[11] OGC Standards, http://www.opengeospatial.org/specs/?page=specs.

[12] Buyya, R., Murshed, M.: GridSim: A Toolkit for the Modeling and Simulation of Distributed Resource Management and Scheduling for Grid Computing, Concurrency and Computation: Practice and Experience (CCPE), Volume 14 Issue 13-15 (2002) 1175-1220. Wiley Press, USA.

[13] Song, H., Liu, X., Jakobsen, D., Bhagwan, R., Zhang, X., Taura, K., Chien, A.: The MicroGrid: A Scientific Tool for Modeling Computational Grids, Proc. of IEEE Supercomputing (SC 2000), Dallas, USA, (2000).

[14] Casanova, H.: Simgrid: A Toolkit for the Simulation of Application Scheduling, Proc. of the First IEEE/ACM International Symposium on Cluster Computing and the Grid (CCGrid 2001), Brisbane, Australia, IEEE Computer Society Press, USA (2001).

[15] Baumgartner, K., Wah, B.W.: Computer Scheduling Algorithms: Past, Present and Future, Information Sciences, vol. 57 & 58, (1991) 319-345. Elsevier Science, Pub. Co., Inc., New York, NY.

[16] Flynn Hummel, S., Schmidt, J., Uma, R.N., Wein, J.: Load-Sharing in Heterogeneous Systems via Weighted Factoring. In: Proc. of the 8th Symposium on Parallel Algorithms and Architectures (1997).

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DISTRIBUTED VISUALIZATION SYSTEMS IN REMOTE SENSING DATA PROCESSING GRID

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Abstract: Implementation of GEOSS/GMES initiative requires creation and integration of service providers, most of which provide geospatial data output from Grid system to interactive user. In this paper approaches of DOS-centers (service providers) integration used in Ukrainian segment of GEOSS/GMES will be considered and template solutions for geospatial data visualization subsystems will be suggested. Developed patterns are implemented in DOS center of Space Research Institute of National Academy of Science of Ukraine and National Space Agency of Ukraine (NASU-NSAU).

Keywords: data visualization.

ACM Classification Keywords: I.3.2 Graphics Systems - Distributed/network graphics, C.5.0 Computer system implementation – General.

1 Introduction

Grid systems providing geospatial data are common and usually have complex visualization subsystems. Wide class of typical problems are weather prediction, satellite data processing can be solved in these systems, some of them are solved in DOS center of Space Research Institute of National Academy of NASU-NSAU. Different interfaces and architecture assumptions can make these Grid systems very hard for development and usage, lowering their value as the data source for decision making. Implementation of standards for data visualization, creation of common template solutions will simplify development and increase usability of these systems.

These approaches are used to implement distributed geospatial data visualization subsystem of national Ukrainian Earth Observation system which is developed in the frame of international program GEOSS and European program GMES.

International GEOSS program (Global Earth Observation System of Systems) is emerged to integrate national and regional Earth Observation systems [1]. One of such systems is developed within European GMES (Global Monitoring for Environment and Security) initiative. This initiative is supported by European Commission and European Space Agency and targeting on providing information services for decision making [2].

The overall structure of Ukrainian segment of GEOSS/GMES has three organizational levels. The top level is responsible for the overall management of the system, the second is responsible for integration of efforts in particular sectors of economy. At the lowest level of system's hierarchy DOS (Delivery of Service) centers are located. These centers are responsible for delivering particular services to end users [3].

