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ZASTOSOWANIE SYSTEMÓW BAZO-DANOWYCH W MONITORINGU DIAGNOSTYCZNYM MASZYN

APPLICATION OF DATABASE SYSTEMS IN MACHINE DIAGNOSTIC MONITORING

Efektywność działania współczesnych systemów monitorujących pracę maszyn jest w istotny sposób określona zaimplementowanymi w nich rozwiązaniami systemów bazo-danowych, wspomagającymi procesy podejmowania decyzji diagnostycznych. Wynika to ze złożoności procesu wnioskowań diagnostycznych, który oparty jest najczęściej na dużej liczbie obserwowanych sygnałów, podlegających skomplikowanym procedurom ich przetworzeń, w tym potrzebom odwołań do historii ich obserwacji. W referacie omówiono problem konstrukcji systemu bazo-danowego dla systemu monitorującego prace pracę szlifierki łopatek silników lotniczych, który powstał w ramach realizacji grantu celowego nr: 6T0220005C09545 dla WSK Rzeszów, a także prac nad budową systemu oceny stanu stalowych konstrukcji szybowych w kopalni „RUDNA" KGHM Polska Miedź. Opisano strukturę budowanych systemów, jak i uwarunkowania ich wykorzystania dla potrzeb wnioskowań diagnostycznych.

***Słowa kluczowe**: system baz danych, monitoring, diagnostyka.*

The action effectiveness of modern monitoring systems of machine run is essentially defined by database systems they implement, supporting diagnostic decision making process. The process is very sophisticated and based on large number of observed signals, which are processed in sophisticated manner, including the need to reference the observation history or the data describing working conditions of the monitored object in any point of time. The paper describes the issue of database construction for the jet engine rotor blade grinder monitoring system that was developed as part of the grant nr.: 6T0220005C09545 for WSK Rzeszow, and also during the development of diagnostic system of the steel shaft construction in the mine „RUDNA", KGHM Polska Miedz. The structure of the systems is described and the conditions of their application to diagnostic decision making.

***Keywords**: database systems, monitoring, diagnostic.*

1. Introduction

Database systems are currently one of the fastest developing branches of information technology and find their application starting from the mobile phones up to military purposes. In general those sysstems might be classified by the data model they implement:

- network model,
- hierarchical model,
- relational model,
- object model.

First two models (networking and hierarchical) are no loger used for their limitations sake and the most developed and mostly used is relational model. But the object model becomes more and more popular for it allows storing of more complex structures, currently used mostly for multimedia data, like video and audio.

Thanks to their properties database system allows for:

- Redundancy control,
- Unauthorized access limitation,
- Permanent storage space for object used in programs,
- Proper storage structures for effective query processing,
- Data loss protection,
- Multiaccessibility,
- Data relation representation,
- Enforced integrity rules,
- Decision making support, rules based actions.

The main task of the database system is to gather and distribute data and also most important from the diagnostic point of view is the ability to make decisions based on the stored date by application of datamining and warehouse techniques.

By means of relational algebra it is possible to create the live history of the monitoring object. Thanks to proper number of measurements it is possible to do some parametrization of the events by searching for the resemblance of the events during the time. Knowledge of those relations allows building diagnostic patterns which in turn create the possibility of quick assessment of the machine state and foreseeing its behaviour in further exploitation. To make it possible the database needs to contain enough information, which demands a lot of time effort, and that is why the systems needs to allow simulation data introduction for the preliminary patterns building. Such patterns might be corrected later by introduction of the real object data. Thanks to database flexibility it is possible to implement totally new patterns that were not taken into account in the development stage.

2. Examples of task solved with use of the described systems

Good example of application of the described properties of databases is implemented monitoring system of jet engines rotor blades grinder (grant nr.: 6T0220005C09545) in WSK Rzeszow. At the current stage the systems are used mostly for the measurement data gathering and distribution from the tested object (filling the database with the real data). The system has been designed to store large number of data (sampling frequency 500kHz) and all additional data related to the measurement and users analysis results. Data from the measurement device (PUD) are sent to database by means of the networking protocol.

The distribution system was split in two stages (Fig. 1): primary distribution where selected groups of users have direct access to the gathered information and secondary distribution where the selected information is presented. Such solution allows unloading the main server which acquires data from networking measurement devices, which allows easy access level control for selected information. To perform this task two servers are used based on SUSE Linux Enterprise 10 (Database Server) and SUSE Linux Enterprise 9 (Data acquisition server) and the database MySQL 5.0.

given at the user application level and may be any value stored in the database or a range of values.

Access to the gathered information is possible through the user applications which visualize measurement data and add extra description of the information (Fig. 3). They also allow automatically processing of the gathered information with use of external programs (MATLAB). It is also possible to access the data by prepared web-page (Fig. 4). Thanks to that data view is possible from any computer connected to the network without the need of installation of additional application, without forcing the use of one particular operating system, which simplifies and widens possibilities of database access.

