KNOWLEDGE-BASED EVENT ORIENTED APPROACH TO CONTROL SYSTEMS: TECHNOLOGIES AND METHODICS

Vikentiev A.*, Vaguine A.*, Poluektov S.**, Mikheev V.**.
*- Moscow Radiotechnical Institute RAS, **-Altey Ltd, Moscow

1. INTRODUCTION

The ICALEPCS-97 report [1] described our approach to a knowledge-based information system connected to an existing monitoring and control system to increase its capability, by using formalized knowledge for planning prophylactic measures and predicting some tendencies. In this paper we describe technologies and methods to provide deep analysis and forecast technical system malfunctioning levels.

The technologies described were used within the control system to analyze malfunctions of technical controls rather then the incidents themselves.

2. MAIN GOALS

The system we describe provides support for decision making by presenting rich operative integrated data; a deep initial information analysis with possible forecasting, and planning corrective measures and effect monitoring**.** This is achieved by:

-multilevel quality and quantity control system safety analysis

-complex quantity safety status estimation, based on a variety parameters

-effective analytical reporting via forms, to aid decision making experts.

3. SYSTEM TASKS

The main tasks of the system are to:

-provide the system manager complete information about the system's safety status

-warn the system manager about unfavorable tendencies in the system's safety.

-provide the system manager a safety analysis for each main subsystem, service, and kind of failure in comparison with the previous period.

-provide the system manager tendency estimations of principal system safety parameters as well as modeling and forecasting.

-provide reports in graphical and tabular form, optimized for use in current and strategic decision making

-automatically receive, store and protect the information, which comes in agreed formats.

4. SYSTEM MAIN FEATURES

The system structure used for knowledge collecting, editing and systematizing, is presented in Fig 1. The system consists of three levels of safety control.

4.1. Local level safety control system.

The operator's main task at this level is to transfer an informal incident description to a formal one using knowledge represented in the central knowledge base (similar incidents, regulations, classifiers etc). Simple to use heuristic case specialization technology gives the operator the capability to complete a three-event incident formal description, using both unformalized description and classifier data. As the result a cause-consequence net structure can place events in time and space relative to the system's objects and its environment.

A reasonable first stage in the knowledge acquisition processes, is to make a detailed formal description of the most dangerous incidents. In practice we came to the conclusion that the most suitable formal structure for the incidents description is a cause-consequence net structure, which has homogeneous nodes (events) with several levels of concretization.

4.2. Analytical level safety control system

The experts working on this level are responsible for the central knowledge base construction. The information taken from incident descriptions (incident data base) are input into the knowledge base through two types of classifiers:

-classifiers of unfavorable events (net peaks)

-classifiers of cause-consequence relations of event pairs (net arcs).

As a result we have a homogeneous knowledge base about the ways incidents start and progress. At this level the expert is provided a statistical three-event data model and a deep analysis of the technical system malfunction conditions. Functions are: event distribution, key event search, stimulating for corrective measures, effect estimation and forecasting.

4.3. Central level safety control system

The experts of this level are responsible for making strategic decisions, either in critical or in normal situations, and for planning corrective or preventative measures. They work out the parameters for safety estimate threshold parameters, safety parameters etc.

4.4. Analytical means

The implementation of power analytical methods for the system safety control has just started. The system therefore has the capability to include very different analytical models, such as: multilevel analysis, comparative analysis, frequency and correlation analysis, tree event analysis, complex parameter synthesis, imitation modeling etc. The optimal analytical model set that we find will be adopted in practice.

4.5. Subject informing

Safety control is a multilevel and multistage process. So a safety control system should have different information levels, such as: factological, registrational, analytical and decision-making. Therefore appropriate means should be used both for operative and strategic analysis at the different levels of expert support.

4.6. Results presentation

Graphics are the most effective means for dynamic process presentation, combined with tables and natural language appropriate to different level experts.

