



INTEROPERABILITY OF INFORMATION SYSTEM COMPONENTS FOR MONITORING OF SEWAGE AND INTELLIGENT ANALYSIS OF WATER RESOURCES

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Abstract. The interoperability problems of distributed databases are important in the developing of the operatively working web services aimed for all sectors of public administration. The following web services are designed for solving tasks in water resource management and contamination evaluation sector with a due attention to the international environment protection context. The paper is devoted to problems of developing the component-based architecture of the integrated decision-support system that afford ground for the monitoring and intellectual analysis of water management. Such investigations are made according to the requirements of European Union (EU) Water Framework Directive, Sustainable development Directives and EIONET ReportNet infrastructure. The main components of decision-support system are analyzed by using different knowledge modelling and web service development techniques. The structure of water resource management information system (WRMIS) becomes the core of the decision-support system in which web services are implemented. The main components for evaluation of processes of contamination and water monitoring are represented by data warehouse structures. The solutions to satisfy the interoperability requirements are demonstrated by architectural design decisions of the system, integrating the distributed data warehouses and geographical information system means. The web services are based on common portal technology. The organizational and political arrangements require deeper and stronger participation activities by all member states of EU in reporting, understanding the importance of sustainable development problems and risk evaluation possibilities.

Keywords: web services, sustainable development, water contamination, decision support system, distributed information systems, interoperability.

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1. Introduction

The realization of the intellectual, working on-line decision support system requires the developing of the innovative web portal infrastructure with embedded intellectual components. The system is designed for the public administration sector in solving sustainable development problems in environmental protection and water resource management field. The integrated, working on-line system must create the possibilities to combine the information from all the participating data warehouses, giving an opportunity to extract useful information by the use of available functions and tools. The multi-component interoperable structure is needed to develop for these purposes in web environment. Web services will provide all types of information for users with different responsibilities. Novel work organization methods, knowledge systems, modern information-communication technologies are of great significance in supporting sustainable development management problems in web environment (Leibowitz, Megholugne 2003; Zavadskas *et al.* 2007; Baltrėnas *et al.* 2008; Dzemydienė *et al.* 2008). Web portal infrastructure is constructed for managing, saving and receiving environmental water sector information on different levels of participator's responsibilities (Jacobsen, Maskeliunas 2003; Komatsoulis *et al.* 2008).

We understand the interoperability as “the capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units” by recommendations of ISO 2382-01.01.47. Interoperability can be examined in different aspects of understanding its framework, concerning physical, empirical, syntactical, semantic, pragmatic, and social layers (Egyedi 2007).

To comprehend globalization phenomena, problems of economic development, trends of information and other technologies evolution, as well as the problems of animate nature, coordination of actions, social security and law are of the most significant trends for progressive development of regions (countries) under development. The social understanding of interoperability concerns intentions, responsibilities and consequences behind the expressed statements and commitments shared as results.

The sustainable development management and administration are organized by envisaging very important problems for:

- Development of industrial potential aims are forwarded for reducing expenses, improving working conditions, diminishing of risk, and implementing of new activity extension opportunities;
- Understanding the abilities for analysis of risk and arising threats;
- Backgrounds of legal regulation of unsustainable factors;
- Assessment of situation and planning strategies and their creation;
- Understanding scientific achievements and technological progress;
- Analysis of sustainable development indicators and connection with possibilities to define the regional situation in many aspects.

The principles of environment protection consist of multiple components and make up a totality of requirements that can be presented as standards of enterprise functioning, requirements of healthy human environment, permission for functioning, taxes for cause pollution

etc. (Analysis... 2006; Baltic 21 2003; Swanson *et al.* 2004; Mickaitytė, Zavadskas, Kaklauskas 2007). These principles give rise to a very serious problem of legal regulation, the significance of which must be analyzed in multi-dimensional complexity and relations with all kinds of in legal system. The current situation recognized in data management and reporting in the water sector resulted in the following findings. The water types have a strong division between groundwater, marine water and fresh (surface) water (Mysiak *et al.* 2005; Richter *et al.* 2003). A lot of data are available at many different locations, in different types of databases, with a high degree of dedication and specialization (Karnegy, Filion 2005).

The aims of this work are to show the possibilities to integrate the distributed data-bases of water management into web portal understanding the requirements of social and pragmatic interoperability, and using physical technological possibilities to describe e-services for public administration. We use data exchange standards of extensible markup language (XML), simple object access protocol (SOAP) messaging and hypertext transfer transport protocol (HTTP), Web Service Definition Language (WSDL), universal description discovery and integration (UDDI) registry for realization of the main interface components of water management portal.

The core of this on-line working system is the water resource management information system (WRMIS) that allows the access to the information distributed in different data warehouses and to recognize the situation on the surface water quality in rivers and lakes, ground water, and point sources (emissions). A detailed description of the main components of monitoring and decision-making is given. The advantages of web service-based solution are presented by solving problems based on services offered by information systems, while estimating proposals in what ways to simulate situations, to make an intellectualized environment pollution estimation by an object. For improving the information system structure and services, research work is pursued.

