Developing OGC Compliant Web Mapping for the UK Satellite Image Data Service

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Abstract
The Satellite Image Data Service provides web-based access for UK academia to orthorectified Landsat, SPOT, European Remote Sensing (ERS) radar data, Advanced Synthetic Aperture Radar (ASAR), Digital Elevation Model (DEM) and Shuttle Radar Topography Mission (SRTM) data for the UK. To view data the user would click a thumbnail tile of an image on the website and see a static screenshot. The aim of this research has been to investigate Open Geospatial Consortium (OGC) compliant services to provide an interactive mapping system. Therefore users can utilise the mapping interface to explore the satellite imagery available and gain integral knowledge of the data before download. In addition, these services will provide the experience to offer services that can interoperate with other UK academic providers of spatial data.

Web Map Services (WMS) and Web Coverage Services (WCS) were created. MapServer detailed in Kropla, (2005) and ER Mapper's Image Web Server was selected as two suitable map engine solutions. Pyramiding, raster extents shapefile indexing and ECW compression formed the data preparation procedures aimed at producing efficient request-response cycles. The web clients Chameleon 2.0 and RightWebMap were customised. Two preliminary mapping interfaces have been produced for the service which was used to test interoperability of MIMAS WMS nationally with WMS available from EDINA, University of Edinburgh and ICEDS, University College London.

Keywords: WMS, OGC, MIMAS, MapServer, Chameleon, ER Mapper.

1. Introduction

1.1 Satellite Image Data Service

The UK Satellite Image Data Service (SIDS) provides web-based access to and support for a range of satellite imagery for the British Isles for research and teaching purposes. Data includes a set of orthorectified satellite images from five satellites, Landsat 5, Landsat 7, Satellite Pour l'Observation de la Terre (SPOT), ENVISAT Advanced Synthetic Aperture Radar (ASAR) and European Remote Sensing (ERS). The data cover the UK over a variety of temporal periods. All data is available for download from the Landmap website by students and academics who attend a subscribed institute. The satellite imagery has been orthorectified and projected to British National Grid and can be used in image processing software, in association with user's data or other mapping data such as Ordnance Survey data in a Geographical Information System (GIS) (Landmap 2006). In addition, a Digital Elevation Model (DEM) of the whole of the British Isles at 25 meter resolution is available derived from interferometric methods using ERS 1 and ERS 2 data (Kitmitto 1999). The data can be accessed from the Landmap website http://landmap.mimas.ac.uk. Prior to download, users would only be able to view the satellite imagery from a static image therefore no interaction with the data was available. The aim of this project was to develop a web mapping client with some simple functionality which would provide users of the service the opportunity to interact and explore (at a range of spatial scales) the satellite imagery available from the service. Web service interoperability with external organizations in academia such as Integrated CEOS European Data Server (ICEDS) and EDINA was also tested in a Joint Information Systems Committee (JISC) funded project.

1.2 Open Geospatial Consortium

The SIDS role is to acquire, create, maintain and disseminate data to academia as part of the academic provision of basic support for research and teaching in Higher education of the UK. Web services provide a method of disseminating this data. Open Geospatial Consortium Inc (OGC) web service specifications deal with geographic information specifically (Zhang and Li 2005). The OpenGIS® Consortium was established in 1994 to improve geospatial interoperability (Longley *et al.,* 2002).The international organisation consists of industry, government agencies and universities focused on developing web environments for geo-spatial data that are standardised and interoperable (Kim *et al.*, 2005). SIDS identified two OGC specifications applicable to serving satellite imagery, Web Map Services (WMS) and Web Coverage Services (WCS).

WMS produces maps of georeferenced data which is a visual representation of the geodata stored on the server, the returned image from the server is provided as a JPEG PNG or GIF (OGC 2006*a*; Kim *et al.*, 2005). Three WMS operations can be requested:

GetCapabilities – Provides metadata about WMS, data available, data format and projection in XML.
GetMap – Returns a map image from defined geospatial and dimensional parameters.
GetFeatureInfo – Allows a client to request information about features shown on a map (Kolodziej 2003).

WCS require data representing space-varying phenomena therefore in raster (coverage) rather than vector format (Lee *et al.*, 2005). OGC (2006*b*, 10) states: -

> *'WCS provides access to potentially detailed and rich sets of geospatial information, in forms that are useful for client-side rendering, multi-valued coverage's, and input into scientific models and other clients'.*

GetCapabilities, DescribeCoverage and GetCoverage requests can be submitted to a WCS. GetCoverage requests enable coverages to be downloaded to the user in a specified format such as GeoTIFF.

There is a third common OGC specification Web Feature Services (WFS) similar to the WCS but for vector data (OGC 2005). Using a GetFeature request geographic data can be retrieved from the server in Geographic Markup Language (GML) and hence like WCS delivers actual data not just a representation (OGC, 2005).

