An architecture for open and scalable WebGIS

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SUMMARY

This paper discusses an architectural model that is used in implementation of Ginis framework for realization of open and scalable Web-based geographic information systems (WebGIS). WebGIS system is considered as a whole that consists of a WebGIS portal and many Web-enabled GISs. For developing of all application components of an overall WebGIS, we introduced and developed unified model of geoinformation systems. Unified model leads to implementation of Ginis framework that further produces configurable GIS application components. Realization of systems using configurable components involves usage of explicit semantic descriptions of application domains for their configuring. For encoding of these semantic descriptions we defined Ginis Application Definition Language (GADL).

KEYWORDS: GIS, WebGIS, OGC, WMS, WFS, framework, semantic

INTRODUCTION

Traditionally, geographic information systems were realized as monolithic and platform-dependent applications (Wong et al., 2002). With development of Internet and World Wide Web, GISs have evolved and adapted to this new environment (Shekhar et al., 2001). The "WebGIS" became a synonym for Web information systems that provides a functionality of geographic information systems on the Web through HTTP and HTML (Shanzhen et al., 2002).

WebGIS, as it is considered in this paper, should provide functions for displaying and navigation trough maps, so as functions for querying of geographic data using both spatial and non-spatial criteria. It is obvious that these functions can cover only some of a GIS functionality stated in (Soomro et al., 1999). For capturing, storing and manipulating with geospatial data we still need more traditional application environments. Sharing of geospatial data for Web presentation purposes can be done by extending of existing traditional GISs with a set of "Web interfaces". In order to build model of a WebGIS that is open for connecting to a range of different geodata sources we need commonly acceptable standards for realization of these Web interfaces. Open Geospatial Consortium (OGC) (Open Geospatial Consortium Inc., 2004) interface specifications for building Web services that enable retrieval of custom maps (Web Map Service Implementation Specification, 2002) and querying of geospatial entities (Web Feature Service Implementation Specification, 2002) seems as a quite reasonable choice.

The paper is structured as follows. In the second part, we shortly describe architecture of an overall WebGIS system, identify subsystems, and specify use-cases and non-functional requirements. The third part of this paper is dedicated to the unified model of geoinformation systems that is base for implementation of all components of suggested overall WebGIS.

AN ARCHITECTURE OF AN OVERALL WEBGIS SYSTEM

To identify subsystems of an overall WebGIS we started from a general assumption that geoinformation related to some area (i.e. city) cannot be captured, stored and maintained in a single organizational unit GIS. Some of this information can have mutual and public importance, so it should be **shared** and be **accessible** over Web.

Suggested architecture relies on a client/server model. A subsystem that acts as a client that enables access to geoinformation is a WebGIS portal, while the function of sharing (role of a server) is realized by expanding traditional GISs with a WMS and a WFS Web interfaces (Web-enabled GIS). Using of OGC WMS and WFS interfaces for building WebGIS systems can be also found in (Korduan and Bill, 2004). Figure 1 illustrates interrelation between components that correspond to subsystems.

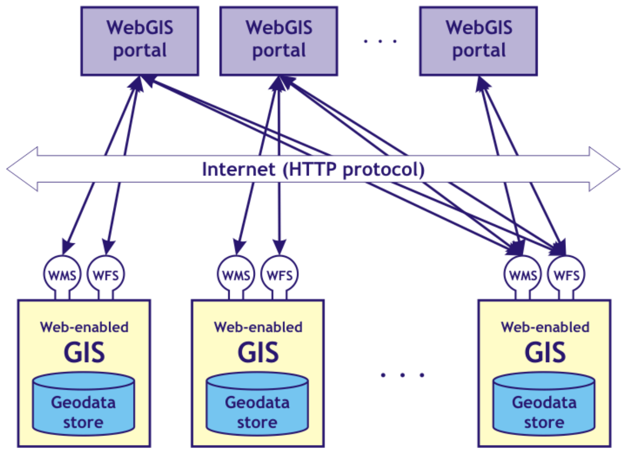

Figure 1: Schematic view of an overall WebGIS architecture

Use-case model of the overall system

WebGIS system that is being presented is used by three classes of users: *Web Users*, *Authorized GIS Users* and *WebGIS Portal Administrators* (see figure 2). Generalization relationship between user classes represents ability of a user to play multiple roles.

