MANAGEMENT AND VISUALIZATION OF
INTERDISCIPLINARY RESEARCH DATA WITH ARCGIS SERVER

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ABSTRACT:

Centralized data storage and data exchange is a key issue in many interdisciplinary research projects that focus on environmental field studies and regional modelling on various scales. Furthermore, the overall success of such projects depends on a well organized and prepared graphical representation of spatial project data within web mapping applications.
In this contribution, we introduce the data management system with focus on the management and visualization of spatial data of the inter- and multidisciplinary research project "Transregional Collaborative Research Centre 32: Patterns in Soil-Vegetation-Atmosphere Systems: Monitoring, Modelling, and Data Assimilation" funded by the German Research Foundation.
The data management design is a combination of file management, database, and online-interface including web mapping applications. Management, visualization, and analysis of spatial data are realized with ArcGIS Server connected with ArcSDE, PostgreSQL, and the ArcGIS Server Image Extension. Therefore, the huge amount of spatial data has to be organized well. The established map services are used internal for analysis in ArcMap Desktop clients and external as OGC WMS or WCS. Map services are also used in a Java Web application and in combination with Microsoft Virtual Earth™ as a mashup.

1. INTRODUCTION

The management of research data including data storage and data exchange (between several project sections) is particular important for interdisciplinary research projects which focus on environmental field studies and regional modeling (Mückschel and Nieschulze 2004) on various scales. In this context primarily a well prepared and organized representation of spatial research data is important. Typically this is implemented within web mapping applications ('Web-GIS').

Especially Transregional Collaborative Research Centres (TR-CRC) that are funded by the German Research Foundation and focus on spatial data modeling need a well organized data management including metadata management and web mapping applications. These TR-CRCs are characterized as research projects that are based at separate locations. They are planned to operate for up to 12 years and combine cross-disciplinary research interests and resources. Projects that are funded by the DFG even have the duty to maintain, manage, backup, and document their research data in a sustainable, stable, and permanent system realized in cooperation with a local computing centre. This corresponds with the 'good scientific practice' (DFG, 1998).

In this contribution, we introduce the management and visualization of spatial data within an interdisciplinary research project. This is mainly done with a PostgreSQL database and ESRI ArcGIS Server. Mapping services are used for internal data analysis and external as OGC (Open Geospatial Consortium, Inc) services and in web mapping applications.
The approach will be presented by means of the Transregional Collaborative Research Centre 32 (TR32): 'Patterns in Soil-Vegetation-Atmosphere Systems: Monitoring, Modelling, and Data Assimilation' (http://www.tr32.uni-koeln.de) funded by the DFG.
First of all, a short review about the project background and the whole data management concept is given, following by a detailed description of the management and visualization of spatial data. The contribution finishes with a discussion, conclusion and outlook.

2. PROJECT BACKGROUND AND DATA

The TR32 is a joint project between the Universities of Aachen, Bonn, Cologne, and the Research Centre Jülich. The TR32 research partners cover several fields of hydrology, geophysics, soil, and plant science, remote sensing, meteorology, and mathematics. The focus of this research project is on exchange processes between the soil, vegetation, and the adjacent atmospheric boundary layer (SVA). The overall research goal of the TR32 is to yield improved numerical SVA models for the prediction of water-, CO_2-, and energy-transfer by accounting for the patterns occurring at various scales (SFB-TR32, 2009).
The research area of the TR32 is defined by the catchment area of the river Rur situated in Western Germany, parts of the Netherlands, and Belgium. The field research of several subprojects is focused on three sub watersheds that represent three typical land use forms (forest, arable-, and grass land).
As a result of the interdisciplinary background of the TR32, there is a multiplicity of different data that is produced from the project participants. Beside a huge amount of data that is collected by various field measurements, sensor networks, and flight campaigns, also laboratory data and computational modeling data is created. Results are for example soil temperature, soil moisture, or heat fluxes.

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Adequate geodata in different scales that is needed by several project sections for their research tasks is purchased from various institutions and agencies like the National Survey Agency of North-Rhine Westphalia, Germany's National Meteorological Service or the National Agency of Geology. These data are for example topographic, soil, land use, elevation, weather, or remote sensing data.

Hence, as a result of the huge amount of measurements and corresponding analysis's consequently publications, presentations, pictures, and reports about the TR32 project evolve.

3. TR32 DATA MANAGEMENT AND VISUALIZATION

The visualization of interdisciplinary research data of the TR32 with ArcGIS Server is part of a complete data management structure. Therefore, there will be a short overview initially.

