Towards a Planetary VO: EuroPlaNet-IDIS Activities in VO-Paris

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ABSTRACT

IDIS (Integrated and Distributed Information System) is a part of the Europlanet project which aims at developing a prototype of Virtual Observatory in Planetary Science. VO-Paris in one active partner in this development. The architecture of this VO system and selected solutions are presented here, together with existing demonstrators.

Keywords: Virtual Observatory, Planetary Science, Solar System, Data services

INTRODUCTION

VO-Paris Data Centre is a structure of the Observatory of Paris developing Virtual Observatory activities. As a partner in Europlanet-IDIS, VO-Paris contributes to defining the future European VO in Planetary Science. On one hand, VO-Paris is in charge of the IDIS thematic node "Planetary Dynamics and Extra-Terrestrial Matter", which provides data resources related to this field, including resources developed by other Europlanet Work Packages. On the other hand, VO-Paris is a partner in the Joint Research Activity (JRA4) which designs the VO infrastructure, and is the co-leader of the task "Added Value Services". Besides, VO-Paris is a contributor to the IVOA and a partner in VAMDC, HELIOS and CASSIS programs [1].

The architecture currently foreseen for IDIS is to connect distributed data services with existing IVOA protocols whenever relevant, or with a future IPDA protocol. VO-Paris therefore contributes to PDAP development by defining its application to specific data types (such as spectral cubes or atmospheric profiles) and by contributing to a related Data Model. The data services will be accessible through a registry system similar to IVOA's.

Concerning the data resources involved, our aim is to set up a core of data services on which the community will accrete new data resources accessible through VO protocols. This initial core is currently expected to include AMDA (CDPP's service in plasma Physics), SSODnet (in development at VO-Paris), GhoSST (solid samples spectroscopy service developed at IPAG), the PSA (ESA's space missions archive), and various topical services such as a reference data base set up in LESIA to support the Herschel TNO key-program (currently restricted).

Limited demonstrators are available from the OV-Paris IDIS node at: http://voparis-europlanet.obspm.fr/ A web portal demonstrator allows the user to query PDAP services, which can then be plotted using existing visualization tools. Another demonstrator shows how to read PDS spectral cubes and plot them in Aladin, VOspec, or SPLAT. A name resolver for solar System objects is also available.

PROPOSED ARCHITECTURE

A general scheme is proposed in Fig. 1, which illustrates the sequence of steps in a typical working session. The user is working at his computer, sends queries to data bases, and gets answers. Then the data must be loaded in memory, plotted in various forms (images, spectra…), and are possibly sent to more elaborated tools performing specialized functions. These steps of processing are commented below.

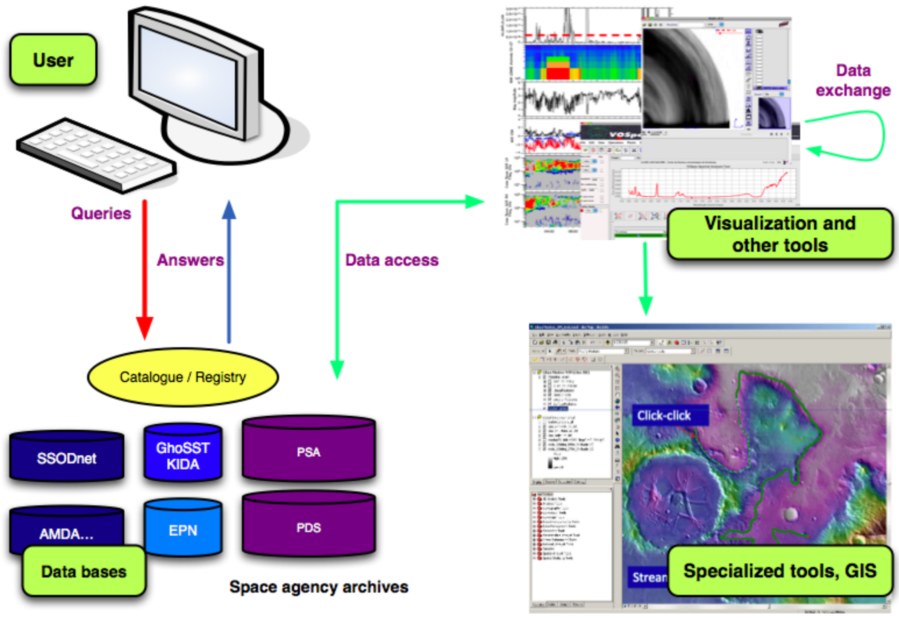

Figure 1: Overall scheme proposed for EuroPlanet-IDIS VO

DATA SCOPE

The perimeter of data to be accessed by the Europlanet VO derives from the objectives stated in the program proposal. It includes (Fig. 2):

- Data bases produced by various work packages during the Europlanet program (including JRA4/task4 and TNA3).
- A selection of space borne data from planetary missions. This includes data from European space missions, i.e. the PSA [2].
- Data of interest selected by SA-IDIS participants.