Web users are the most general class with the least functionality available. They access the system trough a WebGIS portal for viewing maps and querying geographic features. Web mapping and querying are not all possible WebGIS functions, but it is the set of functions most suitable for city GIS portals which are primarily target of Ginis framework (Stoimenov et al., 2004).

Authorized GIS users have access to all functions of their local GIS applications. A necessary minimum (not a limit) of functionality should enable creating of a geoinformational content that can be accessed over the portal. Such a requirement can be satisfied by implementing functions for map viewing and querying, but also inserting, editing and deleting of geographic features.

Finally, the portal administrator is responsible for defining content that will be available to Web users. For that purpose administrator can specify layer hierarchy trough which geoinformation will be presented and, depending on a layer type, assign and remove WMS and/or WFS services to the layer.

An important feature of suggested WebGIS portal is ability of an integration of geoinformation. This characteristic is issued from the architectural model where one portal can access many Web-enabled GISs shared data. Two levels of information integration can be achieved:

- **Display level integration** - composite map is formed by overlapping of raster images gathered from several Web Map Servers that are services of selected layers.

- **Query level integration** - execution of a query specified on one feature type (layer) can result in the query execution on several Web Feature Servers that are services of the layer and its sublayers.

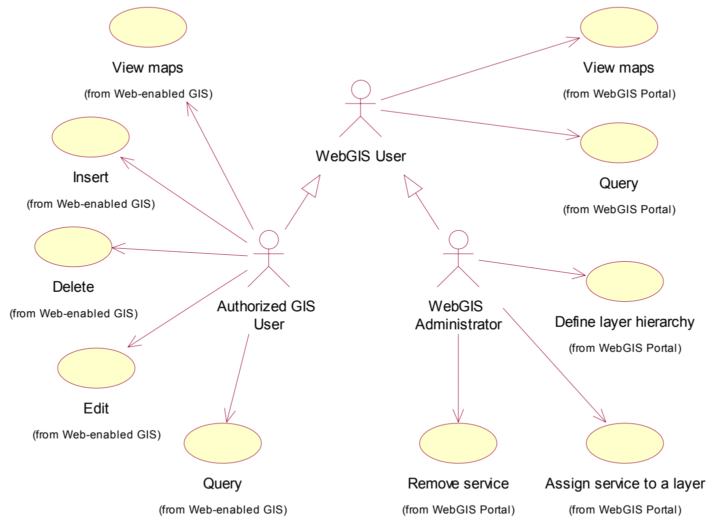

Figure 2: Use-case model of the overall WebGIS system

Non-functional requirements

The most important non-functional requirements for the WebGIS that has been designed are *code and component reusability*, *scalability* and *openness*.

Reusability is the most important non-functional requirement and it is achieved trough Ginis application framework. A design of the framework relies on use of explicit semantic descriptions for building concrete systems (Stoimenov and Djordjević-Kajan, 2005). A semantic description of an application domain consists of specification of a layer structure trough which geoinformation is organized and services for geodata accessing and manipulation. For encoding of these descriptions we defined XML language named Ginis Application Definition Language (GADL). The framework, on the other hand, produces configurable application components that use GADL encoded semantics and realize concrete applications and services of an overall WebGIS. A relationship between Ginis framework and GADL is tight because both of them rely on a same model of a geoinformation system that will be described in next section.

Scalability is the requirement that regards geoinformational content of a WebGIS portal. It is ability of extending a portal by linking it with new Web Map and Web Feature servers. As we already told, geoinformational content of a portal is defined by adequate GADL description, so it can be changed or extended by simple editing of the corresponding XML document.

