Tisza River Information System (TRIS) – A GeoData Server and Spatially Enabled Internet Applications for Water Resources Management

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Abstract – One of the objectives of the "Tisza River Project" was the establishment of real management oriented exchange of data and information among the countries sharing the Tisza basin. This objective was achieved by developing the web-based Tisza River Information System (TRIS), designed by the DGHM from the FSU-Jena. TRIS is based on Open Source Software (OSS) components comprising the object relational database management system (DBMS) PostgreSQL, and extended by a GIS component (PostGIS). TRIS is implemented as a GeoData Server containing GIS data layers, time series, documents and metadata (ISO 19115). Flexible and time saving access to that database is guaranteed by web-based interfaces for data visualization and retrieval.

Keywords: GeoData Server, Map Server, GIS, Integrated Water Resources Management.

1. INTRODUCTION

The EU project "The Tisza River Project - Real-life scale integrated catchment models for supporting water- and environmental management decisions" (Contract No: EVK1-CT-2001-00099) dealt with the use of integrated catchment modelling tools to help solving the most critical water and environmental problems in the Tisza River basin in line with the relevant EU policy objectives, aiding amongst others the introduction of the Water Framework Directive of the EU in the countries of the Tisza Basin.

Multiple water and environmental issues have to be handled in this large basin because it is seriously affected by water pollution from both point and non-point sources including accidents like the catastrophic cyanide spill in 2000. Furthermore floods are the main quantitative issue in almost all flatland regions of the basin. There is also a growing international concern about the state of the aquatic ecosystem with special regard to wetlands of the floodplain. The three years project has terminated at the end of 2004.

The research partners jointly working on that project were distributed in seven European countries which required a sophisticated data assessment and information management comprising geo-referenced distributed data components, measured or simulated time series, and socio-economic information.

Networking international research structures by means of the internet pose new challenges to Geoinformatics in respect to a web-based distributed data base, metadata and GIS-information management, geo-referenced data query and visualization. Such data management must include powerful and efficient data exchange and information sharing policies and software tools to ensure that decision making can jointly be done on the base of the best information available.

A literature survey (ANZLIC, 2000, 2005; FGDC, 1997; UNRCC-Americas, 2001; UNRCC-AP, 1997; PCGIAP, 1998) revealed that there are numerous attempts to organize and coordinate national, regional and global geo-spatial data. However, integrating such diverse data and information as specified in the Tisza River Project objectives (see below) and required by the project consortium has not been reported so far in the context of such a program.

2. OBJECTIVES

River basin water research is based on the principles of integrated systems analysis and resides on knowledge obtained from research done to understand the complex interactive process dynamics across scales. The latter requires the collection and managing of diverse data and information comprising beside others point related time series related to water quantity and quality, socioeconomic census data, and digital maps presenting the spatial distribution of such information.

From this diversity the following **conceptual objectives** for the Tisza River database have been identified:

(i) The system must be able to handle geo-spatial information as 'hard' and 'soft' data have a geographic reference that can be specified by a Cartesian coordinate system.
(ii) The structure of the data and information administration must reflect the differentiation of the river basin's 'real world' subsystems. The latter in turn comprises generic components based on the natural environment within the global setup as well as basin related components which reflect the regional basin conditions.
(iii) The system must have the ability to integrate the different kinds of data and information so that the needs of the decision making process and of the design of "what-if-scenarios" for dynamic system modelling can be served.
(iv) Information and knowledge from past research should be organized in a river basin information system accounting for the conceptual structure of the 'real world' river basin.
(v) The system's structure must be flexible enough to make extensions depending on the progress of the system's understanding within the researchers and decision makers community.

(vi) The sophisticated data assessment must include raster layer, vector data from GIS coverages, measured process data and metadata for model parameterization. Furthermore there are needs to integrate multidisciplinary information and research knowledge related to Integrated Water Resources Management (IWRM) comprising information obtained from remote sensing, GIS analysis, modelling, and socio-economic assessments for vulnerability and mitigation.

In addition to these conceptual objectives some important **technical objectives** must be met if the international Tisza River database should be successfully applied not only in the Tisza River Project but also in present international research programs:

(vii) Common GIS data formats like e.g. the Arc-View shape files and other map formats must be supported in terms of import, export and visualization.
(viii) Distributed installations must be realized in a Web-based 'thin client-server' design.
(ix) Software for the DBMS and its components should be available on demand.