In addition, the Europlanet VO is expected to be sufficiently open to allow external data providers to include their data bases in the system with minimum efforts.

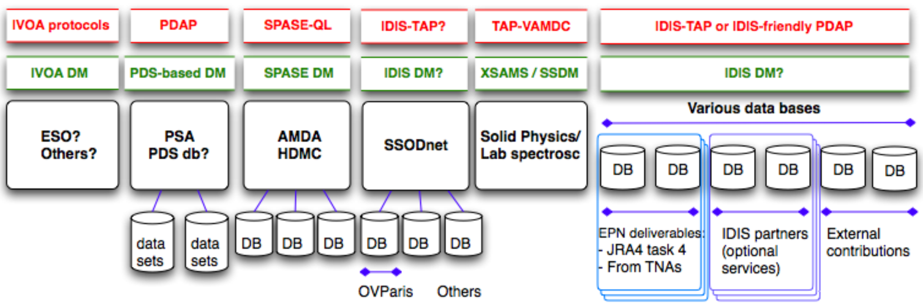

Figure 2: Data expected to be included in the IDIS VO, plus related access protocols and data models

VO-Paris also develops data services relevant for Planetary Science. This includes:

- SSODnet, a data service connecting external databases related to small bodies of the solar System and local services (such as name resolver, ephemeris server…).
- Database of atmospheric profiles of Mars and Titan, and historical telescopic images database (BDIP) at LESIA.

In addition, existing databases at VO-Paris are being connected to IDIS:

- Comet ephemeris server and the Natural Satellites Data Centre, at IMCCE.
- The Nançais Comet Database at LESIA
- The Extrasolar Planets Encyclopedia at LUTH, with VO interface developed at VO-Paris.

QUERIES / DATA MODEL

The user is expected to write queries describing his search. Such queries must be translated in a standard form and used to search a catalogue of available data.

Two main solutions are available to write queries related to Planetary Science data:

- Existing IVOA protocols, which allow searching the data according to various criteria.
- PDAP protocol, currently being defined in the IPDA frame. PDAP is mainly intended to address the entire contents of the PSA by querying this sevice as a whole [3].

Such queries could be sent from a web questionnaire, from software, or directly from visualization tools, as done in the IVOA system (e. g., in Aladin). However, this requires the protocols to be implemented in the visualization tools, and therefore heavier developments.

IVOA protocols appear to be poorly adapted to the usual workflow in Planetary Science, because some of the major features have no equivalent in Astronomy. For instance, these protocols do not allow the user to easily formulate queries related to coordinates on a planetary surface, to atmospheric profiles, or to internal structures, which is a major issue in this context.

Usability assessments of PDAP were performed at VO-Paris and CDPP [4]. The protocol proves able to address the data we are usually dealing with, provided topical extensions and perhaps some adjustments. A drawback is that PDAP is not implemented in IVOA visualization tools, as IVOA protocols are (TAP, Cone Search…). However, since PDAP is strongly related to space archives and PDS dictionaries (keywords/values), it is unclear if the protocol can be versatile enough to support other kinds of data sets (including telescopic images, spectral libraries, dynamic and physical parameter lists…). For these reasons, VO-Paris and CDPP are also currently working on an IDIS-friendly version of the TAP protocol based on a specific Planetary Science Data Model [1] [5].

Such a data model would typically associate keywords and values so that all data sets can be described in a uniform way. It can then be used to build up queries according to a given protocol. These queries should use common metadata defined in the data model and the associated dictionary, which are currently being defined [5]. Specific domains may not be included in a single data model though, and can be handled with different systems. In particular, other data models are being defined in relation with laboratory data bases of solid spectroscopy (SSDM for GhoSST) [6] and atomic and molecular spectroscopy of gases (XSAM(S)), both in collaboration with the VAMDC program.