3.1 TR32 data management design

The TR32 data management is primarily a combination of file management and database technologies combined with a Web-Interface (http://www.tr32db.uni-koeln.de) including web mapping functionalities (fig. 1). The enabling of data storage and data exchange for and between different project sections is one of the main duties of the data management. This includes besides the storage and maintenance of corresponding metadata, the supply of backup functionalities as well as the visualisation of collected and purchased project data. It is important to design a stable and sustainable system, with regard to a project duration of maximal 12 years. This system is called the 'TR32 Database' (TR32DB) as already described in Curdt et al. (2008).
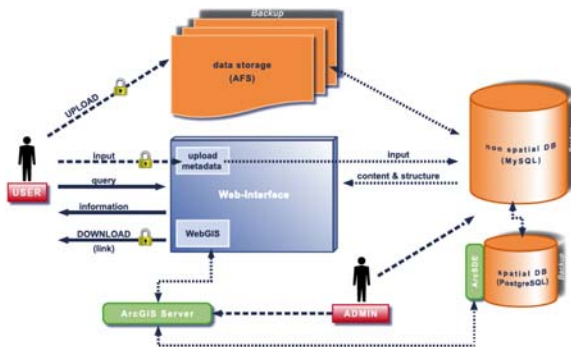

Fig. 1: TR32DB Structure (Curdt et al., 2008)

The physical storage of the non spatial data is in the Andrew File System (AFS), a distributed networked file systems. This system was chosen in cooperation with the Regional Computing Centre (RRZK) of the University of Cologne. Main reasons for the AFS are beside security, scalability, cross plattform access, and location independence, also simple archive and backup funtionalities. A cooperation with the RRZK ensures the data availability past the finish of the project duration.

The AFS is combined with a database. A multithreaded, open-source, relational MySQL database handles non-spatial TR32 data including e.g. administration data and metadata of the TR32 project data.

The Web-Interface provides several functionalities. Basic functions are the representation, search, and download (only

TR32 participants) of non-spatial project data as well as temporary download of purchased and processed geodata (only TR32 participants). However, a main duty is to enable the entry of metadata via the Web-Interface according to uploaded datafiles in the TR32 data storage.

3.2 Visualization and supply of TR32 data with ArcGIS Server

The visualization, analysis, and supply of spatial TR32 data is an important part of the whole TR32 data management. As described before a huge amount of data including spatial and non spatial data needs to be handled.

There are several possibilities to manage and present geodata in a centralized system. In order to establish a sucessful result it is first of all essential to organize the huge amount of TR32 geodata, as already introduced previously.

The geodata are devided into vector data and raster data. Vector data are e.g. the Information System Geological Map, the Digital Landscape Model or the digital cadastral map. Raster data are e.g. topographic maps, digital orthophoto quadrangles, elevation or satellite images.

With regard to the SVA modelling purpose the data is organized thematically accordingly to the SVA structure. Therefore the purchased data is classified in serveral topics like soil, land cover, topography or elevation data. Furthermore, the topics also need to be sorted depending on their map scale levels. For example the topic 'soil' is arranged in order by a ferderal soil map of Germany 1:1,000,000, a regional soil type map 1:50,000 or a local soil information sytem 1:5,000.

Over 30 datasets are used and organised as mentioned above in this approach. The data amount is around 150 GB.

Preparation of TR32 services (server architecture)

The client-server architecture of the TR32 consists of several components (fig. 2). They will be described in detail below.
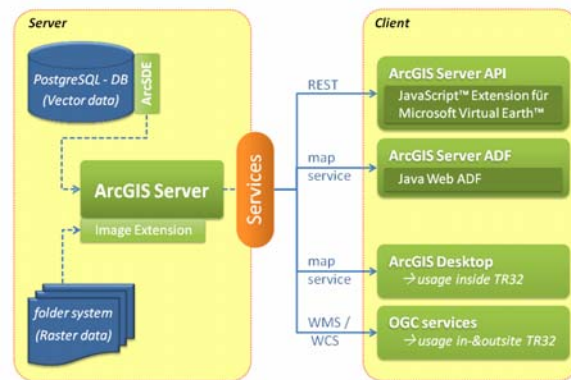

Fig. 2: TR32 – Server and Client Connection

Within the architecture, the storage of the geodata is in two different components, depending on the type of data (vector or raster data).

Hence, all raster data are stored in a folder system on the server. The vector data are stored and managed in the open-source object-relational database management system (RDBMS) PostgreSQL which is extended with PostGIS. The main reasons for this choice are beside the excellent management of geodata

also the possibility to connect the ArcGIS Server via the Arc Spatial Database Engine (ArcSDE) technology.