2. Substantiation of sustainable development management

The solutions of risk management must be solved in accordance with deeper organizational efforts of interstate, inter departmental and interregional cooperation in a new way of understanding the complexity and possibilities of unsustainable development. The conception of sustainable development includes the way to match two different and sometimes contradictory attitudes as follows: “development – progress – growth” and “stability – security – environment“. Brundtland Commission has brought forward this dilemma. They were the first who had defined the objective of sustainable development: „*Sustainable development is the process that meets present requirements without comprising the ability of future generations to meet their own needs*“.

Seeking to achieve a sustainable development of the town, planners face the underlying problems (in Lithuania and other similarly developed countries of Europe):

- Municipalities do not possess land proprietary rights;
- The majority of cities have not prepared any strategic or general plans for town development that correspond to the conditions of market economy as well as the principles of sustainable development;

- New territories are being reclaimed for constructions, while social, technical and communicational infrastructure stay behind hopelessly;
- The majority of construction objects are being built within a very long time and this necessarily causes a high price for buildings;
- The work quality of city passenger transport is getting worse.

The general objective of sustainable development is to protect and improve the quality of life. Therefore, both preventives need new innovative management methods which have a global influence on sustainability. People, however, appreciate many moments of environment that are not related to the physical part of environment such as aesthetics, cultural environment, rural areas attainability and quietness as well. Again, inhabitants are concerned about very material things that are not environment at all. Material standards of living, social health and security, education opportunity, public health care, completeness of life, personal career possibilities, self-expression, community, culture, social life, recreation – all these things are treated as a part of the quality of life.

This research study is aimed to analyze activities of enterprises, institutions, and organizations according to some components of sustainable requirements dealing with the ecological sustainability, cleaner goods manufacturing, and economic growth. The water management and water quality treatment is one of important problems related to environment protection, survival of variety of biological life cycles, and implies many requirements for a sustainable management (Baltic 21 2003; Swanson *et al.* 2004, Dzemydienė *et al.* 2008). The current situation recognized on data management and reporting in the water sector resulted: having different treatments of water types (ground-water, marine water, surface water etc); a lot of data are available in many different locations, in different types of databases. The amount of data to be stored and analyzed will dramatically increase in the near future. This results in some difficulties to share data: no strong tradition for coordinating and sharing the data and knowledge. We illustrate the distribution of rising needs of the consumers of water resources in the cities placed near the Baltic Sea region, by the demographical data presented by Nordregio fixed geographical map picture (Fig. 1). The rising needs of water resources influence the sewage quality management issues.

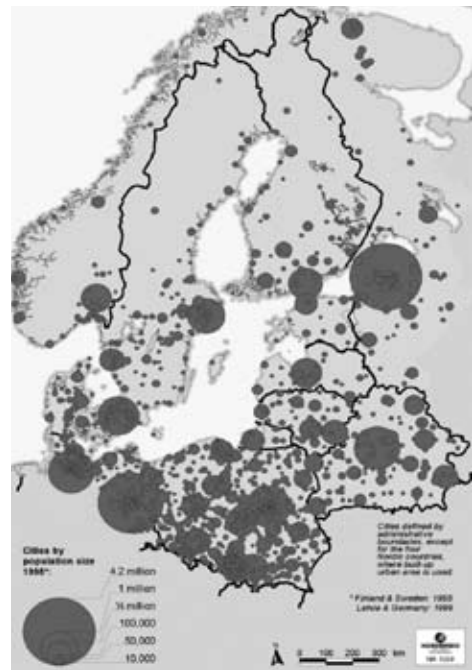


Fig. 1. Illustration of distribution of consumer service needs of water resources in the Baltic Sea region by the demographical data of Nordregio¹

¹ Cities with > 10 000 inhabitants in the Baltic Sea Region. <http://www.nordregio.se/bsr/fig02-05.jpg>

In the light of these attitudes of sustainable development, researchers have raised the purpose to determine the possibilities of cities' development, at the same time evaluating various factors that influence the extents of investments in different towns for a cleaner environment.

The activities of large enterprises, institutions, and organizations should be based on versatile responsibility of enterprises and stimulation of efficiency, paying ever more attention to the requirements of sustainable development and to the issues of environment protection: strategic and tactical planning and control, estimation of economic-social balance, application of information technologies and constant check systems, as well as to legal regulation effect.

The described decision-support system helps in analyzing the development processes of enterprises in accordance with water evaluation. We suggest that the means should be based on responsibility of enterprises and stimulation of efficiency, paying even more attention to the requirements of sustainable development.

3. General solutions of component-based decision-making system development for evaluating water contamination processes

The core of our decision-support system and portal web service realizations is the information system – WRMS that realizes main interoperable functions of distributed information systems of water data storage. This water resource management information system (WRMIS) is developed under the project “Transposition of the EU Water Framework Directive in Lithuania” (Carl Bro as and AAPC 2003). The EU Water Framework Directive (Directive 2000/60/EC) and the future European environmental data reports repository ReportNet (Saarenmaa 2002) imply.

