Web-based tool for Environmental Risk Assessment and Management

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Abstract: - Although the international and EU legislation and guidance on risk assessment and management is well defined, a commonly agreed framework and procedures are still lacking. An attempt in this direction has been made within the STRiM project and the Web-based tool for Environmental Risk Assessment and Management has been developed to support the application of the proposed STRiM framework in the specific environmental case studies. This tool is used to describe the environmental case studies, perform qualitative risk assessment and risk management options appraisal, and provide automatically generated reports. It integrates a map server to handle GIS maps, Risk Assessment indicator database and document database. In this paper the emphasize is on the applied 3-tier architecture and the application of AJAX, Java Server Faces and Enterprise JavaBeans technologies in the implementation of the Web-based tool for Environmental Risk Assessment and Management. The tool has been successfully applied in four case studies covering different types of environmental risks (damage from flooding, forest damage from storms, water pollution and wetland loss from water abstraction).

Key-Words: - Web-based Applications; Decision Support Systems; Risk Assessment; Risk Management

1 Introduction
Society is increasingly aware of the need to manage its activities in a way that minimizes the risks of environmental damage. In recent years, there has been a shift from reactive measures to protect the environment to more proactive approaches aimed at preventing or minimizing (rather than remediating) environmental damage and loss. Risk assessment (RA) has established itself as an essential tool for the management of environmental risk. Its primary goal is to inform decision making, thus supporting environmental protection. However, for this to be achieved, it is imperative that RAs are undertaken within legally mandated decision making processes. There have been some attempts to integrate RA in legally mandated and widely implemented procedures such as EIA (Environmental Impact Assessment) and SEA (Strategic Environmental Assessment), but they have been ad hoc in nature (Finnveden et al 2003 & Demidova & Cherp, 2005) and there is still no universally agreed methodological and procedural framework as to how to accomplish this integration. STRiM (Remotely Accessed Decision Support System for Transnational Environmental Risk Management) project, addresses this issue by embedding RA within EIA and SEA procedures into STRiM Risk Assessment and Management Framework. This enables decision makers to make informed decisions which incorporate uncertainty, to facilitate transboundary environmental protection.

Web-based tool for Environmental Risk Assessment and Management (ERA&M) has been developed within the STRiM project. Functional requirements specified this tool to be Web-based (accessible via web browser), portable, scalable and reliable application, available to large number of potential users in different countries and on different platforms. In order to best satisfy all this requirements, the three-tier client-server architecture with thin client was used in development. Another request was that during development and implementation, Open Source softwares (Database Management System, Integrated Development Environment and Application Server) were to be used. This way the additional costs were avoided for non-commercial use.

After a brief description of the STRiM framework, an overview of the architecture and technologies applied in ERA&M is given.

2 STRiM Framework
STRiM Risk Assessment and Management Framework is generic in nature and primarily based on the DEFRA (2002) Environmental Risk Management guidelines due to their focus on risk management and applicability to various types of environmental risk. It can be applied to a wide range of hazardous activities and environmental systems,
and across a diversity of spatial and temporal scales. ERA&M, developed within STRiM project, facilitates an automatic Qualitative Risk Assessment based on the user’s estimation of risk specific magnitude of impacts and three probabilities contributing to risk: probability of hazard occurring, probability of receptor being exposed and probability of harm occurring. It also supports Options Appraisal of different risk management options using Multi-Criteria Analysis (MCA) and enables the selection of the best option according to the multiple criteria defined for the assessment of management options. This tool is a Decision Support System (DSS) for Environmental Risk Management, which enables environmental administrators and decision makers to carry out generic risk assessment and management identifying areas where detailed risk assessment is needed as well as appropriate risk management options. For each new case study the application guides a user through the six steps of STRiM Risk Assessment and Management Framework:

- **Step 1. Initiation** is the starting point of any RA or RM, which entails the consideration of the need to perform the assessment.
- **Step 2. Problem Formulation** is composed of four components: baseline description, potential risk identification and components description, identification of risk generating processes and definition of boundaries and controlling factors.
- **Step 3. Generic (Qualitative) Risk Assessment and Management Process** includes qualitative risk assessment of selected hazards and options appraisal of appropriate management options.
- **Step 4. Risk Management** evaluates and discusses the preferred risk management options and monitoring strategy.
- **Step 5. Risk Communication** specifies the risk communication procedure followed in the case study.
- **Step 6. Monitoring** plays a central role throughout the STRiM risk assessment and management and is performed in order to gain continuous or periodic information about aspects of an intention before its beginning, during its lifetime and after its finishing point.

To support and illustrate the main claims made in the Problem Formulation step, the user is able to upload a particular set of GIS thematic maps for each case study.

In order to test the functionality and applicability of the STRiM Risk Assessment and Management Framework as well as ERA&M, as part of the project, four pilot case studies have been created. These pilot studies are: Keritis watershed risk assessment and management of water pollution (Crete, Greece), Risk assessment and management of wetland loss resulting from water management processes in Axios delta (Greece & FYROM), Assessment and management of flooding risks in the Sava river basin (Bosnia and Herzegovina, Serbia and Montenegro) and Generic Risk Assessment and Management for storm break in the national parks of Sumava (Bavaria and Czech Republic).

### 3 System Architecture

ERA&M is a Java application based on Java Enterprise Edition 5 (Java EE 5) and three-tier client-server architecture. For the development and implementation of this application, the Open Source database (PostgreSQL 8.2), Integrated Development Environment (NetBeans IDE 5.5.1) and Application Server (Sun Java System Application Server 9.1) are used. Because one of the main requests was that users can use this tool anytime anywhere from their web browser, thin client three-tier architecture was implemented. This three-tier structure has proved to be immensely useful for enterprise application development. The three tiers are: Presentation tier, Business tier and Data tier (Figure 1.).

The presentation tier contains ERA&M Web pages, the business tier contains one Enterprise Java Bean, Working Session, while data tier contains ERA&M Database, STRiM GIS, RA indicator database and document database.

ERA&M serves as an integration platform for the other components of the system: map server (IMS), indicator database and document database.

Indicator Database contains a set of environmental indicators for risk assessment for different environmental domains collected from a number of existing and generally used environmental databases.

STRiM GIS acts as a spatial database which contains the thematic maps needed for better assessment of risks. These thematic maps are attached to case studies developed using ERA&M. The document database contains documents describing relevant RA&RM legislation, risk communication guidelines, possible pathways and receptors, which should help a user in the preparation of a specific case study.

#### 3.1 Data Representation

ERA&M Database is a relational database used to store information about the objects in ERA&M application: users, case studies, baselines, hazards, risk generating processes, boundaries, controlling...
factors, magnitude of impacts, probabilities, risk prioritization, management options, options appraisal, risk management, risk communication, monitoring etc. This relational database is implemented using a Postgres engine, version 8.2. The database schema is designed to provide obvious, consistent, and efficient access to the data and referential constraints are enforced to insure data consistency.

Fig. 1. Architecture of ERA&M

There are 38 tables that are basically divided into groups that correspond to 6 steps of STRiM Risk Assessment and Management Framework.

3.2 Business Tier
The business tier is the most important part of this system. It contains:
- Working Session, which performs retrieval and storage operations for the Initiation, Problem Formulation, Generic Risk Assessment and Management Process, Risk Management, Risk Communication and Monitoring steps of the STRiM Risk Assessment and Management Framework.
- MS Server Components used for handling GIS files, fetching data from STRiM GIS and communication with the underlying UMN MapServer.

Working Session is a Stateful Java Session Bean running in Enterprise Java Bean (EJB) container of
the Application Server. All communication with the ERA&M Database is performed in this session bean using the corresponding JDBC driver. Besides performing database retrieval and storage operations for the data describing case studies, this session bean is also responsible for the construction of reports and the selection of the best risk management option using Multi-Criteria Analysis.

