WEB-GIS BASED COLLABORATION ENVIRONMENT USING SCIENTIFIC DATA OF THE MOON

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ABSTRACT:

On 14 September 2007, the first Japanese large-scaled lunar explorer “Kaguya” (SELENE), developed by JAXA (Japan Aerospace and Exploration Agency) was launched. Kaguya successfully reached moon in October 2007, and started nominal operation from 21 December 2007, As of the end of April 2008, Kaguya is conducting lunar surface observation from lunar polar orbit. Kaguya will acquire large amount of lunar data including lunar surface pictures and mineral composition, topographic features (altitude) and many other scientific data. By combining a number of scientific data sets, lunar scientists are anticipating that they can answer longstanding riddles of the moon such as the birth of the moon, lunar interior structure and local and regional lunar geology. Therefore, a scientific platform which enables to gather observation information and scientific result, compare and discuss is required. The key and base data of the science integration will be the camera data, as the camera data is the fundamentals to construct lunar map which will be the start point for lunar research. Kaguya has three scientific camera, Multiband Imager (MI), Spectral Profiler (SP) and Terrain Camera (TC), and the collective designation of these three cameras are LISM (Lunar Imager / SpectroMeter). Based on LISM data and altitude data obtained by laser altimeter, we are now constructing lunar topographic data display and collaboration system. This system is based on the WebGIS concept and includes basic display function and collaboration capability (data uploading and downloading, online discussion capability, content recording). The system is also a modern example for scientific collaboration tool and data mash-up platform. In this paper, we will present about the objectives of the development and current implementation situation.

1. INTRODUCTION

1.1 The science of Kaguya

The aim of the lunar explorer “Kaguya” is a complete understanding of lunar science. The scientific goals of exploration of Kaguya is summarized as follows (JAXA, 2007(1)):

- Science of the moon: the most important scientific target is the clarification of the birth of the moon. Through the past analysis of lunar samples collected by Apollo missions, “the giant impact theory” is becoming the plausible theory for the birth of the moon. However, our current scientific resource to verify the theory is insufficient because of lack of detailed knowledge of global data of lunar surface composition of both minerals and elements. These essential data are expected to be obtained by Kaguya survey.
- Science from the moon: the lunar circular orbit is an ideal platform to observe terrestrial plasma fluctuation. The plasma imager of Kaguya will observe Earth’s plasma.
- Science on the moon: This includes detailed observation of lunar surrounding environment. The amount of charged particles, plasma conditions, or other environmental condition measurement will be conducted. This will be utilized for evaluation of future lunar manned mission.

As for the conduction of the research about “Science of the moon”, the lunar surface data is essential, and the key component to obtain the lunar surface data is the scientific camera, LISM and the laser altimeter (LALT). The topography of the moon will be deduced from the topographic measurement of LALT and stereo photographic mapping of TC. The initial result of the analysis of TC data (JAXA 2007(2)), shows the extremely fine structures of lunar surface in several tens of meter order.

Also, the surface composition of minerals will be clarified by MI and SP. The first result (JAXA, 2007 (3)) demonstrates the capability of these instruments which can extend the spatial and wavelength resolution.

Many lunar scientists involved in Kaguya mission are anticipating that, by the 10-months nominal mission and expected extended mission, Kaguya will obtain many data about lunar topography and surface composition.

1.2 Need for scientific platform for integrated science

As the lunar science covers many areas of scientific fields including geology, geophysics, mineralogy and other geo-sciences, the scientific integration work is necessary to draw on the scientific findings. To enable such integrated science, the place that the many scientists in different fields can gather and discuss about the obtained data and the analytical result each other. However, in Kaguya mission, the conventional meetings are not efficient.

One reason is that the many scientists involved in the mission are scattered in the whole country, therefore the frequent meeting is unrealistic. Another reason is the large amount of data obtained by Kaguya. The estimate of Kaguya's data is approximately 20 terabytes. By adding the interim data produced by the scientists during the research, the amount will rise up. This makes all scientists very difficult to see all data exchanging with each other and keep these data up to date for all scientists.

Based on above understandings, we decided that the scientific platform for analysis of Kaguya's topographical data should be the virtual, which is set in a network environment. By locating in the network, users can access from anywhere from country-wide (and even from worldwide) using the Internet. And, by using servers with large data storage, the huge amount of data can be stored.

1.3 WebGIS-based system

Currently, WebGIS system is becoming more popular for geospatial application. As WebGIS system requires only the browser to access and retrieve the data, users can operate the system intuitively. And, from the administrator, WebGIS-based system is easy to maintain and operate as the system is generally extension of the popular web server. Also, the web-based system is very versatile and easily extended. If the open-source based software are used, the administrator can also extend system by rewriting the source file.

