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Design and Implementation of the Japanese Virtual Observatory (JVO) system

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ABSTRACT

The Japanese Virtual Observatory (JVO) is a web portal to various kinds of astronomical resources distributed all over the world. We have started official operation of the JVO portal since March 2008. The JVO provides seamless access to the VO compliant data service, and also access to the reduced Subaru data and on-line data reduction system for Suprime-Cam instrument of the Subaru telescope. The system implements standards of the International Virtual Observatory Alliance (IVOA) to communicate with the VO components in the world. As of October 24 of 2008, over 2,400 astronomical data resources are registered to the JVO portal.

Key words: Virtual Observatory, JVO

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. The most of the functionality of the JVO portal is open to everyone, and some limited functionality is restricted to a registered user. The access URL is **http://jvo.nao.ac.jp/portal**.

There are a lot of astronomical data archives accessible thorough the Internet, which enables astronomical researcher to conduct their research based on the public databases very easily. As an increase of the number of the databases, visibility of of each database become lowered and it become difficult to find a database which is suitable for an individual research. Therefore, a general way to publish the data resource need to be defined. International Virtual Observatory Alliance (IVOA) was formed to define the standard way to publish the data resource and make it searchable in a standard method.

There are many activity to make an environment which provides better usability of the data resources distributed in the world by adapting 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 many other VO projects and we have enough computing and storage resources at the NAOJ, we selected the latter approach.

We also aim to increase the usability of the Subaru data by distributing the data thorough 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 thorough 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 thorough the VO interface and on a dedicated web interface. We also provide a access to an on-demand data reduction pipeline by which user can reduce the data by their own data selection criteria.

2 JVO PORTAL

The JVO system consists of several independent components as shown in Figure 1. The component shown at the center of

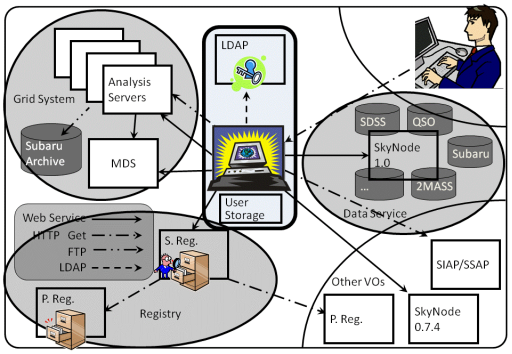

Figure 1. Overview of the JVO system

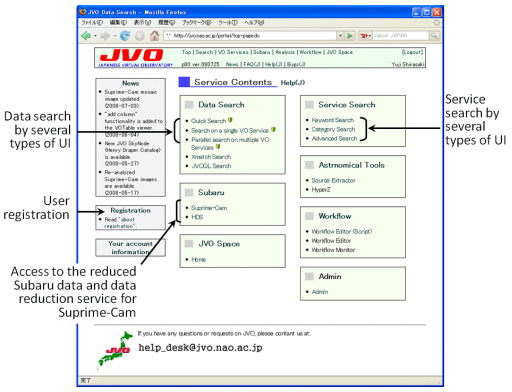

Figure 2. Top page of the JVO portal

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 result and uploaded files are saved. So the portal is a core component of the JVO system, and plays a role of a kind of broker so that a user can seamlessly utilize a lot of VO components both of the JVO and the other VO project.

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 system, respectively. All the VO services of the JVO are searchable with the SkyNode interface, and some of the image data archives are searchable with the simple image access (SIA) interface too. JVO skynode toolkit(Shirasaki et al. 2006) is developed for setting up the VO compliant service, and is freely available ⋆ .

The registry service component shown at the left bottom of the figure is a metadata database of 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 † . As of October 24 of 2008, ∼2400 resources are registered in the JVO searchable registry. It is used to find astronomical resources with a given search condition among the thousands of registered resources, and also used to resolve the service endpoint URL in executing a query requested by a user. 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 by Shirasaki et al.(2008 ; 2007 ; 2006).

