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METHOD TO EXTEND OPERATIONABILITY OF WEB-GIS BASED MARINE SERVICES USING SSE PLATFORM

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ABSTRACT

Earth Observation (EO) products are widely used by geospatial society. Over the last years a number of new applications of satellite imagery were proposed. This led to an increased interest in EO products, not only from researchers but also from companies and individuals. The authors constitute the essential part of the team that created the marine, web-GIS system - SafeCity GIS - for dissemination of data obtained from a 1.5 metre HRPT-MetOp satellite ground receiving station. To increase the operationability of the system the authors successfully attempted to broaden the offered functionality by integration with Service Support Environment (SSE). Due to this, EO products for the Pomeranian Region are served as web-services; amongst them there are True Color imagery, meteorological, algae monitoring and fire-detection services. The authors present the created solution for web service support for GIS system based on Service Support Environment and discuss its advantages and disadvantages.

Keywords: EO, GIS, SSE, HRPT MetoOp, SafeCity GIS

INTRODUCTION

Earth Observation (EO) products, e.g. satellite images are the data type widely used in modern Geographical Information Systems (GIS). Companies and research institutions utilizing this data must face issues connected not only with specific system purposes, but also with more general and typical GIS problems including geoprocessing, data storage, system efficiency etc., that are typically not cost-effective and are time consuming [2, 5, 12-16].

Moreover, the complexity of modern computer systems causes a need for additional parameters to be taken into consideration. Vast systems are difficult to administer, which leads to the common issue of redundancy in the functionality offered by the software. One of the possible solutions to this is to create systems using a Service Oriented Architecture (SOA) design pattern. This pattern assumes that separate parts of the software offer functionality to other applications in the form of web services. The World Wide Web Consortium defined a web service as: "a software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format (specifically WSDL)" [9]. Simply speaking, functionality offered by a specific application is achieved by chaining several basic services to one complex service. Since a service can be easily used in multiple solutions, the problem of redundancy is resolved.

During research conducted by the Department of Geoinformatics, Gdansk University of Technology, all the above issues were encountered. The authors constitute the essential part of the team that have recently developed a specialized maritime web-GIS system - the so-called SafeCity GIS - for processing and archiving of satellite imagery obtained from an HRPT-MetOp satellite ground receiving station [8]. SafeCity GIS data products are disseminated in different ways, one of them is through specialized geospatial web services. The development process provided a plausible solution; one of its aspects is the selection of the best available platform for services management. The Service Support Environment (SSE) platform was created to overcome the aforementioned problems, evaluate standards for EO products exchange and allow companies/researchers to focus on application-specific issues. In this paper the authors present the created solution for web service support for GIS systems. As a case study SafeCity GIS is used [5].

HRPT-METOP SATELLITE GROUND RECEIVING STATION

Since 2009 the Gdansk University of Technology Geoinformatics Department has operated a 1.5 metre HRPT-MetOp satellite ground receiving station capable of receiving the High Resolution Picture Transmission (HRPT) from polar orbiting satellites. This station, with the use of an antenna located on the roof of the building (Fig. 1a) of the Faculty of Electronics, Telecommunications and Informatics, and an internal part consisting of the receiver and acquisition-storage-control computer unit, allows the receipt of data about circumpolar orbits from EOS – Earth Observing Satellites.

Fig. 1a. 1.5 metre HRPT-MetOp antenna in radome

The ground station is capable of obtaining data from the Advanced Very High Resolution Radiometer (AVHRR) which is a major sensor onboard of NOAA-15 – NOAA-19, MetOp-A and MetOp-B meteorological satellites [8, 11].

Due to the localization of the ground station (N54° 22'15.60", E18°36'45.48") and the sensor geometry constraints, the geographical areas addressed with the service mostly cover Poland, the Southern Baltic (including the Gulf of Gdansk) and some adjacent regions. The typical footprint of a registered and received satellite scene is presented in Fig. 1.

