Implementation of the KOMPSAT European Regional Archive Supporting the OGC WebMap-, WebFeature-, and WebCoverageService as well as International Catalog Interoperability

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1 ABSTRACT

The development of the KOMPSAT European Regional Archive (KERA) aims to demonstrate and prove an implementation concept for easy access to Earth Observation (EO) data. The basic results are (i) the offer of enhanced products based on the principles of a high degree of automation, (ii) an easy access to data and services, (iii) and the availability to both expert and non-expert users. This implementation was facilitated by the well established scientific and technological collaboration between the Korea Aerospace Research Institute (KARI) and the Austrian Research Centers - Seibersdorf research Ges.m.b.H. (ARC-sr), Intelligent Infrastructures and Space Applications Department.

The archive is intended to provide full and easy access to the EO data in an adequate time. Therefore, a database considering existing standards and specifications is designed for use in an Object-Relational Database Management System (ORDBMS). Access to the data is granted through Open Geospatial Consortium, Inc. (OGC) Web Services (OWS), namely WebMapService (WMS), WebFeatureService (WFS), and WebCoverageService (WCS).

There are several different access points to the data stored in KERA. One is implemented and located at ARC-sr. It acts as a client to the WMS, but has additional functionalities concerning the archive. Other access points are via the Service Support Environment (SSE)-Portal and the eoPortal, both hosted by the European Space Agency (ESA).

2 INTRODUCTION

With computers and Internet being more and more part of our everyday lives, the possibility to provide Earth Observation (EO) data to a greater audience has significantly grown. The development of the KOMPSAT European Regional Archive (KERA) aims to demonstrate and prove an implementation concept for easy access to data. Basic results are the offer of enhanced products based on principles of a high degree of automation, an easy access to data and services, and the availability to expert and non-expert users.

The data processed at the Austrian Research Centers - Seibersdorf research Ges.m.b.H.1 (ARC-sr), Intelligent Infrastructures and Space Applications Department are images derived from earth observation satellites. Currently nearly all data arrives from the first Korean Multi Purpose Satellite (KOMPSAT-1). The archive will be expanded by data from the future KOMPSAT-2 satellite. Both missions are developed and operated by the Korea Aerospace Research Institute2 (KARI). The development of KERA is possible due to a well established scientific and technological collaboration between KARI and ARC-sr [1].

The KOMPSAT-1 satellite collects high-resolution imagery at 6.6 m spatial resolution. The sensor, called Earth Observing Camera (EOC), delivers panchromatic images. The future KOMPSAT-2 platform with its very-high-resolution Multi-Spectral-Camera (MSC) will provide imagery with one panchromatic channel with a spatial resolution of 1 m and four multi-spectral channels with 4 m spatial resolution.

Considering the archive it is necessary to store all required data and metadata in an appropriate way. Hereby, an Object-Relational Database Management System (ORDBMS) is used. The design considering existing standards and specifications and some implementation details of this database are presented.

Additional developments for KERA are achieved by applying the Open Geospatial Consortium, Inc. (OGC) Web Services (OWS) WebMapService (WMS), WebFeatureService (WFS), and WebCoverageService (WCS). These standardized web services are used to access the data in various ways over the Internet.

Furthermore, different access points to the EO data stored in KERA are explained. The method implemented and located at ARC-sr is introduced as well as the access points via the Service Support Environment (SSE)-Portal and the eoPortal, both hosted by the European Space Agency (ESA).

3 METADATA CATALOG SERVICE

It is very important for every data warehouse to store metadata, mostly defined as "data about data". The biggest data collection is good-for-nothing if nobody knows which and how data is stored. The Internet and it's high availability offers the possibility to search the archive from all over the world at any time. It additionally offers the possibility to search more than one storage place at the same time. Many difficulties arise if two or more servers are queried at the same time. They need to "talk the same language" and therefore there is a big need for standardization on metadata storage and access.

The international standard on metadata [2] from the International Organization for Standardization's (ISO) Technical Committee ISO/TC 211 Geographic information/Geomatics3 is one of the attempts to solve this problem. At ARC-sr it is also important to take ESA's SSE ICD [3] into account to make the archive searchable and accessible via the SSE-Portal and the eoPortal.