3. METHOD

The methodological approach for the establishment of the web-based international Tisza River database comprises:

- Examination of existing data bases with respect to homogeneity, correctness, and plausibility.
- Setup of a geodata server for storage, processing and analysis of spatial data together with common relational data.
- Implementation of interfaces enabling the online access via Internet.
- Input of vector and raster GIS layers, measured process data and metadata for model parameterization into the project's database.

4. TISZA RIVER INFORMATION SYSTEM

The establishment of real management oriented exchange of data and information among the countries sharing the Tisza basin was achieved by creation of the web-based Tisza River Information System (TRIS), designed and developed by DGHM from the FSU-Jena, Germany, based on OSS components (http://tris.uni-jena.de).

4.1 Setup of a Geodata Server

The examination of existing databases resulted in the choice of a hybrid concept of a DBMS which combines a relational data model with a DBMS extension for spatial data management. This extension transforms a relational DBMS into a so called GeoData server which enables the storage, processing and analysis of spatial data together with common relational data. For this purpose geographic data types are converted to relational data, which then can be handled like any other data type via standard Structured Query Language (SQL) queries. This technology introduces geographic data types, geographic functions, spatial reference systems, spatial indexing, and particular geographic metadata management. Thus data attributes and geodata can be linked, queries of geometric attributes as well as spatial queries can be sent out, and spatial operators can be used.

4.2 Software Implementation

With respect to the project's long-term objective to establish a really operative, international Internet accessible database, software license restrictions as well as costs for software purchase and maintenance had to be considered. Over the last decades, OSS has grown tremendously in scope and popularity. OSS has gained the attention of the Geoinformatics community and created new opportunities for implementing Spatial Data Infrastructures.

There are already several OSS packages available that could be tailored to develop spatial databases and to suite the needs of water authorities in the Tisza River basin. Consequently, TRIS is based on OSS components which are complemented by the developments done by the DGHM from the FSU-Jena, Germany (http://www.geogr.uni-jena.de/geoinf):

- The PostgreSQL data base model (Worsley and Drake, 2002) has been selected as a DBMS. It enables a structured data administration in a normalized data base scheme, is highly extensible, and permits the use of SQL.
- PostGIS (http://postgis.refractions.net/) has been used as the geo-spatial extension to add support for geographic objects to PostgreSQL relational database (Ramsey, 2003). PostGIS "spatially enables" the PostgreSQL server, allowing it to be used as a backend spatial database for GIS. PostGIS follows the OpenGIS "Simple Features Specification for SQL" (http://www.opengis.org/ specs/).
- The visualization of maps is done by means of the University of Minnesota Map Server (http://mapserver.gis.umn.edu/).
- The APACHE Web-Server with its PHP extension is used for the client/server communication (http://apache.org/, http://www.php.net/).

4.3 Data Model

The conceptual and physical data models were created according to the International Standard 19115 for Geographic information – Metadata (ISO, 2003) and have been extended for timeseries and documents.

5. TRIS MAP SERVER

MapServer software - originally developed by the University of Minnesota (UMN) in cooperation with NASA and the Minnesota Department of Natural Resources - was installed as an open source development environment for building spatially enabled Internet applications (Regents of the University of Minnesota, 2003). Beyond browsing GIS data, MapServer allows to create geographic image maps, i.e. maps that can direct users to content.

The architecture of the TRIS MapServer component is based on a complete three tier web-application approach. As a result of this approach, different users can use the same web interface, the kind of functionalities depends on their respective user permissions. The access of functionality and data is controlled by access control lists, each functionality or data of the system can be assigned to a user or user group.