3.1. The constructions of the core system

Main principles of water resource management information system development:

- a holistic approach (requiring integration of data and knowledge from different institutions and regions);
- high data storing, analysis and reporting requirements;
- assured interoperability based on XML Web Services, SOAP, HTTP protocols;
- requirements for reporting in a format of GIS maps.

On the other hand, the detailed guidelines and software tools of ReportNet for Water sector data have not yet been finalized.

A focus area for the WRMIS prototype is to facilitate an easy dataflow between the institutions and give access to data for relevant institutions and the public.

Most of the existing environmental information systems have evolved during a long period of time. Also, they stem from different traditions. Therefore the systems are found to be both heterogeneous and scattered – without many possibilities to use data and information in an integrated manner. In the years to come it will be a necessity to combine data from many

sources to better understand the environmental processes and to be able to make the required reporting. It is possible to overcome these barriers by creating an environmental portal.

Also, it has been cleared up that the main general challenges to be met in developing such environmental portals:

- Ownership of data;
- Telecommunication/Digital infrastructure (allowing sufficient Internet throughput);
- Maintenance and development (i.e. involvement of more institutions, regional departments of the Ministry of Environment; integration with external data warehouses and Web Services – for reporting the EU etc.): institutional setup, manpower;
- Openness and a proper public participation.

The various types of data providers to the system require that some special software should be available for them. It can be achieved by implementing a Client/Server system, based on services at the participating data warehouses.

The scheme of relationships between main components of the water resource management information system prototype, corresponding to the mentioned requirements of technical interoperability is presented in Fig. 2.

The databases and allocated tools have to be secured by restricted access.

A distributed database system, based on data warehouses (DW) and web services, was chosen because it improves both the quality of data and the value of the reports. It allows us to eliminate some of the boring and time-consuming work associated with collection of data from different sources and bringing it on a format so to be used in the common context. In addition, it has been decided that the system should be independent of which type of database provider is selected. This is the case where the following tools are used:

- 4th-generation-language development environment suitable for a Rapid Application Development;
- The whole access to the databases should be performed by use of SQL;
- XML and its technologies should be used for data exchange and presentation.

Continually we have to evaluate the situation according to the sustainability in the given region. For this purposes we deal with the decision support, integrating main components for evaluation of environment contamination processes (Dzemydienė *et al.* 2008).

Decision-making aimed to on-line evaluation of the pollution processes of an enterprise deals with: the complexity of structures of processes; multiple subsystems with complex mechanism interacting of internal or external parts; time and space/geographical dependencies; great volume of data acquired from the processes; multi-criteria decision-making; causal, temporal relationships and interaction of processes.

The complexity of structures of processes, multiple subsystems with their own complex mechanism interacting as internal or external parts, time and space/geographical dependencies, a great volume of data acquired from the processes, and multiple-criteria decision making are essential features for the analysis and representation of such an application domain.