All this geographic metadata needs to be stored somehow on the computer. The best way to do to this is to use a database and a Database Management System (DBMS). Nowadays, such systems are commonly used and have many advantages e.g. control of concurrent access by multiple users, prevention of data inconsistency, easier local and remote access, etc. At ARC-sr it was decided to use PostgreSQL4 as database management system because of various reasons. First, PostgreSQL can be extended with software

1URL: http://www.space-applications.at
2URL: http://www.kari.re.kr
3URL: http://www.isotc211.org
4URL: http://www.postgresql.org

like PostGIS5, which adds support for geographic objects to PostgreSQL. In effect, PostGIS "spatially enables" the PostgreSQL server. Second, PostGIS follows the "OpenGIS® Simple Features Specification for SQL" [4]. Third, PostgreSQL is an OpenSource Object-Relational Database Management System (ORDBMS).

4 GEOSPATIAL SEARCH

The most common search, dealing with satellite derived images, is the simple spatial search (e.g. Which images cover Vienna?, Which images are within Europe?). What has to be done to get the correct answers to these questions? First the outline of every image has to be stored as object in the database. The PostGIS object POLYGON is the appropriate data-type. The four corner coordinates of the image are stored in simple longitude/latitude coordinates using the World Geodetic System (WGS84).

All needed spatial functionality, like re-projection of objects, spatial search, etc., within the database is provided by PostGIS. The PostGIS function Intersects() determines if objects share common points or not. The function GeometryFromText() constructs geographic objects from a Well-Known Text (WKT) format [4] for use in PostGIS. Thus the following SQL-command retrieves whether the image given with the polygon is showing Vienna (given in the POINT object) or not:

```
SELECT Intersects(GeometryFromText('POLYGON((16.02063625 48.86594772,16.2
6286888 48.89667965,16.81641535 47.30641733,16.58351857 47.27637656,16.02 063625
48.86594772))',4326),GeometryFromText('POINT(16.37 48.2)',4326));
```

There are also some problems arising with the use of PostGIS. The first problem occurs from the fact that Earth is not flat. PostGIS assumes all objects to lie in a plain surface using the coordinates in a two dimensional Cartesian coordinate system. On the horizontal axis the longitude is measured and on the vertical axis the latitude. Longitude is defined to be in the interval lon: -180° ≤ lon ≤ 180°. What happens if a search crosses the line of ±180° longitude, which lies opposite the prime meridian? This line is mostly identical with the international date line, which reveals a new problem if the search is also considering date. The worst case is caused by the poles. If one of the poles is covered by the image everything gets much more complicated.

Fortunately, there is another extension to PostgreSQL to cope with these problems called pgSphere6, which provides spherical data types, functions, and operators. The only problem, or maybe another advantage, with pgSphere is that it takes the Earth curvature into account and thus there are some differences in the search outputs compared to PostGIS. A combination of PostGIS and pgSphere can perform all tasks required.

It depends on the application which extensions are best to be used. Currently at ARC-sr, just PostGIS is being used since there are only images of Europe and nearby countries to manage and therefore, no problems with the ±180° meridian and/or the poles arise.

5 DATABASE DESIGN

The logical schema of the database is best explained in a graph. Thus, the schema is shown using the class diagram of the Unified Modeling Language (UML) (Figure 1) as described by Kemper and Eickler [5]. UML is a non-proprietary, third generation modeling and specification language, used especially for object-oriented modeling.

The "main"-entity is shown in light orange and called "image_metadata". For every image at ARC-sr an entry in this table with primary key "ImageName", which is a string with a fixed count of 24 characters, e.g. "eoc06182_20010216T091614", is created. The name of this image tells, that it was captured at orbit number 06182 on February 16, 2001 starting at 9:16:14 Universal Time Coordinate (UTC) with KOMPSAT-1's EOC.

The second basic entity is "process" which is a generalization of "raw", "geo", "ort", "wms", and possible future processes e.g. "urb". Generalization means, that the generalized entities inherit the superclass's, here "process" attributes. Every processing step done with an image gets logged here. "raw" implies the process of getting a new raw-image and storing it in the file system together with a browse image (quick-look) which needs to be generated and managed as well. "geo" describes the process of looking up geographic coordinates and assigning them to image-pixels. "ort" is the process of taking the points-files from the "geo" process, orthorectifying the image, and storing it in the file-system. "wms" (light-blue) finally is the process to prepare the image resulting of the "ort" process for usage within the OpenGIS® services. For easier, controlled, and advice providing content management an administration tool was developed at ARC-sr. This tool can be accessed with every standard web browser.

