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JVO and NaReGi (Japanese Grid middleware initiative)

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Abstract. Japanese Virtual Observatory (JVO) project has entered into its operations on the data service (http://jvo.nao.ac.jp/portal/) since March 2008. It provides access to more than 1,900 data resources via the IVOA standards, SIAP, SSAP and so on. JVO has constructed a Grid-like data analysis server system in order to process the SuprimeCAM data of the Subaru telescope, and the processed mosaic images can be downloaded on demand. Access statistics to the JVO system has shown that about 1 Tera bytes per month were retrieved only from the data resources under the JVO management, suggesting that more data should have been retrieved from data resources in the world.
JVO has also construct a test bed Grid system by means of the NaReGi middleware, by federating the National Astronomical Observatory of Japan and the KEK (Institute for High Energy Physics, located in Tsukuba, Japan).

Key words. virtual observatory, federated databases, interoperability, standardization

1. Introduction

The National Astronomical Observatory of Japan (NAOJ) operates the Subaru telescope in Hawaii and the large millimeter-wave telescopes in Nobeyama. All the observed data are digitally archived and are accessible via internet. The radio telescopes of Nobeyama produce about 1 Tera bytes per year, and the Subaru telescope outputs about 20 Tera bytes per year. NAOJ has joined the international project, ALMA, and it is foreseen that more than a few Peta bytes of data per year will be produced for the astronomy community.

Because astronomical objects radiate electromagnetic waves in wide frequency range, it has been recognized that multi-wavelength analyses are essential to understand physical and chemical behavior of galaxies, stars, planets and so on. The idea of the Virtual Observatory (VO) has recently appeared to resolve such situation, and the system has been developed in 15 countries and one region around the world. These individual VO projects have established an alliance, the International Virtual Observatory Alliance (IVOA[1]), to define standardized protocols for their interoperations.

Japanese Virtual Observatory (JVO) is designed to seamlessly access to multi-wavelength, federated databases and data analyses systems for astronomers through high speed network facility. The basic concept and a new query language to access to the distributed

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1 http://www.ivoa.net/

databases, JVO Query Language, are described in Ohishi et al. (2006).

Since JVO is a member of the IVOA, and have adopted many Recommendations in implementing its portal system. Thus the JVO portal will provide access to more than 1,900 astronomical resources worldwide, as of July 2008. Further JVO has been collaborating with the Japanese national research Grid initiative (NaReGi[2]) toward utilizing distributed data analysis environment. This paper describes the current status of the JVO portal system and an experiment to federate several servers in NAOJ and KEK (High Energy Accelerator Research Organization) by means of the NaReGi middleware.

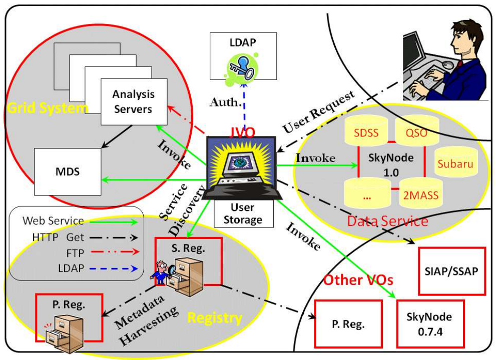

Fig. 1. Architecture of the JVO Portal System

2. Architecture of the JVO portal system

Schematic diagram of the JVO portal system is shown in Figure1. Its fundamental design is similar to our previous prototype systems (Tanaka et al. 2005; Ohishi et al. 2006). Major differences are, e.g., adoption of the Web Services instead of the Grid Services, adoption of standardized protocols for the VOs (SIAP for images, SSAP for spectra, and ADQL for catalogs), and introduction of resource meta data exchange mechanism based on the OAI-PMH.

Queries issued by a user are sent from the user terminal to the JVO portal, and are parsed into single queries to appropriate servers that are found by consulting the registry. The parsed querying processes are executed by the scheduler, being passed to individual servers through appropriate protocol. The query results are sent back with the VOTable format.

