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ASTROWEB ASTROINFORMATICS PROJECT AND COMPARISON OF THE WEB-GIS PROTOCOL STANDARDS

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Abstract. At this time finished AstroWeb project was implemented some advanced GIS (Geographical Information System) information techniques, based on the one of most commonly used WMS (Web Map Service) protocol. Like a WMS, Open Geospatial Consortium offers another WEB-GIS protocol, named WFS (Web Feature Service). AstroWeb Astroinformatics Project is a good starting point to produce scientific research of this two protocols effectiveness.

1. THE PROJECT ASTROINFORMATICS AND VIRTUAL OBSERVATORY ASTRO WEB

Astroinformatics, the new field for scientific research, arises as a result of applying modern information and communication technology in astronomy. Astroinformatics is an interdisciplinary area of science based on the achievements in data transfer and information services on the Internet.

Leading specialists in the fields of astronomy, math and informatics from various institutions of the Bulgarian Academy of Sciences (BAS), as well as other Bulgarian scientific institutions specialized in other close scientific areas have participated in the Astroinformatics project, which started a few years ago.

Among the goals of the project are building of a compatible interactive database with a web interface and insuring a web access to digitized astronomical data and imagery. Bulgarian scientist and specialists, in cooperation with international initiative are working on building a WFPDB, containing millions of professional astronomical photo-images. The complicated information structure of maintaining data in extraordinarily large volumes brings the need of creating an effective, easily accessed and user friendly informational system with an intuitive interface, easily used by professionals as well as amateur astronomers. Among the achieved goals of the project Astroinformatics is the software solution „Astroinformatics AstroWeb Virtual Observatory", shortly named AstroWEB (Kolev et al. 2012).

AstroWEB is build as to provide a natural and comfortable interface for visualizing and accessing data from the astronomical database WFPDB. The basis of the software solution AstroWEB are open-source software products for creating web-based GIS (Geographical Information System), maintained by the international organization OGC (Open Geospatial Consortium) (http://www.opengeospatial.org/standards). Application of the OGC standards covered in the present realization of AstroWEB, as well as in its future evolutions are discussed in this paper.

2. OGC STANDARDS AND CURRENT REALIZATION OF THE ASTROWEB PROJECT

The Open Geospatial Consortium is an international industrial association, containing hundreds of business organizations, government agencies and universities, all of which support the process of developing and publishing of standards for compatibility of spatial and geographical data and services, predominantly based on web information technology. These standards make possible the technological development of complex spatial databases and online services for visualization and analysis.

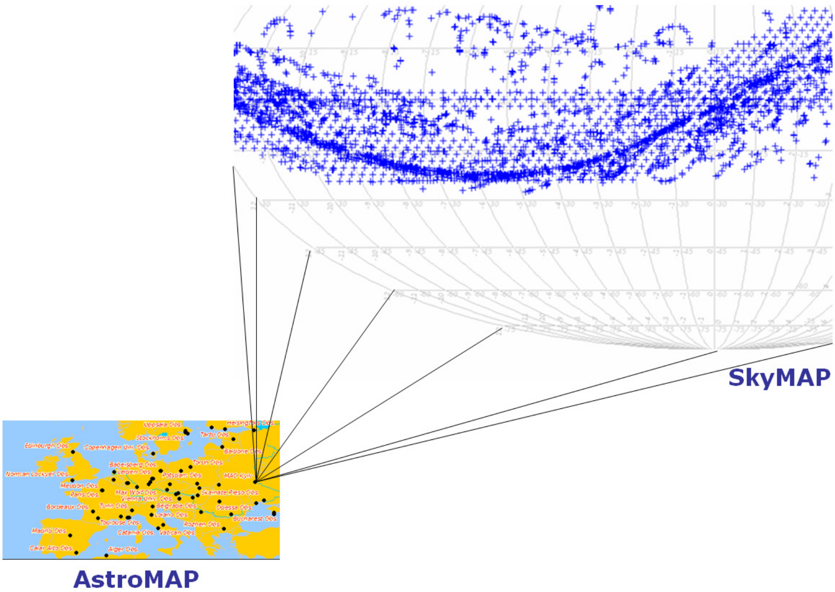

Figure 1: Basic functionality of AstroWEB.

