The Analisis of Gis Software Engineering Pattern under the Cloud Computing Environment

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***Abstract*—This paper introduces the basic concepts of cloud computing and the characteristics of GIS software engineering, and analyzes the impact of cloud computing on the GIS software development. It discusses the GIS software engineering design method under the cloud computing environment from the aspect of GIS software architecture, development organizations and deployment management, and proposes some suggestions for problems that need to be paid attention to during the GIS software development under the of cloud computing environment.**

Keywords-cloud computing; GIS; software engineering

I. INTRODUCTION

Driven by the Internet and IT giants, the era of Cloud Computing is coming in the near future. The hardware industries leading by Moore's Law and the W INTEL hardware architecture, as well as the traditional business pattern of software industry, corporate IT structure, and even the lives of ordinary people would be changed due to the coming and development of cloud computing. Geographic Information System (GIS for short) is information systems built on the solid foundation of Information Technology (IT for short), the coming of cloud computing era will have far-reaching impact to the development of GIS.

Cloud computing is essentially another innovation to the software and information system architecture of. It redraws the borders of system software and applications. The main feature of GIS software engineering pattern under the Cloud Computing Environment will be the unified provision of basic data services and software services by professional agencies and based on which to build a more complex GIS application software system.

II. CLOUD COMPUTING INTRODUCTION

A. Cloud Computing Theory

Cloud computing is a distributed computing technology, the basic concept is to automatically split a huge computation program into numerous small subprogram through a large computing network, and such subprogram would be handed to a huge system composed by multiple servers and the results would be back to the user after search, calculation and analysis. Through this technology, network service providers can deal with tens of millions of or even billions of information within a few seconds, reaching the same powerful performance of network services as the "super computer".

The narrow Cloud Computing refers to delivery and usage patterns of IT infrastructure, that is, to obtain the required resources (hardware, platform, software) through the network in the way of demands and easy extension.

The general Cloud computing refers to the delivery and usage pattern of service, It indicates accessing required services through the network in the manner of easy to expand access to services. Such service can be IT, software and Internet-related, it also can be any other service.

Cloud computing is always confused with parallel computing, Distributed Computing and Grid Computing. The concepts of Cloud computing is the result of the mix and evolution of virtualization, utility computing (Utility Computing), infrastructure as a service (IaaS), platform as a service (PaaS), Software as a Service (SaaS).

B. Characteristics of cloud computing

- Very large scale. "Cloud" has a considerable scale. For example, Google released Google Apps services (a free office package provides simplified data storage and processing on the Internet) from the beginning of 2007, up to now, Google's cloud computing already has more than one million servers; the "cloud" of Amazon, IBM, Microsoft , Yahoo and the like has reached hundreds of thousands of servers. "Cloud" gives users an unprecedented computing power and data storage capacity.
- full virtualization. Cloud computing allows users using a variety of terminals to access application services at any location. The requested resources come from the "cloud" rather than from a fixed physical entity. Application is running in somewhere of the "cloud", but in fact users do not need to know or worry about the specific location of running applications. With only a laptop or a cell phone, all services that one needs can be achieved through the network, even complete tasks like supercomputing.
- High reliability. "Cloud" using multiple copies of data tolerance, computing nodes with the same structure and other measures to ensure service reliability. In addition, professional data management staffs and better data management platform are provided to maintain data security and effective use.
- wide versatility. Cloud computing is not for a particular application, under the support of "cloud", different application can be constructed and a same "cloud" can support different applications running simultaneously. From the user's point of view, different users see

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different "clouds" and different "clouds" give user different permissions.

- High expansibility. The size of "Cloud" can be extended dynamically, meeting the application requirements and scale growth of user automatically. However, such extension is transparent to users.
- on-demand services. "Cloud" is a huge resource pool which can be used on demand, and "cloud" can be used as cable television, subscription services can be provided as needed.
- extremely cheap. As the special fault-tolerant measures of "cloud" can be realized by using very low-cost nodes, the automated centralized management of "cloud" frees large number of companies from the burden of increasingly high administration cost of data center. The universal of 'cloud' enables the utilization of resources significantly increase compared to the traditional system, therefore, users can fully enjoy the low-cost advantages of "cloud" and tasks that used need to be completed in several months with tens of thousands of dollars would be completed in a few days with just hundreds of dollars.

III. CONCEPTS AND FEATURES GIS PROJECT

A. Concept of GIS project

GIS software engineering refers the engineering activities that organized GIS software design development and maintenance using the concepts, principles, techniques and methods of software engineering. It not only includes the technology of GIS project planning, design, implementation, evaluation and maintenance, but also the management skills such as demand control, quality control, schedule control and risk control, GIS data production management and quality control system.

B. The main features of GIS projects

1) the complexity of large systems

Software complexity are closely related to several factors:

a) The quality and quantity of delivery documents. The delivery document includes software requirements specifications, system design documents, user manuals, program listings, test reports and related note on spatial data and its spatial analysis function, which increase the contents and difficulty of the document.

b) micro-complexity of the software. As many factors are involved in GIS, together with issues like large data capacity and complex functions, the GIS software program is long and the internal structure of the software is quite complex.

2) maicro-complexity of the software. The difficulty in understand the space theory and the relative lack of GIS software talents in China makes software development more difficult.

The special status of data in the system.

The features of GIS lies in the support for heterogeneous mass data processing, therefore, database building plays a very important position in GIS software development. During the process of system development, aspects that need to be paid attention in data preparation are listed as follows:

1) Data quality. High-quality GIS data need to be entered or it is likely to influence the system efficiency and realization of functionality, and may even cause system crashes. GIS data has strict requirements in the spatial relations (mainly topological relations, point and relations), metadata, layers, graphics and other associated aspects.