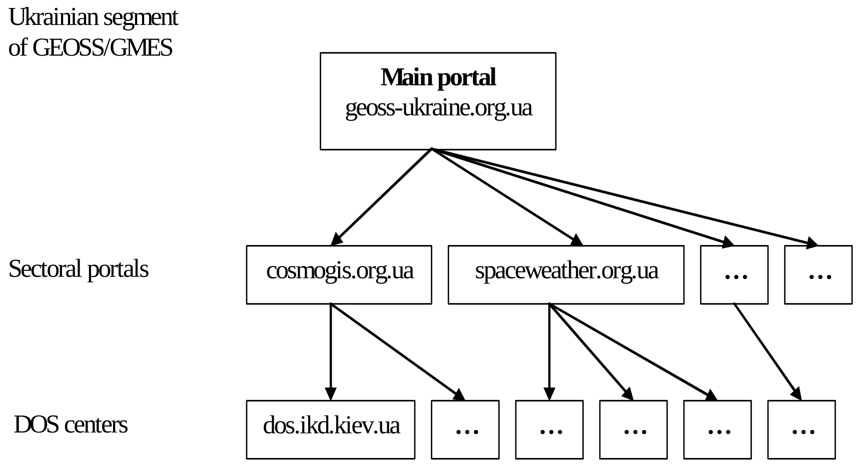

Fig. 1. Hierarchical structure of Ukrainian segment of GEOSS/GMES

To represent activities at all levels of Ukrainian segment of GEOSS/GMES the following hierarchy of Web-resources is created (Fig. 1):

- Main portal [4]
- Sectoral portals (http://cosmogis.org.ua, http://spaceweather.org.ua, …)
- Web-resource of DOS-centers

The most developed sectoral system of Ukrainian segment of GEOSS/GMES is CosmoGIS system supported by NSAU [5]. CosmoGIS is created to stimulate cooperation in the field of remote-sensing data processing and to provide end users with new quality thematic products. Environmental monitoring using remote-sensing involves execution of complex workflows of data processing and often requires computationally intensive ecological simulations. For such applications Grid computing is desirable. Typical Web-site of DOS-center presents an interface to target Grid system and provides facilities to visualize and distribute results of processing.

Contrary to top level of Ukrainian segment of GEOSS/GMES sectoral level involves substantial interactions between components (DOS-centers). One of the goal of CosmoGIS as sectoral system consists in integration of DOS-centers, in particular providing a means for distributed data visualization and delivery. To attain this goal CosmoGIS uses open standards of geospatial data presentation. At present the most advanced standards in this area both in capabilities and available software are standards of Open Geospatial Consortium (OGC). The utilizing of OGC standards ensures possibility of integration with similar systems at national level, in particular within GMES program.

In this paper different approaches to DOS-centers integration will be considered and template solutions for geospatial data visualization subsystems will be suggested. Developed patterns are used to implement DOS-center of Space Research Institute of NASU-NSAU.

2 Approaches to organization of visualization systems

One of the main obstacles on the creation of distributed systems in Ukraine is a not sufficient high throughput networks and nonuniform distribution. To account the insufficiency of high throughput networks centralized and decentralized approaches to create of distributed visualization system for geospatial data are considered [7]. The differences between these approaches consist in different traffic routing schemes between end user and DOS-centers and places where mapping products are created. Both schemes assume that DOS-centers are using OGC Web Feature Service (WFS) [8] standard to distribute vector geospatial data and OGC Web Coverage Service (WCS) [9] to distribute raster data.

The typical structure of centralized version of the system is shown on Fig. 2a. The figure shows how the thin client accesses the portal with the directory of available services and makes a request to the specified service. This request routed to the mapping service, packed into WFS/WCS request and send to the service site (DOS).

The result is routed back, processed by to the cartographical service and send to client. In this case the centralized mapping service is responsible for producing cartographical output.

This first approach exhibits ability to use thin clients (and as result to serve broader range of end users), to produce high quality mapping output independent of end clients capabilities. As a drawback this scheme has potential bottlenecks in network throughput and computational power of central mapping server.

Within decentralized scheme each DOS-center uses own mapping service (Fig. 2b). Cartographical output of service center is delivered using OGS Web Map Service (WMS) [10] protocol and client software is responsible for combining created maps. Central portal only holds references to DOS-centers and routes user requests to DOS mapping services. The second approach relaxes requirements on network throughput and available computational power at the cost of using more sophisticated clients.

In both schemes dedicated software such as geoinformational systems (GIS) can call DOS directly using WCF/WFS protocols.