5. BASE TECHNOLOGIES

5.1. Distributed objects.

The main parameters considered for the system are - reliability, maintenance, and modification expense. It should be possible to create the system as a complex of simple, reliable and cheap functional modules, each with its own life cycle (specification, development, testing, use, and modification). The system uses DCOM to achieve this, which has had some positive results:

-the system with the very first functional modules starts working and has an economical effect immediately

-system modification is rather simple – a module replacement and change procedure goes through the central computer and causes the configuration of the work stations automatically

-all the bugs in a module can be solved by replacing the module with its previous version

-the whole system life cycle increases significantly in so for as new modules can be developed on a different SW and HW platform in parallel

- compatibility through DCOM gives the possibility to integrate other high quality functional modules into the system (MS Word, MS Excel, Internet Explorer, graphics etc).

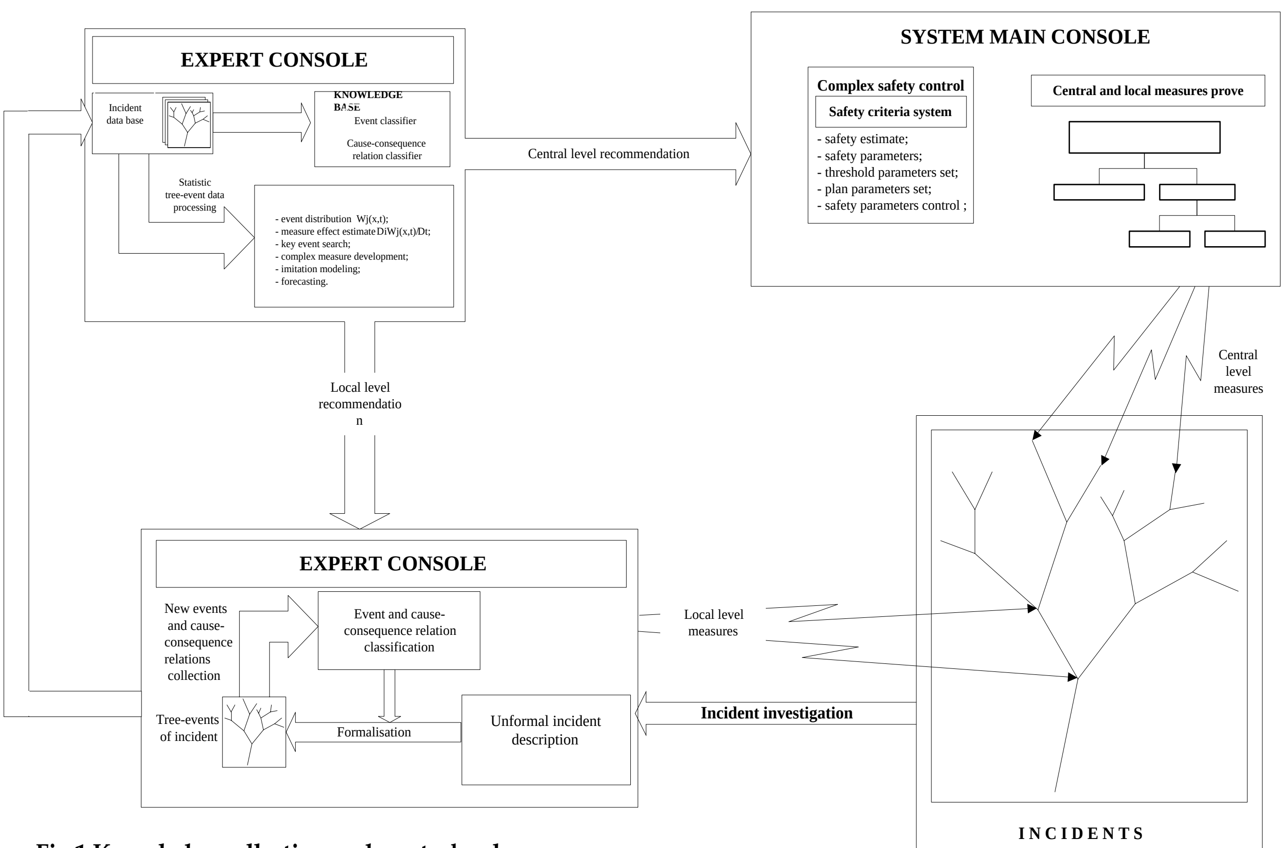

Fig.1 Knowledge collection and use technology

5.2. Data concentration

All the data in the system should be well protected but also be easy to input. 3-tier SQL technology used. Along with the usual SQL functions for data protection (against client program malfunction, HW and network failure) we use special middleware to add informational protection, administer user rights, control users' behavior etc.

5.3. Data mining

Data warehouse technology is used in the system for increasing productivity by operative analysis of the information. The information approved by the experts is exported from the running system into a data mine for statistical processing. Only safety control related information stored in the data mine. The data warehouse was developed as a Star Join structure to have maximum speed in solving complex analytical tasks.

5.4. Analytical forms configuration

While developing the output reports in the system it was pointed out that the expert uses some empirical parameters for an integral safety estimation and the set of parameters is changing from time to time. To meet this expert needs we developed technology for constructing output reports from the knowledge base. On an expert's request the administrator can quickly create the description of a new form, store it or use it for copying.

5.5. Data communication

The system can work with wide area network data communication systems (Internet etc.) and specialized systems as well.

5.6. Analysis technology

Subject informing is the main problem solved along with analytical technologies and system output reports. The way from the initial data to the final decision may take many stages of processing with different analytical instrumentation. Under the subject informing the results obtained at a certain stage should be clearly proved by the data from previous stage and at the same time should prove the next level results. This means that each processing stage should have its own effective analytical techniques and presentation forms (displayed or printed).

