Geoprocessing Services Over the Web

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Abstract. Spatial Data Infrastructures served through the web combined with the ever increasing network and telecommunication capabilities, and made geospatial data largely available over the last several years. In addition, providing semantic specifications to geospatial information, data sharing and interoperability has also been achieved. The next step was to combine spatial data from different sources and apply composite geoprocesses, in order to produce geoinformation over the web, directly available and applicable to a wide range of geo-activities of significant importance for the research and industry community. Towards this direction, the Open Geospatial Consortium has instituted the Web Processing Service standard, in order to define the rules for handling web geoprocesses as web services. In this context, this paper aims to review and identify the available and directly exploitable spatial data infrastructures and related geoprocesses. Furthermore, it aims to propose potential web processes for producing valuable geoinformation, focusing on those applicable to satellite images and relevant to remote sensing, such as image composition, Normalized Difference Vegetation Index calculation, change detection, raster limitation etc.

Keywords. WPS, geospatial processing services, Spatial Data Infrastructures.

1. Introduction

Gathering and combining satellite imagery data from different sources had always been a laborious and time consuming task for researchers and professionals. It is mainly because such kind of data and their metadata do not conform to a common standardized sharing format, they require high network and communication capabilities and significant processes to be applied before publishing. Once satellite images are acquired, processes over them were mainly an autonomous offline job undertaken by specialized desktop mainly Geographical Information Systems (GIS) and image analysis software. These processes include sequential preprocessing operations in order to correct geometric, atmospheric and radiometric distortions and also post-processing operations for extracting information by implementing various analysis methods [1], [2].

The development of Spatial Data Infrastructures (SDI), and their enhancement with semantic specifications over the last several years, not only have they made geospatial data largely available but also they have increased data sharing and interoperability [3]. Towards this, proven web standards such as Geography Mark-Up Language (GML) based on extensible mark-up language (XML) standard have been adopted, combined with geospatial services concerning maps (WMS) features (WFS) or catalogs (CSW) released by Open Geospatial Consortium (OGC) [4]. As far as data processing is concerned, the Web Processing Service (WPS) specification [5], provided spatial processing capabilities through a standardized service interface based on Hypertext Transfer Protocol (HTTP) [6].

The afore mentioned standards have been thoroughly developed and applied on systems supporting complicated processes on vector geographic data -commonly termed as features- and descriptive data, however in the case of raster and satellite imagery data, there is still enough room for progress. In most cases, the systems serving raster data do not offer processing capabilities on these data over the web, while systems providing processing services usually refer to vector data processing. In addition, systems providing geoprocessing services related to raster and satellite imagery data either require from the clients to upload data or apply these processes on specific raster datasets [7], [8]. A system providing additional capabilities of specifying a desired area of interest (AOI) and in turn applying a specific geoprocess upon the specified data, over the web, yet generates challenges. In fact, such a system will have to accomplish interfaces, transparent to clients, with multiple satellite data servicing providers and satisfy end-user AOI request. The next step is to combine satellite data from different sources and apply composite geoprocesses in order to produce geoinformation over the web directly available and applicable to a wide range of geo-activities of significant importance for the research and industry community.

In this context, this paper aims to review and identify the available and directly exploitable spatial data infrastructures and related geoprocesses. Furthermore, to propose potential web processes for producing valuable geoinformation focusing on those applicable to satellite images and relevant to remote sensing, such as image composition, Normalized Difference Vegetation Index (NDVI) calculation, change detection, raster limitation etc. As all the afore mentioned technologies rely on open interfaces and tools and conform to cloud computing essential characteristics [9], the proposed system architecture obtains extreme significance.

2. Proposal

Up to now, the development of Web – based geospatial applications focused on vector data processing rather than raster data, such remote sensing images [10]. Geospatial processing over the Web related to satellite imagery datasets is of crucial importance since it provides useful information concerning earth's environment including without being limited, land cover change, ecosystems monitoring, forest fires, surface water monitoring etc.

In contrast to vector based web processes, satellite imagery processing requires as an initial stage data search and acquisition. In this context, web geoprocesses for satellite data can be divided into two groups of services, namely "Acquisition" and "Analysis" (Figure 1).

- Imagery Acquisition
  Ideally this may be implemented by shared data infrastructures providing to the developer a set of web services that specify the above functionality and may be incorporated into custom applications. Such web services include:
  - Data discovery web service, facilitating the capability of providing information about what data is available over a particular area of interest
  - Request validation web service, verifying and validating information obtained from data discovery service and returning to the user fully parameterized URL(s)
  - Download web service, which initiates a request for data, queries the system to obtain a job status, and returns the requested data to the user
- Imagery Analysis
  In this stage, processes are further categorized into two processing service levels with regard to the type of functions they are performing.
  Essential Functions that are related to image display, subsetting and re-projection:
  - RGB composite images or single band display supported by different stretching functions in order to facilitate image interpretation
  - Image subsetting in order to eliminate image extend in the area of Interest
  - Image re-projection in order to be provided the ability to obtain imagery information at a user's specified coordinate system, as it can be integrated with different spatial data (GIS layers)

Transformation Functions concerning spectral enhancement functions based on simple band math function such as band ratios (e.g. NDVI) and image subtraction (change detection).