Access to an archive of digitalized images is realized in the functionality of AstroWEB, as data can be accessed from the different observatories by pointing. The basic screen forms AstoMAP and SkyMAP execute this action as shown in Fig. 1. Both screen forms have WEB-GIS properties – scaling, panning, selection of objects, and are dynamically generated by OGC standards.

In the interest of AstroWeb software project are few OGS standards:

- **WMS** (Web Map Service). Provides operations in support of the creation and display of map-like raster data views of geographic information;
- **WFS** (Web Feature Service) Allows a client to retrieve geographic data encoded in GML text data format. The specification defines interfaces for data access and manipulation operations on geographic features and information behind a map image;
- **GML** (Geography Markup Language). Is an XML encoding for the transport and storage of geographic information, including both the geometry and properties (textual and numeric attribute data) of geographic features;
- **SLD** (Styled Layer Descriptor). Is an XML encoding that allows user-defined symbolization of geographic feature data. It allows the system to determine which features or layers are rendered with which colors or symbols.

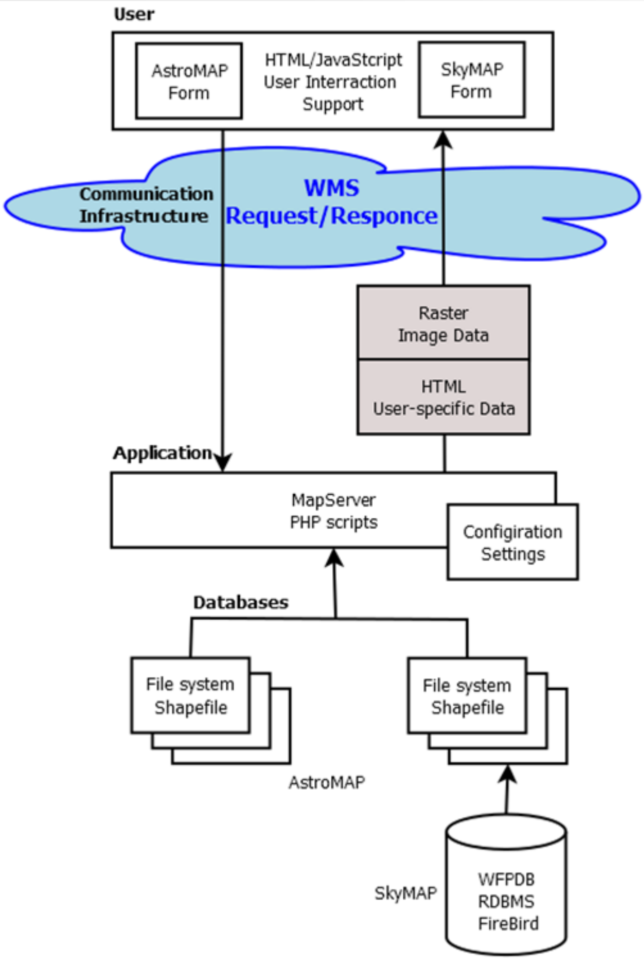

Figure 2: Current AstroWEB realization.

A dataflow diagram is presented in Fig. 2, which illustrates the principal sequence of working stages in AstroWEB.

The current realization of AstroWEB is built adhering to the principals of the WMS standard. The basic software is a FGS (Free GIS Suite http://maptools.org/fgs/), in which a server and client subsystems are included. The server subsystem is built with the MapServer software – a project of a OSCGeo (Open Source Geospatial Foundation http://www.osgeo.org/), in collaboration with OGC (OSGeo http://wiki.osgeo.org/wiki/Open_Geospatial_Consortium).

A dataflow diagram illustrating the principal working stages of the current AstroWEB realization is presented in Fig. 2.

For the needs of the current analysis, details of the basic structural programming modules are presented, which are: **databases, application, communication infrastructure and user layer**.