As in Astronomy, a potential difficulty to write valid queries is related to the many names of potential targets/objects. But this problem is much worse for solar System objects, which cannot be identified by their position in right ascension / declination. A name resolver is therefore required to process user's queries correctly. Such a name resolver has been studied during preliminary developments of SSODnet at VO-Paris, and a development version is available on the VO-Paris site.

CATALOGUE / REGISTRY

Queries should be sent to a global catalogue containing a description of all accessible data services and their capabilities. This description is provided according to the above data model, and allows the system to make a first order selection of services matching the user's query. In the IVOA, this is done using a system of mirrored registries where data providers can register their data. Declaring a new data service in the registry system is the normal way to make it available in the VO, and to publicize it. IVOA-like registries exist at VO-Paris and ESAC; VO-Paris also develops a registry system for the VAMDC program. Although the PDAP 1.0 document mentions a possible registry system, the level of detail involved is still unclear.

The content of the IDIS registry itself, i.e. the data services accessible through IDIS, is described using an IDIS Service Data Model. The IDIS registry/catalogue currently follows a minimal IVOA-like scheme (Fig. 3): it only contains a short description of the available data services, including their address and the protocols they support. The detailed description of the services and their contents (data sets…) is stored and maintained locally by the data providers. In this context, a data service is a series of data sets located in a given place, accessible through the same protocol and described in a unique, local, catalogue.

According to this scheme, the queries are processed at two successive levels: services of interest are identified at the registry level, the query is passed to them according to the protocol indicated, and is processed locally. The query is therefore performed in two steps: first to identify the data sets of interest, second to identify the relevant data files.

The registry structure mentioned above is expected to make maintenance of small data services much easier, although it may not be optimal for big data repositories like the PSA. Small to medium size data services could be handled with software such as SItools2, which will offer both database management and external interfaces [7].

Whatever catalogue system is finally retained by Europlanet-IDIS will need to be maintained beyond the program lifetime (ending Jan. 2013). Compatibility issues with other information systems are best anticipated by adopting the OAI-PMH standard, which is the widely used standard for metadata exchange (used in particular by the IVOA – this is a strong recommendation from the Astronomy community). This standard includes the use of the "Dublin core" metadata.

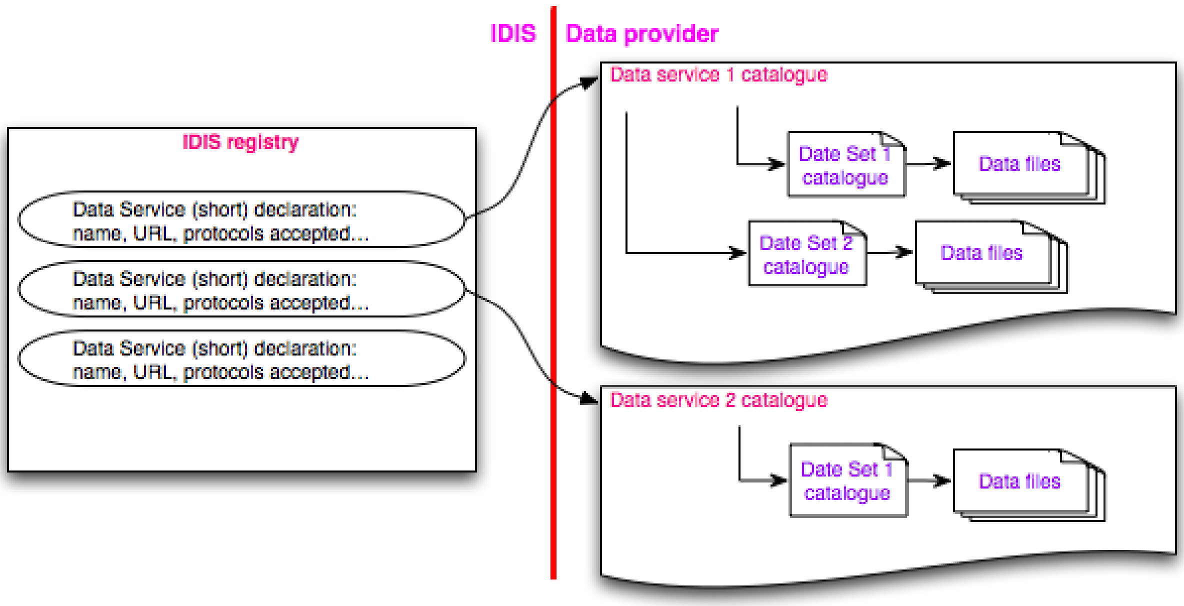

Figure 3: IDIS registry /catalogue and data services

DATA ACCESS

The answer to a query is sent back to the user. It typically provides a description, a link to the data, and information about data interface, but not the data themselves (only metadata). To be directly usable, it must also be formatted according to a known standard. This formatting can be either related to a data model, or remain at a general level (e.g. VOTable). The latter solution is the baseline for IDIS.