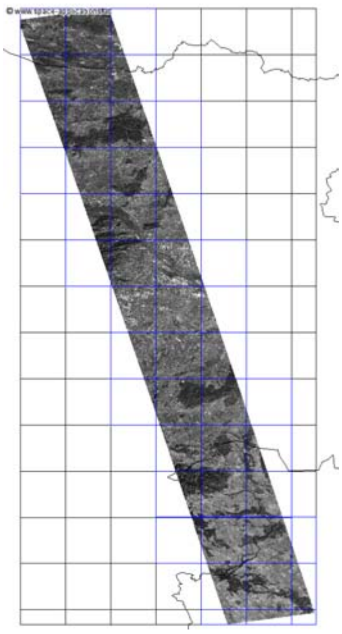

Figure 1: Tiling: Blue lines are outlines of tiles, black lines represent the full image.

5URL: http://postgis.refractions.net
6URL: http://www.pgastro.org/cgi-bin/wiki.pl?pgSphere

6 THE WMS PROCESS

"wms" is the name of the process to prepare the image for the usage within the WebMap-, and WebCoverageService which will be introduced in the next section. A short response time is very important for these services. To increase speed and performance the large raster images are tiled into smaller pieces and shapes are created for their outline (Figure 2). These shapes are saved in the database. After the database has been searched for the required area (based on the outline vector shapes) just the actually required raster images have to be loaded and processed. The tiling has the additional advantage that only tiles that contain information need to be saved.

If the size of the tiles is given with 2048 *pixels* the image shown in Figure 2, which has a size of 13380 *x* 27240 *pixels*, is tiled into 7 *x* 14 = 98 *tiles*. Only 47, out of the 98 *tiles* created, need to be saved since the other contain no data.
The tiling process also generates so-called "overviews" which are images at half resolution in both dimensions, and therefore only a quarter in size of the original image. These overviews are also tiled and the process continues until the smaller image extent can be shown by one tile. For the image in Figure 2 the first overview has 4 *x* 7 *tiles*, the next one has 2 *x* 4 *tiles*, and the last one has 1 *x* 2 *tiles*. Because the tiles with no data are deleted only 71 *tiles* out of the 136 created are saved.
This tiling and building of overviews has turned out to be the fastest solution (for display on the web) among some alternatives (e.g. GeoTIFF with the built in tiling and overview options, compressions like JPEG) which were all tested at ARC-sr. It is also recommended to store the images in the most often used projection because reprojecting images on the fly is very time consuming.

7 WMS, WFS, AND WCS

This section explains which and how services can make use of the database. Especially the remote access via a network to these services is of interest. The Open Geospatial Consortium, Inc.7 (OGC) has specified several OpenGIS® web services like the WebMapService (WMS) [6], the WebFeatureService (WFS) [7], and the WebCoverageService (WCS) [8]. OGC is an international consortium of companies, agencies and universities. They define themselves as "a non-profit, international, voluntary consensus standards organization that is leading the development of standards for geospatial and location based services in different working groups". Through their member-driven consensus programs, they work together with government, private industry, and academia. Virtually all well-known providers of software for Geographic Information Systems (GIS) take part in the OGC.

A web service is defined as any software that makes itself available over the Internet and that supports interoperable machine-to-machine interaction over a network. Software applications written in various programming languages and running on various platforms use web services to exchange data over computer networks, e.g. the Internet, in a similar manner as inter-process communication on a single computer. This interoperability is possible due to the use of open standards, like those of OGC.

The WMS is one of OGC's most popular standards. This service produces maps, which are visual representations of georeferenced data. These maps are not the data itself. The specification defines the syntax of requests as well as the format and features of the result. The platform supported by the service is the World Wide Web (WWW) or more specifically Internet hosts implementing the Hypertext Transfer Protocol (HTTP), like every standard web browser.

A WFS publishes feature-level geospatial data to the web. This means that instead of returning an image, like a WMS does, the client directly obtains information about specific geospatial features of the underlying data, at both the geometric and the attributive levels. Finally, the WCS returns representation of space-varying phenomena like satellite images - i.e. it returns data with its original semantics (instead of pictures like the WMS) as coverages together with a detailed description. Coverages can be interpreted, extrapolated, etc. and not just portrayed like maps.