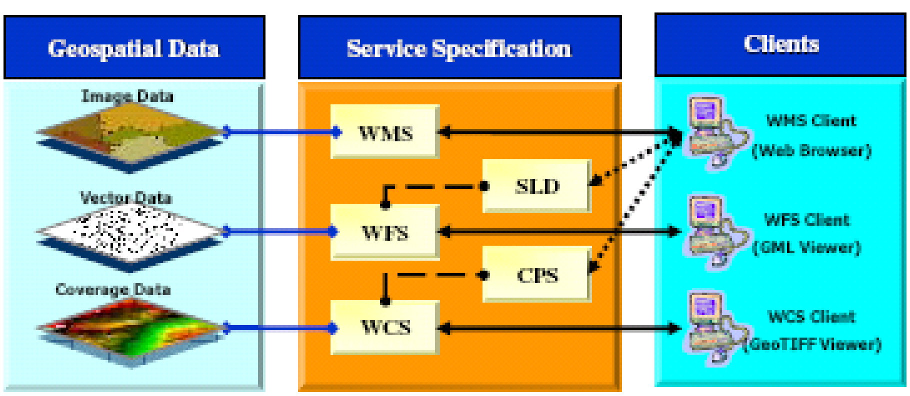

Figure 1. Specifications of geospatial web services derived from OGC (Lee *et al.*, 2005, 1137)

EDINA produced a range of WFS for Ordnance Survey data for the JISC Interoperability Project. The diagrammatic summary of these specifications (Figure 1.) illustrates the types of geospatial data accessible via different OGC services. The standardised syntax for operations e.g GetMap, GetCoverage and GetFeature are composed as request-response message pairs carried over Hypertext Transfer Protocol (HTTP) (Cox 2003).

1.3 Interoperability

CÖMERT (2004) defines interoperability as the ability by which different applications can talk and cooperate with each other. Prior to OGC services data sharing would involve sending data on a CD to the user or downloading data from a website. Due to the heterogeneous nature of geographic data, conversion into other formats to use in an image processing or GIS software would usually be the first process in a project that needed to use geospatial data.

The collaboration of commercial companies to build in support for OGC specifications and the growth of open source alternatives means that the creation and provision of OGC compliant services are open to all with the expertise and equipment to implement them. Popular commercial tools for data sharing over the web include: - MapXtreme from MapInfo, Image Web Server from ER Mapper and ArcIMS from ESRI (Zhang and Li 2005). ESRI states that by employing industry wide computing standards in its software, ESRI supports both GIS and information technology interoperability (ESRI 2006*a*). ER Mapper's Image Web Server 7.0 provides support for OGC WMS, ESRI's ArcIMS/ArcXML, HTTP and Enhanced Compressed Wavelet Protocol (ECWP) for image streaming (Jensen 2005; ER Mapper 2004*a*).

MapServer from The University of Minnesota and GeoServer are examples of open source alternatives for publishing geographic data to the web (Erle *et al.*, 2005). MapServer supports all OGC Web Services (OWS) this enables users to combine OWS into one Graphical User Interface (GUI) which allows interoperability of spatial data across organisational boundaries irrespective of data format. GeoServer conforms to the OpenGIS WFS, WMS and GML specification and is supported by The Open Planning Project (Erle *et al.*, 2005).

1.4 Web mapping clients

The use of the WWW for mapping spatial information is the fastest growing area of the spatial software market (Lee *et al.*, 2005). The simplest web map would be to post a pre-drawn map on a web page (Zhu 2001). The SIDS aims to create an interactive mapping application enabling users to view and query satellite imagery in an integrated manner with navigational tools such as zoom, pan and roam (Morgan *et al.*, 2005).

There are many examples of on-line mapping applications and clients the most well known being Google Maps and Google Earth. Since the launch of Google Earth in June 2005 the geographic information science community has witnessed a huge rise in geographic data use. Casual users intrigued to view their home or workplace from a satellite image utilise the simple interactive tools (Butler 2006).

The SIDS web mapping client aims to provide a simple intuitive interface with supporting help documentation. MapServer and ER Mapper's Image Web Server have been used as map engines for the project. Chameleon 2.0 has been chosen as the web client to configure with MapServer and RightWebMap produced by ER Mapper will be used as the web client supporting Image Web Server. This combination of products will offer a contrast between open source and non open source solutions.

The following objectives have been devised to create prototype web mapping clients for the SIDS.

- Prepare data for serving as OWS
- Create WMS and WCS for the SIDS.
- Test MapServer as an Open Source solution with Chameleon 2.0 web client against ER Mapper's Image Web Server with RightWebMap web client, investigate image streaming.
- Interoperate SIDS WMS with WMS from EDINA and ICEDS.

2. Methodology

2.1 Data Preparation

Several steps were taken to improve server response time.

Pyramiding involves creating different versions of the same data at lower resolutions (ICEDS 2005). ERDAS Imagine 8.7 Interpreter > Utilities > Degrade option was used to create ortholandsat imagery at 50m and 100m resolution from the original resolution of 25m.

