EnviroInfo 2005 (Brno)
Informatics for Environmental Protection - Networking Environmental Information
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An Internet – and Knowledge-based Alert-system for Groundwater Disaster Management

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Abstract

To guarantee a continuous supply of drinking water, the resource "groundwater" is the most common in Germany (about 70%). According to this fact, the demands on water with unobjectionable quality properties are very high. The groundwater body is in particular at risk, if a dangerous situation occurred (e.g. defined pollution in the soil, exceeding of a critical value, technical interferences, danger of flooding). Therefore the correct measures have to be taken immediately to avoid environmental hazards. For those cases, emergency plans have been developed by the governmental authorities, the supply companies and the civil protectors separately. Components of these plans contain the emergency cases itself, the knowledge base, the involved participants and the required measures. A model-based and integrated software support for cases of emergency does not exist at present to notify all involved participants and to provide the essential knowledge about the basic-information and possible measures automatically.

This paper describes the rule-based notification extension of the pilot project "Grundwasser-Online" to react on critical situations concerning large-scaled groundwater bodies immediately and with the adequate measures. Therefore a rule-based expert-system with automatic notification-mechanisms and an integrated workflow-system have been implemented. In addition to the defined rules, the emergency-cases with all related participants and the required material for a special decision-support can be described. Also the suggestions for the adequate measures and the kind of real-time notification (system, SMS, eMail) can be defined.

1. Point of departure

The pilot project started in 2000 with the aim to supervise and control the groundwater situation in an active way. Therefore new approaches for the collection, management and evaluation of data from all related water supply companies and local authorities were developed [Meißner, 2002]. Since November 2004 the project switched to an official operation mode. In one of Germanys largest and most critical groundwater reservoirs (the "Hessian Ried", with a size of 1238 km²) the monitoring is based on a small meshed net of groundwater and river gauging stations, wells, springs, infiltration facilities and climate measuring points. At present more than 2.500 gauging stations are stored in the systems database. The actual information can be accessed by authorised users by local modules which store the data in local databases or directly over an internet portal accessing the centralized server database. At regular intervals the content of the local databases (seven databases at present) is synchronised with the centralized server database over specific replication mechanism [Rüppel, 2003], so that finally all the data from all supply companies, engineering societies and local authorities is stored in the central server database (figure 1).

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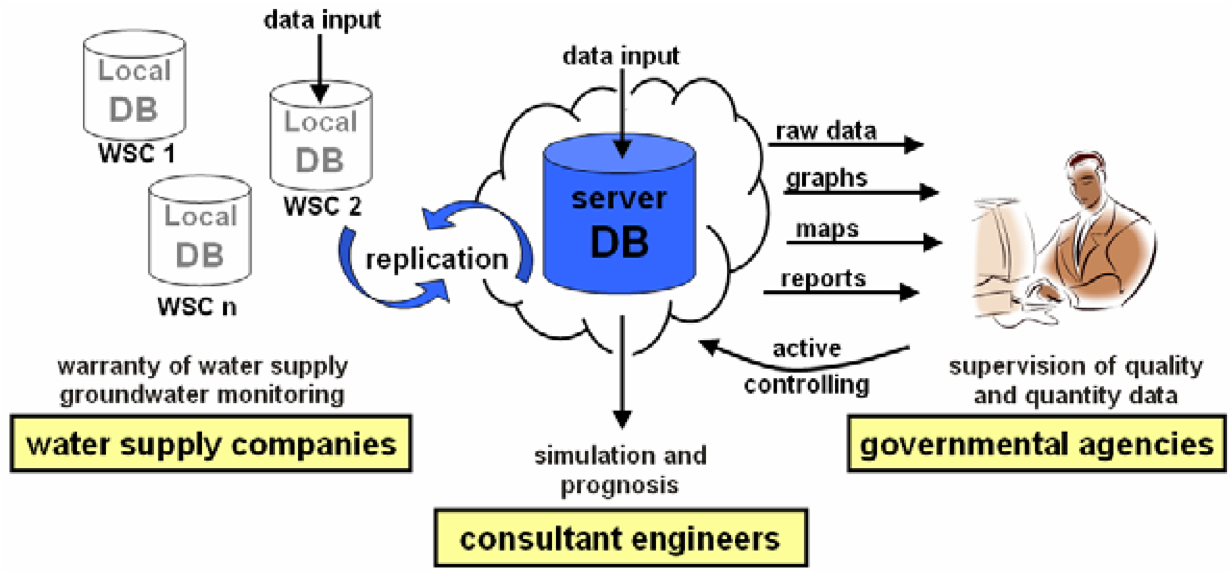