Reading the data can be practically difficult, given the wide variety of formats used in Planetary Science. A special problem arises with PDS3 data (used by all current space data archives), for which no versatile reader is available. Although PDS4 is expected to greatly simplify this issue in the future [8], availability of "historical" space data in PDS4 is an open question. PDS data of many types can be read on-line, and then sent to IVOA tools using a mechanism set up at VO-Paris (LecturePDS library ran in an IDL/GDL shell, then transmitted through a JavaScript interface, see Demonstrators below). Other current data formats such as FITS are routinely handled by IVOA tools.

TOOLS / PROCESSING

Many visualization tools for basic data types were developed in the IVOA framework. The baseline for IDIS is to use such existing tools, which are maintained by external teams; the development activity on the IDIS side is then reduced to interface layers. The most flexible tools in this context appear to be Aladin and SAOImage DS9 (for images and cubes), Splat, TopCat, VOPlot, and VOSpec (for tables and vectors), and VisiVO (for volume data). These IVOA visualization tools implement a data exchange protocol called SAMP (XML-RPC based). Once the data are loaded by one of these tools, they become readily available to other tools through this protocol.

Specialized data types however may require specific visualization and measurement tools, which may be part of the data services. For instance, spectral laboratory data can be handled with precision in the GhoSST interface provided by IPAG together with the database [6]. Similarly, AMDA includes a specialized environment for plasma and solar Physics [9].

Many planetary data need to be projected in a particular coordinate system. Different situations may occur:

- Sky coordinates (used e.g. for images of a target on background sky). This situation is expected to be handled by Aladin and similar tools [9]. The IMCCE Skybot service is already available from Aladin to identify moving targets.
- Planetary coordinates (e.g. for orbital images of planetary surfaces). This is similar to geographical coordinates on Earth. Apart from the geometric computation (which is expected to lie on the provider's side), plotting in such frames may also be an issue. High resolution imaging in particular requires a detailed description of planetary coordinates frames, including control point networks, in the Data Model. Converters between coordinate systems may also need to be developed.

Among the functions of interest to IDIS, accurate registration of imaging data has a special importance. A large fraction of our community works with GIS to handle orthorectified data, either bitmap or vector. The GIS community has developed tools using standards elaborated in the framework of the Open Geospatial Consortium (OGC) which can be used for Planetary Science [10] [11].

LINK TO EXTERNAL ENVIRONMENTS

Services on data may also include standard computation/inversion algorithms. The question arises of the environment used to perform such operations, and their link to IDIS. Several possibilities are being studied:

- Aladin Java plug-in system allows developers to implement basic operations on images (such as computing the average spectrum of a region of interest).
- IDL can exchange data with Aladin in some environments. Compatibility with IDL (or GDL) would give access to a very wide range of applications in public IDL libraries. This would also provide a link with ENVI, which is widely used for surface studies and imaging spectrometry.
- ISIS is a classical environment dedicated to planetary cartography, maintained by the USGS.
- The Orfeo Tool Box is a very large open source library of image processing algorithms provided by CNES (developed for its Earth observation program). The French project Vahiné aims at providing a graphical interface to this library for remote sensing in Planetary Science [12].

IDIS CLIENT

OV-Paris is designing a demonstrator of IDIS VO client chaining all the functions described above. Figure 4 illustrates these functions. The client will first provide an interface to send queries to the IDIS registry. The latter will return a list of services possibly containing data of interest, with a description of their interface. The client should be able to translate the initial query according to the indicated protocols, and to send it to the various data services. The answer will be a VOtable providing a list of selected data files, which can be used either to restrain the query further, or to select data for quick-look. In this case, the data are downloaded, converted from PDS to FITS if needed, and transmitted to visualization tools via the common SAMP hub. The data files can also be passed to external, specialized environments for further processing.