A demand for openness imposes usage of interfaces and exchange of data by commonly accepted standards. This requirement is satisfied using OGC standards (WMS and WFS) for Web services interfaces and data interchange. Although Ginis framework offers full support for the Web-enabled GIS, third parity OGC conformant Web Map and Web Feature servers can be successfully linked to a WebGIS portal. For further extending of the portal functionality beyond mapping and querying, extending of this set of standard services should be considered.

UNIFIED MODEL OF GEOINFORMATION SYSTEMS

Unified model provides basis for implementation of Ginis framework, while GADL is defined in terms of a model. The model is qualified as "unified" because it is used for all application components of an overall WebGIS. The idea behind is that a desktop GIS application, WMS, WFS and a portal Web application are just different interfaces to unique set of data and operations. The model is strongly influenced by the OGC reference model (OGC Reference Model, 2003) slightly modified by separating layers with geographic features that can be queried via WFS and encoded in the GML2 (Geography Markup Language, 2002), from layers with a coverage that can be only displayed. UML class diagram for the model is shown on figure 3.

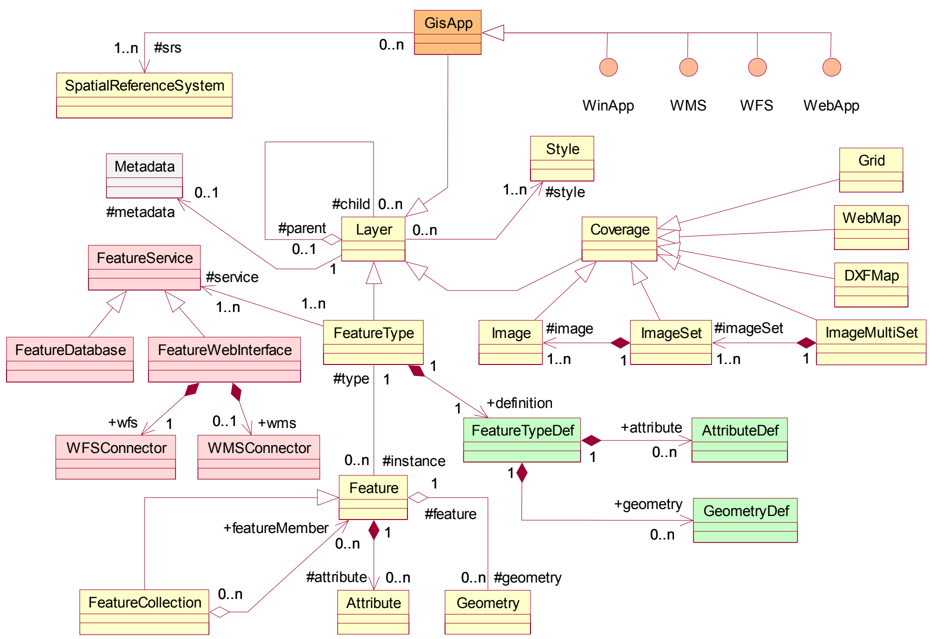

Figure 3: Unified model of geoinformation systems

Classes *WinApp*, *WMS*, *WFS* and *WebApp* are interfaces for implementation of different components of overall WebGIS. These classes are derived from a general GIS application class *GisApp*, which is derived from the central class of this model – class *Layer*. This affects in inheriting operations defined on a layer to an application.

The suggested model is characterized by organization of geoinformation trough hierarchy of layers (see class *Layer*). Organization of layers into tree enables aggregation of layers and classification of feature types. Functions that a layer transmits to child layers are display and query, i.e. if the top layer is selected for displaying or querying, all of its sublayers will be displayed or queried, too.