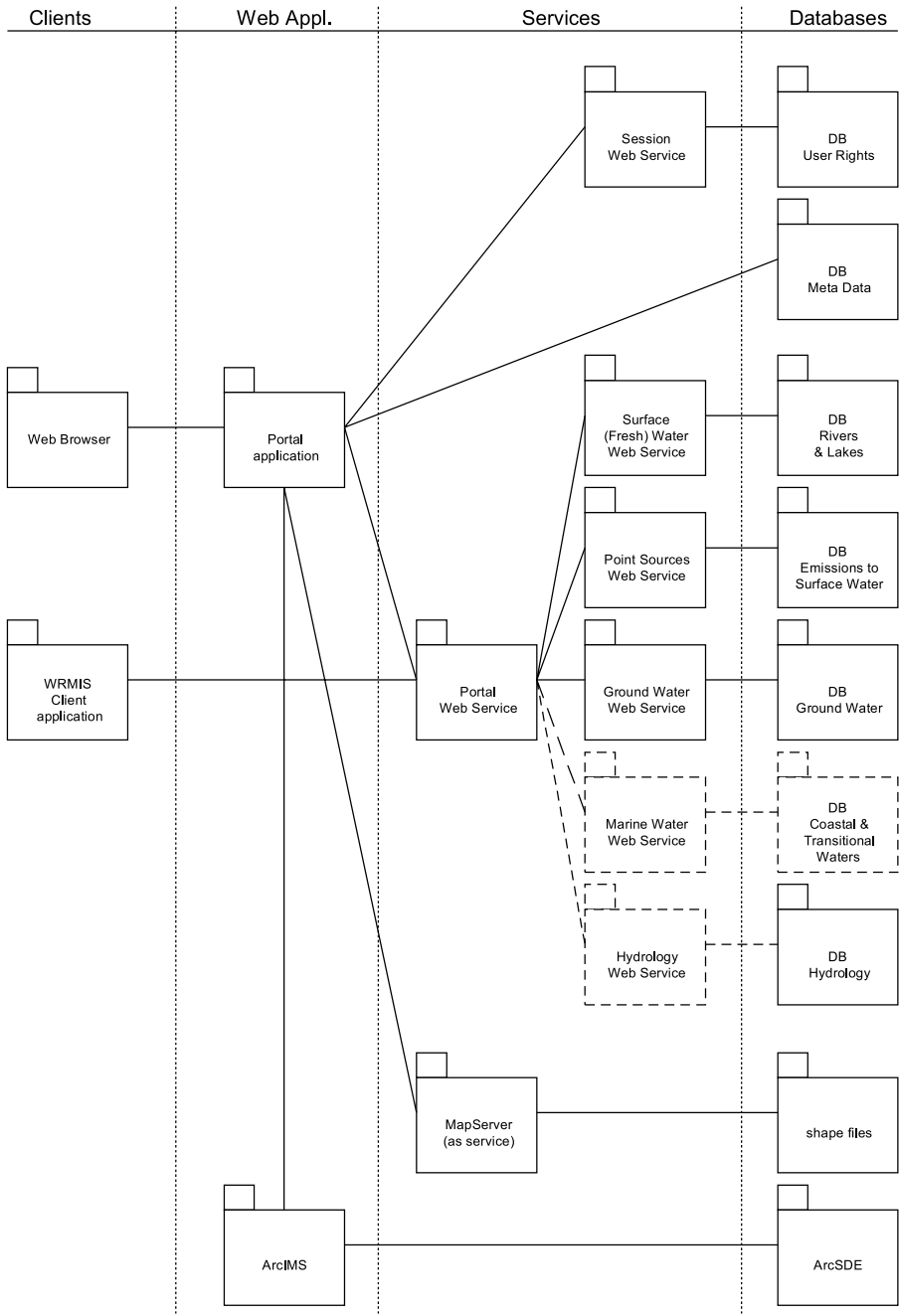


Fig. 2. The structure of interconnections of packages of the water resource management information system

3.2. Knowledge-based description of processes for evaluating contamination

The main purpose of the advisory system is to assist in environment protection control processes, creating of suspect profiles by giving computer-aided instructions, planning and situation recognition techniques. The advisory systems may also improve legal training, for example, providing environment protection agencies with advice on the type of information required by inspection to reduce the pollution activities. As an example, we consider the activities of enterprises, firms, and organizations, i.e. the main stationary objects, to estimate pollution of water bodies. In line with the object functioning nature, the project reflects information on the activities pursued while the license defines the limit in which environment pollution is allowed, i.e. limits of pollutants cast are drawn. Besides, the objects must give reports according to their activities pursued and in line with statistical account ability forms.

The level of representation of dynamical aspects shows the dynamics of observable processes. The multiple objective decision-making deals with the analysis of information obtained from the static sub-model taking into account all possible measurement points revealed in dynamic sub-model of such a system. Further actions, operations, etc. are determined through the mechanism of cooperation of agents that are working by using the temporal information registration window.

A dynamically changing environment imposes time constraints. Many problems are to be solved simultaneously. The values of the observed parameters may change dynamically, depending on time and the events occurring. Solution of different problems is interfered with one another. For instance, the high concentration of harmful material thrown out into the air is related with the risk factors referring prevention of links that are of biological significance and time-dependent, etc. Another essential aspect of such an application domain is its spatial dimension. While in many other application domains the problems of study are within a very precise and, usually, narrow frameworks. For instance, the contamination problem of an enterprise (e.g. manufactory, firm, and plant) deals with spatially varying phenomena of unbounded limits.

The complexity of environment research problems consists in the complexity of criteria and differences of attitudes.

The knowledge representation framework supports organizational principles of information in a static semantic model. The model of behavioral analysis of the target system shows the dynamics of observable processes. One of its characteristics is a need for a lot of data to properly model and verify these problems.

Let X_{ext} denote the extension of a concept X_{con} with respect to its extensionality and X_{int} denote the extension of a concept X_{con} with respect to its intentionality. Then, the definition $(\forall x/X_{ext})(\exists pp/X_{int})(\forall p/pp)p(x)$ is the intentional representation of a concept X_{con} .

Three types of abstractions of relationships between chosen concepts are used in constructing a semantic model: generalization, decomposition (aggregation), and transformation.

Generalization abstraction defines the type of intention “concept – concept”: $E_j IS_A E_i$, where another generalizes one concept, is defined by the set of other concepts.

Apart from time evaluation property, E-nets have a much more complex mechanism for description of transition work, some types of the basic transition structures, a detailing of various operations with token parameters. In addition to Petri nets, two different types of locations are introduced (peripheral and resolution locations).

The exceptional feature is the fact that the E-net transition can represent a sequence of smaller operations with transition parameters connected with the processes.

It is possible to consider the E-net as a relation to (E, M_0, Ξ, Q, Ψ) , where E is a connected set of locations over a set of permissible transition schemes, E is denoted by a four-tuple: $E = (L, P, R, A)$, where L is a set of locations, P – the set of peripheral locations, R – a set of resolution locations, A – a finite, non-empty set of transition declarations; M_0 – an initial marking of a net by tokens; $\Xi = \{\xi_j\}$ – a set of token parameters; Q – a set of transition procedures; Ψ – a set of procedures of resolution locations.