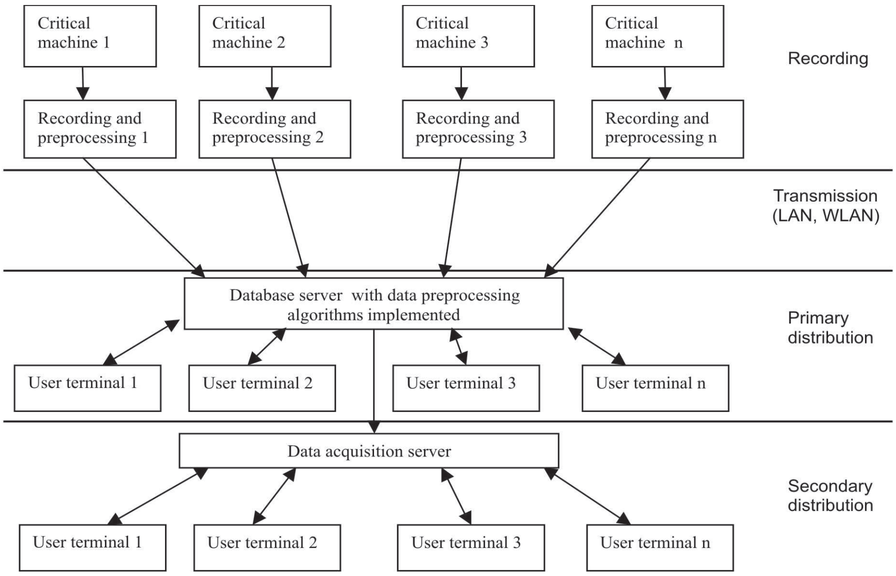

Fig. 1. Monitoring system schematic for jet engine rotor blade grinder (project nr: 6T0220005C09545) WSK Rzeszow

Data from the measurement device are moved directly to the first server. At this stage the data are preliminarily analyzed and made available for selected group of users.

What will be sent to server 2 decides a set of users application which are part of „decision module 1", which control filter transmitting chosen data sets to server (Fig. 2). Structural database stores measurement data (time series recorded on the machine) and all additional information about the recorded signal like date and time of the record, sampling frequency, gain.

The database allows storing additional information for more precise identification of the gathered information that is exact description of the measurement point (machine, sensor location), measurement device information. It is also possible to store results from 8 measurement channels and 3 marker channels and there is no limitation for the number of measurements and calculations for given channel. Each channel recorded during the measurement and stored in the base might be precisely described by forced rules that derive from the structure of the database and they may be information defined on the fly by the user. Such solution allows making groups of the gathered data considering particular criterias: measurement date, type of the analysis made and the groups defined by the user.

The system allows quick access to the gathered information by searching for an interesting information with particular criteria

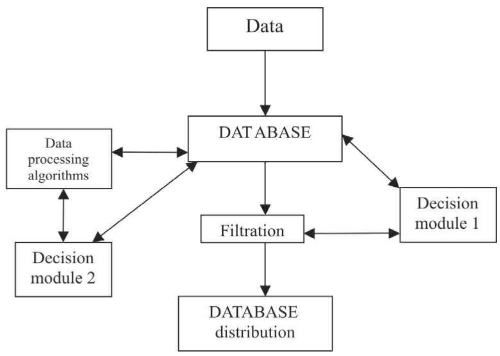

Fig. 2. Data flow model

Another example of database systems application is a assessment system for the steel shaft construction state in the mine „RUDNA" KGHM Polska Miedz.

The designed system stores measurement data, calculation and all data describing tested part, which in this case is a single pilot. Database system allows detailed description of particular element of the whole shaft construction:

- location,
- type of lashing,
- date of lashing,
- another measurement data (eg. thickness).

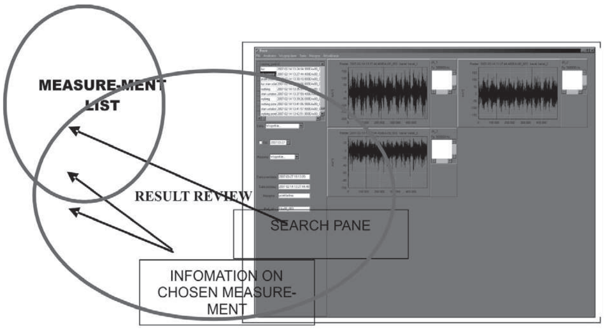

Fig. 3. Main window of the application

Thanks to the database application it is very easy to find information about the particular pilot and conduct its analysis. That is very important because of the large number of data and large number of tested elements (a lot of pilot in one shaft, two sections in one shaft).