– Band ratios, to facilitate vegetation mapping or mineral exploration
– Image subtracting, to provide the ability of tracking changes over the time

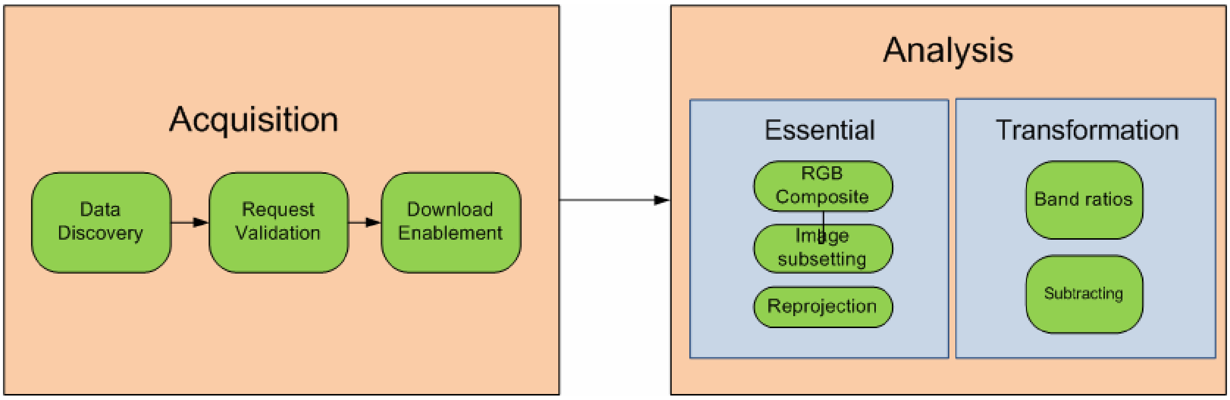

Figure 1: Two major groups of services proposed for satellite imagery processing.

3. Architecture

The proposed System Architecture is based on the principles of the typical multi-tier client-server software architecture. It is a 3-tier system architecture which consists of three discrete and logically separated system layers. Although the basic concepts of the proposed architecture have been very well documented in various web-based systems, through the above lines emphasis is given on the interoperability between independent system components and the way in which the presentation, application processing and data management functionalities are performed through open standards and specifications (Figure 2).

The Client Layer is the presentation level of the system providing to end-users with an interface in order to display information related to the offered services. The client layer communicates with the other system components by sending requests and receiving responses. Clients are categorized into thin clients (browser-based applications), thick clients (standalone software) and mobile clients in case of client software installed on mobile devices. Users can explore and visualize spatial information through clients, they perform querying actions in order to receive information, they discover, find and bind to data and processes by exploring their metadata information. In any case, the client is responsible to translate the information so that users will be able to understand and display it.

The Applications Layer contains the software and the appropriate services to provide users with the demanded functionality. This layer coordinates the applications to perform all the necessary actions such as data processing and calculations according to user requests, and it also establishes the connection and performs the necessary data transmission between client and data layer. On top of this layer there is a web server application which is responsible to host services and direct requests and responses between clients and applications. The catalog server applications keep records of metadata information of data and processes provided by various sources and in addition makes information discovery easier. The map server applications provide data requested by clients, in a standardized OGC service form such as Web Mapping Service (WMS), Web Feature Service (WFS), Web Coverage Service (WCS) or in raw format. The processing server applications offer a repository of geospatial processes and allow users to implement calculations over spatial data. The processes can be called by clients as Web processing services (WPS). First, clients have to discover processes by their metadata descriptions and then they provide the appropriate input parameters in order to execute the process. The processes can be modules of GIS software, libraries or new developed modules.