3.3 User Interface

The Web-based tool for Environmental Risk Assessment and Management offers an intuitive, user-friendly interface (Figure 2.). It is implemented using Java Server Faces (JSF) technology to facilitate an easy use of the application functionality.

![ERA&M user interface](image)

Having defined the weightings you are then asked to consider all possible management solutions for each specific hazard, and characterize them using the fixed drop down menu according to their social acceptability, feasibility, effectiveness in risk alleviation, duration, cost, and required skills and know-how. Once you have completed this process for all risk management options of each hazard press next and you will be provided with the best management option ranking.

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Receptor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Damage resulting from river flooding</td>
<td>Excessive rainfall and snow at River network</td>
</tr>
</tbody>
</table>

**Fig. 2. ERA&M user interface**

Developed through the Java Community Process (JCP), JavaServer Faces is a server-side application framework, included in Java EE 5, which establishes a standard for building Java web-based user interfaces. Along with a component-centric development model, JSF provides a highly flexible rendering architecture that defines a loose coupling between component behavior and presentation.

In order to provide a richer, faster user experience, ERA&M also uses Ajax (Asynchronous JavaScript and XML) technology. Ajax is a combination of asynchronous JavaScript, Dynamic HTML (DHTML), and XML, which enables web applications to perform partial updates to a web page rather than reload a page in its entirety.

There are several strategies that provide a way to add Ajax functionality to a JavaServer Faces technology-based application. These are:

- Dynamic Faces
- Ajax4JSF
- Icefaces
- AjaxAnywhere
ERA&M uses Dynamic Faces because it provides a flexible, efficient way to add Ajax capabilities to existing JSF technology-based application without giving up on any of the benefits provided by the JavaServer Faces component model. This is most easily done by using fireAjaxTransaction function, one of the JavaScript functions that Dynamic Faces provides. As its name suggests, it fires an Ajax request in response to a particular event, such as clicking on a component. As such, this function gives the developer component-level control over what is updated in the page. Figure 3. shows one example of Ajax usage in ERA&M. When user selects the map from the list of uploaded maps on the left, selected map description is retrieved from the server using Ajax and displayed in the Map Description text box on the right without the need of refreshing and rendering the entire page.

The following piece of the JSP page shows how the fireAjaxTransaction function is used to update Map Description text box via Ajax:

```html
<webuijsf:dropDown
  binding="#{Boundaries.
    intentionMapsDropDown}'
  id="intentionMapsDropDown"
  items="#{Boundaries.
    intentionMapsDropDownDefaultOptions.
    options}'
  onChange="DynaFaces.fireAjaxTransaction
    (this,
      {execute:'form1:intentionMapsDropDown',
      render:'form1:intentionMapDescriptionText
    Field'});
  style="font-size: 16px; left: 264px;
    top: 609px; position: absolute;
    width: 153px"
  valueChangeListenerExpression="#{Boundaries.
    intentionMapsDropDown_
    processValueChange}'"/>
```

4 Conclusion

In this paper we have described some implementation details concerning the application of a 3-tier architecture and some web-based techniques in the implementation of the Web-based tool for Environmental Risk Assessment and Management. The first impressions in the exploitation of the system were positive and several case studies conducted within the STRiM project proved its usability and validated the defined requirement specifications. By applying the JavaServer Faces and AJAX technologies in the development of the system an easy, intuitive and comfortable user interface has been developed.

Having in mind the non-functional requirements regarding the use of Open Source development software and platforms, we have chosen Java Enterprise Edition 5 (Java EE 5) as a working environment for the ERA&M application. Java EE 5 is not dependent on specific operating system (Windows, Unix, Linux, …) and there is a lot of Open Source software for both, developing and running the applications.

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