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The Japanese Virtual Observatory in action

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Abstract. The Japanese Virtual Observatory (JVO) is a web portal for astronomical data and analysis system, and utilizes the standards developed by the IVOA to communicate with the VO-compliant resources in the world. We have started official operation of the JVO since March 2008 at http://jvo.nao.ac.jp/portal/. The JVO provides the following web-based services: 1. search for VO-compliant data services in the world, 2. search and access to the astronomical data through the VO standard interfaces, 3. use of on-line astronomical analysis tools, 4. on-line data reduction for the Subaru telescope, 5. use of data storage of the JVO system. We also operate several VO data services (SkyNode, SIA, SSA) and a publishing registry. As of January 22 of 2009, over 1,900 resources in the world are registered to the JVO portal. More than 40 thousands pages are requested to the JVO system every month. 1.6 TB of data have been downloaded since the start of the official operation. GRID computing system is introduced to provide massive computing resource for reducing the data obtained by the Subaru telescope. In the initial operation, we offer 48 CPU cores, 4 GB memory per core, 1 TB of locally attached hard disk and 100 TB of NFS storage area in the GRID computing system.

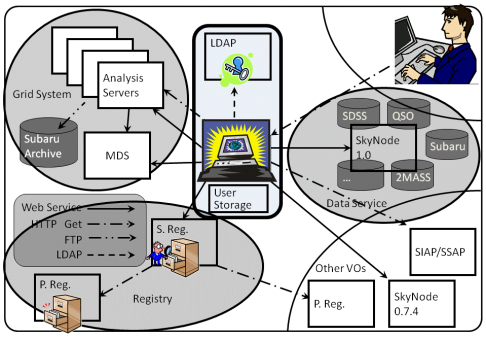

Figure 1. Overview of the JVO system

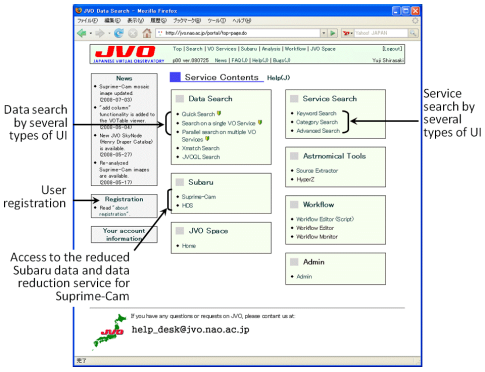

Figure 2. Top page of the JVO portal

1. Introduction

The Japanese Virtual Observatory (JVO) is a web portal to astronomical data, and it provides seamless access to the distributed databases, and quick overview of the data, and also provides astronomical data analysis services.

There are many activities to make an environment which provides better usability of the data resources distributed in the world by adopting the VO standards. There are two major approaches; one is to make a stand-alone application, and the other is to make a server side web application. The advantage of the former approach is that it can provide a fancy interface and better interactivity. The advantage of the latter is that user does not need to install any software other than a web browser, and most of the processes are done on the server side so it does not require high performance PC even when the large amount of data is used. Considering that the former approach are made by some other VO projects and we have sufficient computing and storage resources at NAOJ, we selected the latter approach.

We also aim to increase the usability of the Subaru data by distributing the data through the JVO system. Especially the data of Suprime-Cam have a remarkable feature that it provides a wide field and deep image of the Universe and it contains a lot of information unexplored by the primary investigator of the data. The raw data is distributed through the Astronomy Data Center of NAOJ, however, there are difficulties on downloading the large amount of data, and reducing the data is not an easy task. So we reduced all the Suprime-Cam data and they are distributed through the VO interface and on a dedicated web interface.

2. JVO system

The JVO system consists of several independent components as shown in Figure 1. The component shown at the center of the figure (portal) is a web application which authenticates a user, accepts a query and job submission request from a user, creates and executes a workflow to achieve the request (Tanaka et al. 2006), and manages the user storage where search results and uploaded files

are saved. The data service component shown at the right middle and bottom of the figure is a collection of VO compliant data services under the JVO and external VO systems, respectively. The registry service component shown at the left bottom of the figure is a metadata database of the VO services. The publishing registry is used to expose metadata of the JVO data services. The searchable registry periodically collects metadata from the publishing registries which are registered in the IVOA's Registry of Registry [1]. The grid system shown at the left top of the figure is used to execute astronomical data analysis, such as data reduction of Subaru Suprime-Cam, source extraction from an image data, and photometric redshift calculation for a given multi-band catalog. More details is described in Shirasaki et al. 2008, 2007, and 2006.