Shapefile indexing was applied to the satellite imagery. The supporting open source Geospatial Data Abstraction Library (GDAL) needed to be downloaded http://www.remotesensing.org/gdal/. The shapefile index files were created for the tiled data using the gdaltindex utility tool and applying the command: -

/gdaltindex.exe assign_name.shp *.ecw

* Path to imagery storage directory

The indexing is specifically for using with UMN MapServer (Kropla 2005). The SHAPEFILE tag within the MapFile should specify the directory the shapefile indexes are located (MapServer 2006). When a request is sent to the server the process will be more efficient, as only the tiles in the user defined bounding box would be sent as a response from the server rather than the whole image.

All data for WMS was converted to Enhanced Compressed Wavelet (ECW) format using ER Mapper's Image Compression Wizard. File size was significantly reduced e.g. ASAR image mode scene in GeoTIFF format is 253,111Kb, when saved as ECW the file size was reduced to 15,096Kb. The data in GeoTIFF format remained on the server for download via WCS. ER Mapper (2004*a*, 15) state that 'ECW compressed image format is the most popular worldwide standard for managing large volumes of imagery'. The ECW conversion process also prepared the satellite imagery for streaming via ECWP with Image Web Server.

2.2 Web Mapping Configuration

Two different solutions for developing a web mapping application for SIDS will be described in this section. The first using open source products and the second using ER Mapper's Image Web Server.

2.2.1 Open Source MapServer & Chameleon

MapServer creates map images of spatial data either in vector or raster format. The two native raster formats the program can read are GeoTIFF and EPPL7. When supported by GDAL over 20 raster formats can be read including ECW (Kropla 2005). MapServer was used in combination with Chameleon Server which communicates with MapServer to generate and integrate the mapping content into the web mapping application as illustrated in Figure 2 (DM Solutions Group Plc 2005).

MapServer 4.8.1 for windows was installed, available for download from http://mapserver.gis.umn.edu/. The HowTo documentation is very useful for beginners which can be found on the MapServer website. MapFiles were created for the five different types of satellite imagery hosted by the service for WMS and WCS. WCS contain an addition parameter within the LAYER elements of the MapFile called DUMP which should be set to TRUE and TYPE should be RASTER not VECTOR. Metadata for WMS and WCS is mandatory and should be found both in the WEB and LAYER elements. Once the data layers had been added to the MapFiles a GetCapabilites request can be submitted to MapServer to test whether the services are working; The request initiates the creation of an XML file providing information about the data layers in the service, contact details of the service provider and metadata information. If successful then a GetMap or GetCoverage request can be submitted.

The next step was to install PHP 5.1.2 and configure PHP using the php.ini file and IIS 6.0.

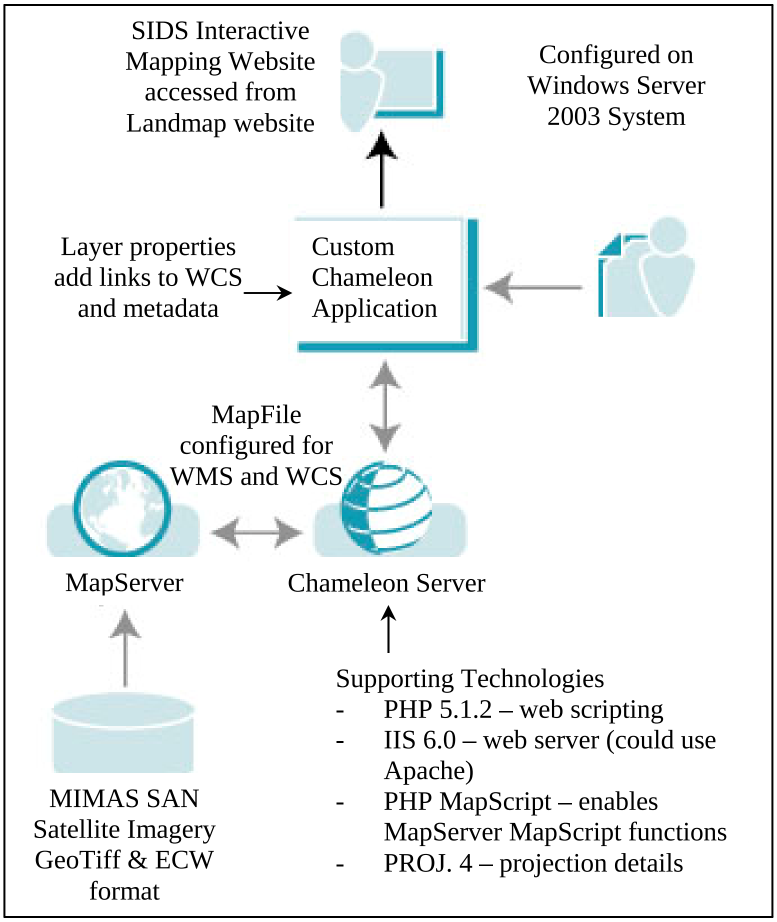

Figure 2. Configuration of MapServer and Chameleon for SIDS mapping client. Adapted from DM Solutions Group Inc. (2005 on-line http://www.dmsolutions.ca/technology/chameleon.html).