Figure 2 shows a snapshot of JVO portal top page. There are links to various user interfaces each of which are dedicated interface to some specific functionality of the JVO. Those links are categorized according to their functionality. 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 (Figure 3), 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. Since the database are constructed under the JVO system and a quick coordinate search algorithm is employed (Tanaka et al. 2008), query response is fast; It just takes 0.8 s to search thousands of objects from three billions objects. At the parallel search page, one can submit region queries to all the VO data services at once (Figure 4). 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. If you want to get only the coordinates and brightness of objects in a specific region, "Quick Search" page is recommended for the first use. If you cannot find data by the "Quick Search", try to use the "Parallel Search" page. If you have a specific service which you want to search on, you may use the "Single Service Search" page.

Search result described in a VOTable format, which is a VO standard format to exchange tabular data, can be viewed by using a VOTable viewer, which run on the server side and translate the VOTable to an HTML, so it can be viewed on an web browser. The VOTable viewer can be invoked by clicking the "Result" button that appears after the query is completed, or by clicking the filename on the JVO space viewer. The JVO space is a data storage for a JVO user, where one can save the search result. The tabular data can be plotted using the JVO plot, which currently support 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, which convert the FITS data to a graphical format that can be displayed on a web browser. 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 applets developed by VO India (VOPlot), CDS (Aladin), and ESAC (VOSpec) to plot the tabular data, view the image and spectrum data, respectively. To use them, you need to install Java on the local machine.

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

⋆ http://jvo.nao.ac.jp/download/skynode-toolkit
† http://rofr.ivoa.net

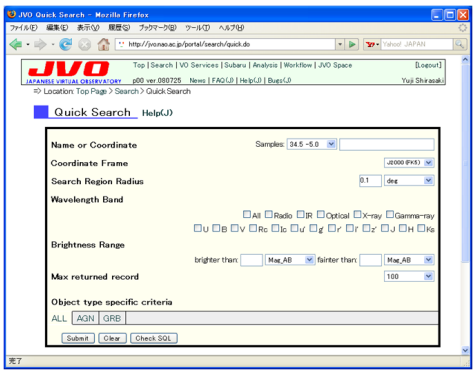

Figure 3. Query interface for the Digital Universe.

data set that have the same object name are stacked to make a single mosaic frame. Different demands on image quality are expected depending on the science target of each research. So we applied seeing selection when stacking the ccd frame data, and created mosaic frames of four different quality levels. It is also possible to submit a data reduction job and create a mosaic frame with ones own criteria. The 1D spectrum extracted from data taken by the HDS instrument are also available although they have not been corrected by flat fields.

Figure 5 shows the usage statistic of the JVO system. There are more than 40 thousands of page requests for all the JVO system every month, however, 36 thousands 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. The data download size is dominated by Subaru data retrievals; the ratio exceeds 90% of the total download since March 2008. The contribution of automated periodic accesses is just a few hundreds MB/month.

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. We are also trying to improving the content of the "Digital Universe" by collecting the data from VO services in a automated way. 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 application.

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Figure 4. Result of the parallel query.

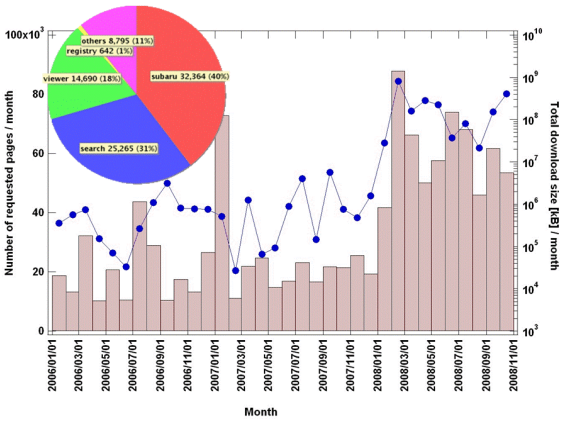

Figure 5. The histogram shows the history of number of requested pages per month (left axis) for all the JVO system (portal + skynode + registry). The Solid circles connected with lines represents download size in kB per month for the JVO system. The pie chart shows the usage ratio (based on the number of requested pages) for each resource of the portal system.

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