6. INFORMING STAGES

6.1. Factological informing

A typical example of this is the information given to the manager about unfavorable events for the day or the stored information about similar event occurrences. The safety analysis target on this level is to pick out the information related to a given parameter for the manager or the expert.

The analysis at this level is done by search and data filtering systems. The analytical result is a brief or detailed account of the unfavorable events in the tables or text forms, and reports about the facts and details of the events needed to take an operative decision.

6.2. Registration informing

This level's objective is to present the full and proved quantity of the violation related to the geographical or administrative units referred to time period with the positive or negative estimation.

The analytical means of the level are multilevel tables in the geographical – administrative coordinates. Negative or positive estimations are given in comparison with the previous period's data. The day reports are typically statistical information from this level.

The results of the safety analysis from this level are reports to the manager on the total value of the unfavorable events over this period and their distribution over the basic components of the whole system (functional systems, geographically distributed systems, events, cause – consequence events etc.)

Presentation is in the form of a table with color highlighting.

6.3. Analytical informing

These are statistical reports about safety dynamics, tendencies and forecasting.

The target of the safety analysis is to pick out both negative and positive tendencies in the safety status related to the geographical or functional subsystems to distinguish key tendencies in the safety status along with itheir parametrical estimation. For example,

-mean number of the events per time unit;

-mean number of the events related to the whole system by time unit;

-tendencies in number of events related to different time scales (year, month, week etc);

-tendencies in the distribution of events on the kinds of unfavorable events and their causes;

-dynamics in quantity of damage etc.

Presentation is by tables and graphics. The analytical results are filtered to emphasize the most important information.

6.4. Strategic decision-making support

This module presents the subject-analytical notes describing the most important and actual analysis results of the safety status taken from the different stages of analysis for use it in the decision making process.

The object is to present the safety status of the system and to point out potential corrective measures along with positive tendencies. The presentation is given automatically using natural language.

All the stages of the safety analysis are supplied with the corresponding analytical methods and report forms.

7. REFERENCES

[1] Vikentiev A., Vaguine A., Poluektov S., Mikheev V., Knowledge-based event oriented approach in control system.ICALEPCS 97, Proc. 1997, p.400