The web service extensions .phtml and .php were added to IIS 6.0 (MapServer 2006). Finally Chameleon was installed, configured with IIS 6.0 (creation of several virtual directories is required) and the files chameleon.xml and cwc2.xml allowed parameters such as image path and the location of the php_mapscript.dll file to be specified. To check Chameleon is configured correctly the URL http://servername/chameleon/admin/main.phtml provides a list of settings for PHP, MapScript, CWC and Chameleon.

Chameleon 2.0 was chosen for this research because it has been designed to work with UMN MapServer, the interface can easily be customized with little programming skills from a wide range of widgets which provide dynamic functionalities and there is a good support network for this technology provided by DM Solutions Group Plc and also from the Chameleon user list.

2.2.2 Image Web Server & RightWebMap

Popular vendors in the GIS and remote sensing industry are members of the OGC. The commitment to OGC has resulted in vendor products designed to support OWS specifications (ESRI 2003; ESRI 2006*b*; ER Mapper 2004*a*). The option to use a vendor web serving technology was available rather than open source. Initially ArcIMS and ArcSDE were considered, ArcIMS was tested briefly, but it was concluded that these did not provide the best tools for managing a large raster dataset. It was decided that ER Mapper's Image Web Server 7.0 available at a reduced cost for academic institutions, (same as for ArcIMS), was the preferable option which also has the ability of image streaming. The installation CD installs Image Web Server as an ISAPI extension to Internet Information Server (IIS) 6.0.

To enable image streaming all the satellite imagery needs to be in ECW format and an ecwp virtual directory created in IIS during initial installation. Using the Image Web Server Console and selecting Tools > ECW ArcXML/WMS, directories can be added pointing to where the satellite imagery is stored (in this case the MIMAS SAN). The benefits of ECWP are real-time zoom and roam capabilities are experienced by the end user.

Image Web Server also supports WMS GetCapabilities and GetMap requests Version 1.1.1. GetMap requests are returned as either JPEG or PNG formats, GIF is not supported. A GetCapabilities request can be submitted to provide details of the data available in XML (Figure 3):
http://camber.mc.man.ac.uk/ecwp/ecw_wms.dll?request=GetCapabilities&service=wms.

The web client supplied to support Image Web Server is RightWebMap 7.0. MapXtreme, ArcIMS, MapServer, MapGuide and MapPoint .NET servers can all be used within RightWebMap (ER Mapper 2004*b*). The RightWebMap client contains two key files:

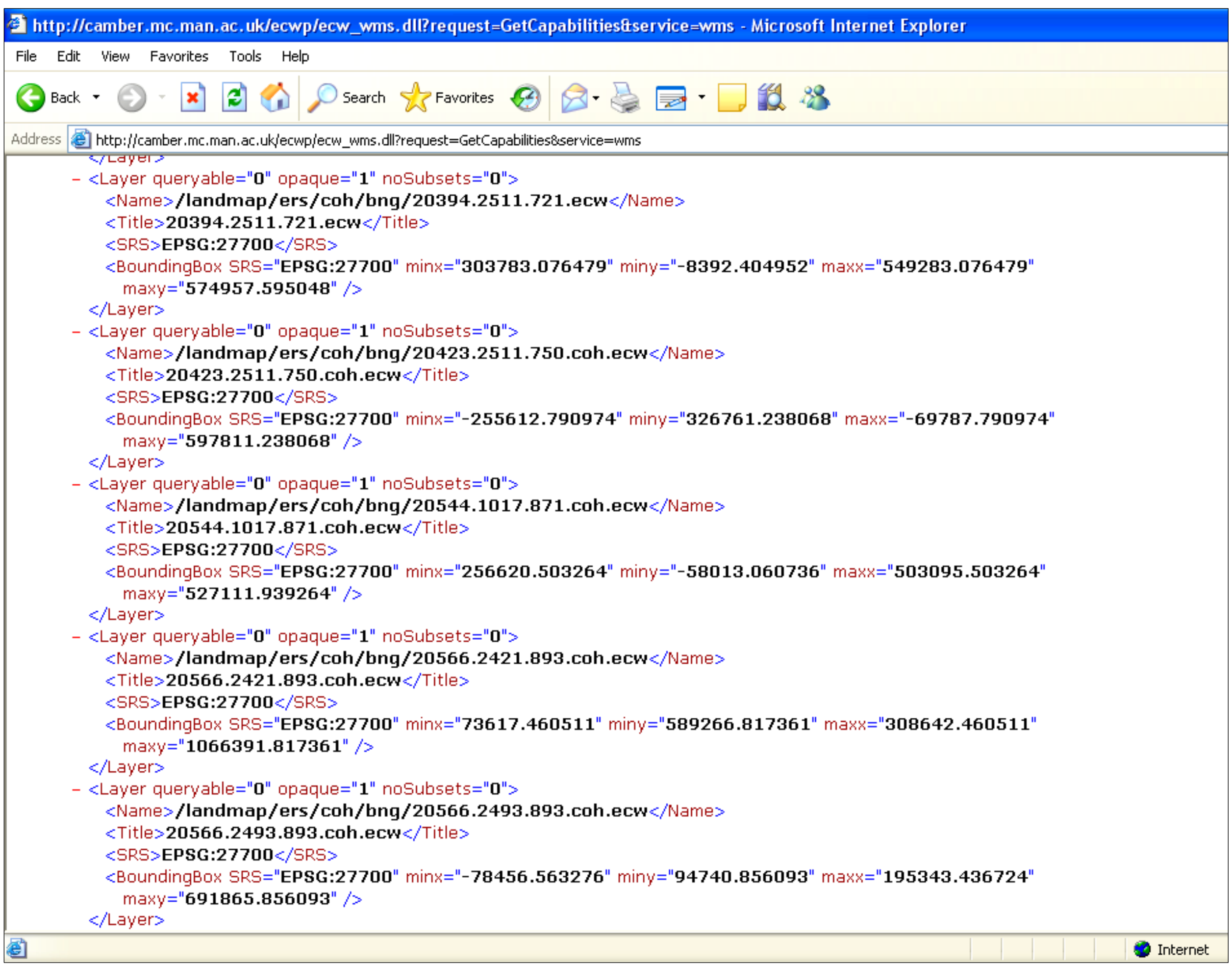

Figure 3. GetCapabilites XML generated from ER Mapper's Image Web Server.

Table 1. Code to add to RightWebMap.htm for different kinds of web services

Type of Service	Code
ECWP	svc = catalog.addService("MIMAS ECWP Landsat Mosiac's","ecwp",0,0,0,true); layer = svc.addLayer("Landsat 5 Mosaic" ,"Landsat 5 Mosaic","ecwp://<server_name>/landmap/mosaics/landsat/l5mosaic.ecw" ,true,true);
Local SIDS WMS	svc = catalog.addService("MIMAS MapServer WMS", "mapserver", "camber.mc.man.ac.uk/cgi-bin/mapserv.exe","<path_to_mapfile>/wms_mimas_mosaic.map",100,true);
External WMS	svc = catalog.addService("DEMIS OGC WMS", "wms", "www.demis.nl/mapserver/request.asp?", "",100,true);

- *RightWebMap.htm* - Image layers are specified and the type of protocol to use to access them, toolbar buttons, title and logos (main area for edits)
- *RightWebMap.js* – object orientated code for server integration (no edits required)

The RightWebMap.htm file calls the RightWebMap.js file in the HEAD of the code. The JavaScript file contains the code which provides the functionalities for the web client and LayeredView control (ER Mapper, 2004*b*).

To add a web map service involves adding a few lines of code to the HEAD of RightWebMap.htm (Table 1). A number of common plug-in check files are listed at the top of RightWebMap.htm which will send the user to an upgrade HTML page if the necessary JavaScript version is not detected.

2.3 Investigating Interoperability

The SIDS took part in a national interoperability project funded by JISC. This involved creating a demonstrator web client which contained several WMS from distributed data sources. Project partners included EDINA National Data Centre, ICEDS at University College London Geomatics Department, Natural Environment Research Council (NERC), DataGrid and University of Leeds, Centre for Computational Geography (CCG). WMS from EDINA and ICEDS were successfully added to the RightWebMap client and Chameleon client. The Chameleon client was further customised to provide links to WCS provided by ICEDS and WFS provided by EDINA. Therefore interoperability was successfully demonstrated at the mapping and data level.

3. Web Mapping Results and Discussion

3.1 Evaluation of Open Source Solution compared to ER Mapper Vendor Solution

Figure 4 and Figure 5 illustrate the final web mapping clients created. Figure 4 shows the web client for the open source solution using a combination of MapServer and Chameleon. The image displayed is of a Landsat 7 Panchromatic mosaic which is the first layer switched on within the table of contents. Data layers were organised into types of satellite imagery e.g. Landsat 7, Landsat 5, SPOT and Elevation. Figure 5 illustrates the ER Mapper vendor solution using a combination of Image Web Server and RightWebMap. The map image is of an ENVISAT image mode multi difference colour composite.