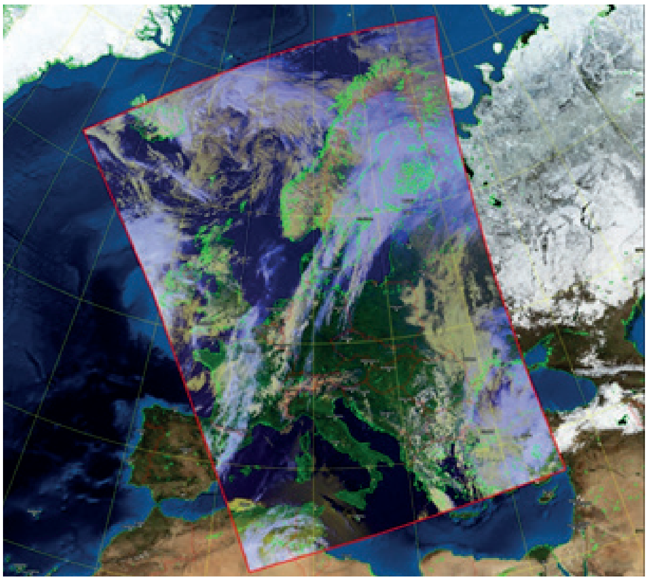

Fig. 1b. Typical footprint of the AVHRR scene received by the satellite ground station

HRPT-MetOp ground station receives the EO data on a regular basis during the satellite visibility [4]. Received information is preliminarily processed by the control panel's built-in software. Further analysis and usage of the data requires an advanced informatics solution. The SafeCity GIS [5] is a computer system associated with the station, is responsible for satellite data acquisition, archiving and dissemination. The EO satellite products are processed by the web GIS Data Adaptation Module, processing capabilities are implemented as separate routines in Data Analysis Module and may be also used with other sources of data [1].

SERVICE SUPPORT ENVIRONMENT (SSE)

Service Support Environment (SSE) is an openly distributed, service-oriented environment developed for the Ground Segment Department of the European Space Agency (ESA) Center for Earth Observation (also known as the European Space Research Institute – ESRIN) [7]. SSE aims to provide infrastructure for business-to-business and business-to-client interactions. Its environment is based on hosting and orchestrating the internet services. The main objective was to maximally simplify the processes of service creation and administration. The available SSE tools allow service identification, integration, merging (chaining several services to achieve one more complicated one) with possible usage of both a local and/or an outside provider's data. The creation and definition of services is also simplified by the platform. SSE offers the possibility to integrate various types of Earth Observation and geospatial web services, including product catalogues. The SSE environment supports service prototyping and demonstration processes, allowing the design of automatically executed workflows. This avoids manual replication of the same task, with a valuable decrease in the overall development effort. In this way, SSE streamlines both the time to get the EO data and that needed to deliver the service to the end-user. Users that create, deploy and deliver services based on both local and SSE data and algorithms are called service providers [10].

SSE Portal is a frontend to an SSE platform which aims to provide a standard interface for basic environment functionalities. The main motivation for this portal's creation was to bring an easy-to-use tool to integrate automatic and manual services in an SSE framework. From the point of view of the standard user, available services can be utilized without knowledge of SOAP or XML technologies. From the Service Provider point of view, user-friendly web based graphical interfaces allow service monitoring, management and deployment. Parallel with the SSE Portal, SSE Test Portal exists with the same set of functionalities available. This web page is purposed directly for Service Providers, allowing them to test deployed services before making them available for all users [1, 10].

SSE Portal allows the deployed services to use the WebMap Viewer. This is a tool (i.e., web graphical component) responsible for displaying the world map (alternatively the map of the key area) in most of the services. Service can be created directly through SSE Test Portal, and after the testing phase can be moved to SSE Portal. The second option is a TOOLBOX that is an SSE tool for managing web services. This environment, installed locally at the Service Provider side, allows the changing of any legacy web services to SOA (Service Oriented Architecture) services. Workflow of the services in the SSE engine can be described using the standard workflow definition language WSDL (Web Service Description Language). Service Provider can create a completely new workflow or use one of the standard workflows provided by the system [10].

It should be noticed that SSE is currently in transition to a new version, due to the work of the ESA Heterogeneous Mission Accessibility program.