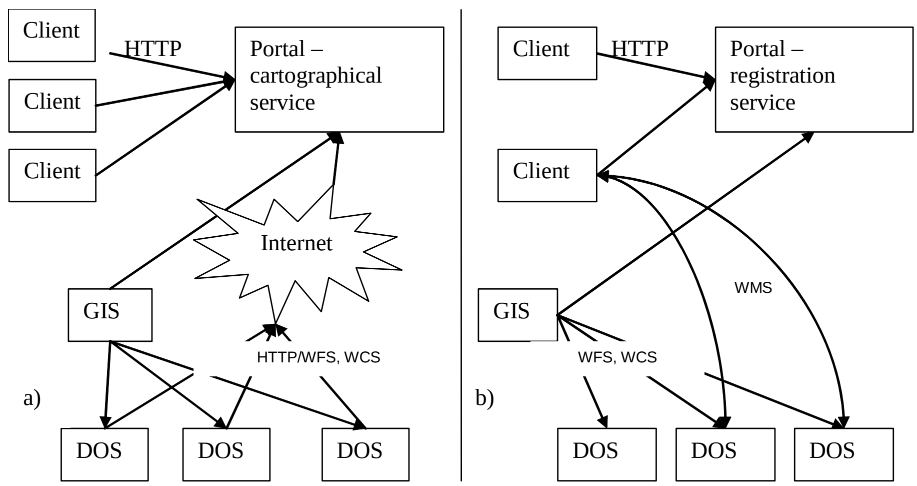

Fig. 2. (a) centralised and (b) decentralized approaches to distributed visualization of geospatial data

3 Template solutions for visualization

In this section two template solutions for visualization subsystems will be described. One solution is based on the thin client model while another utilize thick clients. Templates can be used to develop data visualization subsystems for DOS-centers and for portals at sectoral level. Both template solutions have different advantages and drawbacks. Visualization template using thin client model has a low scalability, minimalistic user interface (without navigation, dynamical scalability, etc), but does not require expensive hardware for both client and visualization server. Thick client

model visualization template has better scalability and usability, but requires expensive server or group of servers for mapping service.

3.1 Visualization systems using thin client model

First pattern of visualization system is based on the thin client model. To access the service a simple web browser is sufficient. Within this pattern, visualization system implements open standards of data presentation including OGC WMS to deliver cartographic products and OGS WFS/WCS to deliver geospatial data. Typical structure of such pattern is shown on Fig. 3

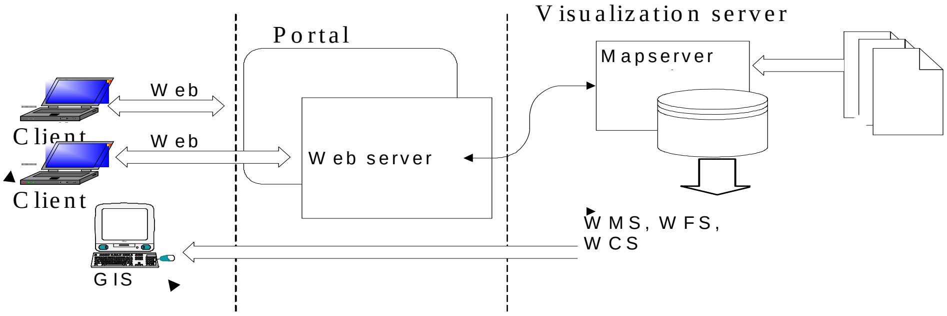

Fig. 3. Visualization system using thin client

The vector and raster data produced by Grid system is visualized by mapping service. Both mapping service and Web-interface are implemented in the framework of open source software UMN Mapserver [11]. Mapping service and visualization system located on single server, this server has sufficient performance for visualization of only a few layers on the target map. Performance restrictions are critical for visualization tasks, not all available Grid systems can use this pattern because of these restrictions. On the other side simple client software, cheaper hardware for both client and server makes this pattern very suitable in Ukrainian segment of GEOSS/GMES.

The main advantage of described pattern is the standard interface of mapping service, which grants compatibility with existing and new client applications. Once developed, client applications and DOS-centers can easily switch data sources with minor or no modifications of source code. This improves scalability and availability of entire segment. GIS can use visualization server as a client, visualization server implements standard protocols for data representation.