The benefits of both web mapping clients are they have the ability to change the order of layers so that the user can produce different composite maps (Kolodziej 2003). Both clients provide

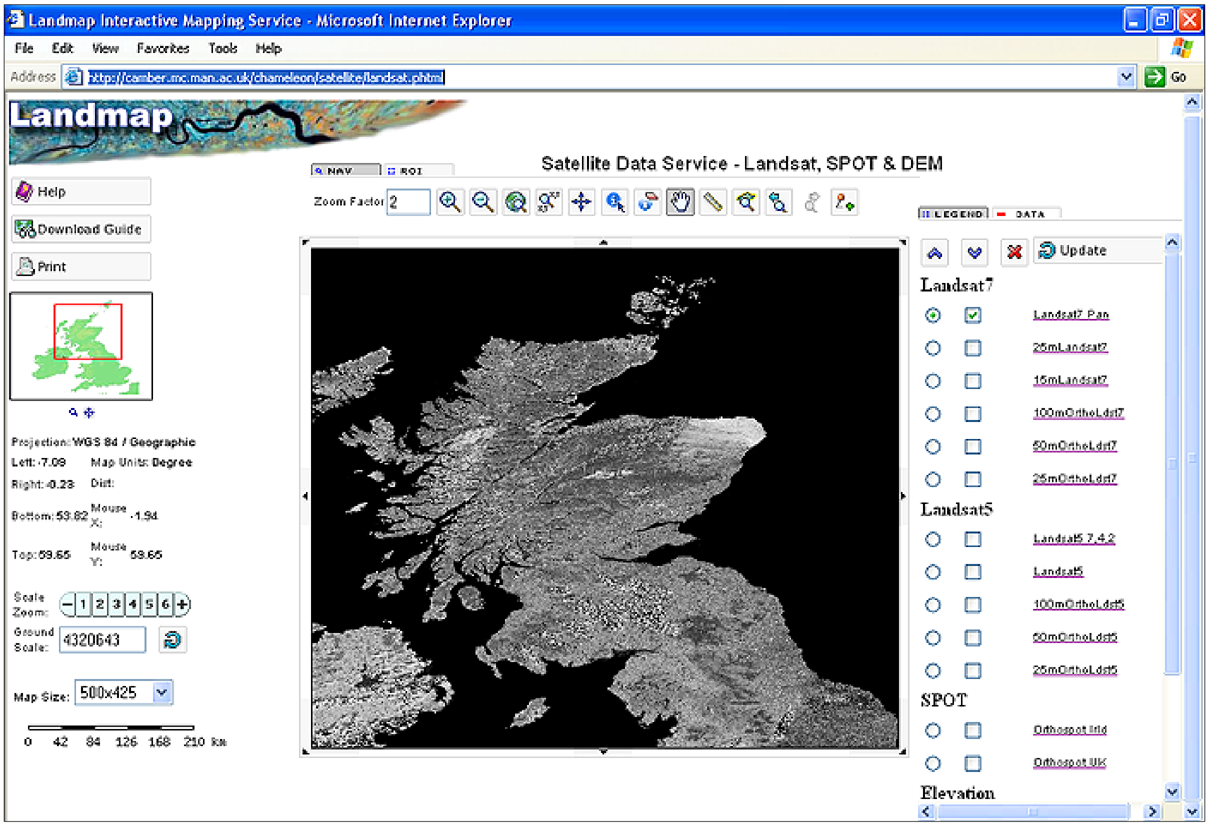

Figure 4. Chameleon Web Mapping Client – Open Source Solution.

