Integrated Emergency Monitoring System in Krasnoyarsk Region

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Abstract. We have developed the monitoring system for the early emergency situations alarm. The
system includes data warehouse, OLAP tools, web tools and the geographic information subsystem.
Technology integration allows collecting, analyzing, storing and providing different kinds of data
for quick automatic identification of risks and threats.

Introduction
The number of natural and man-caused disasters has increased in the recent decades [1]. The
emergency risk level is caused by the global phenomena of the climate changes as well as the social
and economic processes happening in industrialized countries including Russia, especially in such
large industrial territories as Krasnoyarsk region [2]. Early danger prevention and reduction of the
consequences demand the use of various monitoring technologies [3]. Monitoring data is the basis
for the decision-making for prevention and elimination of the emergencies. However, proliferation
of measuring tools and data transmission systems lead to avalanche growth of the observation data
volumes. Data collection and processing efficiency growth is reached due to integration of the
modern information technologies allowing automatic identification of dangers and threats, finding
regularities of dangerous processes development, using various methods of the analysis and data
representation.

This article describes the technologies of the emergency situations monitoring system developed
for the Krasnoyarsk region of Russia.

System Tasks and Features
The emergency situations monitoring system is designed for early detection of natural and
technogenic disasters and threats, and information-analytical decision support. The tasks of the
system:
− consolidation of heterogeneous data in a centralized data warehouse, including processing,
correction and conversion into a uniform format;
− online monitoring data analysis using OLAP-tools for assessment of risk indicators, and
dynamic data representation via cross-tables, interactive maps and quick reports;
− publication of the monitoring and analytical data at the website and mobile apps;
− dynamic cartographic visualization of the current situation with the use of the tools of the
geographic information subsystem (GIS).

The main idea of the monitoring system is to expand the range of tasks through the integration of
technologies. OLAP and GIS integration allows to display the results of the analysis of multi-
dimensional spatial data on dynamic maps [4]. The integration of web technology and data
warehouse is used for distributed information collecting. Integration of web and GIS allows to
visualize the situation on dynamic multi-scale maps with different granularity.
Data Consolidation Technology

Data consolidation technology deals with different data sources, such as departmental systems resources, distributed databases of monitoring subsystems and open web resources (Figure 1).

Departmental information resources include observation networks data, dangerous events’ and objects’ characteristics. The primary volume of the initial data on a current situation is collected by departmental systems (meteorological and seismological services, automated radiation control systems, engineering constructions control systems etc.). A large amount of monitoring data created at the departmental systems is supplied into a centralized data warehouse.

Distributed databases of monitoring subsystems include the data of the automated observation posts, rescue units’ data, dangerous event and infrastructure characteristics. The technology of data collection directly from the monitoring devices (irrespective of their assignment) has the following features. Group of devices (for example, the automated meteorological station, the radiation level sensor etc.) together with the industrial computer equipped with the appropriate software, are integrated in a uniform observation post. Primary measurement data stays at the local database which allows avoiding losses of information in case of a temporal rupture of communication. Special rules of data preprocessing and transfer are used for identification of critical values of the measured parameters, and also for filtering of the redundant information.

The data collection web system serves for updating of the formalized information on dangerous events, characteristics of the objects for protection, rescue units and means of quick response. Due to implementation of a uniform subject area information model, a flexible setup of data collection with the safety support mode is realized [5]. The subsystem also uses the local database. It increases fail safety of online system in general.

All of the pre-processed data obtained from different sources is consolidated in the centralized data warehouse. The uniform classifiers and data store control technologies allow to flexibly customize the system for connection of different formats, to select the rules of data updating, to create and adjust procedures of data removal and updating. The classifiers and the consolidated data warehouse structure are designed taking into account the organization of a two-way information exchange with the enterprise information systems using API technology.

The developed technology allows to quickly connect new data sources – the tools of control of the situation and departmental monitoring systems.
Information-analytical Decision Support

Data processing and representation technologies are used for information support of administrative decisions. Figure 2 shows the data processing for information-analytical support in the cases of threats and risks appearance, and also for long-term planning of emergency situations prevention.

Figure 2. Data processing and representation technologies.