Major database servers connected to this prototype are SuprimeCAM from Subaru telescope, ASCA (X-ray satellite) database operated by the Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency (JAXA /ISAS), and others. We succeeded to interoperate the JVO prototype with VOs in the North America (NVO, VO-Canada) and Europe (ESO, ESAC, AstroGrid, CDS) in December 2004, and more than 1,900 astronomical resources are accessible as of July 2008.

The protocols to access images, spectra and catalogs have been developed separately. Therefore it is necessary to prepare separate query interface to access to each resource. Astronomical researches may sometimes utilize images, spectra and catalogs simultaneously, and it is desirable to use an integrated query interface to make such queries easier. **?** proposed such an integrated query language by using the "virtual column" concept. We implemented the integrated query language interface to the interoperable JVO prototype, and succeeded to retrieve images/spectra/catalogs though a single interface.

Figure2 shows an access statistics to the JVO portal system, as of July 2008. The figure has two statistics: downloaded data size per month in kB (in histogram) and total requested pages per month (in a graph). Note that the ordinates are the logarithmic scales. When we opened the Subaru SuprimeCAM on-demand mosaicing service, the downloaded data size has dramatically increased. This suggests that there has been a high potential to use the Subaru data in many countries.

2 http://www.naregi.org/index_e.html

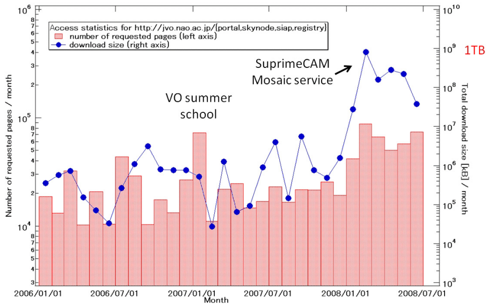

Fig. 2. Access Statistics of the JVO Portal System, as of July 2008

Search radius	Result objects	Elaspted time (sec)			# of HTM conditions	
arcmin	#	Postgre SQL	Our method	ratio	Postgre SQL	Our method
1	2	6.460	0.042	154	32	32
10	165	3.807	0.030	127	16	16
60	6697	6.468	0.107	60	32	32
100	26720	2.016	0.307	6.6	4	16
180	57246	9.044	0.709	12.8	48	72

Fig. 3. Results of Performance Measurement and Comparison with the PostgreSQL

3. Virtual Integration of Multiple Catalogues

Since we started experimental operations of the JVO system, we noticed that several databases, such as Subaru databases, SDSS, 2MASS, and so on, are frequently accessed. Since the total records in these databases count up to about 10^9, this meant that the accesses to these databases could be the bottle-neck of the JVO performance. Therefore we developed an integrated, quick "Multiple Catalog Search" system through designing a common meta data table which consists of position, wavelength (frequency) and intensity (flux) extracted from individual databases together with pointers (links) for further detailed information (Tanaka et al. 2008).

We also utilized the Table-partitioning by means of the HTM (Hierarchical Triangular Mesh) with 32,768 upper levels. After implementation we made performance measurements, and found that our method is more efficient than the PostgreSQL by a factor of 150 at maximum (see Figure3 (Tanaka et al. 2008)).

4. NaReGi Federation Experiment between NAOJ and KEK

NAREGI, the National Research Grid Initiative, was created in 2003 by the Ministry of Education, Culture, Sports, Science and Technology (MEXT). From 2006 through 2007, the research and the development were continued under the "Science Grid NAREGI" Program of the "Development and Application of Advanced High-performance Supercomputer project" being promoted by MEXT. NAREGI aimed to make fundamental building blocks in the Cyber Science Infrastructure (CSI), which has been operated by the National Institute of Informatics (NII), and its goal is to provide a large-scale computing environment for widely-distributed, advanced research and education (the Science Grid). The NAREGI Grid Middleware Ver. 1.0 has been released in May 2008. NII endeavors to build the Grid infrastructure by continuing software maintenance and user support services.