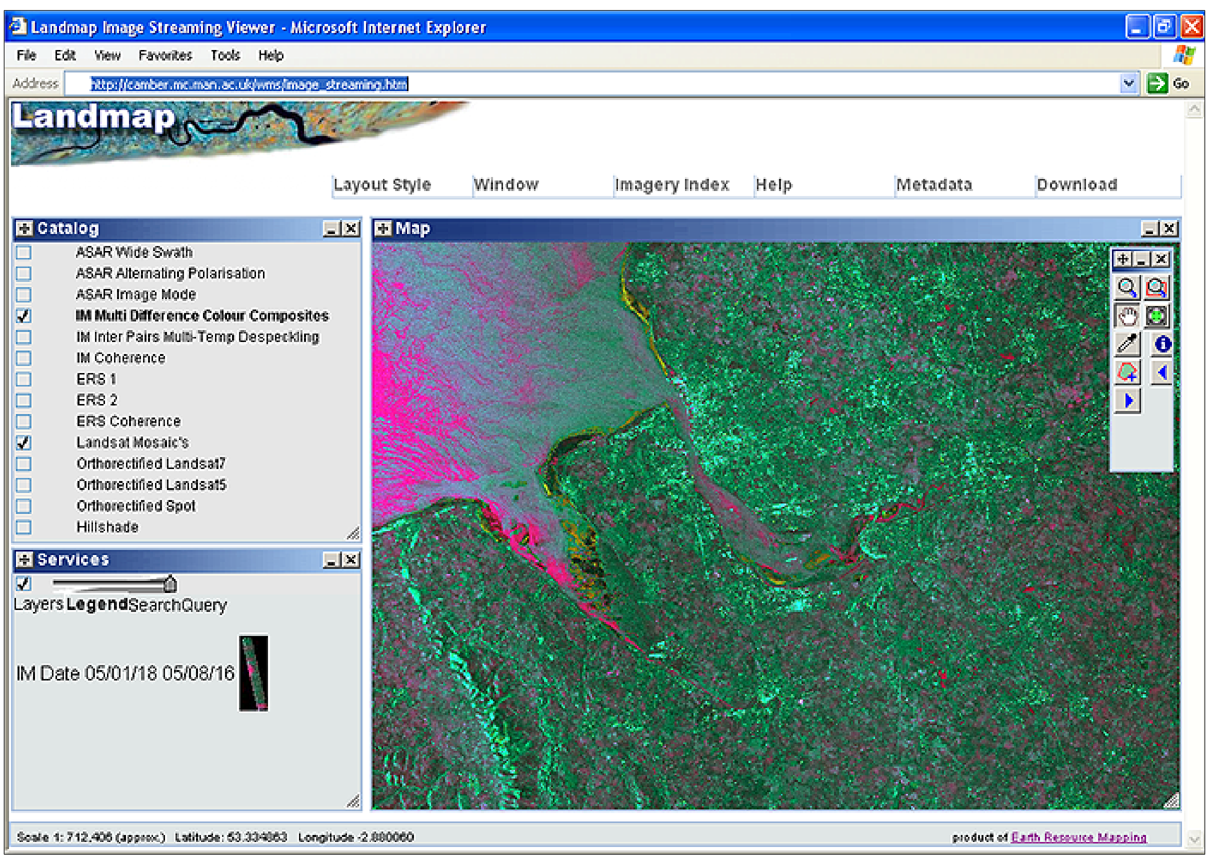

Figure 5. RightWebMap Client – Vendor Solution.

simple intuitive navigational tools and provide areas where customisations can be incorporated such as drop-down menus, pop-up boxes and buttons. Both clients were relatively easy to install. Chameleon took longer to configure however there was good support from DM Solutions Group during this process. The clients provide a good size map viewer for users to browse the satellite imagery.

The web mapping clients also have a number of differences; the Chameleon client had additional code available which provided more functionality (widgets). The widgets were added between CWC tags within HTML files. A map annotation tool, printing option and region of interest tools were added. In comparison to add these kinds of functionalities in RightWebMap client would have required programming in JavaScript and creating new code. Therefore customisations in the RightWebMap client were very simple a metadata and download drop-down menu was added which provided links to HTML pages where the data can be downloaded.

The Chameleon client was customised so that each layer is hyperlinked this initiates a pop-up layer information box. The layer information box contains links to metadata, WCS links to download 8 bit GeoTIFF and ECW imagery. There is a complication at this stage; if the user has Microsoft Office Document Imaging installed on their PC then the file downloaded will open automatically if the link is directly clicked. Therefore a Download Guide was created providing steps on how to download imagery from WCS. The document specifies to right click onto the link and Save Target As.

There was some difference in performance between the two solutions. The RightWebMap client when using Image Web Server ECWP rendered the images instantaneously whereas when MapServer was used there was a 2 - 4 second delay. When the Chameleon client is loading imagery from the WMS there is a 3 second delay even when the data has been converted to ECW. When switching on a new image in the RightWebMap client just the map viewer section of the page reloads, whereas the whole page reloads in the Chameleon viewer which can cause some delay.

The RightWebMap client only works fully in Microsoft Internet Explorer version 6.0 whereas the Chameleon client can be viewed in Internet Explorer version 6.0, Mozilla 1.7.12, Firefox 1.5.0.1, Safari 2.0.2 Opera 8.01 and Netscape 7.2.

3.2 Testing Interoperability

MIMAS, ICEDS and EDINA WMS were successfully integrated into a web client proving geodata interoperability is possible nationally between UK academic organisations. Figure 6 illustrates the types of OWS services provided by each of the organisations and how a geospatial value added chain could be developed when using OWS together (OGC 2003). Potentially a user could access a range of OWS services via a web client and perform spatial analysis to extract further meaningful information from the data.

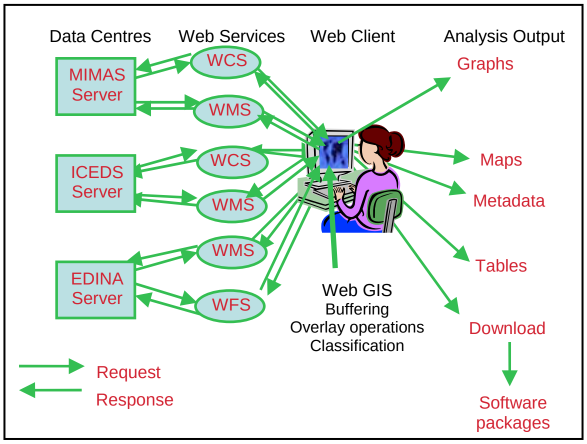

Figure 6. Geospatial workflow, ideas from OGC (2003).