TECHNICAL REALIZATION

SafeCity GIS encompasses adaptation and integration of data collected by the HRPT/MetOp satellite station. This data is periodically uploaded on the SafeCity GIS server by the satellite station. The server adapts newly received data for web-GIS. On each new portion of data some analysis algorithms can be run automatically. Another functionality converts and georeferences data written in an HDF format. This is a complex task, because it requires the changing of the geometry of an input image. These adaptation procedures can be supported, by correlative re-reference software. Two modes of the service deployment are implemented in SafeCity GIS. The first mode assumes that SafeCity GIS provides services through the SSE environment. In general, the services deployed in the SSE range from data dissemination to data processing types.

The technical mechanism responsible for the adaptation and processing of the EO data with SSE services is the associated GIS system, as given in the Fig. 2.

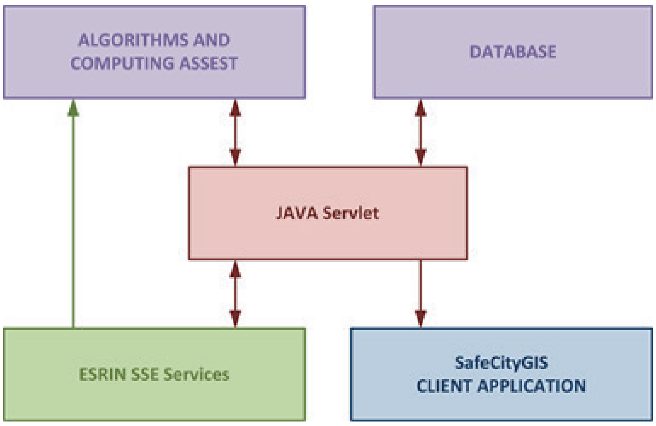

Fig. 2. SSE data processing mechanisms in SafeCity GIS

This mechanism provides a connection between the SSE and GIS layers of the system. It adapts the SSE services to the SafeCity GIS. JAVA Servlet is a transmission layer which provides a connection between the SSE Services data and SafeCity GIS client application. The Servlet communicates with an additional sub-module which helps to compute the required operations. Additionally, JAVA Servlet has a connection to the database in order to correctly process the information gathered by asynchronous SSE services. Results and other data gathered from SSE services may be represented as a spatial-temporal varying layer inside the SafeCity GIS client application (e.g. in the form of a WMS layer deployed on the GeoServer).

The AVHRR SSE service stub developed in GUT under the ESA SafeCity GIS project was already registered and configured on the SSE test Portal. The GUT_AVHRR service is used to make the data publicly available on the Internet.

The technical implementation is presented in Fig. 3. To configure the service properly, the XSLT file (which generates a user interface) and WSDL files of available operation are needed. WSDL files are generated by TOOLBOX Developer Environment. After configuring the service there is a need to configure the TOOLBOX applet on an application server. While the user is using service by SSE Portal, it communicates (using SOAP protocol) with a TOOLBOX server. TOOLBOX server runs XML scripts which are connected to the called service and its operation. XML scripts refer to another JAVA Applet or WebService which provides results for user queries. Then, results are sent back to SSE Portal, and transformed to proper view for the user described in an XSLT file.

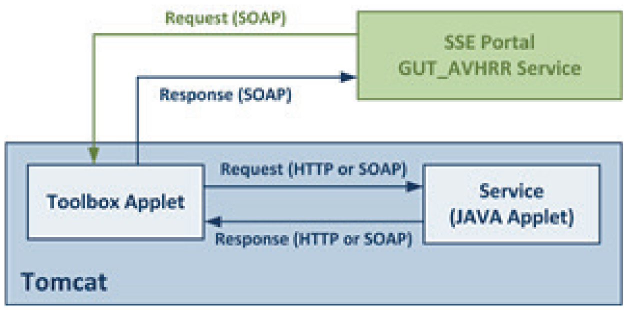

Fig. 3. GUT_AVHRR data dissemination service

DATA DISSEMINATION SERVICES

In this section the technical characterization of different types of services (which are dependent on the data from the satellite ground station) used in SafeCity GIS are described including the algorithms and other details of the services.

Basically, there are two different types of services in the SafeCity GIS which are dependent on the data from the HRPT Satellite Ground Station:

1) Native SafeCity GIS services,
2) Service Support Environment-based service.