The E-net transition is denoted as $a_i = (s_i, t(a_i), q_i)$, where s_i is a transition scheme, $t(a_i)$ a transition time and q_i – a transition procedure. In order to represent the dynamic aspects of complex processes and their control in changing environment, it is impossible to restrict ourselves on the using only one temporal parameter $t(a_i)$, which describes the activity delaying, i.e. the duration of transition (Noe, Nutt 1973). The input locations L_i' of the transition correspond to the pre-conditions of the activity (represented by the transition in Fig. 4). The output locations L_i'' correspond to post-conditions of the activity. The complex rules of transition firing are specified in the procedures of resolution locations Ψ and express the rules of process determination.

A concrete parameter of token obtains a definite value according to its identification, when the token is introduced into the location $b_j(\xi_k)$. Such a combination of locations with the tokens in them, the parameters of which obtain concrete values, describes a situation for process execution.

Such an understanding of the transition procedure enables us to introduce the time aspects into procedure of control of processes and determine operations with token parameters in time dimension.

The exceptional feature is the fact that the E-net transition can represent a sequence of smaller operations with transition parameters connected with the event/process. Operations are described in the transition procedure with these parameters $\Xi = \{\xi_j\}$.

The E-nets support a top down design in a graphical representation manner. The hierarchical construction of dynamic model is simplified by representing macro-transition and macro-location constructions.

More in details we consider the example of the analysis of water resources and the pollution of the enterprise sewage. The production pollutants enter the water in some cases.

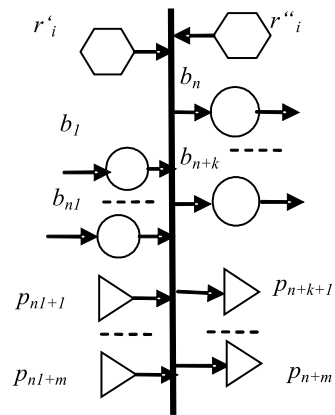


Fig. 4. The common transition schema of E-net representation

Such cases we find out by the construction of E-net distribution processes of sewage in the enterprise (Fig. 5).

The harmful materials that are represented by peripheral locations of the E-net (Fig. 5) are very important for evaluating the water pollution of an enterprise:

- $p_{1,1}, \dots, p_{1,n}$ are materials included in water efflux;
- $p_{2,1}, \dots, p_{2,n}$ are waste materials from the primary sewage purification plant;
- $p_{3,1}, \dots, p_{3,n}$ are waste materials from the common sewage purification plant;
- $p_{4,1}, \dots, p_{4,n}$ are materials entering into open reservoirs, that are not detained in the sewerage system of the enterprise;

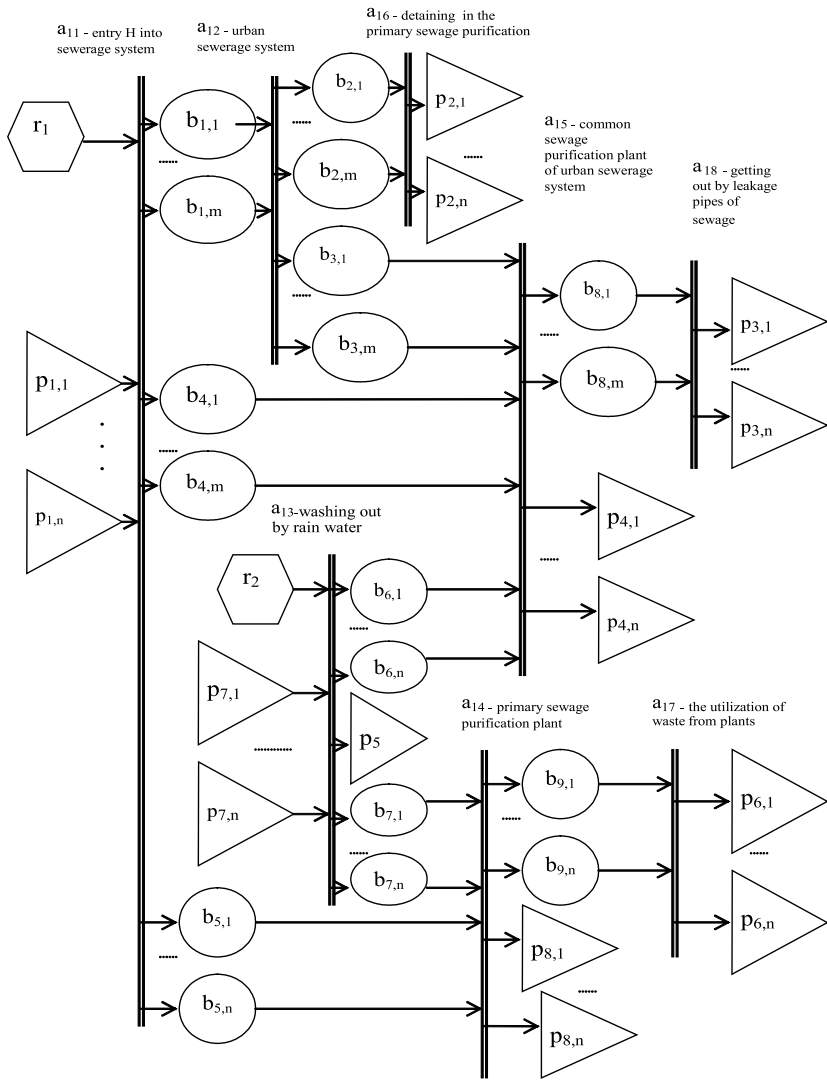


Fig. 5. The E-net of distribution processes of harmful materials in the water of enterprise