Presently the RightWebMap client which illustrates the Landsat 7 mosaic combined with a MODIS Bluemarble image (provided by ICEDS WMS) has the ability to combine services together and alter transparency of the imagery for viewing but does not have the ability to perform any spatial analysis or output the results (Figure 7). Mooney and Winstanley (2006, 10) state:

> *'Interoperability problems reach a maximum when organisations want to share data, query each others data holdings, or allow users to download or integrate datasets with their data holdings'.*

The key issues that were highlighted from the project included: -

- Semantic heterogeneity, problems such as raster layers and feature data described differently across organisations.
- For MIMAS and EDINA a subscription fee is required to access datasets therefore a way to authenticate users is required to securely implement WCS and WFS.
- Also the scalability and resilience of the OWS needs to be explored and tested at the national level.
- Metadata to support the OWS is an essential requirement which needs further development.

Similar findings have been highlighted in Zhang and Li (2005) paper which investigated the use of WFS and WMS for a crisis management application. The Style Layer Descriptor (SLD) proposed by OGC to provide standards for the display of symbols would also be useful when combining OWS from different external organisations (Rocha *et al.*, 2005).

4. Conclusion

The research aim was to create an OGC compliant web mapping system for the SIDS. Both open source and ER Mapper vendor solutions successfully provide a web mapping client using WMS and the Chameleon client also could be configured to provide links to WCS to download satellite imagery directly from the client. Image streaming was also investigated using Image Web Server via ECWP and this was found to provide the best performance for

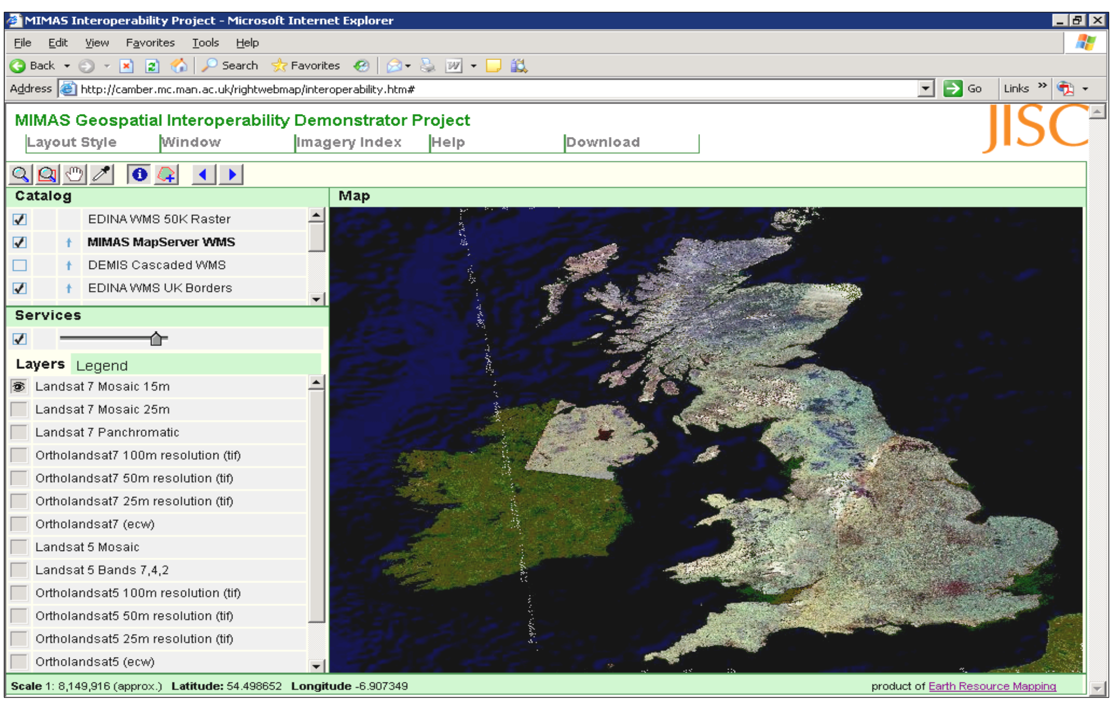

Figure 7. Demonstrate WMS Interoperability from EDINA, MIMAS, ICEDS and DEMIS

serving satellite imagery, however the RightWebMap client was only fully functional from the Internet Explorer browser. MapServer as an open source solution is also efficient at serving satellite imagery; improving performance could be further investigated and the Chameleon client has the advantage of being accessible from a wide range of internet browsers. Monitoring the degree of use of both mapping interfaces would be a good start in deciding which solution to finally select for the SIDS in combination with user feedback.

The SIDS at MIMAS successfully interoperated WMS with OWS from EDINA and ICEDS. Collaboration with these institutions on a national scale has highlighted areas for further investigation such as scalability, authentication, semantic heterogeneity and metadata development. Collaboration has been beneficial in exploring open source technologies and sharing expertise.

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