In the native system services, the data from the satellite ground station is accessible directly via the SafeCity GIS client application. In this mode of operation, the satellite data is adopted as WMS services. The acquisition workflow in this mode assumes that newly obtained data is transferred to the GIS server (i.e. GeoServer) and deployed in the form of a WMS layer.

The native services provide the results for a SafeCity GIS Web client. These results are obtained by processing the

AVHRR data to get value-added graphical products. The results are available in the form of a Web Map Service (WMS) due to its easy integration with the SafeCity GIS Web clients.

Among the graphical value-added products there are available:

1)AVHRR & HRPT True Color imagery (Fig 4.),

2)Fire detection(Fig. 5),

3) algae monitoring (Fig. 6);

These services differ in their technical details. The first service presents the satellite imagery in the whole extent defined in the system. It combines three selected and radiometrically calibrated bands to form True Color image. The fire detection algorithm processes the whole image and detects fire spots that are further presented in a discrete manner on the map. The algae monitoring service, processes the satellite imagery of the sea in the coastal area and estimates the mean algae bloom probability in the chosen sub-regions of the coast. The first service doesn't distinguish between cloudless and cloudy areas whereas the algae monitoring and fire detection eliminates the cloudy areas from the analysis in the preliminary phase of the process.

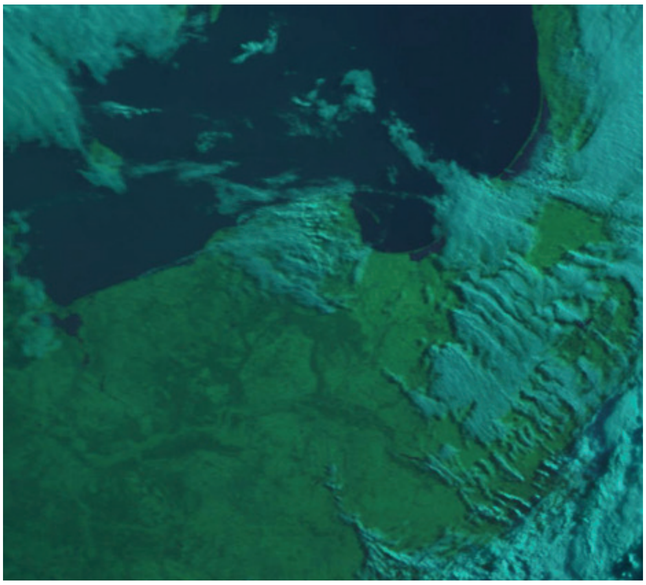

Fig. 4. AVHRR & HRPT True Color imagery sample (September 5, 2014, 2:06PM)

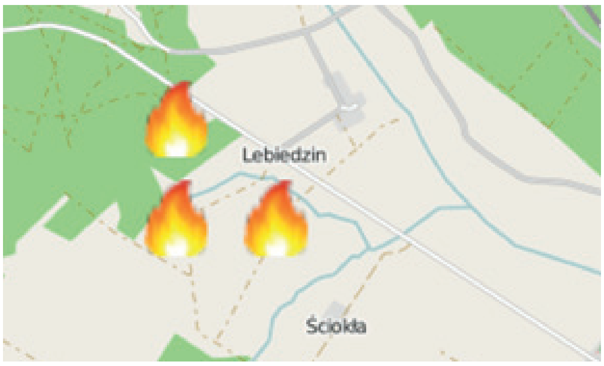

Fig 5. Fire Detection service example, fire icons represent hot spots, which mark areas that have a high probability of fire

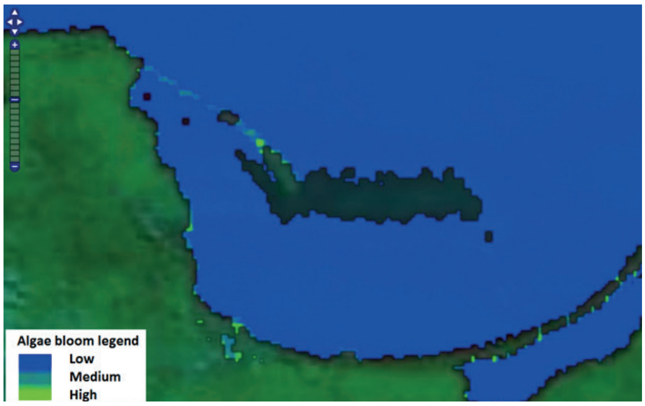

Fig 5. Fire Detection service example, fire icons represent hot spots, which mark areas that have a high probability of fire