$p_{5,1}, \dots, p_{5,n}$ are materials entering into open reservoirs, if there is no rainwater collection system;

$p_{6,1}, \dots, p_{6,n}$ are utilized wastes from primary purification plants;

$p_{7,1}, \dots, p_{7,n}$ are materials entering into rain water if they are stored openly in the enterprise territory;

$p_{8,1}, \dots, p_{8,n}$ are materials entering into the external reservoir from the primary sewage purification plant.

The E-net structure, which describes the decision-making process, gives visually the parameters needed for control and the control structure relation with tasks and decisions.

4. Web portal structure for water management by requirements of interoperability of information systems

The portal has been developed as a web portal, where the users can receive information related to WRMIS according to the water framework directive (WFD). It combines data from the participating data warehouses (DWs) and gives the users an opportunity to extract useful information by use of the functions and tools available.

The portal has been developed by Active Server Pages (ASP – server-side script engine for dynamically-generated web pages, and it communicates with the DWs by use of SOAP/XML (see an example of ASP code for generating SOAP calls in Fig. 6). The portal gives access to information on: surface water quality, ground water, and point sources (emissions).

```
Dim xmlDocRoot, xmlDocChildren
Set XMLClient = Server.CreateObject("MSXML2.ServerXMLHTTP")
SoapText=SOAPCallBegin+"<SOAPSDK1:GetSites xmlns:SOAPSDK1=""urn:SfinxIntf-ISfinx"">"+_
    "<ASessionId>" + CINETSessionID + "</ASessionId>" + _
    "<ARegionNo>" + ARegionNo + "</ARegionNo>" + _
    "<ASiteId>" + ASiteNr + "</ASiteId>" + _
    "<AStartDate>" + "1995-12-30" + "</AStartDate>" + _
    "</SOAPSDK1:GetSites">" + SOAPCallEnd
SoapServer = SOAPServerURL
Call XMLClient.open("POST",SoapServer,"False")
Call XMLClient.setRequestHeader("Man", "POST" + " +SoapServer+ HTTP/1.1")
Call XMLClient.setRequestHeader("MessageType", "CALL")
Call XMLClient.setRequestHeader("Content-Type", "text/xml")
Call XMLClient.send(SoapText)
Set ObjXML = XMLClient.responseXML
Set xmlDocRoot = ObjXML.documentElement
Set xmlDocChildren = xmlDocRoot.childNodes
Set xmlDoc = Server.CreateObject("Microsoft.XMLDOM")
xmlDoc.Load(ObjXML)
Set objXSL = Server.CreateObject("Microsoft.XMLDOM")
objXSL.async = false
styleSheet = StylesheetDir & "\siteinfo.xml"
objXSL.load(styleSheet)
```

Fig. 6. Example of SOAP call to “getSites” by using ASP

Table 1. The main operations of web services of the developing portal

Operation	Description
ListOfRegions	Returns a list of region IDs and names
ListOfSites	Returns a list of site IDs and names
GetSiteInfo	Returns site information, such as name, coordinates, distance to river mouth, etc.
GetSamples	Returns a list of sample dates for the specific site
GetAnnualMeans	Returns annual means for a specific monitoring site in a specific period
GetAnalysisResults	Returns raw data for a specific monitoring site and period
ListOfPS	Returns list of point sources
GetPSInfo	Returns main information for a specific point source
GetPSOutlets	Returns raw data for a specific point source and period

The portal includes services where the users can have useful information related to the WFD and the WRMIS, including links, documents, and news.

A login procedure has been established on the WRMIS portal to secure that only registered users can have access to the available information. The WRMIS system administrator has special rights to the system, that give access to maintain the system by updating the news, links, documents, meta database, and the system administrator is responsible for granting rights to the system users. The list of portal Web Service operations is in Table 1.

The UDDI registry of WRMIS Web Services is developed for internal purposes, having in mind that exposing it freely on the Internet increases the security risks (Data Junction 2002).

4.1. Surface water database (DW1)

A data warehouse has been established based on data of “Water monitoring in rivers and lakes (VANMON)” database. Database structures similar to the VANMON database have been created in Oracle, and an interface by use of a database SOAP server has been established on top of the database. The database server provides SOAP-based Web Services with basic functions for using and maintaining the database, e.g. selection from, update of, and appending to the WRMIS VANMON database.

By connecting to the WRMIS portal and selecting a Surface Water item in the menu, the user is able to retrieve data from a specific river monitoring station. He has a possibility to select a site and get all the analysis results stored in a table form, and to save the retrieved data as an Excel spreadsheet.