Databases: The functioning of AstroMAP in the sense of the WEB-GIS application as seen from the database is maintained by a few "shapefile" file structures. Maintenance of the AstroMAP is insured by geographical data in a few commonly based layers and an additional georeffered data layer for astronomical observatories. The functioning of SkyMAP also depends on a "shapefile" structure and provides an image of a selected digitalized archive of astronomical data. The used RDBMS (Relational Data Base Management System) is Firebird, with the information structure WFPDB. The intermediate georeffered data of the "shapefile" type is generated programmatically with WFPDB information;

Application: The most important component in the application layer is the MapServer module. In response to a user request, the MapServer module generates a requested image in a raster format, in addition to specific data in HTML format, which are visualized on a client web-browser, and together create an adequate user interface;

Communication infrastructure: An existing web infrastructure, or a local network with http protocol support. Driven by the user request, the server system generates a response containing graphical data of a raster type in accordance to the WMS standard for building a functioning WEB-GIS system and HTML structure for maintaining the user interface;

User: At the AstroWEB Virtual Observatory's end user disposal is a standard modern Operational Systems WEB browser. The user interface is created using HTML and JavaScript code. The user has WEB-GIS disposal – he is presented with a graphical navigation interface (pan&zoom) though the screen forms AstroMAP and SkyMAP. When selecting an astronomical observatory-type object, the form AstroMAP and a mediary form for digitally archiving list selections belonging to the selected observatory, together generate the relevant SkyMAP form with a graphical image of the requested archive. In the last form the available astronomical objects are visualized in their natural positions on the celestial plane, where the pictogram "filled square" signifies a digitized astro-object, and a "plus sign" signifies an object from the catalog which isn't yet digitized. Selecting the "filled square" pictogram draws additional information about the digitized object and previews the digitized Wide Field Plate.

3. POSSIBLE REALIZATION WHEN APPLYING A WFS STANDARD

Fig. 3 represents a dataflow diagram which describes AstroWEB's software operation under the WFS standard. We'll note the main differences between it and the version using the WMS standard.

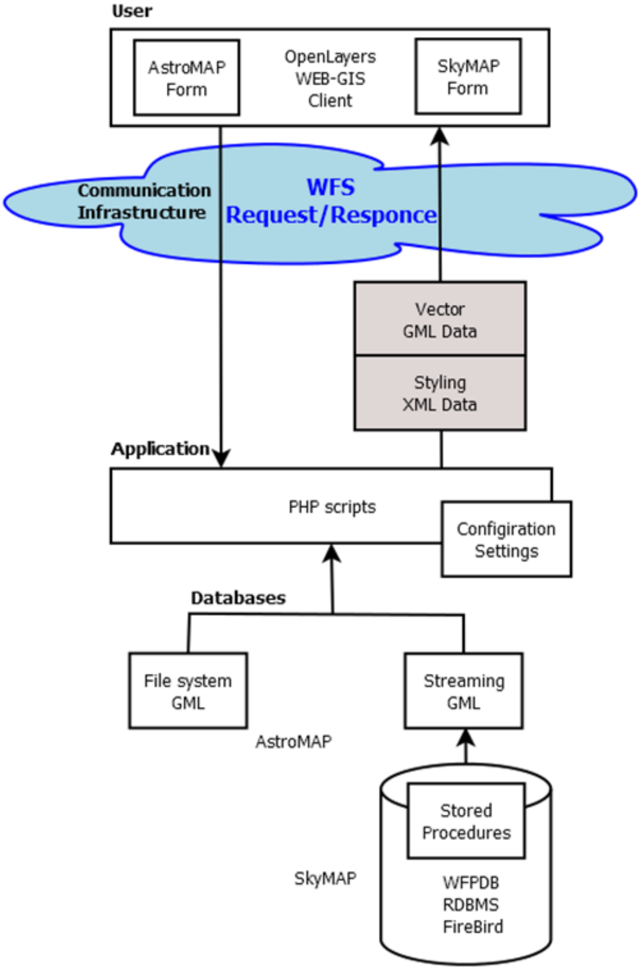

Figure 3: Possible AstroWEB realization.

Database: In addition to the aforementioned current realization, a "stored procedures" programming code is defined in the RDBMS Firebird. With it, the screen form AstroMAP uses georeferred data of a file type with a structure under the GML standard. The screen form SkyMAP uses data of the same type. When processing a user request, the "stored procedures" generate GML data of a stream type that isn't saved as files on the file system;

Application: Consists of a server script which communicates with the RDBMS and processes user requests.