The ArcSDE technology is since ArcGIS version 9.2 integrated into the ArcGIS Desktop and ArcGIS Server products. The ArcSDE supports the easily storage, access, and management of spatial data within a RDBM, e.g. Oracle or PostgreSQL. Thus, it serves as a gateway between several GIS clients and the chosen RDBMS. (ESRI, 2009a)

The ArcGIS Server is a complete and integrated server based GIS that contains user services and applications for geodata visualization, management, and spatial analysis. ArcGIS Server is a standard based platform that offers complex GIS capabilities and comprehensive data management tools. This promotes a centralized GIS management architecture. ArcGIS Server enables geospatial capabilities using browser based, desktop, and mobile clients. (ESRI, 2009b)

ArcGIS Server comes with several Extensions. Within this contribution the ArcGIS Server Image Extension is used. The Image Extension is a server technology that enables dynamic mosaicking and on-the-fly processing for a large amount of images. Furthermore, a simplified image management and maintenance of the data is supported as well as fast, server-based access times. The access of created services is either through ArcGIS Desktop or Server products possible.

Within the TR32, excellent experiences were gained with the processing of the digital orthophoto quadrangles that have a total filesize for the whole project area of 80 GB. With the Image Extension it is possible to enable a rapid access to the images.

TR32 utilization of services (client architecture)

The access to the TR32 geodata services is possible with several clients (fig. 2). Theses will be described in the following.

Within the TR32 several map services are used in ArcGIS Desktop for analyses, e.g. for the allocation of specific SVA parameters for several important points within the research area. Therefore e.g. an image service of digital orthophoto quadrangles may be joint with a soil parameter. These services are also used for advanced land use classifications (Waldhoff et al., 2008).

Furthermore, ArcGIS Server can publish services that are compliant with the OGC e.g. Web Map Services, Web Feature Services or Web Coverage Services (OGC, 2009). It is possible to use these services in other Clients and without ESRI technology.

For public illustration and for internal use in the TR32, there are several possibilities for web mapping applications with the ArcGIS Server. In the following, two important applications for the TR32 are described.

Within the Java Web Application Developer Framework (Java Web ADF) ArcGIS Server provides an already developed Sample Java Viewer. The main reason for choosing this viewer for the TR32 are already implemented functionalities e.g. accurate identification, cross-fade of layers, drawing, adding map services, OGC support, etc. (ESRI, 2009c). The possibility to expand the Java Viewer with own functionalities is another advantage.

ArcGIS Server also offers the opportunity to build Web applications using a JavaScript™ API (application programming interface). JavaScript™ APIs are characterized as browser based APIs for developing high performance and easy to use mapping applications. They are powered by the REST API. Several JavaScript™ APIs are provided by ESRI that mashup map services, Google Maps, or Microsoft Virtual Earth™ (VE) data (ESRI, 2009a). Within the framework of the TR32 the ArcGIS JavaScript™ Extension for Microsoft VE™ is used. This enables the extension of the Microsoft VE™ API with a TR32 specific map services. The result is embedded in the TR32 Web-Interface (fig. 3).
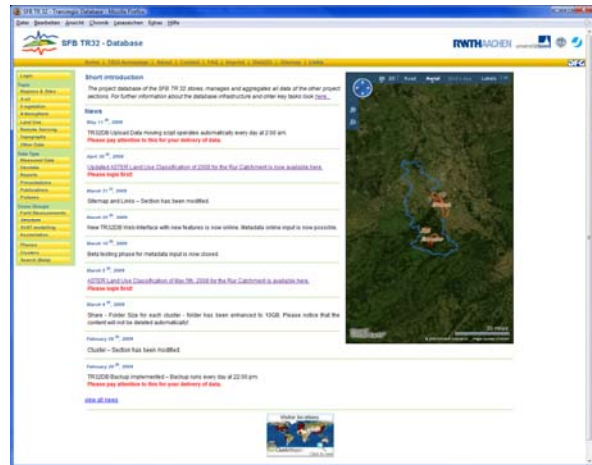

Fig. 3: TR32 Web-Interface with embedded JavaScript VE API

3.3 Implementation principles

The whole TR32DB design is developed according to recent standards and principles (e.g. from DCMI, OGC, ISO and W3C). Programming standards as Java, JavaScipt™, PHP, XHTML, CSS, and SQL are used to develop and customize the interaction between the databases Web-Interface and web mapping application.

4. DISCUSSION, CONCLUSION, AND OUTLOOK

The establishment of web mapping applications within the implementation of a data management system for a huge, long-term, and interdisciplinary research project that focuses on environmental field studies and regional modeling on various scales is essential. The implementation of the web mapping application needs to be developed according to the requirements of the research partners. Therefore, several solutions were chosen as described in the contribution.

With regard to further developments it is planned to implement functionalities for online calculations of specific analysis. Furthermore, the preparation of 'self-made' individual printable maps for TR32 participants should be implemented. In addition, it is planned to link measured field data with purchased geodata for analyze and visualization purpose as well as to present spatial results. Above all, web services could be used for mobile applications, e.g. for field mapping of training areas for land use classifications.

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