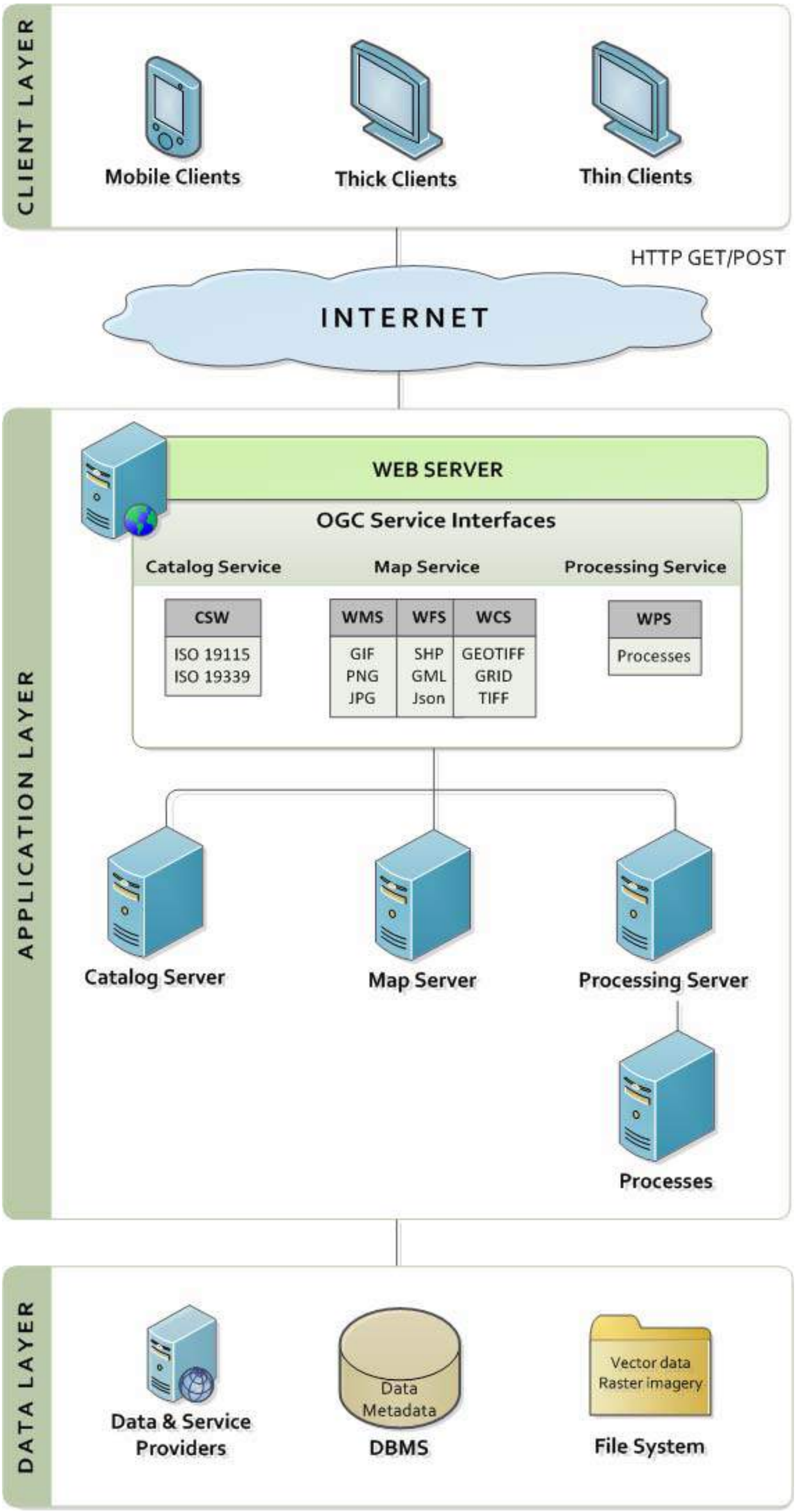

Figure 2: An integrated system architecture for imagery WPS implementations.

The Data Layer is the level where all the information is stored and retrieved. It supplies the application layer with data in order to perform calculations and processes and it also hosts some space in order to save temporal data provided by the executed processes. The information can be spatial data and their metadata stored in relational databases, file systems or may be served by external providers such as organizations offering satellite imagery (e.g. USGS) or OGC compliant services (e.g. WMS, WFS, KML etc.). It contains all the software in order to manage the stored information and to make it available for further manipulation.

4. Conclusions

Since web based geoprocesses mainly focus on vector data processing it is of crucial importance to identify and standardize processes applied on satellite images utilizing proven standards.

Towards this direction, standardizing imagery data acquisition is considered as the initial stage for deploying an integrated system satisfying the imagery processing needs. To satisfy data acquisition, the server side should implement interfaces to appropriate data infrastructures that support standardized discovery and download services. In this way, end users can perform image search and acquisition without having to locate data providers.

Such capabilities provide significant advantages especially to the community of remote sensing and cooperative fields of expertise, since most of their needs include raster acquisition and analysis processes.

The proposed model may lead to significant cost reduction for both client and server. The client side employs minimum software and hardware infrastructure and avoids time consuming processes such as satellite images discovery and download. Regarding the server side, data acquisition is performed through providers compliant to data servicing standards, exploiting in that way the advent technology of cloud computing.

To conclude, it is quite challenging for professionals and experts at various fields of expertise working with dynamic spatial data, to adapt their work in a fully web-based environment containing SDIs integrated with WPS implementations.

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