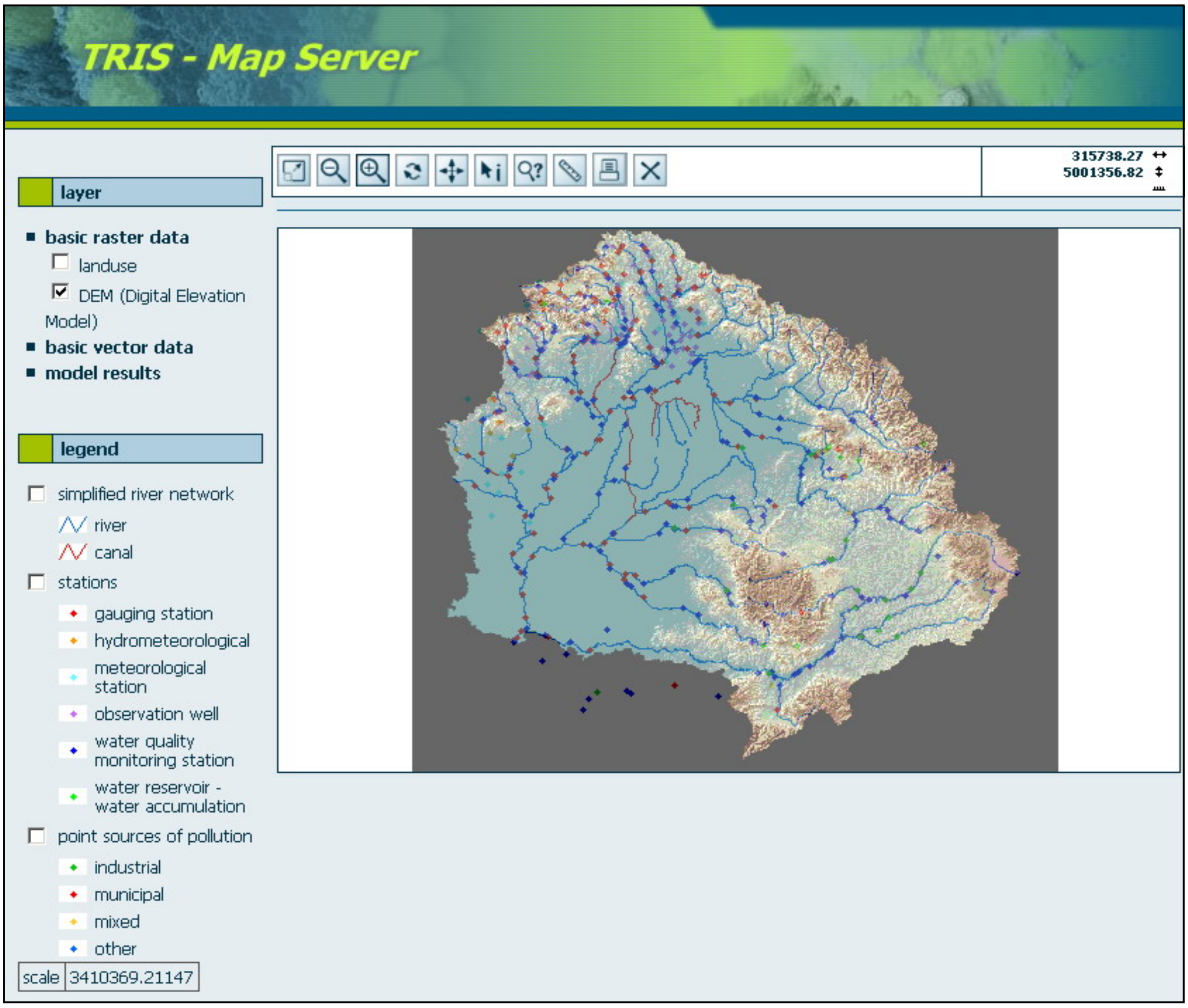

Figure 1. TRIS MapServer showing different raster and vector GIS layers of the Tisza River Basin (http://tris.uni-jena.de/tris).

As the vector and raster data as well as all metadata information are stored in the DBMS, TRIS data could be used by other applications in the future. The integration of the smarty template engine (Ohrt and Zmievski, 2004) and the use of the cascading stylesheed system (css-approach) enables the division of design and content of the whole TRIS application.

The access to TRIS MapServer (http://tris.uni-jena.de/tris) is given with the guest account "trisview" and the password "tris2005". After login to the system, users have access to data and different functions such as map, import, export, spatial operations, etc. The user frontend interface is a separate browser window which is divided in the sections (i) map frame, (ii) layer management, (iii) legend and info selection, (iv) map controls, and (v) coordinates/measurement display (Fig. 1). TRIS MapServer interface offers different standard GIS functionalities as zoom in/out, pan, graphical and attribute search, a measurement tool and the pdf print of a map.

6. TRIS METADATA PORTAL

For each dataset in TRIS core metadata elements must be provided according to ISO 19115 for Geographic information – Metadata (ISO, 2003). The ISO 19100 series is a multi-part international standard for Geographic Information that is being developed by Technical Committee 211 Geographic information/Geomatics of ISO. This standard provides a procedure for describing digital geographic datasets using a comprehensive set of metadata elements. These elements support four major uses: discovery of data, determining data fitness for use, data access and use of data. The standard provides information about the identification, extent, quality, spatial and temporal scheme, spatial reference and distribution of digital geographic data. For the Tisza River Project, this standard has been extended for timeseries and documents.

From the technical point of view, the user completes online html templates which are then transferred to the database by PHP scripts.