A typical example of thin client pattern implementation is cloud mask visualization service which is described in section 4.1.

3.2 Visualization systems using thick client model

The second pattern of visualization system is based on thick client model. To access a service a Web-browser with JavaScript is required. Key feature of proposed solution is extensibility, new versions of framework software requires more system resources. This pattern uses previous as base and adds advanced navigation capabilities for interactive users.

Another advantage of this architecture is the possibility of parallel processing of user requests allowing integration of different data sources. This feature increases the system scalability while the system remains transparent for target users. More sophisticated applications can be developed, because of performance increase, routing capabilities and load balancing. Within this template, the solution visualization subsystem is developed using open source software Cartoweb 3.2.0 [12]. In this system SOAP is used for interserver communication (among different visualization systems), allowing integration with virtually any DOS-center, even without WCS/WFS support. CartoWeb can be extended using plugin approach that makes interface modifications simple.

The main features/advantages of common Cartoweb-based interface are visible on main map control – it has scale and position arrows that can be used for scale the adjustment and navigation, this feature being commonly used with dynamic (i.e. clickable) keymap. Other commonly used features are the measuring tools for distances and surfaces measurement. The control panel has layers tree – CartoWeb supports an arbitrarily complex hierarchy of layers, with infinite depth. The interface contains a geographic query tool which can be used for geographical search. Additional features are language switch for internationalization support, users and roles support for an implementation of basic (file-based) authentication mechanism, print dialog for fully configurable PDF document production.

Typical structure of such system is shown on Fig. 4. All capabilities of previous pattern are preserved, to use new system little or no modification in existing application is required.

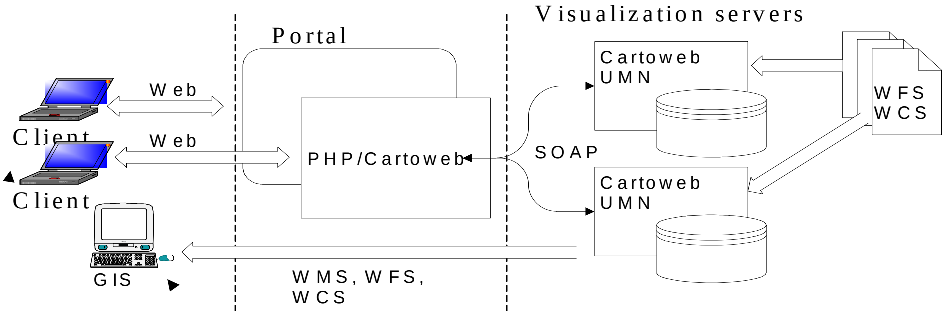

Fig. 4. Visualization system using thick client

4 Implementation

The developed patterns for visualization subsystem were used to implement the DOS-center of Space Research Institute's of NASU-NSAU [13]. This center was created under the umbrella of CosmoGIS sectoral system of Ukrainian segment of GEOSS/GMES.

The thin client-based pattern was used to implement cloud mask visualization service which is described in section 4.1, the thick client-based approach is demonstrated on example of visualization in Numerical Weather Prediction (NWP) described in section 4.2.

4.1 Service of cloud mask extraction from Meteosat remote sensing data

The cloud mask visualization is a typical application of the thin client pattern. The main source of data for this service is provided by European Meteosat meteorological satellite. The cloud mask extracted from Meteosat infrared band using Markov Random Fields (MRF) approach. Cloud mask extraction is being executed on the top of Grid system developed in Space Research Institute [14, 15].

There are few layers visualized on single machine with single service, single server has sufficient performance for smooth presentation with reasonable delays. Typical service interface is shown on Fig. 5. On the left map of this figure cloud mask is shown with country names and boundaries. Middle reference map is used for navigation. Right control panel is used for map navigation, selection of the date and additional features to be included in resulting map. Available data layers include country boundaries, Digital Elevation Model data, Meteosat infrared remote sensing data, cloud mask and clouds borders.