The dropdown box with regions is the result of a SOAP call to the Surface water data warehouse. When the user selects a region in the dropdown box, or when the user clicks on a region in the map, a new map and an additional drop down box with sites appears. This

map can be zoomed to the selected region. In the map the site and river layers are visible, and the site layer is click-able.

The surface water Web Service has the next operations: Init, Meta Tables, Meta Fields, Reload Meta Data, Add To Table, Delete From Table, Update In Table, Select From Table, Select From Table(2), Joined Select, Replace Lookup Select, Union Select, and Get Object.

4.2. DW1 client application

For the WRMIS VANMON database a special client application has been developed, that enables the users to update the central WRMIS VANMON database by using the Internet. The application makes it possible for the staffs both in the Regional departments and in offices of EPD to work with the common data.

The application can be downloaded from the WRMIS portal and installed on a local PC. The use of this application is managed by the WRMIS VANMON database administrator, who grants user rights to all users.

The client application, the portal SOAP server, and the database SOAP servers have all been developed by use of Delphi. The server applications run on the Internet Information Server, while the client application can run in a Windows environment on the local PCs.

4.3. Point source database (DW2)

A second data warehouse similar to the surface water data warehouse was established on top of the point source (emissions) database. The system gives access to information on outlets from point sources. The database was made up by redesigning and integrating separate annual FoxPro databases into one common database.

The functionality of the Point Source database and the corresponding Web Service is rather similar to that of the Surface Water database.

4.4. Ground water database (DW3)

The third data warehouse has been found in the Geological Survey of Lithuania (GS). The WRMIS staff in GS has elaborated this data warehouse in the Java environment. Web Services that give access to information stored in the GS Oracle Ground water database have been developed and made available on the Internet.

The technology used:

- Programming language (lgt.* classes), Java JSDK 1.4 API
- SOAP server (SOAP Servlet), Apache SOAP v2.3.1
- Servlet Container (Web server), Apache Tomcat 4.04
- Database (geological dataset), Oracle8 Enterprise Edition Release 8.0.6.2.0
- Link to Database, Oracle JDBC Thin JDBC Driver
- Server Operating System, SunOS 5.8 (Solaris 8) Generic_108528-17 sun4u sparc SUNW, UltraAX-i2

- Server Platform (hardware), Sun Fire V120 Server, 650 MHz UltraSPARC-IIi

The WRMIS prototype has a wide use of digital maps in the GUI both for presentation and administration purposes. All digital maps are stored either in ArcSDE, or in shape files. The system uses maps for selecting data. Two map servers have been developed, making it possible for the users to receive information in a map and to compose their own maps on request. The first solution has been developed by means of the MapServer (hosted in EPA) and shape files. The MapServer is an open source development environment²; MapServer functionality is easy to integrate in Internet-based GIS applications. Another solution has been achieved by use of ArcIMS and ArcSDE (hosted in the Ministry of Environment).

A meta-database with information on the digital maps used in the Map tools has been formed. The meta-database holds information described as mandatory in the ISO 19115 standard³.

The system is ready for data interchange with external Web Services. Also, the system can be easily improved to share information on digital maps with external systems by implementing, using and supporting the OpenGIS Web Map Server (WMS) and Web Feature Service (WFS). Both Mapserver and ArcIMS can be configured to support WMS.

A large amount of measurement points at different time and conditions causing overlapping and conflict between different observations, and the inaccuracy of measurements and reports.

The example of recognition of situation in efflux of water is demonstrated by the data of sewed pollutants during 2001–2005 years in Vilnius city (from the data warehouses of the Statistical Department) and presented in Fig. 7.

5. Conclusions

Consequently, intelligence programs have been developed, leading to recognition of a field of activity, called contamination analysis, which has been described as the identification of and the provision of insight into the relationship between environment data and other potentially relevant data with the view to specialist experts. A key part of this approach enforcement is to understand those activities, through the development and use of methods, models and tools for collecting and then interpreting the large volume of data available in real time for environment protection investigation. Some issues for qualitative information representation including statistical analysis are considered.

The water resource management information system proves that it is possible to establish a Web portal that provides the users with information on request, in a system based on decentralised data sources. This project has also proved that it is possible to integrate information from different institutions, based on different technology, into a common information system by means of the Internet, XML and Web Service technologies, and by bridging to the well-known existing systems.

² <http://mapserver.gis.umn.edu/>

³ <http://www.isotc211.org/scope.htm#19115>, <http://www.isotc211.org/publications.htm>