We adopted the WebGIS-based system for the scientific collaboration system with some extensions facilities to meet the demand for the lunar science application.

2. THE SYSTEM

2.1 Basic concept and system requirement

Upon the consideration of the users' demands and data handling capability, we selected the following requirement for the system.

- System is web-based, with the database server as the backend of the system.
- The web server and database server should be operated in separated machine to increase performance for data handling.
- The web server should work with the mapping server. The mapping server is the main component to map the data.
- The system should facilitate data upload and download capability.
- Users do not need to access using terminals. What users need is the web browser only.
- The server programs should be open-source based to be ready for future upgrade and extension.
- The system has large data storage to ensure to keep large amount data (observation data and interim scientific analysis) inside.
- The system should be connected to high-speed network to enable transmission of large amount of data.
- Ensuring security.

2.2 System design

Upon the system requirements noted in section 2.1, we decided the system design as shown in Figure 1.

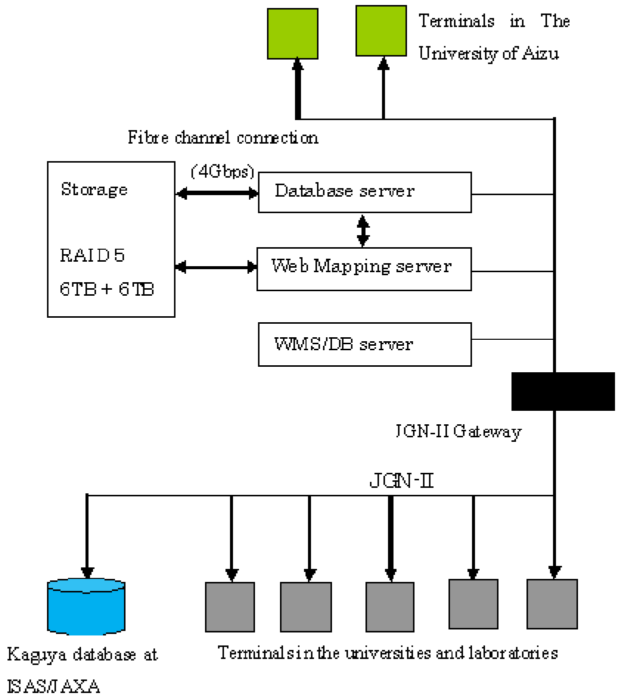

Figure 1. The system design of our WebGIS-based collaboration environment.

The main system is two servers, a web mapping server and a database server. These two server is the center for the data distribution and collection, and controls all data.

A WMS (Web Mapping System)/database server in the middle of the Figure 1 is located to make an experiment of distributed GIS between the University of Aizu and the Institute of Space and Astronomical Science, JAXA.

The main two servers are equipped with the large storage which has approximately 12 terabytes of data storage area. Due to the limitation of the file system capability for Linux ext3 architecture, the maximum partition is confined to 6 terabytes. Therefore, this storage was separately connected to each server. Also, each area is cross-mounted using NFS (Network File System). However, as the NFS performance is very inferior to the direct connection, main data transmission will be done by directly connected interface.

The terminal which each scientists have are connected to the Internet. They will access to server via the net (see 2.5). These terminals are Windows-based personal computers with analytical software (ESRI) installed.

2.3 Hardware

The both server, a web server and database server have quite a same specification.

- Fujitsu PRIMAGY RX200 S3
- CPU: dual-core Intel Xeon 5110 (1.60GHz x 1)
- Memory: 8 GB
- Disk: RAID 1, 73 GB x 2
- 4Gbps fibre channel interface to the storage
- 1000Base-T network x 2
- Operating System: Red Hat Enterprise Linux 4 (kernel version: 2.6.9)

The attached data storage has the following configuration.

- Fujitsu ETERNUS 20000 model 100, base unit plus drive enclosure extension.
- Interface: 4Gpbs fibre channel x 2
- RAID 5: (five data disks and one parity disk) x 3, RAID 5 (four data disks + one parity disk) x 1, and one hot-spare disk. There are 48 disks in total.
- Total physical capacity: 18000 GB
- Total system capacity: 12858 GB

All the servers and a storage are stored in one half-height rack. Figure 2 shows the photograph of the system.

Figure 2. The photograph of the system.

The capability of CPU is considered enough to handle the large amount of data and process these data. Also an storage is sufficient to store the data for collaboration.

