in this way it is no longer necessary for the user to have any specialized hardware and software while the full mobile access to data is provided.

3. DATABASE IMPLEMENTATION BASED ON SDK-1 SYSTEM EXAMPLE

3.1. System structure

SDK-1 Railway Diagnostics System has been developed with the purpose of collecting and presenting all kinds of diagnostic data generated by railway signaling equipment. The fact that rail signalling systems installed at railway locations are distributed over a large area is their characteristic feature. Therefore, a solution that is based on distributed structure, local servers and a single central server has been deemed as optimal for this purpose. A simplified structure of the system is shown in Fig.1

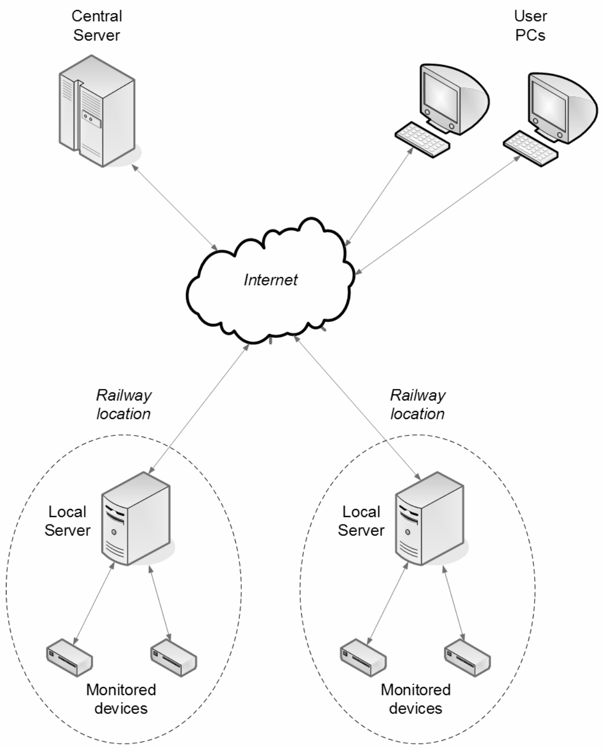

Fig. 1. Simplified structure of the system
Rys. 1. Uproszczona struktura systemu

The data received from monitored devices is transferred to local databases which are on the Local Servers that are installed at respective railway locations in the vicinity of the monitored equipment. The fact that structure of local databases is identical with the one of the database on the Central Server is one of the essential assumptions that the architecture of the SDK-1 system is based on. The contents of the tables differ only, as the subset of data available on the Central Server is stored locally. Thanks to such an assumption the transfer of data to the Central Server is carried out according to the principle of cyclic database synchronization.

The users gain access to the data collected and analytical tools via the Internet in the form of a website service via a standard web browser.

3.2. Database arrangement and organization

The extensive network of relations between the tables determines the capabilities of the databases. The linkages between diagnostic data coming directly from the monitored equipment and the application, service-related data and technical documentation is one of the most valuable features. The interrelation of the data within a uniform structure guarantees access to comprehensive information on the device that is installed at a specific location and allows for conducting comprehensive analysis.

The database applied contains over 100 mutually linked tables which are grouped according to the categories of information stored.

Table 1

Grouped categories of information that is stored in the database

Category	Information stored
Diagnostic data	• Data received from the monitored devices with the use of data acquisition software. • Data gathered with the use of measurement devices and manually entered data. • Parameters of the data acquisition processes and information allowing for appropriate physical interpretation of data collected.
Equipment	• A list of types of monitored systems, devices and modules together with the mapping of the internal hierarchy. • A list of systems and devices/equipment installed at specific railway locations including identification data and technical and installation-related details concerning respective pieces of equipment/devices. • Historical data concerning subsequent stages of equipment operation and use. • Interfaces between the systems and devices/equipment, including specific application parameters of the devices within the system. • Technical documentation of the systems and devices/ equipment.
Local Server	• Hardware and software parameters of Local Servers. • Parameters of data acquisition processes. • Linkages between the acquisition processes and monitored devices.
Central Server	• Hardware and software parameters of the Central Server. • Configuration of management of the incoming information about the events and failures. • List of current events and failures detected by the system. • Historical data concerning the use and changes to the Central Server configuration.
Locations (objects)	• Identification data concerning the respective railway locations (objects), including the railway-specific data and geographical data. • Mapping of the organization of the national railway network. • Mapping of the national administrative division. • Technical documentation concerning the locations, including historical data on operation in the said locations.
Service & maintenance support	• Information on failures/breakdowns and repair work systematized according to defined categories. • Warranty information. • Schedules of technical inspections.
Users	• Data concerning the authorization and configuration of authorization granted to system users. • History of user access to the system, covering the changes they have made to the contents of the database. • Telephone numbers and addresses of companies and persons who are involved in using the system.

3.3. System capabilities

The selected, advanced functions of the system that can be provided thanks to organizing the information in the database in an appropriate manner as well as to the application of advanced analytical techniques are presented below:

- Real-time, automatic analysis of data that allows for detecting the events on a current basis according to any defined criteria and detecting the failures and disruptions to device operation and performance, in particular,
- Automatic notification of selected users on the events detected, also via SMS and e-mail,
- Predicting the failures and disruptions to device performance through comparison of current data with historic data made by an expert system,
- Examining the impact of environmental and operational conditions on device performance,
- Comparing the performance of freely selected population of devices, including selection in terms of time and geography,
- Defining the parameters of reliability models for respective types of devices and systems,
- Assessing the impact of changes made to hardware and software on reliability,
- Scheduling inspections and maintenance work for each device or system individually, depending on the current condition and to-date performance of the devices and systems,
- Identifying weaknesses of the systems through searching for the least reliable components,
- Comprehensive and extensive access to the whole information on a specific device, including information on its type, configuration, interfaces to other devices, failures and repairs that have occurred to-date, history of installation and maintenance work, customer comments etc.

4. CONCLUSIONS

The growing volume and complexity of diagnostic data that can be acquired from systems and equipment represent the current trends on the rail signalling market. Thanks to using databases as the main element of a monitoring and diagnostic system it is possible to manage the data in a highly effective manner which is difficult or even impossible to ensure in any other way. The problem with overflowing of data that is frequently encountered in various fields has been eliminated to a great extent in this very case, whereas a well organized, growing information base can serve as a valuable and independent resource. The value of this resource will grow proportionally to the currently observed, intensified development of advanced methods and analytical tools that are based on neural networks and artificial intelligence solutions.

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