Prior to the official release of the NAREGI Grid Middleware Ver. 1.0, we were invited to use its β version to evaluate its functionalities and usages. Thus we constructed a test bed together with the KEK (Institute for High Energy Physics, located in Tsukuba, Japan), which is shown in Figure4. Because past NAREGI test beds were constructed among the NAREGI project member institutes through the VPN connections, we intended not to use the VPN connection since the Grid middlewares would be used, in most cases, without the VPN connections. The test bed consists of several Linux servers in the NAOJ site and the KEK site. The servers in the NAOJ site were the QuadCore machines, and a few NAREGI nodes were constructed on a single CPU by means of the

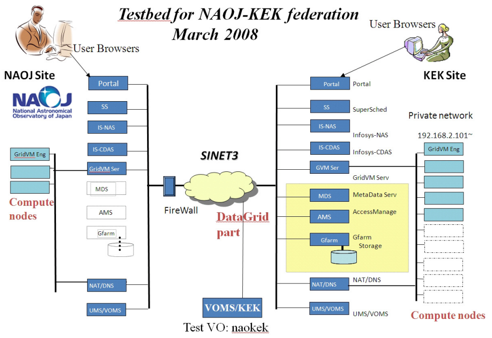

Fig. 4. Configuration of the Federation Experiment

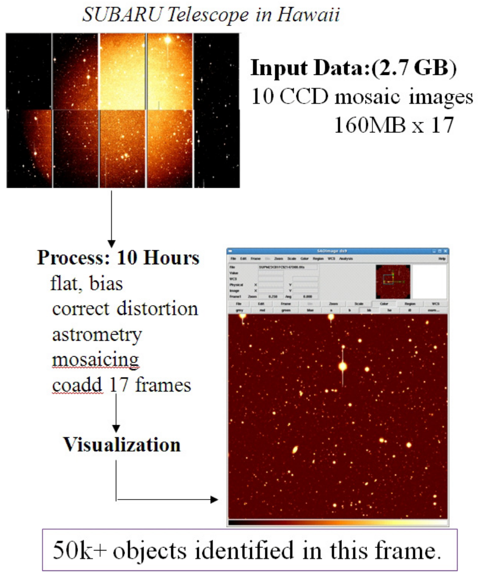

Fig. 5. Data Processing Flow of the Federation Experiment

VMware environment. On the KEK site each node was constructed on separate machines. Both sites were connected through the firewall to simulate the real use of the NAREGI middleware.

On the computing nodes in NAOJ and KEK we installed some astronomy libraries to perform data reduction of the Subaru SuprimeCAM images. A single image from the SuprimeCAM has the images size of 160 Mega bytes, and 17 image files were used for a single data reduction. These image files were GridFTPed from the NAOJ site to the KEK site, and the data reduction jobs were submitted from the NAOJ site to the KEK site through the NAREGI super-scheduler. A single data reduction took almost 10 hours because there are many CPU-heavy steps, such as flat, correction of image distortion, astrometry (measurement of star positions), mosaicing, and coadding all the images). The resultant images were, then, transferred from the KEK site to the NAOJ site via GridFTP, and visualization software on the NAOJ site was used to show the final images. We experienced several problems during the installation process, the data reduction process went quite well. For example we were able to detect more than 50,000 objects in a single mosaiced image (see Figure5).

The problems we found during our federation experiment were reported to the NAREGI project, which were already fixed before the official release of the NAREGI Grid Middleware Ver. 1.0.

5. Summary

We have opened the JVO system to the astronomy community in March 2008, meaning that it was established to access data servers via VO interfaces. Thus it is necessary for astronomical researches to analyze obtained data on the VO environment. We have been designing a work flow language to access remotely located analysis engines. The work flow language will enable users not only data queries but data analyses through a single user interface (Tanaka et al. 2006). Then we plan to implement Single-Sign-On mechanism for secure user access, and other standardized interfaces by the IVOA, and to disseminate standard VO interfaces to astronomy communities not only in Japan but in (East) Asian countries to further promote international collaborations. Such activity is crucial for the ALMA era that we expect to produce more than a few Peta Bytes per year.

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