2) Data of current situation. It refers the timeliness of data. In the GIS, spatial data change quickly and data is easily outdated, which may leading to data invalid, therefore ongoing data collection would be needed.

3) Reasonable data structure. Data that dealt with by GIS includes vector format, spatial data and tables with raster format, other non-spatial data include text, multimedia and so forth. Different organizations have a crucial effect on the system's efficiency and safety.

IV. GIS SOFTWARE ENGINEERING PATTERN UNDER CLOUD COMPUTING ENVIRONMENT

GIS software engineering pattern under cloud computing environment would be discussed from the aspects of software architecture, software development organizations and software deployment, operation management and maintenance.

A. Architecture pattern of GIS Software Engineering under cloud computing environment

Compared with traditional GIS software architecture, the most important features of the GIS software architecture based on cloud computing lie in its unprecedented openness and the maturity of component. GIS applications in the "cloud" side would extensively make use of ready-made GIS component provided by cloud services. Meanwhile, the newly developed software will also become mature GIS components which can be used for the successive GIS application development. known by the characteristics of cloud computing, large scale, efficient and reliable provision of vast amounts of map data and map services can be provided in the "cloud" side, GIS applications with different user requirements can be constructed under the support of 'Cloud'. On the other side of "cloud", users can complete the use of all functions with browser on the computer. Therefore, cloud computing environment can greatly reduce the complexity of GIS software development.

Cloud computing GIS software architecture is fully distributed in nature, integrated by the softwares from client, server, management side, development side and the test side. Clear logic boundary exists between the application, and no more completely separate physical boundary. GIS software architecture is very stable, which bring considerable convenience to the future development of GIS software and data maintenance and updating.

B. GIS software development organization pattern under cloud computing environment

Viewed from the characteristics of life-cycle, the traditional GIS software life cycle pattern is serial, which is the deformation of waterfall pattern in nature. Such life cycle pattern is more easy to control, however, concurrent pattern, multiple spiral pattern will become the mainstream in the cloud computing environment, waterfall pattern, iterative pattern would be used less. In the GIS deployment, the middle version of the software is delivered, and software upgrade will be the norm.

Viewed from the development process, GIS software development is no longer a closed, global control flow, but rather a multiple concurrent and autonomous flow, the integration can either from the bottom up or top-down in a project,

Viewed from each basic stage of GIS software development, the demand phase will occupy a larger proportion of the workload. Architecture structure can be basically determined from the existing matured patterns; detailed design can borrow a lot of matured components and codes; with increase of reuse level of GIS software, the workload of GIS testing documents will greatly reduce, and the GIS software quality would be upgraded effectively. Different stages of the development process, GIS software developers, service providers, software users a variety of roles are the same person software development tools, unified by a cloud computing service providers to provide, development

Organizations do not need to purchase a permanent software license but rather renting software license from 'cloud' service provider on demand during the development life cycle, which can greatly reduce the cost of GIS software tools. The problem of data

C. GIS software deployment, management and maintenance mode under cloud computing environment

Cloud computing bring a high degree of flexibility to GIS software deployment, management and maintenance. For a specific application of GIS function, the process of software deployment, management, maintenance and development is parallel. The first deployment may be just a small part of the functions, continuously improvement would be made in the successive software upgrade. Owing to the cloud computing pattern, the coupling between components of GIS software has been greatly reduced, GIS software, client, server, management-side and so on can be deployed and managed in the way of concurrent or completely independent and even a variety of resources that GIS software run can be upgraded and re-deployed in a transparent manner for the user.

The client software running platform of GIS software based on Cloud computing can used mature virtualization technology to produce a variety of virtual environments, such as Windows, Linux, and even browsers. Users can choose virtual environments according to their preferences; on the server side, large-scale server systems can be virtualized into a single processing unit and the continuous storage unit, reducing the complexity of client management.

Spatial data of GIS software required strong timelessness, which required continuously update and import large number of new collected spatial data with different formats into the existing space database. Under the professional service support of cloud computing GIS service provider, the new collection of spatial data can be seamless connected with the existing spatial data. The bottom hardware systems and fundamental software systems that run by the Cloud computing GIS software can be maintenanced and managed by professional information system integration provider.

V. APPLICATION OF GIS SOFTWARE ENGINEERING UNDER CLOUD COMPUTING ENVIRONMENT

Cloud computing has a very broad outlook, however it is a developing technology, it's positive and negative aspects to software development need to be considered carefully. Such issues would be discussed from the aspect of cost and implementation.

From the aspect of cost, the most important advantage of cloud computing is the ability to greatly reduce costs. For GIS software development organizations, especially SMEs, this will greatly reduce the development cost in hardware and software tools and etc; however to cloud computing GIS service providers, large investment need to be input during the construction of cloud computing infrastructure; If existing facilities and tools can be used, the cost can be further assessed if a large number of enterprises enter the cloud computing GIS software development.

From the implementation procedures, it would be appropriate to developed application software that meet the standard of Software Quality Assurance with could computing architecture. It also accumulate mature components for cloud computing. GIS software development organization should set up department or agency which is responsible for coordinating with the existing GIS system and technical issues during the process of cloud computing.

VI. CONCLUSION

Although cloud computing has not yet reached a very mature stage, but we can not wait until it was put into full-fledged application. From the national conditions, the traditional GIS industry is still in a very unfavorable position, the key core technologies are controlled by foreign vendors. The cloud computing provided a rare opportunity to achieve leapfrog development and we must seize this opportunity to become the global cloud computing country with advanced cloud computing countries in the cloud.

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