During identification of dangers and threats the operational data arriving from different sources is compared to limit values of numerical criteria of each monitoring parameter. The set of criteria is developed for early warning of possible dangers and is constantly replenished. Not only approximation of the controlled parameter to maximum or minimum tolerable limits, but also sudden change of a parameter during the analyzable period can be a threat of danger appearance. Usage of OLAP technology allows to formalize difficult criteria, for example the change of temperature through 0°C or the precipitates’ intensity, or other danger indication methods necessary for monitoring of the situation. The developed signaling technology of "semaphores" allows to focus operator’s attention on a specific point of measurement. Green color indicates norm, yellow means threat, red is dangerous situation. The analytical data allows to assess the situation and to define the methods of response [6]. Using OLAP-simulation technology for data analysis considerably expands the possibilities of information support of management [7].

For the majority of natural and man-caused emergency situations the threat types are identified in accordance with the indirect signs, the joint processing of online data and the precedent data base is most effective. Joint analysis of the operational monitoring data allows to study the relative influence of the controlled parameters. Analytical processing of online and archive data is necessary for identification of the threats with indirect dangers’ impact. For example, the dangerous weather phenomena (hard frosts, gale-force wind, continuous showers, etc.) can become a cause of technosphere objects’ function violation. Formalized precedents database allows to estimate the probability of unfavorable events of technogenic character, vulnerability of objects and infrastructure. The system searches an analogical year and a situation development scenario for cyclic natural emergency situations (spring floods, natural fires, etc.). Joint analysis of online and archive data allows planning of long-term actions for the emergency prevention and consequence reduction. Different sources of data are consolidated in a uniform analytical model [8].

The user analyzes the situation and works with the integrated models presented as a single virtual network of observations. At the same time, it is possible to detail the information, for example, data on a meteorological situation is available to the detail analysis (air temperature, speed and the direction of wind and other). The marked current situation data is presented as the colored table, diagram and dynamic map (Figure 3).
In order to display a current situation, the dynamic map layer is calculated on the basis of an observation network layer, or is created with the use of the event coordinates. The measurement results are visualized on topographical map as icons, numerical values (water levels, air temperature, amount of precipitation, etc.) and symbols (daily change of water levels, the phenomena, wind direction and speed).

The information technologies integration is the basis of heterogeneous monitoring data processing. Synergetic interaction is reached by means of access of the one subsystem to another. For example, generation of a request to data and analytical models of the storage can be carried out by a web subsystem, GIS or a calculation method. Interaction between the data warehouse and the data collection web system is organized. The formalized data collection is realized due to integration of the web system and a classifier subsystem. The data warehouse defines the web publications’ structure, and cartographical representation of the analytical results. Data import from the external sources and website publication of analytical results are performed in accordance with the special data storing procedures. We have developed a shared use of adjustable cross-tables and dynamic mapping methods for creation of cartograms and the spatial analysis performance. Dynamic mapping of online information is provided by creation of the virtual layers of the observations network and situation indices by means of the geographic information system.
addressing to the data warehouse analytical unit. On the basis of the principle of hybridization, the essentially new information models combining technologically diverse elements are realized.

The given examples of technologies’ integration illustrate only a part of the system’s functions. On the basis of the listed principles, all subsystems of the complex monitoring system of the emergency situations are developed. Moreover, the system can be easily expanded through addition of new analytical models and new analytical criteria, allowing to estimate the objects and situations that were not previously examined.

**Conclusion**

The system is implemented in the Krasnoyarsk regional center of monitoring of the emergency situations (www.tcmp.krasn.ru). Operational data and information resources for integrated monitoring are used to analyze natural hazards, risks of industrial accidents, evaluation of safety status of the territory. At the center’s web site one can find a published data of operational monitoring, the results of its analytical processing and evaluation of the current situation. The settings of the online monitoring data publication allows to minimize the data processing time from the moment of its reception from different sources to the situation data page online updating. The observations archive is available at the web-site and is updated every day.

Technological integration provides a wide range of tasks due to the synergistic effect of combination of the features of individual technologies. The system allows to increase the efficiency of solutions in order to reduce the impact of natural and man-caused emergencies through early detection of dangers and threats.

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