Fig. 1: Existing system architecture

High-capacity evaluation modules support the decision makers over an internet browser to do their prognosis in real-time. These modules include an online-generation of charts, PDF-reports and spatial evaluated maps (groundwater contour line, aquifer depth and difference plans) on basis of a GIS map server [Gutzke, 2003]. The usage of these modules is regulated over specific access-rights. Beside the specialists, the public has the opportunity to receive actual groundwater information of selected areas as well as commentated background information over the internet portal www.grundwasser-online.de.

2. Motivation

The groundwater body is (compared with pre flooders e.g.) a slow moving medium. Nonetheless critical situations have to be notified as soon as possible to start the correct countermeasures. Because of the complexity of the hydro-geological system and the large number of involved participants, the necessity of co-operation and information-exchange - especially in emergency-situations - is high. The federal system in Germany, the rangy organisation structure (with for example more than 6.000 water supply companies) and non uniform interfaces, are reasons for a problematic data exchange. The specialists have to start individual research enquiries at the different data providers, collect, process and import the data into their systems and begin with special prognosis. High costs, time delay and a low data quality are the consequence. These problems have been solved within the presented pilot project, where all participants share their data and work on a unique and actual data base.
One major problem still exists: There are no methods implemented to inform the related decision makers and (in cases of emergency) the protecting institutions about the critical situations without a time delay.

3. Concept

The main idea of the described information system is to enhance the structure, the semantic and the functionality of it in such a manner that an internet-based early warning and a measure system can be developed.