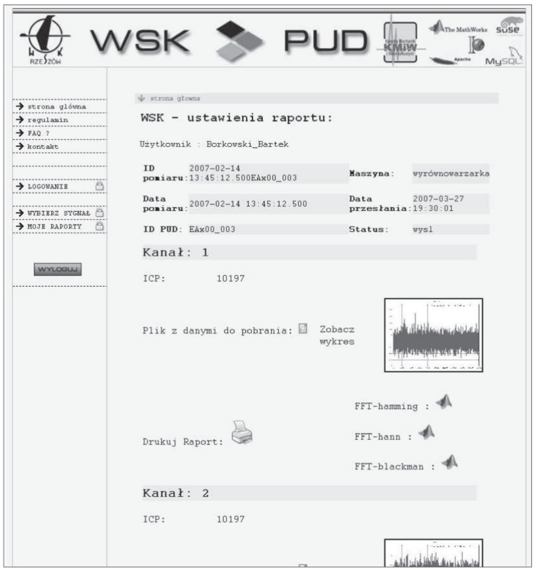

Fig. 4. Web-page report settings – (general information on channels)

Schematic of data transfer is presented below (Fig. 5.). Data from measurement device is sent by internet to the central database and then by intranet is sent to the end-users.

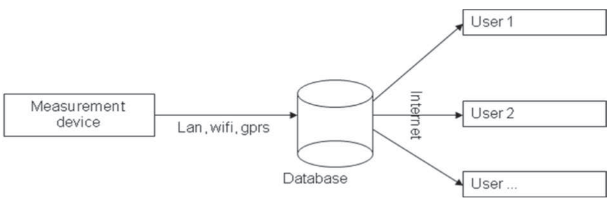

Fig. 5. Data transfer system schematic

The schematic of the database is presented on Fig. 6. Automatic calculations are made on the stored information and the outcomes are also stored in the database. On the results the rules are constructed to make decision about the pilot state. For gathering enough information for rules construction takes time, the system is filled with the simulation data from the laboratory testing.

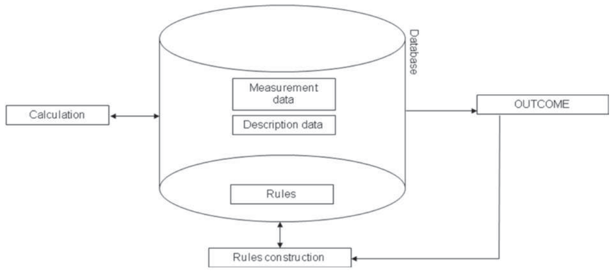

Fig. 6. Schematic of the database

In the figure above a user application is presented which manages gathered information (transfer, acquisition). It allows particular pilot searching, attaching descriptions, comparison of the calculation results and automatic calculations with the external Matlab software.

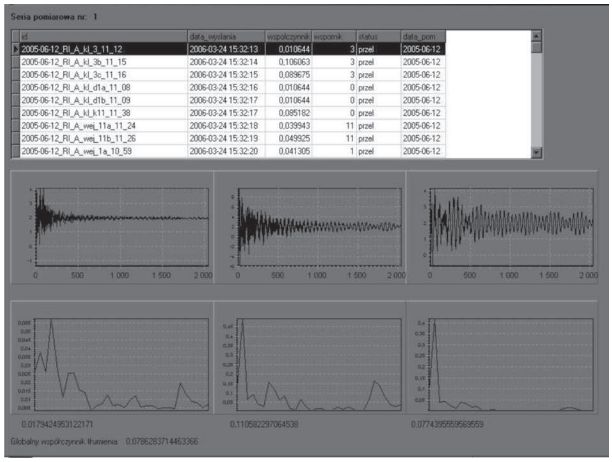

Fig. 7. User application

3. Summary

The article presents proposition of solution for the problem of diagnostic data gathering and processing in monitoring systems based on implemented database system. The main target of this solution is to support the diagnostic recognition process.

The paper contains sample database structure linking description data of the object with the measurement data gathered during the time and the analysis made. The structure allows event history creation which happened during the exploitation time, then, based on it, parametrization of particular symptoms which happened during the exploitation time.

Based on gathered information and during the time it is possible to build diagnostic patterns based on rules system, and such patterns allow current machine state assessment and foreseeing future behavior of the object.

Also by means of the described techniques of data mining the system allows new diagnostic method development which allow effectively search and foresee a particular event.

The whole database system must contain following modules:

- Data gathering, storage and distribution module,
- Pattern building module,
- Pattern search and comparison module.

The main values of the proposed system are better information management, simplifications of decision making process and ability to be used as an expert system for automatic decision making considering the state of the tested object.

That also brings better security and lowering exploitation costs because it is possible to foresee coming failure and precise planning of stoppage and maintenance.

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