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GEOCLOUDS FOR ENVIRONMENTAL MANAGEMENT

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Abstract. Environmental monitoring and management are multidisciplinary tasks which require a continuous and close cooperation among involved stakeholders from various public entities, based in different locations. This fact poses a serious problem on critical aspects of environment-related projects including: data acquisition, processing and management, sharing and interoperability. This problem can be tackled using cloud computing technology and services which can provide to stakeholders capabilities regarding the above issues in real time, thus providing the means for an effective environmental management and decision-making. The present paper aims to document the above relationship by identifying the special features and needs associated with environmental projects which in turn may be satisfied and optimised through geospatial cloud computing components termed in the present as GeoClouds. GeoClouds are proven geospatial tools and services and include services, metadata description editors, and spatial data interoperability formats which may be placed in a typical system architecture and may ideally be implemented in the Cloud.

Keywords: cloud GIS, environmental management, geospatial cloud computing.

AIMS AND BACKGROUND

The present paper aims to identify the degree to which cloud computing capabilities suite to particularities, technical specifications and functional requirements of environmental-related projects. Moreover, considering the spatial nature of the environmental parameters and the capabilities offerred when these are standardised according to geospatial semantic standards, the general purpose of the paper is to identify the benefits of geospatial cloud computing (GCC) in environmental management.

According to the National Institute of Standards and Technology[1] (NIST) '*Cloud Computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources* (*e.g. networks,*

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servers, storage, applications, and services) *that can be rapidly provisioned and released with minimum management effort or service provider interaction.*'

NIST provides the essential characteristics of cloud computing, as follows:

● On-demand self-service, meaning that the resources are automatically provided on consumer request directly from each service provider with no intermediate actions.

● Broad network access to any type of client platform through standard mechanims.

● Resources are pooled and dynamically handled to satisfy demand, and consumers have no knowledge of their exact location.

● Rapid elasticity of the provided capabilities which are percieved as unlimited and are scaled up and down according to consumers demand.

● Measured service facilitating control and optimisation of the resources which are provided in a transparent way both for the provider and consumer.

Cloud computing is further modelled according to the type of the provided service as Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS) or the type of the consumer to which cloud infrastructure is provisioned as Private, Community, Public and Hybrid Cloud.

Geospatial Cloud Computing has emerged due to the growing demand for cloud-based geospatial applications and platforms. This demand is documented through the tremendous utilisation of 'maps in computers' as deployed in web-based map browsers, GPS-enabled applications, in-car navigation services, high resolution Earth imaging systems as well as 'maps and apps' as deployed in mobile smart phone location applications[2].

FEATURES AND NEEDS OF ENVIRONMENTAL PROJECTS

Issues regarding environmental management and monitoring have been extensively documented[3–5] including those involving the utilisation of geoinformation technologies[6]. Many technical characteristics and specifications met in environmental projects as well as processes and functions applied on them may be more efficiently satisfied and performed through GCC capabilities. As most important the following ones are mentioned:

1. Environmental modelling: Especially in complex processes such as those met in fluid modelling, involving also geospatial and spatiotemporal parameters, such as for example the space occupied by pollutants after being dispursed. These cases require high performance computing platforms and efficient process distribution.

2. Environmental data fusion: In many cases location-referenced sensor data need to be combined (fused) with large data sets of traditional GIS data. The advantages offered by typical web-based and moreover by cloud computing technologies

are expected to improve not only the collection process but also the homogenisation, harmonisation, normalisation, calibration and any type of correction process required for data sourcing from disparate and different sensors.

3. Data mining: An usual case in environmental data analysis is to create information through sophisticated mining based on geospatial criteria. Again, collecting and combining data from multiple sources may be significantly assisted by GCC capabilities.

4. Demand management: Environmental projects servicing data to the public or providing geoprocesses which involve environmental data to a large number of users or partners do prerequisite a cloud-based design and implementation. Various environmental-related indices for user-provided data may be calculated through shared geospatial processes as for example an index calculation[7].

5. Data sharing: In case of an environmental authority wishing to share environmental data, including maps, to other authorities and/or the public cloud computing sharing capabilities are already the proper solution.

6. Environmental data delivery: Same as previously, delivery of geospatial data from an environmental project coordinator to its partners or among environmental projects is a pure GCC case.

7. Interoperability: Exploiting data through different platforms have always been and still remains a challenge and a need not only for environmental but for all engineering systems, considering the tremendous increase in sources of data provision, along with efforts being spent in data interoperability-related research and technologies[8]. Cloud computing and GCC are currently a hot topic for achieving establishment of a common framework for environmental geospatial data and services. As a result, in many studies the data layer of the 3-tier architecture includes data acquisition from different data providers[9].

8. Security: Issues related to data and services security concern every activity taking place over the web including those referring to environmental projects. In any case someone has to consider the need for circulating environmental data combined with the associated risks.

9. Data acquisition: For large datasets of spatial data and in special raster heavy sized datasets acquisition is efficientlly performed through distributed data providers based on cloud computing technology. Another interesting applicability is the collection of data sourcing from different automated spatially-dispersed environmental sensors.

GEOCLOUDS

'GeoClouds' have been adopted by the research and industry community to meet the above capabilities/requirements. The term GeoCloud denotes the geospatial aspect of cloud computing and in the present work refers to services, standards, and tools, employed to achieve environmental management in the cloud.

OGC web services. The most important and famous services widely adopted by companies, government agencies and universities and applicable to spatial data, were developed by the Open Geospatial Consortium (OGC).

