Computer Networks for Crises Management in Case of Environmental Disasters and Related Types of Threats

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Abstract
As a result of intuitive considerations, theoretical approaches, practical system tests and related project experience, a proposal is made for the logical structure of such networks, including monitoring and surveillance, prediction and prognostics, early warning, decision support, warning and information of the public and emergency management. The system requirements are described and it will be shown that the proposed architectural design is suitable for the purpose of environmental monitoring, early warning and hazard management.

As an example for the operational feasibility and the technical implementation of such a system, a remote monitoring and surveillance system for nuclear power plants is described, including prediction and early warning based on a dispersion modelled transport calculation in case of radioactive releases.

1. Introduction
Almost every day TV news report disastrous environmental events from somewhere in the world. Earthquakes, volcanic eruptions, hurricanes, heavy thunderstorms, floods and avalanches alternate with tanker collisions, oil spills, coastal pollutions, bushfires, accidents in chemical or nuclear plants (related with the emission of toxic gases or radioactive nuclides) and terrorist attacks.

The loss of human life and the tremendous damages caused by those catastrophes as well as the increasing sensitivity of the general public demand for the protection of the population and the environment by means of a new generation of intelligent surveillance, information, early warning and emergency management systems.

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2. **The Requirements**

Due to the complexity of this challenge, it is obvious that only a network of computers with dedicated individual tasks and an appropriate communication structure will allow for a promising approach to solve the problem. However, defining an adequate logical structure for those networks, a variety of subtasks and prerequisites have to be fulfilled in each case in order to include intelligence in various ways and to reach the goal of an integrated operational system:

- development/integration of adequate sensor systems and sensor networks (autonomous or remotely controlled) providing data and background information
- advanced modelling, i.e. development/improvement of scientific prediction models for prognostic calculations of each disaster type supporting interpretation and extrapolation of data
- integration of scientific prediction modules into operational systems and definition of adequate interfaces to allow for fast response actions even under critical conditions
- development and implementation of risk analysis and decision support systems based on sensor data, prognostic calculations and disaster specific experience
- development/improvement and inclusion of knowledge management components (in general and disaster specific) to account for the long-term experience of experts and observations made in the past
- definition of adequate information, alarm and warning strategies
- definition of appropriate interfaces to catastrophe handling and resource management subsystems (transport facilities, shelters, medical care...)

Special care has to be taken for the flow of information and data streams, providing all subsystems with the relevant information within due time, enabling them to fulfill their specific tasks in a rather autonomous way but sharing the results with other subsystems who, on their turn, need it as input.

3. **The logical structure of the system**

The proposed logical structure is shown in Figure 1 in the form of a Local Area Network (LAN), although some components may be linked together physically by means of a Wide Area Network (WAN), depending on the actual needs of the system under construction.
Fig. 1: Structure of the System

It is highly recommendable to use a communication server to handle the input data streams from various sensor systems and sensor networks and to convert the different data formats, if necessary. This server may also handle the connection to external information networks. In case of higher system loads or larger systems, a specific server computer may be used for this purpose, e.g. a dedicated web server. Since most of the data are usually needed for central access, the concept of a central database has been confirmed by practical experience.

Prediction models and prognostic calculations, such as those for the atmospheric dispersion of toxic gases or radionuclides, tend to need large sets of data and therefore are also best served by a central access. Subsets of the central database may be replicated to remote application servers for specific use.

Decision support systems, based on the data describing the actual situation as well as the prognostic development, will reflect the implications for the population in the affected areas and thus help the crisis squad to make their decisions.

Connected warning networks will be alerted by an alarm function in accordance with the defined warning strategy, and finally, a dedicated emergency management sub system will communicate with the civil defence networks and provide the mission control systems for search and rescue forces with the necessary data.
It has proven essential to consider the full process chain and data flow (from the sensor up to the rescue vehicles) right at the beginning of the conceptual phase in order to provide for an adequate operational use of the intended system.