Figure 2 shows a snapshot of the JVO portal top page. At the "Data Search" section, there are links to five kinds of query interfaces. We provides three easy-to-use interfaces for a novice user, and two interfaces for an advanced user to directly specify an SQL. At the quick search page, one can access to the "Digital Universe", which is a database containing only coordinates and brightness of objects from various published catalogs, such as Subaru deep survey, TWOMASS, SDSS DR6, UKIDSS DR2, ROSAT bright catalog, and so on. Details of the Digital Universe is described in Tanaka et al. 2008. At the parallel search page, one can submit region queries to all the VO data services at once. Over 1,000 resources are queried in 10 minutes. At the single service search page, individual data service can be queried with more detailed search condition. Those interfaces are complement each other.

Search result can be viewed by using a VOTable viewer, which run on the server side, translate the VOTable into an HTML, and display it on an web browser. The tabular data can be plotted using the JVO plot, which currently supports XY scatter plot, histogram plot, and line plot. Image and spectrum data in FITS format can be viewed by using the JVO image and spectrum viewer. Those JVO viewers are running on the server side, so the user does not need to install any software on the local machine. One can also use Java applets developed by VO India (VOPlot [2]), CDS (Aladin [3]), and ESAC (VOSpec [4]) to plot the tabular data, view the image and spectrum data, respectively. To use them, a user needs to install Java on a local machine. A server side image data viewer is being developed to help the user to browse a large amount of data without downloading a lot of FITS data to the local machine (Fig. 3).

We also provide the reduced data taken by the Subaru telescope through the SkyNode and SIA interface, or at a dedicated query page on the JVO portal. The raw data taken by the Suprime-Cam instrument are calibrated, then the data set that have the same object name are stacked to make a single mosaic frame. The 1D spectrum extracted from data taken by the HDS (High Dispersion Spectrometer) instrument are also available although they have not been corrected by the flat fields.

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[1] http://rofr.ivoa.net

[2] http://vo.iucaa.ernet.in/ voi/voplot.htm

[3] http://aladin.u-strasbg.fr/aladin.gml

[4] http://esavo.esa.int/vospec/

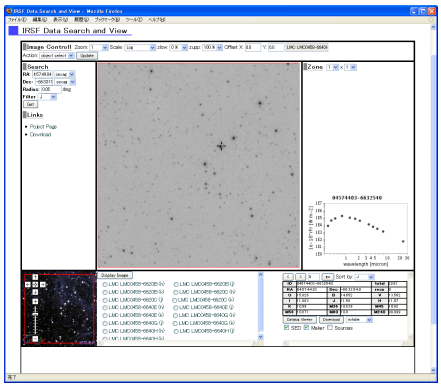

Figure 3. Server side image data viewer

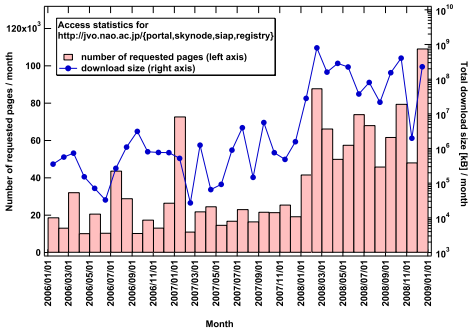

Figure 4. Usage statistics of the JVO system

Figure 4 shows the usage statistics of the JVO system. The histogram shows a history of number of requested pages per month (left axis) for all the JVO system (portal + skynode + registry). The solid circles connected with lines represents downloaded size in kB per month from the JVO system. There are more than 40 thousands of page requests for all the JVO system every month, however, 36 thousands requests are automated periodic accesses from JVO system itself and the external VO system. So the net value is about 4 to 30 thousands for actual usage.

3. Summary

We have started the official operation of the JVO system since March 1st of 2008. Improvement of the capability and usability should be continued by taking account of use cases which many of the users want to do. Currently we are making improvements on enabling the users to do a multiple region search, to make their own multi-band catalog from the different catalogs very easily. Another issue we should tackle is to increase the fraction of VO compliant data services. There are still many data resources which are not accessible through the VO interface. The success of the VO primarily depends on how quickly we can have a large fraction of the data resource accessible through the VO applications.

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