Class *Layer* in the model is basic layer class that only defines interface virtual functions and implements hierarchical organization and metadata describing capability. For representation of different types of geoinformation we use inherited classes: *FeatureType*, *Coverage*, *Image*, *ImageSet*, *ImageMultiSet*, *Grid*, *WebMap* and *DXFMap*.

Class *FeatureType* defines type of geographic feature as a layer. *FeatureType* has its definition (class *FeatureTypeDef*) in term of attributes (class *AttributeDef*) and geometries (class *GeometryDef*) trough which features are presented; set of feature instances (class *Feature*) that holds real geodata for the layer (classes *Attribute* and *Geometry*); and set of services (class *FeatureService*) for acquiring and storing features.

Class *Coverage*, with its derivates, defines type of layer for geodata that overlays some area. Classes *Image*, *ImageSet* and *ImageMultiSet* are used for displaying georeferenced raster images (Rancic and Djordjević-Kajan, 2003), while class *Grid* is used for displaying geographic grids. Class *WebMap* defines a layer that acts as an interface for retrieving of custom maps from OGC Web Map Servers. Finally, class *DXFMap* encapsulates functionality of processing and displaying maps in widely used Autodesk's DXF format (AutoCAD 2000 DXF Reference, 2004).

Suggested model can be easily extended by further specializing *Layer* and *FeatureService* class hierarchy. Specialized classes that could be added must conform to the predefined layer or feature service operation interface. An example of how Ginis framework that is based on this model can be extended is class *DXFMap*. This class is a wrapper around an open source library CadLib (Shahabi, 2005) that enables reading, creating and drawing of DXF files.

Illustration of an implemented prototype of a WebGIS portal using Ginis framework and GADL is shown on figure 4.

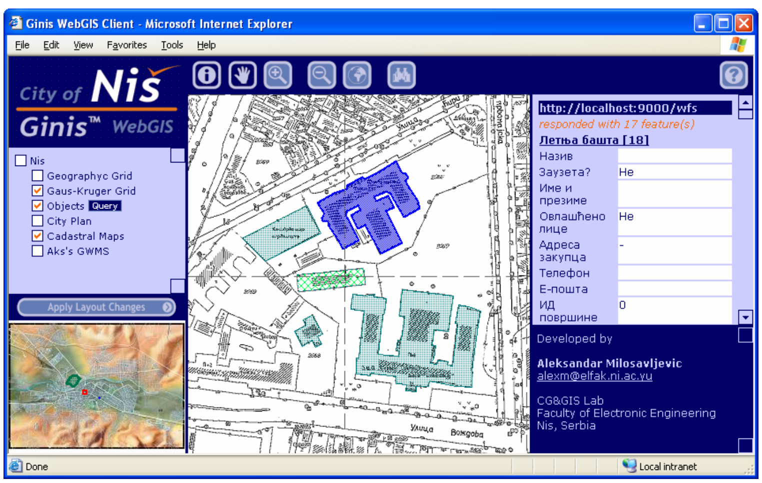

Figure 4: Implemented prototype of a WebGIS portal

CONCLUSIONS

This paper describes the architecture of Ginis framework for realization of an open and scalable WebGIS. For describing of all application components of an overall system, i.e. Web-application of a portal, WMS and WFS, and desktop GIS application for manipulation with geodata, we introduced single model named Unified model of geoinformation systems. The unified model is a base for the framework that further produces configurable GIS application components.

Realization of systems using configurable components involves usage of explicit semantic descriptions of application domains for their configuring. For encoding of these semantic descriptions we specified XML language named Ginis Application Definition Language (GADL). In essence, GADL description of a domain defines layer hierarchy and corresponding services that are used for connecting with sources of geodata. Describing a WebGIS portal using GADL is a special case where sources of geodata for a layer can be only WMS and/or WFS.

A concept of configurable components and semantic descriptions for developing WebGIS enables high-level of reusability and scalability, while openness is achieved trough adoption of widely accepted standards for communication between components.

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