The second type of services, devoted to the exploitation of the 1.5m HRPT/MetOp Ground Station, and developed in the SafeCity GIS project are Service Support Environment-based services. In this example, the data for the Satellite Ground station (AVHRR data) is stored and registered in the SSE dissemination type service – GUT_AVHRR. The GUT_AVHRR SSE service stub was already registered and configured on the SSE Test Portal. The GUT_AVHRR service is used to make the data publicly available on the Internet.

The Service deployed in the SSE Portal provides both raw and calibrated data from the AVHRR sensor onboard the meteorological satellites (NOAA-15 – NOAA-19, MetOp-A and MetOp-B). The acquired data is geometrically and radiometrically calibrated and provided in the form of GeoTiff and possibly HDF file formats. The service provides newly obtained data (not historical) from May 2013. Great effort is put in to provide the data as fast as possible after the observation. For the SSE Portal users the service immediately exposes the WebMapViewer (also known as Area of Interest Tool or AOI) component as a Graphical User Interface (GUI). For this purpose the configuration of the WebMapViewer component is done within the SSE Portal as seen in Fig. 7. The prepared configuration is used in the Graphical User Interface of the deployed service (i.e., seen by a user of the SSE Portal).

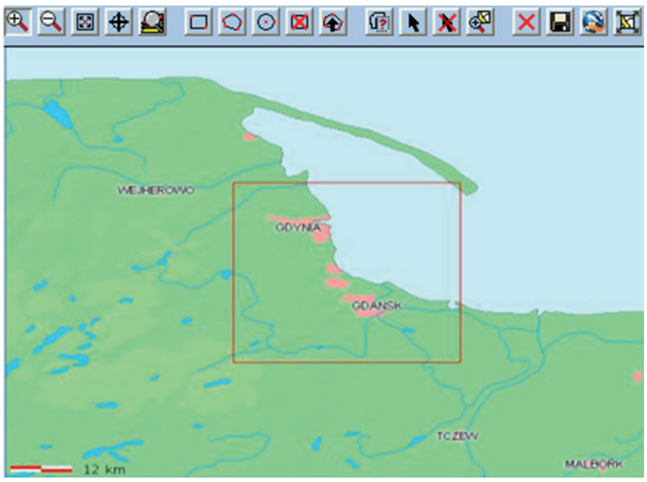

Figure 7. Configuration of the WebMapViewer component during the service deployment on the SSE Portal

The data dissemination service being implemented and deployed in the SSE is the Advanced Very High Resolution Radiometer (AVHRR) data catalogue. The catalogue will allow the user to download earth observation (EO) satellite data received with the 1.5m HRPT/MetOp satellite ground station. In the AVHRR data catalogue service the data is provided to the user for any pre-requested location in the area of Poland and the Southern Baltic.

The AVHRR data catalogue service may be used as a source of the input data to any models and simulations developed in the case of a specific need. Since the AVHRR data catalogue service provides the data in a nearly real-time manner, these specific models and simulations may also assume such a requirement. The AVHRR data catalogue allows one to download statically served satellite data. This data is available via FTP.

The services provide the complete set of data from the AVHRR sensor (raw measurements, calibrated measurements and additional information i.e., solar zenith angle, satellite inclination, nadir to pixel angle). Analogical to the native services, Fire detection (based on hot spots) and AVHRR True Color imagery services are available.

Detection of fires implementation is based on the hot spot detection procedure [3, 6] The hot spots are detected in the AVHRR data based on the computed brightness temperature (BT) values. The brightness temperatures are derived from three near-infrared channels. The idea for the fire detection by identification of hot spots, is that fires result in large discrepancies in the brightness temperatures i.e. the areas of fire have a higher BT than the surrounding regions. The brightness temperature is derived from a single channel as a calibrated value. The computation of brightness temperature uses the calibration coefficient disseminated with the AVHRR data. Current work aims to improve the algorithm of the hot spots detection. New methods of classification are being tested, including tests performed on new data sets (real fires) for the territory of Poland received by the satellite ground station.