2.4 Software (servers)

As already mentioned, the system uses open-source based server for extending capability and easy installation and management. The main server application of the system includes:

- Web server ... Apache 2.2.8
  An JSP (Java Server Pages) extension will be installed as needed.
- Database server ... PostgreSQL 8.2.5 and PostGIS 1.3.1
  PostGIS is a spatial extension to PostgreSQL developed by Refractions Research. It enables PostgreSQL, the widely-used RDBMS as the backend of spatial database.
- WMS server ... MapServer 5.0.0
  MapServer is GIS mapping interface works as the backend of the web server, developed by the University of Michigan. Several styles of display by CGI and scripting such as PHP and Python are supported.
- Web scripting language ... PHP 5.2.5
  PHP is a widely-used web scripting language, co-working with web server software. By using PHP scripts, users can add some web pages capability (database connection, scripting function, and interactive data processing).

The most current version of these programs are used to avoid vulnerabilities, as long as compatibilities are ensured.

2.5 Network

The transmission of large amount of data needs high-speed network. Currently, the system is connected with the Japan Gigabit Network II (JGN-II). From April 2008, the network migrated to the new JGN2plus network, but basic functions are same. The JGN-II network offers the Gigabit-class high-speed network transmission in the backbone system and several hundred Mbps access network in branch. The speed of the connection to the system is 100 Mbps. The all bandwidth of the network is dedicated to this system.

The system is located in The University of Aizu, Fukushima prefecture (northern Japan) and users are distributed all over the Japan including Tokyo and Osaka (western region of Japan). And, the primary data is stored in ISAS/JAXA, Kanagawa prefecture, near Tokyo. The distance between The University of Aizu and ISAS/JAXA is more than 300 kilometers away.

Currently, no data transmission is made between ISAS/JAXA and the system because the system is not well arranged, but in future, we will conduct several experiments to exchange data.

3. IMPLEMENTATION STATUS

Now the most system setups are completed, we are currently trying test of the system load and network traffic. In parallel, we are beginning construction of the components of the WebGIS collaboration system

These components have the following functions:

- User authentication

  This system is intended for using small number of scientists first for verification and improvement of the function. Therefore, the user authentication function is basically necessary. The authentication includes recording of login time, logout time and session duration. In future, the user tracking function will be implemented to record users' trend for data access, map clicking and other behaviour. Sharing this information will enable measuring the scientists' interest in specific position of the moon.

  These tracking information as well as logging records will be stored in database tables and utilized by the display application.

- Data upload and download

  In this system, scientists can freely upload their data and products. However, conventional FTP upload has many weak points in security. And upload by FTP should need terminal access and preparation for designation of uploading places. By using HTTP upload, the system administrator can manage data upload more precisely than FTP upload by using the designated web pages for uploading. Moreover, HTTP upload can organize uploaded data according to the programming by CGI or some other web scripts.

  Currently, we are implementing data upload function using PHP scripts. PHP has the data upload function in the language specifications, therefore the implementation will be easy compared to using other language such as Perl or C.

  Also, the automatic data conversion programs from PDS (Planetary Data System) format, the data format commonly used in lunar and planetary science, to the conventional image data format such as PNG or JPEG are required.

  The uploaded data should be managed for access and browse, and the record should be stored by the database.

- Online data conversion and calculation

  As the users will need to operate data online, some simple calculation and conversion of data are desired. For example, image rotation, enlarging / contraction and displaying the intensity information of the point are essential. Hopefully, the tool can be added by users using some API or library.

- Online communication tool

  The communication function is also the key of this system because users are discussing each other seeing the data. The communication function includes:

  - online interaction such as chat or voice communication.
  - sharing of the discussion progress. The tool like a whiteboard are desirable.
  - recording of the discussion. All transactions during the discussion should be recorded and stored in the database, and should be reviewed after the discussion if necessary.

- Coalition of other interface

  One of the merit of WebGIS system is that, by setting a link to the data or any form of materials, users can access from the browser. This merit can be utilized by using other interfaces for this WebGIS system. For example, the search system of lunar features (Terazono et al., 2008b) can be utilized as the entrance of the WebGIS system, by adding the link for appropriate data to the search result.

  Also, other interface can be developed by mash-up technology and a traditional link method (denoting URL). We will proceed to the test implementation of the coalition interface between the search system and this WebGIS system.

4. SUMMARY

As we mentioned above, our WebGIS system is not only the lunar and planetary application of WebGIS architecture, but the inclusion of whole environment of research and discussion for the lunar and planetary scientists. Additionally, foreseeing the increasing data amounts in future lunar and planetary missions, this system is endurable and extensible for the handling of the large size of data. Also, utilizing the cutting-edge technology adopting open-source software, this system can be empowered with the most recent applications. We will continue to develop the each component of the system and proceed to the test operation when these components can be interoperable.

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