Communication infrastructure: In contrast to the aforementioned realization, here the response to the user request is in conjunction with the WFS standard's requirements for building WEB-GIS systems. The data sent to the user is vector georeferred data in GML format and graphic style data used for visualization in an SLD format;

User: Like in the previous case, the client module is a standard web browser. The WEB-GIS functionality of the screen forms AstroMAP and SkyMAP are maintained by the specialized client software OpenLayers. OpenLayers is an open-source product of OSGeo and insures the necessary functionality when presenting geographical data in different WEB-GIS standards. OpenLayers is a JavaScript object library that gets loaded on-line and works in the web browser.

As a principal difference between the two described approaches the author points out the application of the different WEB-GIS software environments. In the Fig. 2 realization, the main WEB-GIS software package is the product "MapServer", while the newly proposed realization insures WEB-GIS functionality whilst applying the OpenLayers software. This principal difference reflect in the organization of the database (RDBMS), the organization of the application layer, the type of geodata and the client subsystem's way of functioning.

In regards to the RDBMS, it starts overloading when the "stored procedures" are applied. Their purpose is to extract a subset of available georeferred data and generate the respective GML structure.

In regards to the application layer, the newly proposed realization does not require use of the MapServer system. There, the application layer is presented by a general-purpose script server language.

The main difference in the data type is that the current AstroWEB realization sends a raster image in response to the client's request, while the newly proposed variant sends the geodata in a GML text format.

In the newly proposed solution, the client subsystem (or user layer) is an object-oriented library of JavaScript classes. This library takes over the functions of rendering the georeferred image in the user's web browser.

Fig. 4 presents diagrams explaining the structure of the georeferred data in the case of using the WFS standard when generating a current image for the screen forms AstroMAP and SkyMAP. For this purpose, the outflow code (which is specially formatted as XML text for the GML and SLD structures) is processed via reverse-engineering. As the figure points out, the GML and SLD data for the two screen forms have some differences.

The main differences in the GML structure when building the AstroMAP and SkyMAP images are in the volume, naming and type of attribute data which the database presents as information to the user. Important attribute data for the

AstroWEB form are geographical coordinates, the screen name of the observatory and the outside key to the charts with supported digital archives for any given observatory. With the SkyMAP format, which pictures a digitalized archive of astronomical images, the important attribute data are the star coordinates of every digitalized object from any given catalogue, data about the observatory and astronomer who did the digitalizing, and a flag signifying the availability of a preview for the original image.

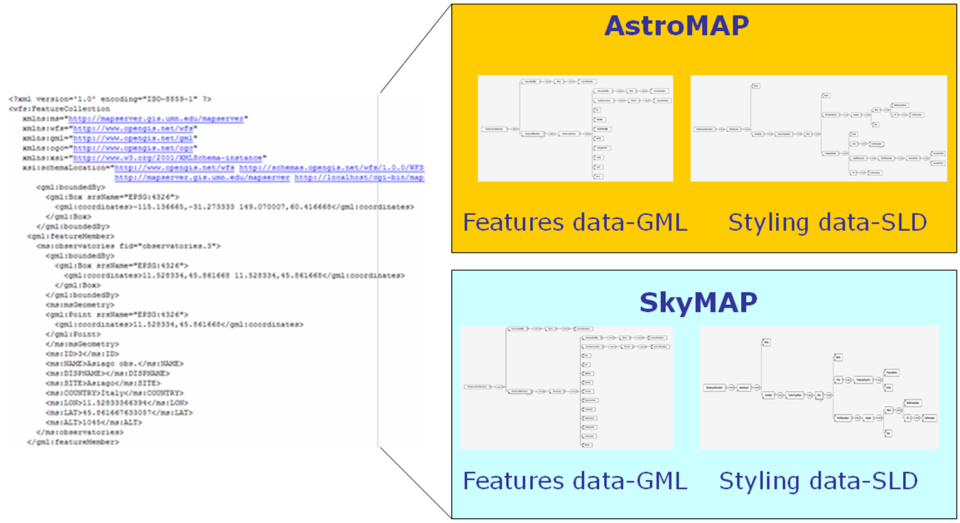

Figure 4: GML and SLD data on the basic screen forms.

The differences in the SLD structures for the two screen forms are more substantial. In the case of drawing the AstroMAP form, data for the color and shape of the point styled image of any given observatory and data on its relative position, color and font of the on-screen text for the observatory's name is supported. When drawing the SkyMAP form, a logical filter for the image is applied. Elements of the catalogue for the astronomical objects, for which the preview availability flag is raised, are visualized with the "filled square" form, which has a set size and color. The rest, for which a preview is not available, are visualized as a "plus sign", also with a set size and color.