	#	Dataset Title	Dataset Contact Person	Map Data
[Details]	1	Zagyva (HU): 5 classes landuse classification of Zagyva catchment (30 m), Hungary	Böhm, Bettina	
[Details]	2	Zagyva (HU): Soil map of the Zagyva River Catchment, Hungary	Corluy, Jan	[Show]
[Details]	3	Zagyva (HU): OTAB - digital map of the surface water system of Zagyva River Catchment Area, Hungary	Zsuffa, István, Dr.	[Show]
[Details]	4	Zagyva (HU): OTAB - digital map of settlements of Zagyva River Catchment Area, Hungary	Zsuffa, István, Dr.	[Show]
[Details]	5	Zagyva (HU): OTAB - digital map of the road-system of Zagyva River Catchment Area, Hungary	Zsuffa, István, Dr.	[Show]
[Details]	6	Zagyva (HU): OTAB - digital map of the railway-system of Zagyva River Catchment Area, Hungary	Zsuffa, István, Dr.	[Show]

Figure 2. Browse of basic geodata in TRIS Metadata Portal (http://tris.uni-jena.de/metadata); the link to Map Server can be activated with the button "Show" in the column "Map data".

TRIS Metadata Portal offers three components for metadata handling: (i) an **input tool** to insert new metadata, (ii) a **query tool** to search for existing metadata, and (iii) an **update/delete tool** to modify or delete existing metadata entries.

The access to TRIS Metadata Portal (http://tris.uni-jena.de/metadata) is given by the guest account "trisview" with the password "tris2005". The navigation menu is splitted into two main topics "Basic data" and "Model results". Both have the subtopics "Geodata", "Time series data", and "Documents", additionally basic data contain metadata about "Station data" and "Responsible parties" while model results contain metadata about "Models". Each subtopic has its own subnavigation.
The browse function is activated by clicking to the subtopic name. Detailed information can be listed with the button "Details" (Fig. 2). The associated layer or feature in the map can be accessed by activating the **link to TRIS MapServer** which is done (i) with the button "Show" in the right column of the data overview (Fig. 2) or (ii) with the button "Show associated map data" in the detailed list.

The detailed listing for time series data offers a visualization interface. For this purpose the following parameters can be specified:

a) a start and end date defining the visualization time interval,
b) whether or not each of the individual timeseries parameter should be displayed.

The timeserie is visualized as a PNG image which is created using the JPGraph library (http://www.aditus.nu/jpgraph).

7. CONCLUSION

The web-based Tisza River Information System (TRIS) was designed and developed by the DGHM from the FSU-Jena, Germany, to establish real management oriented exchange of data and information among the countries sharing the Tisza basin. TRIS accounts for the methodical and conceptual system requirements, and is based on open source software complemented by software developments of the DGHM. A relational data model is used for TRIS which permits a modular component structure required for the regionalization of the distributed system dynamics.
The modular component structure of TRIS provides sufficient flexibility for distributed node installations as required by international research programs. It also accounts for the different security requirements of data providers having their own dissemination policies that can be implemented by the TRIS administrator. As the data model and the software components are adaptive to various river basin setups, the web-based database system will continuously be improved and is ready to be implemented in other EU-projects and regional research programs.

8. REFERENCES

ANZLIC the Spatial Information Council, "Discussion and background papers", Proc. of the ANZLIC Clearinghouse Workshop, 3-4 May, Adelaide, Australia, 2000.

ANZLIC the Spatial Information Council online, 2005. Standards & protocols. http://www.anzlic.org.au/infrastructure_standards.html

FGDC, "Framework, Introduction and Guide", Book of Federal Geographic Data Committee, Washington, 1997.

ISO, International Standards Organization, "International Standard ISO 19115 Geographic information – Metadata", Reference Number ISO19115:2003(E).

Ohrt, M. and Zmievski, A., 2004. Smarty - the compiling PHP template engine. http://smarty.php.net/manual/en/

PCGIAP, "A spatial data infrastructure for the Asian and Pacific region", PCGIAP Publication, No. 1, Canberra, 1998.

Ramsey, P., 2003. PostGIS Manual. http://postgis.refractions.net/docs/

Regents of the University of Minnesota, 2003. MapServer, Current Version 4.0. http://mapserver.gis.umn.edu/

UNRCC-Americas, "Proceedings of the United Nations Regional Cartographic Conference for Americas", USA, January 2001.

UNRCC-AP, "Resolutions of the 14th United Nations Regional Cartographic Conference for Asia and the Pacific", 3-4 February, Bangkok, 1997.

Worsley, J. C. and Drake, D., "Practical PostgreSQL", O'Reilly and Associates, 2002.