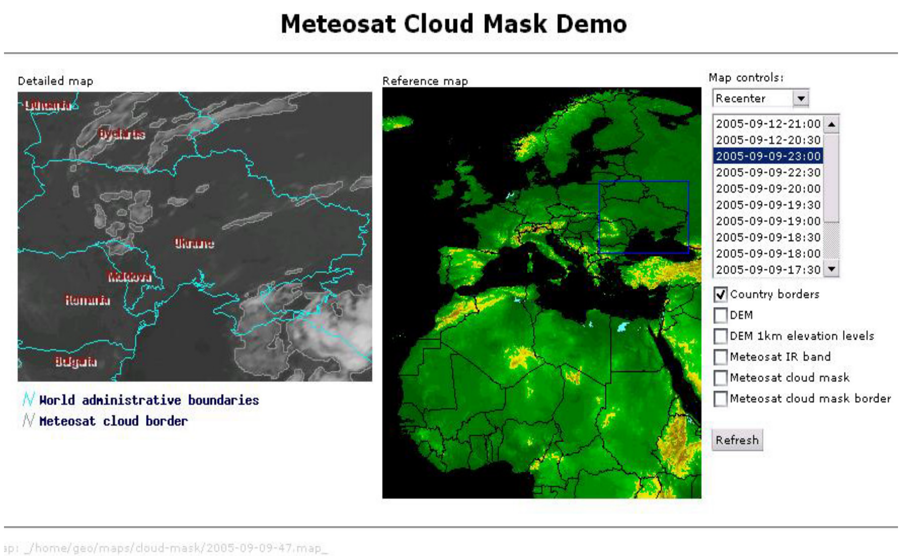

Fig. 5. Thin client system for cloud mask visualization

4.2 NWP model visualization

The visualization of NWP results is a good example of implementation of thick client-based pattern. This pattern was used to visualize results of WRF mesoscale model simulations which is regularly preformed in Space Research Institute. NWP models predict a lot of meteorological parameters. Due to the fact that these many visualization layers have to be calculated on different servers, layer options are too complex for single mapping service.

A typical user-friendly output of visualization system is shown in the Fig. 6. The main visualization controls and options located in right panel of the figure. Currently visible tab folder shows background and geopolitical reference options. Other tabs of this panel includes options to access measurement tools, which can be used for area and length calculation, print dialog for PDF exporting support, query tools for visual MapServer query creation, and outlining tools for map annotation. On the right part of the figure WRF model temperature output is shown. In the upper left corner of this map reference keymap with relief data is shown. Visualization map has advanced zooming and navigation capabilities. Zooming can be used not only with scale switch in bottom right corner, but can be applied for user-selected region. Different line and polygon drawing tools in upper panel can also be used for map annotation.

This example refers to a thick client model because navigation interface is implemented using JavaScript, uses AJAX technology for map operations.