OGC Web Services (OWS) are standards created for use in World Wide Web (WWW) applications and support interoperable solutions that 'geo-enable' the web[10]. Depending on their usability they are categorised as:

● Portrayal services providing an interface for requesting map images defined by the geographic layer and the area of ineterest and response with map images displayed in a browser application. Web Map Service (WMS) is the dominant in this category.

● Data services providing direct access to spatial data with specialised retrieving capabilities, i.e. clients can retrieve or modify only the data they are seeking and not the whole file containing the data. Web Feature Service (WFS) to be considered as the prevailing one in this category.

● Processing services facilitating publishment of available geospatial processes from the provider side and discovering of and binding to those processes from the client side. The web processing service (WPS) is emerging as the promising standard for geospatial processing over the web and has been implemented in numerous projects such as the 52° North Initiative for Geospatial Open Source Software[11] and the ZOO (Ref. 12) open WPS platform.

● Catalogue services such as the OGC CS Core which are charged with the discovery and retrieval of spatial data and services metadata.

GeoMetadata management tools. Data from different sources: (a) governed by; (b) collected with; (c) corrected using, and (d) maintained under different methods and/or methodologies and/or assumptions require advanced Metadata documentation. Adopting a geospatial data tool for metadata management (e.g. INSPIRE GEOPORTAL Metadata editor)[13] is a key action towards a successfull environmental project

Interoperable spatial data exchange formats. For systems deployed under different platforms, software components with different underlying data models, interoperability may be achieved through:

● XML-based encodings for spatial data (GML, KML);

● Other web semantic standards for data interchange on the web such as RDF.

An indicative physical design depicting the location of the above-mentioned GeoClouds in typical 3-tier system architecture is provided in the following Figure. In the client layer appropriate web services satisfy end-user interaction with the project. The application layer contains the software and the appropriate services to provide users with the demanded functionality and the data layer supplies the application layer with data in order to perform calculations and processes.

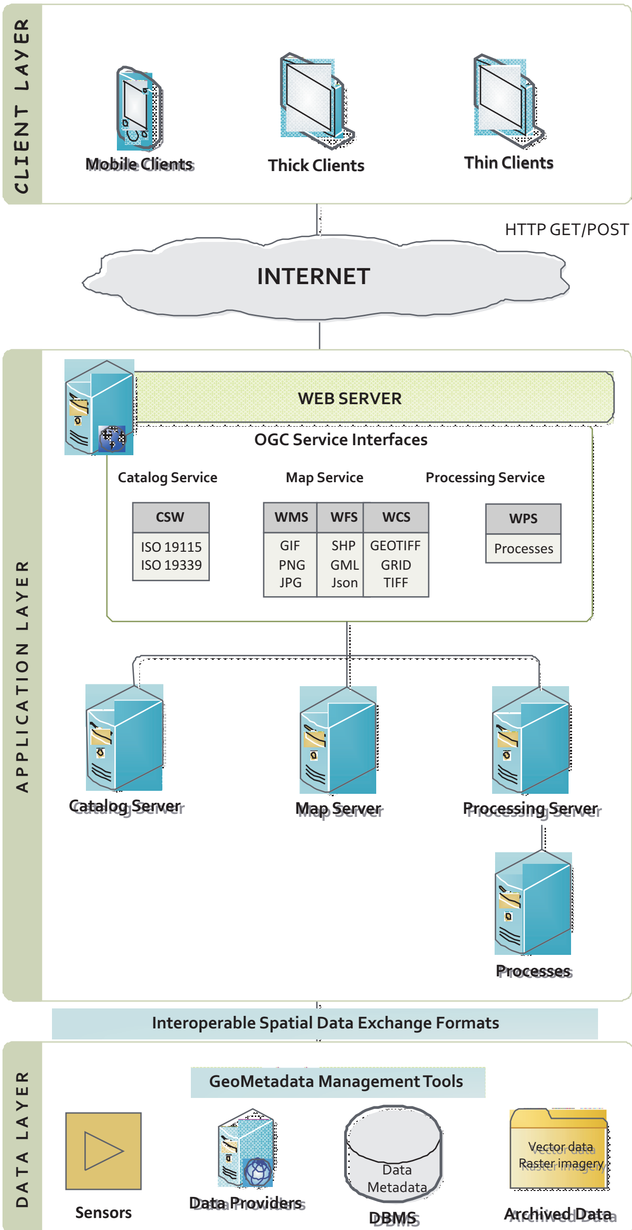

Fig.1. Placing GeoClouds in the typical 3-tier system architecture ideally implemented in the cloud

CONCLUSIONS – FURTHER DEVELOPMENTS

Environmental projects require real-time and archived data manipulations, homogenisations, remote access and management functionalities provided by cloud computing. The spatial nature of environmental parameters combined with the tremendous penetration of smartphones and the development of location-based services place GCC as the hot topic for state-of-the-art environmental management.

Current and future developments may include, without being limited, refinements and optimisations on the following hot topics:

- specialised telematic apps for controlling hardware equipment based on alerts/triggers sourcing from environmental sensors;
- repositories in the cloud connected with sensors dispersed around the globe providing real time environmental data and information;
- real time and archived data from fusion/combination/mining;
- environmental-related processes offered through the cloud from specialised geoprocessing providers.

Concluding, the continous progress occurring in Cloud Computing technologies combined with the growing ability of spatial data exchanges through interoperability standards has created the necessary conditions for a tremendous increase in the productivity and capability of researchers and professionals working in Earth system science, and these benefits will extend to environmental management.

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