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Visualizing geologic data on the web with open source software solutions

Theses of PhD dissertation

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Budapest, 2017

Research background

For long decades, the publication of spatial geoscience data was made with the use of paper maps. The emergence of computer technologies brought about a change, allowing digital maps to be created with the use of them. By the beginning of the 2000s, the evolution of GIS desktop software products and widespread use of the Internet provided the potential to publish digital maps on the Internet, which is nowadays one of the most general tasks of GIS data providers.

Starting from the 1990s, the Hungarian Geological Institute of Hungary was actively involved in applying the latest available technologies related to the GIS area, but at the same time it kept its high level cartographic values, too. The Institute published its first basic web mapping application in 2005, and though the name of the Institute changed in 2012 to Hungarian Geological and Geophysical Institute, it kept its high standards and continued to publish more and more maps on the web.

The rise of open source software development techniques and the continuous evolution of hardware products facilitated the appearance of new software products in every segment of IT, including the GIS area. These new GIS tools are not only free, but also allow developers and users to customize them as needed, which may provide better results than commercial solutions.

Aims

My main motivations in my research was to investigate the aforementioned open source GIS software products for the application of a WebGIS structure, and to create an architecture that may provide a map publishing procedure for geologic maps resulting in interactive web mapping applications. As part of my research I focused on identifying the potential missing parts of the architecture, and to efficiently harmonize the system's elements, from the database storage segment to the client-side visualization. As an objective, I also tackled the problem of migrating databases and cartographic symbols from commercial software products related to geologic data.

Methods

Overview of general WebGIS architectures

As one of the first steps of my research, I provided a general overview of WebGIS structures and their general planning considerations. I divided these systems into three segments irrespectively of the used technology, which are the data storage part, the server side data provider component, and the tools responsible for client side visualization. In the introductory chapter of my dissertation I presented the general WebGIS architectures according to this subdivision.

The first part of the overview investigates the potential available methodologies for data storage and it focuses on how those may facilitate web based spatial data dissemination. The section concludes that for this specific task, relational database management systems offer the best solutions.

Throughout the analysis of server-side components, the functions and responsibilities of crucial hardware parts are described, and some observations are made about how those affect their potential application for certain tasks. Next, the general working principles of server side components were shown, including standardized web services.

The section about the examination of client-side technologies primarily focuses on browser-based solutions; and in this part both plugin-based tools as well as client-side libraries are presented. The latter solutions are based on the native language of the browser's, Javascript, and as a consequence I have shown why those tools present a more future-proof technique for the interactive presentation of GIS data on the web.

Constitution of parallel environments

After investigating general WebGIS architectures, I have created two parallel systems on identical hardware environment; one with open-source software products and the other with commercial ones. Both environments were optimized for geologic data, taking into account network and data considerations. These included, but were not limited to type and volume of GIS data to be disseminated, as well as number of users and their typical usage of the data.

During the creation of both systems the original data storage methodology of the Institute (ArcSDE) was considered as an input parameter of these systems, I therefore investigated how data storage may be GIS software independent. To solve this problem, I have developed a desktop tool for the purpose of converting GIS data from ArcSDE (based on Microsoft SQL Server) to a PostgreSQL/PostGIS environment.

This tool has provided the base for creating the same data background for both WebGIS architectures, thus the parallel systems may only differ in the used technologies, not in the data. The advantages and disadvantages of both architectures were described as well as their detailed structure.

The creation of an open-source architecture

My dissertation gives detailed description about the created open-source WebGIS architecture. The data storage task is solved with the use of PostgreSQL object-relational database with the PostGIS extension, while the serving of the maps and the GIS data was made with the use of QGIS Server, which used the complex cartographic symbols and visualizations made in QGIS Desktop. The client side interactive presentation of maps was created with the use of the Openlayers and Bootstrap libraries.

As I have created this architecture, there were a few missing components. Firstly, the migration of maps and their symbolizations from ArcGIS was a problem to

solve, and the other issue was to somehow provide a flexible client-side framework for the interactive visualization of geologic data.

For the migration of cartographic designs I created a methodology which consisted of two main steps. The first step included reading out the symbolization information from an ArcGIS related format, and the second was to convert these symbolization rules to QGIS Desktop symbolization format. Followed by this migration, cartographic designing of geologic maps may have continued in QGIS Desktop.

Based on the maps created in QGIS Desktop, QGIS Server is capable of starting Web Map Services, and these services then may be consumed by a client side application. Though Openlayers provide interactive visualization in websites, it does not provide a graphical user interface with extendable functionality. For this task I have developed a client side framework that can be parameterized from within a single file. For the development, I also used Bootstrap for the GUI components as well as jQuery for effective Javascript programming.

The developed migration tools and methodologies and the created client-side framework, completed the missing parts of the open-source stack; it thus became possible to disseminate geologic spatial information on the web with open-source software solutions.

Results

1. **I have created a migration utility that made all geologic vector data accessible regardless of the used software technology.** The utility may be integrated as a GUI component into ArcGIS and is capable of migrating enterprise geologic vector data from ArcSDE format to PostGIS. As a result, geologic vector data may be available from within both ArcGIS and open-source environments.
2. **I have worked out the methodology for migrating cartographic symbols from commercial GIS software to an open-source format.** With the application of this method cartographic designing process may be shortened in open-source environments, as the most valuable part of symbolization may be migrated and created automatically from the ArcGIS environment.
3. **For the purpose of visualizing geologic GIS data on the web I have created two parallel architectures with open-source and commercial software products, and investigated their advantages and disadvantages.** Throughout my research I have created a system based on ESRI products and another that based on open-source solutions and standards. In my dissertation I gave a detailed description about how they may be applied for presenting geologic data on the web in an interactive manner.
4. **I developed a configurable client-side web framework which provides data providers a solution to easily create interactive web mapping applications based on geologic data.** After using the previously developed migration tools it was possible to create Web Map Services with QGIS Server based on the high standard cartographic maps created in QGIS Desktop. These services then consumed by the application framework that I have developed, and the coding structure made it possible to configure the application from within a single file, providing a configurable framework that may be used later for multiple themes.

Conclusion

The open-source WebGIS architecture presented in my dissertation proved to be a real contender of other architectures created with the use of commercial software products. The presence of open-source solutions in the WebGIS area may enhances the potentials related to the web map publishing process, but it can be capable of substitute the current ESRI-based web map publishing system, too.

The established open-source system not only enhances the flexibility of web map publishing, but it may also cut down the costs related to GIS software products. At the same time it has to be emphasized that the application of such technology within a whole enterprise or institute requires thoroughly planned strategy and proper human resources.

The developed architecture primarily constructed for geologic data, but at the same time it has to be mentioned that it may be applicable at other areas of WebGIS, which includes vector based maps with high cartographic requirements. The migration tools developed are also can used in other fields of GIS and cartography regardless of the data themes.

Publications and presentations

Publications

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