4. Technical implementation of a reference system

As an example for the operational feasibility and the technical implementation of a system in accordance with the proposed logical structure, a remote monitoring and surveillance system for nuclear power plants (RM/NPP) will shortly be described in this section.

The task of this system is to monitor the operation of the nuclear power plants (Obrigheim KWO, Philippsburg KKP I and II and Neckarwestheim GKN I and II) in the Federal State of Baden-Württemberg, Germany, and of foreign nuclear power plants (Fessenheim, France and Leibstadt, Switzerland) close to the German border.

The actual operational state of the nuclear facilities including their emissions into air and water, together with the radioactive immissions into the environment are automatically recorded. In addition, the RM/NPP system continuously surveys the meteorological data at the sites and also receives data from external measuring networks, thus adding up to a volume of approx. 100,000 measurement data per day.

The RM/NPP system provides numerous possibilities to visualize the data and to check them against threshold values and protection objectives. In the case of a radioactive leak, potentially affected areas can be determined at an early stage by a dispersion modelled transport calculation (DMTC) and protective measures can be adopted by the ministry in cooperation with the authorities responsible for civil defence.

Apart from the results of the DMTC, additional information can be overlayed onto a computer generated map enabling a more accurate assessment of an incident, e.g.

- Wind vector fields for varying heights
- Precipitation fields
- Helicopter flight paths and the results from measuring flights.
- Positions of measuring vehicles
- Water levels
- Additional measured values from stationary and mobile measuring stations

The concept, the architectural design and the user interface of this system had to meet extremely high demands. Therefore, and in accordance with the logical structure proposed above, the system was conceived in form of a client/server architecture.
with the following components:

- Communication Server (CS)
- Central Database (CDB)
- Application Servers (AS)
- Dispersion Modelled Transport Calculation (DMTC)
- PC based User Interface (Clients)

All important components of the control centre, measuring data recording and networking are organised in a redundant manner. The central data storage is hosted on a computer cluster, which is being additionally provided with an emergency power supply. Standard PCs are used as clients, enabling the RM/NPP data to be accessed and visualised with the assistance of GIS functions (Geographical Information System). The RM/NPP client software provides standardised export interfaces to office and graphical applications. In order to support the information of the public, the RM/NPP system also allows to be accessed via WWW-browser technology without special need for of the RM/NPP client software. The local networks (LAN) which are installed in the individual locations are connected by routers via redundant wide area networks (WAN).

5. Conclusion

A proposal has been made for the logical structure of computer networks for crises management in case of environmental disasters and related types of threats. It has been shown that the proposed architectural design is suitable for the purpose of environmental monitoring, early warning and hazard management.

As an example for the operational feasibility and the technical implementation of such a system, a remote monitoring and surveillance system for nuclear power plants has been described. The high demands placed on the user interfaces in order to guarantee a secure and simple operation of this very complex system could be met due to the ergonomic design, consequent use of graphical and geographical visualisation and operating technologies from the GIS environment.

The described remote monitoring system for nuclear power plants enables the supervisory authorities to meet their obligations under atomic legislation in a safe and economical manner. The extended possibilities of evaluating and visualising measured data, together with the complex models for the transport calculations and the visualization of their results and implications support and ease the assessment of an incident by the supervisory authority and the Regional Administrations responsible for civil defence.
Note: The system described above is in full operation since August 2001 and was contracted to T-Systems GEI GmbH by the Federal State of Baden-Württemberg, Ministry of Environment and Transport, as a turnkey system, with the integrated service “DMTC” provided by the Institut für Kernenergetik und Energiesysteme (Institute for Nuclear Energetics and Energy systems) of the University of Stuttgart (IKE). The research work related with the development and integration of the DMTC was supported by the Ministry of Environment and Transport within the framework “Umweltinformationssystem (UIS)” (Environmental Information System) Baden-Württemberg. The underlying program modules of the DMTC were taken from the library of the OECD Nuclear Energy Agency.

Bibliography