4. CONDUCTION OF A SOFTWARE EXPERIMENT, RESULTS AND CONCLUSIONS

After the structural analysis of AstroWEB's modifications when migrating from the WMS to the WFS standard, the question of what advantages does the end user gain after this system upgrade remains open. To answer this question, the author elects to conduct a simplified software experiment, the goal of which is to determine the response times of the application layer and respectively the server subsystem, whilst separately using both WMS and WFS standards when visualizing the AstroMAP screen form. In the first case, the time in which a raster image generates in .png format is taken into account, and in the second case - a GML data structure in XML text format for a few hundred dots of the WFODB database with astronomical observatories is observed.

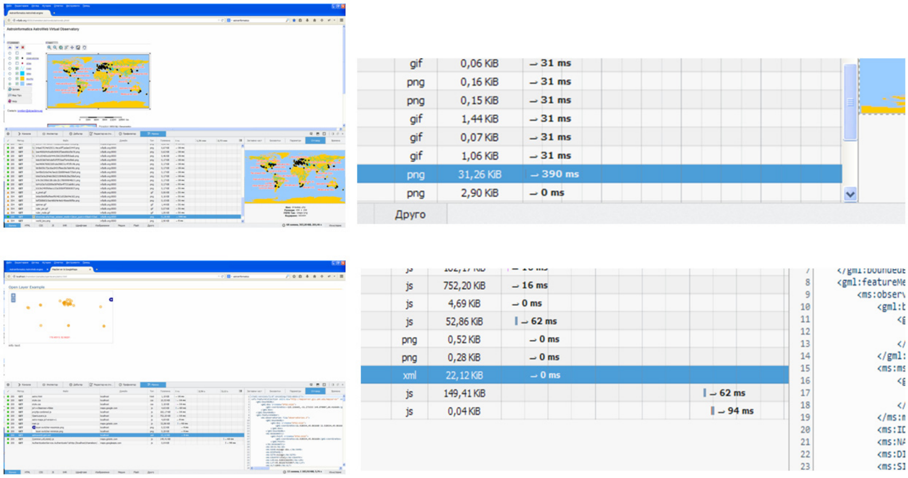

Figure 5: In the case of WMS and WFS standards response times.

Fig. 5 shows functional AstroWEB screens with a visualized AstroMAP form (up), using raster data in a WMS standard and an experimentally created form for visualizing the same set of data, but using vector data in an WFS standard (down). The server subsystem's reaction times are shown on the right. To determine the reaction times in question, Firefox 30.0's Web Developer Web Console Network Analyzer was used. A simple comparison of the reaction times shows that in the conditions of the WMS standard, the raster image is generated for about 390 ms, while under the WFS standard conditions, the vector data for rendering an image to the client is generated for less than a millisecond.

In light of the expected positive results on increasing the productivity of the application layer, and thus the server subsystem, let's look at the possible difficulties that could arise when converting from the WMS to the WFS standard of geodata in relation to the AstroWEB project. As seen in Fig. 3, the GML and SLD files of XML text format are expected to generate whilst applying the "stored procedures" of RDBMS Firebird. This process of generation could provisionally be divided into two phases – executing a spatial request for selecting a subset of data, and the creation of a GML structure. The current version of Firebird doesn't include built-in software tools that could aid either phase. In contrast, both the PostGIS of RDBMS PostGres and SpatialDataTypes of Microsoft SQL Server (versions post-2008) add-ons possess built-in mechanisms for processing spatial query data and generating GML data. That is why, in the interest of a seamless transition to an WFS standard for the AstroWEB project (especially concerning the SkyMAP module, in which the archives of astroimagery contain hundreds of thousands of units), applying an appropriate spatial data system for the indexing, as well as finding an efficient approach to creating text GML vector georeferral data are of paramount importance.

Acknowledgments

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Links

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OGC® Standards and Supporting Documents, http://www.opengeospatial.org/standards, accessed may 2014 #3.
OSGeo, http://wiki.osgeo.org/wiki/Open_Geospatial_Consortium, accessed may 2014 #6.
OSGeo, http://www.osgeo.org/, accessed may 2014 #5.