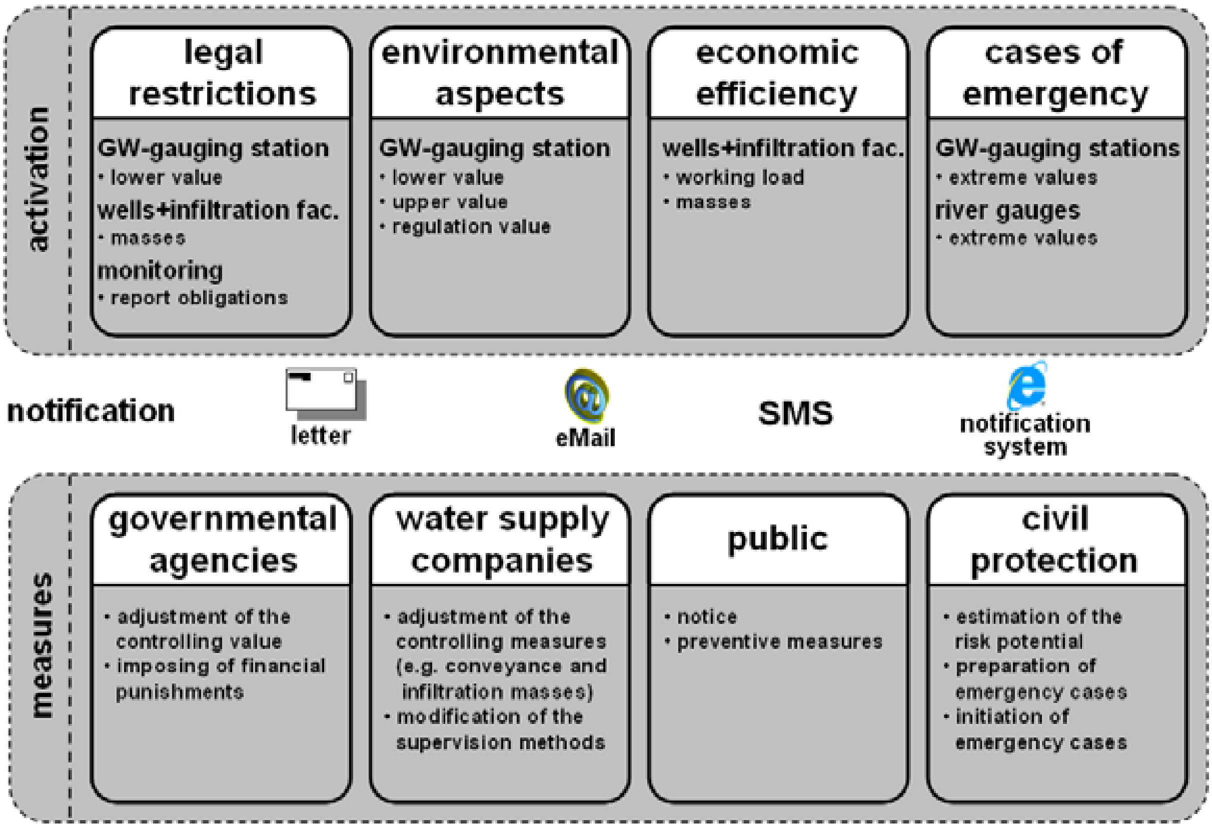

Fig. 2: Overview about activation parameters, initiation methods and measures and involved participants

In the first step the required rules have to be defined. Legal restrictions like the conveyance masses of wells, the infiltration mass of infiltration facilities and boundary values for the groundwater level are the basis for these rules [RP, 1999]. Environmental and economic aspects can require additional rules for an early warning system. Together with the rules, the responsible decision makers, the (counter) measures, existing experiences and evaluation material, which support the involved participants, should be provided to guarantee a consistently basis for decision (figure 2). Over specific online-frontends or the replication of the distributed local databases, the new or updated data is stored in the central server database.

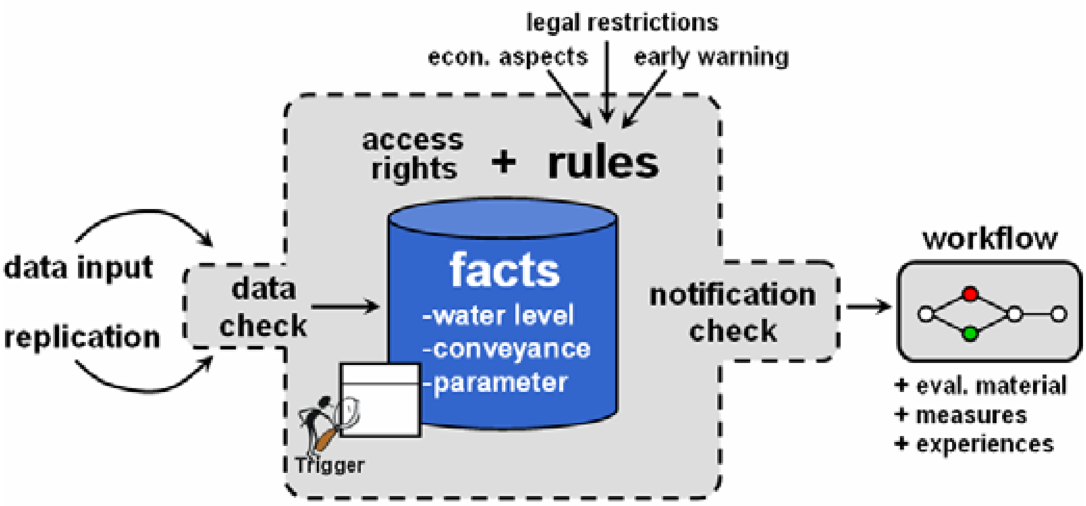

Fig. 3: Structure of the rule-based information system

All data changes (facts) are checked by the defined rules. If a rule is violated, a three-stage notification process starts (figure 3):

Stage one:
The skilled worker who stores the collected data into the database will be informed by the system about the violation of a rule to verify (and to revision) the logged value immediately. If the critical value is confirmed and stored in the system, the second stage will be activated by the system automatically.
Stage two:
The predefined decision makers from the company in which the critical value occurs will be informed by the system. One of the authorised decision makers can decide which measures have to be initiated. The range starts by ignoring the problematic value up to informing the related governmental agencies, the protecting institutions and the public (stage three). Their basis of decision is supported by the system. Lists, diagrams and spatial evaluated maps for the specific area and time-period can be generated.
Stage three:
Over an internet-based workflow-component a structured notification-process can be initiated by the responsible decision maker. The system can offer a predefined workflow with all involved participants. This workflow can be dynamically adapted to the actual task or a completely new workflow can be generated. The workflows consist of the participants, the sequence, the tasks and the processing time of each participant. All the materials can be added to a workflow, so that all participants can work on the same data base. All documents can be modified or added by new files (like statements, expertises etc.).