To implement the OGC Web Services (OWS) described so far the software MapServer8 is used at ARC-sr. MapServer was originally developed at the University of Minnesota (UMN), which is an associate member of the OGC. The choice to use MapServer was made because it is an OpenSource development, supports all required OWSs, and data input through PostGIS, which is used for the archive, is allowed.

The WCS can be used for data delivery. Following request will provide the image shown in Figure 2 in its original resolution, which will result in a GeoTIFF-format file with about: 350 MB.

```
http://spacey.arcs.ac.at/cgi-bin/wms?SERVICE=WCS&VERSION=1.0.0&REQUEST=Ge
tCoverage&COVERAGE=eoc06182_20010216t091614_scale1&CRS=EPSG:4326&RESX=0.00005925
26158445443&RESY=0.0000594823788546256&FORMAT=GeoTIFF
```

8 SERVICE INTEGRATION

This section covers the client side of KERA. The first access point to KERA is a WMS client implemented at ARC-sr. This client is implemented to show and extend the possibilities of the WMS. It is important that everybody is able to use the client with a standard web browser without having to install any software (i.e. plug-ins, applets, etc.). Therefore a mixture of JavaScript and PHP with MapServer's PHP/MapScript scripts was developed and implemented. The client implements standard GIS functionality as well as functions to search the archive and obtain metadata.

Other access points are via the Service Support Environment9 (SSE)-Portal and the eoPortal10, both hosted by the European Space Agency (ESA). For both, ESA provides a neutral infrastructure, capable to foster the seamless integration of Earth Observation (EO) archives, products and services.

7URL: http://www.opengeospatial.org
8URL: http://mapserver.gis.umn.edu
9URL: http://services.eoportal.org
10URL: http://catalogues.eoportal.org

The SSE acts as service broker, which registers published service providers under particular service categories. It also acts as search service provider, that allows users to search catalogs of connected data providers. Currently a service for searching the KERA catalog is implemented.

The eoPortal, also provided by ESA, is a non-brand portal providing an interface for space data providers to connect their catalogs. The KERA catalog at ARC-sr is now available as data collection and therefore searchable via the eoPortal catalog client.

Figure 3 shows the interaction between the individual parts of the implementation at ARC-sr including these access points. The system can be divided into four functional units. The first three units with light-blue background represent ARC-sr whereas the dark-orange one Korea Aerospace Research Institute (KARI). The first of the ARC-sr units (light-orange background) represents the access point via the SSE-Portal. The second one (blue background) includes all the WMS related components as well as the local client. The third one (green background) shows all parts required for the access via the eoPortal. Finally, the last unit on the right, actually a copy of the third one, represents the implementation at KARI which allows access to their international KOMPSAT archive also via the eoPortal.

9 CONCLUSION AND SCOPE

With the Internet being more and more part of our everyday lives, many barriers have already been removed and, assuming easy access, satellite images could be enjoyed by a greater audience. For example, in Europe the demand for easily accessible, online, very high resolution, geocoded information products is continuously increasing, driven by mass market applications which have cartographic data needs, e.g. car multimedia navigation systems and other navigation devices. To integrate satellite derived data in these devices, standards, like those of OGC, are required and will be used.

Additional many different web services exist focusing on EO data. Chaining these existing services will create various new services and products. The SSE-Portal provides the ability to chain existing services. Due to the integration of many different web services focused on EO into the same portal with respect to existing standards, the data dissemination will, hopefully, grow and a greater number of users will use EO data. Sometimes they will not even realize to which services their devices connect but sometimes they will develop services by themselves that possibly integrate other services.

The aim of the development of the KOMPSAT European Regional Archive (KERA) and its different access points is to offer enhanced products based on the principles of a high degree of automation, easy access to data and services, and availability to both expert and non-expert users. The proven concepts of the successful integration of the KERA into various systems namely WMS, SSE-Portal, and eoPortal provide the basis for further developments.

Making satellite data more accessible and reducing the necessity of investment in software and time to learn the handling, will improve the acceptance and increase the number of users. These improvements might additionally enlarge the various possibilities to use satellite data in miscellaneous applications.

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