Detected hot spots are marked on the AVHRR True Color imagery with suggestive markers stitched on to the detected hot spot location. Alternatively, hot spots are accessible as a separate data source (without the imagery). The second data type would be convenient for thematic composition with different layers of spatial data.

In the AVHRR True Color composition the bands 1,4,5, are used. They are separately assigned to colour components in the Red, Green, Blue model (RGB). Due to the spectral characteristic of AVHRR bands, the assignment is as follows: 1-red, 4- green, 5-blue. The Radiometric resolution of a single AVHRR band has 10 bits whereas the colour component has only an 8 bit resolution. Therefore, the next step is histogram equalization. The minimal and maximal values of each band are evaluated, and the spectral range is equally distributed to the 8-bit scores colour component values [5].

Algae monitoring service provides information about the possibility of algae presence Fig. 6 presents the coast of Gdańsk with an algae-monitoring layer. Red color shows areas with a high possibility of algae presence, green Grey – a low possibility, while grey is reserved for areas in which the meteorological situation did not allow the evaluation of the possibility.

Additional services are planned to be deployed. Amongst them are: explosion effect, chemical pollution and flooding simulations. The explosion and chemical pollution simulations will allow the user to simulate which areas will be affected by the threat. The result would include spatial features in the form of polygons with additional information concerning the affected regions. Flood simulation will be used to determine the size of the area awash. This simulation model will use a Digital Terrain Model (DTM) and data related to the soil, and ground properties. Service results include information on the flooded area. Explosion and chemical pollution simulations will produce vector data, which can be served as a shape file or in GML form dynamically via FTP. On the other hand, the results from the flood simulation model – as being more complex – will be presented in raster form. The output will contain information concerning the water level altitudes for the gridded area.

CONCLUSIONS

During the development of data dissemination services for EO data obtained by the HRPT-MetOp ground satellite station and accompanying GIS system, various issues connected with the development of web services were faced and resolved.

Service Support Environment is an easy-to-use tool which can be included in vast GIS environments with minimal effort. Tools provided with the platform incorporate widely used technologies and programming languages, which accelerates the process of merging the SSE and native platforms.

Dissemination of data through web services is made easy with SSE. Due to open distribution of this environment, services are easily accessible and available for geospatial society. Since the SSE is accessible through the ESA's web-pages, and is connected with their other services, the number of data receivers is expected to increase. Shared data and functionality can be used by other systems, which affects the lower cost of this developed solution.

Due to integration with SSE, the operationability of the system substantially increased, especially in the context of data dissemination capabilities. Aforementioned advantages of the SSE platform were taken into consideration, leading to the conclusion that choosing the ESA's SSE for services management is a plausible option.

The spatial data awareness tends to be more and more important in the maritime applications. As an example, the maritime administration (MA). Nowadays in Poland, there are approximately 20 different spatial data sets which are in competences of MA. Most of them are related to the sea, and some of them are related to the land. Examples of sea-related, are hazardous areas for boating and fishing (with the deadlines for the recognition of a dangerous zone), established flow routes, sea routes or the axes of submarine cables and pipelines. Those related to the ground are designated by boundaries of the coastal belt (technical belt and protective belt). Coastal belt is an area of land adjacent to the sea shore. The coastal belt includes the technical belt - which is an area of mutual direct impact of sea and land and requires very high environmental protection, and the protective belt which covers an area in which human activities have a direct impact on the technical belt.

The synergy from the combination of the "native" spatial data of MA and other sources of spatial data, may be considered as substantial. For example, using real-time satellite observation in the hazardous areas for boating and fishing, or technical best, may help to improve safety and improve decision time in crucial situations. In such a context, usage of the open standards for spatial data dissemination which were applied in the presented system makes the services (and in general our approach) compliant and ready to serve as complementary in maritime applications, including supporting processes in maritime administration.

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