To assist the participants in an active way in the case of emergency a knowledgebase has to be developed to store all existing knowledge about the measures, which have to be initiated. Experienced specialists have the opportunity to feed the system with their experiences, so that the knowledge can be shared between other authorised users.

4. Technical Realisation

To define and to check rules various software tools (e.g. JESS, NxBRE, GotDotNet, AgentOCX) can be used [Friedman-Hill, 2003]. After an intensive analysis of the existing requirements (e.g. <100 rules, semi-complex rules, sparsely rule-alterations, many facts, online and offline verification of the rules), the interference machine was implemented in the software code with RuleML as the underlying schema and encapsulated in a DLL, which can check the rules in the local applications as well as in the internet system [Boley, 2001]. All modifications of the input facts are logged in a separate table and are associated with the corresponding decision makers. The notification in the second stage is realised by an individual task-manager (comparable with MS Outlook tasks). The workflow-component in the internet is developed by using ASP.NET. A special focus lies on the mapping of workflows between the participants. Emergency cases, participants, tasks, rights, processing time etc. have to be created dynamically by using a graphical component in the internet. During a running workflow process it is often necessary to involve new participants and to provide specific information for them. Therefore the SVG technology has been used. The defined emergency-workflows will be started by a responsible decision maker. All involved participants will be informed over selectable media (e.g. eMail, SMS). All activities are logged in the database to supervise the progression and to reproduce special points of interest in critical situations (figure 4).

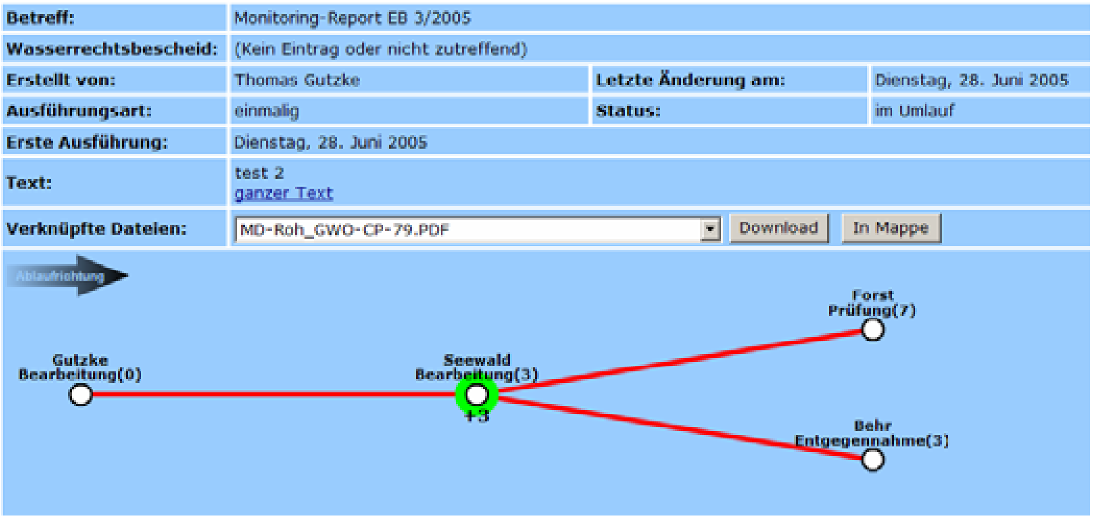

Fig. 4: Supervision of a running workflow process

5. Conclusion

Based on the extensive raw data, collected with the “Grundwasser-Online” information system, a rule and knowledge-based alert and notification component has been developed. By the use of RuleML and an internetbased workflow management system it is possible to support the governmental and the industrial control-processes in an active way.

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