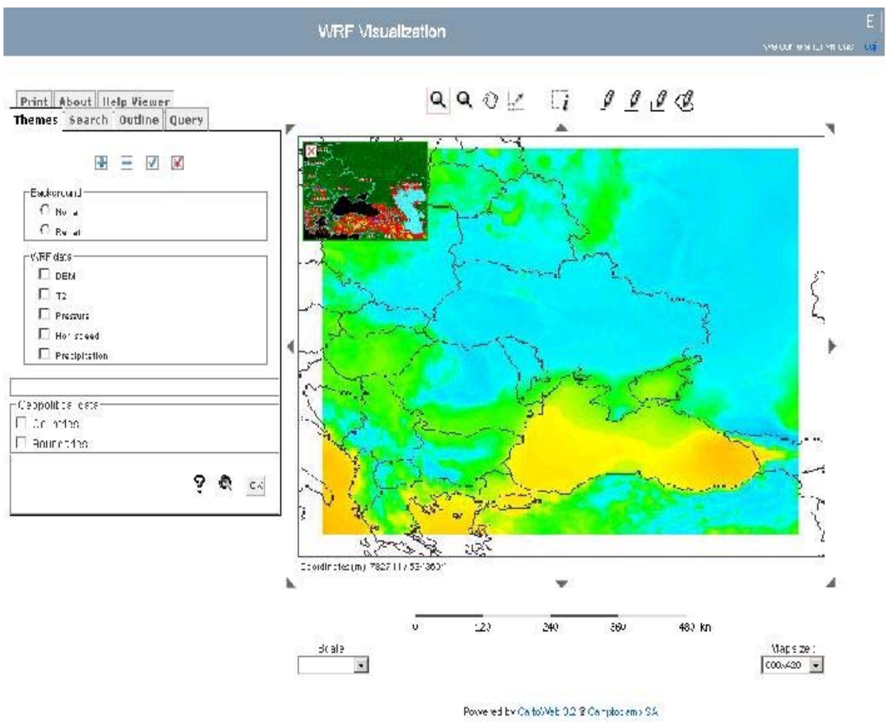

Fig. 6. Thick client system for WRF visualization

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Bibliography

[1] Global Earth Observation System of Systems, http://www.epa.gov/geoss.

[2] Global Monitoring for Environment and Security, http://www.gmes.info.

[3] Fedorov, O.P., Kussul, N.N., Shelestov, A.Yu.: Problems and Prospects of Development of an Information Earth Observation System in the Ukraine (in russian). Journal of Automation and Information Sciences. Vol. 37, Issue 12, pp. 35-39. (2005).

[4] Ukrainian segment of GEOSS, http://geoss-ukraine.org.ua.
[5] Sectoral system CosmoGIS, http://cosmogis.org.ua.
[6] Space Research Institute's of NASU-NSAU service site, http://dos.ikd.kiev.ua.
[7] Kravchenko, O.M., Shelestov, A.U.: Using implementation of OGC standards to develop distributed systems for geospatial data visualization and delivery (in russian). Problems of programming. №2-3, pp. 135-139. (2006).
[8] WFS specification, http://www.opengis.org/techno/specs/02-058.pdf.
[9] WCS specification, http://www.opengis.org/techno/specs.
[10] WMS 1.1.1 specification, http://www.opengis.org/docs/01-068r2.pdf.
[11] UMN MapServer, http://mapserver.gis.umn.edu.
[12] Cartoweb, http://www.cartoweb.org.
[13] DOS-center of Space Research Institute of NASU-NSAU, http://dos.ikd.kiev.ua.
[14] Shelestov, A., Lobunets, A., Korbakov, M.: Grid-enabling Satellite Image Archive Prototype for UA Space Grid Testbed. International Journal "Information Theories and Applications. Volume 12, Number 4, pp. 351-357. (2006).
[15] Shelestov, A.Ju., Kussul, N.N., Skakun, S.V: Grid-infrastructure simulation. Problems of programming.Vol. №2-3, pp. 221-230. ISSN1727-4907. (2006).

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INFORMATION SUPPLY OF GEO-INFORMATION SYSTEMS FOR THE FORECASTING PROBLEM OF THE AVALANCHE DANGER

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Abstract: This article is dedicated to the vital problem of the creation of GIS-systems for the monitoring, prognostication and control of technogenic natural catastrophes. The decrease of risks, the protection of economic objects, averting the human victims, caused by the dynamism of avalanche centers, depends on the effectiveness of the prognostication procedures of avalanche danger used. In the article the structure of a prognostication subsystem information input is developed and the technology for the complex forecast of avalanche-prone situations is proposed.

Keywords: GIS, prognostication, risk, situation, the avalanche danger

Introduction

A study of the natural calamities mechanisms, the development of their connections with the climatic and ecological changes led to the development of the new specialized systems technology for control, which was called geo-information systems (GIS). The basic tasks of GIS-systems are the development of the prognostication methodology for technogenic catastrophes, the estimation of risks and creation of decision making support systems. GIS-systems are intended for working and analysis of the enormous massifs of data for the definition of the characteristics of the zones of high risk, improvement in the planning, which precedes calamities and estimation of damage [1, 2]. The methods and techniques of GIS-systems make possible to evaluate strategies of reduction in the probability of the catastrophes occurrence, including the calculation of social and economic nature. This includes monitoring physical, biological and chemical parameters on the spot of calamity, control of measurement data and development of short- and extended forecast models. The developed GIS-systems make possible to continuously accumulate meteorological information, to perform different