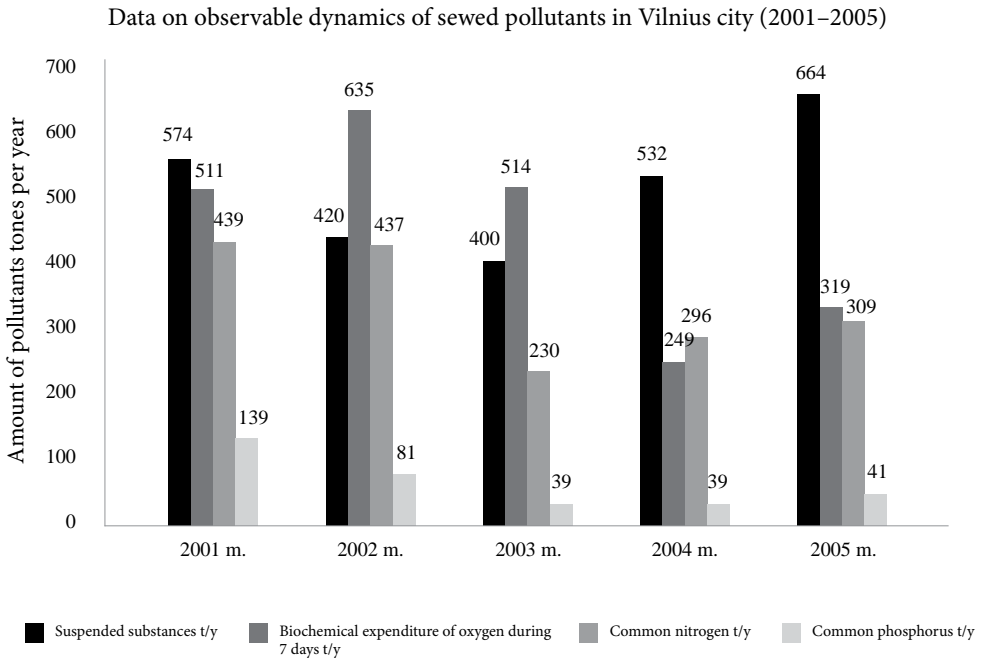


Fig. 7. The example of recognition of situation in efflux of water by data on observable dynamics of sewed pollutants in Vilnius city (2001–2005; Source: Statistical Dept. data)

The WRMS system architecture is designed both to serve a centralised and a decentralised solution. It is therefore possible to configure a system so that the database servers were placed at different geographical locations as well as at the same place. A centralized solution with all the servers placed in one centre can be maintained by a highly skilled staff that can both maintain the hardware, and the software. Such a centre ought to have a powerful equipment and Internet connections and the uptime for services should be close to 100 %. The disadvantages are that data, in many cases, are at the hands of people that have none or but little knowledge on the use of data. There is therefore some risk that the staff have vague motivations for the system performance and further development.

Another solution can be based on decentralized data warehouses, where different topic centres are responsible for the maintenance of their own data warehouse. This requires for a competent manpower able to have the servers running as well as to administrate and maintain the software and databases at each data warehouse.

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INFORMACINIŲ SISTEMŲ KOMPONENTŲ SĄVEIKUMAS VYKDANT NUTEKAMŲJŲ VANDENŲ STEBĖSENĄ IR INTELEKTYNĄ VANDENS IŠTEKLIŲ ANALIZĘ

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Santrauka

Vandens išteklių valdymas ir nutekamojo vandens kokybės vertinimas yra viena svarbiausių problemų, susijusių su aplinkos apsaugos ir žmonių sveikatos uždaviniais. Vanduo yra vienas iš pagrindinių išteklių visiems biologinės įvairovės gyvavimo ciklams egzistuoti. Vandens kokybės reikalavimai daro įtaką daugeliui darniosios plėtros reikalavimų. Aplinkos apsaugos principai susideda iš daugelio tarpusavyje sąveikaujančių komponentų. Didelių įmonių, institucijų ir organizacijų veikla turėtų būti grindžiama įvairiopa atsakomybe už daromos veiklos ir žalos aplinkai padarinius.

Nagrinėjami informacinių sistemų, vykdančių vandens užterštumo stebėseną ir analizę, sąveikumo užtikrinimo klausimai. Informacijos perteikimo metodai yra svarbūs kuriant konsultacines sistemas, kurios padėtų spręsti daugelį sprendimų priėmimo problemų, vertinant kompleksinius aplinkos taršos procesus. Šiame straipsnyje analizuojami pagrindiniai sprendimų paramos sistemos kūrimo komponentai aplinkos vertinimo sektoriuje, leidžiantys efektyviau spręsti šias problemas naudojant E-tinklus (vertinimo tinklus, t. y. Petri tinklų praplėtimą). Modeliai, leidžiantys atvaizduoti ir vertinti sprendimų priėmimo procesus, projektuojami keliais detalumo lygmenimis, taikant semantinio informacijos struktūrizavimo ir imitacinio modeliavimo priemones. Taršos procesai stebimi vykdant monitoringą, pirminius duomenis fiksuojant daugiamatėse duomenų saugyklose ir perteikiant vartotojams sprendimų paramos sistemos analizės priemonėmis. Aprašomi vandens išteklių ir nuotekų kontrolės duomenų analizės modeliai ir gauti rezultatai. Straipsnyje analizuojami pagrindiniai sprendimų paramos sistemos komponentai ir sprendimams priimti svarbūs vandens ir aplinkos vertinimo rezultatai.

Reikšminiai žodžiai: pasaulinio tinklo paslaugos, darnioji plėtra, vandens tarša, sprendimų paramos sistema, išskirstytų informacinių sistemų sąveikumas.

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