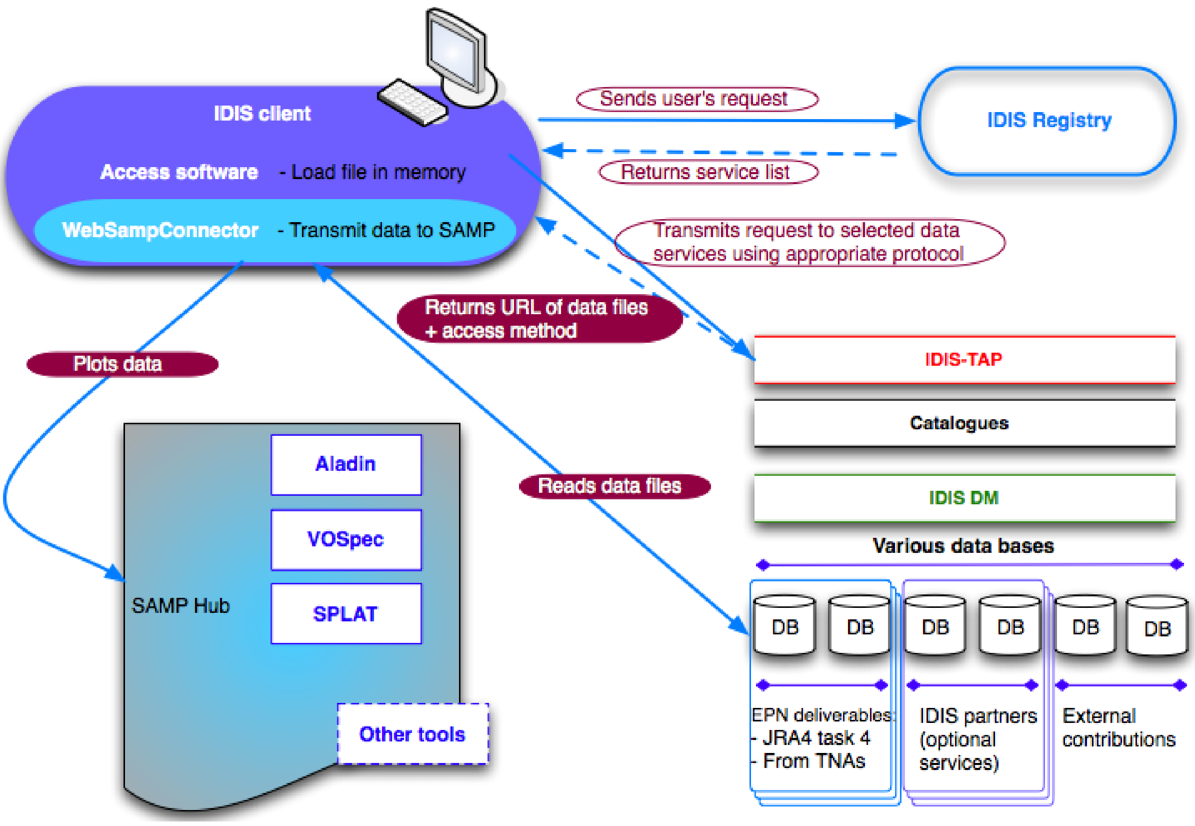

Figure 4: Overall data access through IDIS client

DEMONSTRATORS

Demonstrators of the above mechanisms are available from the OV-Paris IDIS node:

http://voparis-europlanet.obspm.fr

- Queries to planetary data services is implemented at VO-Paris development portal:
  - From the first tab ("Home") the user can send queries to VO-Paris data bases (Astronomy + Planetary Science) using IVOA protocols. TAP has been implemented for Planetary Science.
  - From the "Planetary Data" tab the user can send queries to Planetary Science services implementing the PDAP protocol. The query is sent to VO-Paris data service and also to the PSA and DARTS (i.e. to all services currently implementing PDAP).
- Access to PDS data has been demonstrated using VIRTIS/VEx spectral cubes. A cube is read in an IDL (or GDL) session on the server and stored in FITS, the reference is sent to Aladin and plotted in X/Y coordinates. In Aladin, spectra are extracted on mouse click and forwarded to VOSpec or (preferably) SPLAT for plotting.

- A service to test and validate VOTables and data services is also proposed at VO-Paris. It will be provided as a support to external contributors to IDIS who wish to share data services.
- A name resolver has been studied in developments of the SSODnet service at VO-Paris. A development version (currently restricted) is available. It will eventually be interfaced with the ephemeris server also available on line. The name resolver can also be implemented as a service using PDAP syntax, using a pair of new PDAP "resource classes". The standard values are based on the IAU Minor Planet Center list.

Other IDIS demonstrators

Other IDIS demonstrators are available at CDDP:

- Access to planetary plasma data is implemented in the AMDA tool developed by the CDPP. Queries to distant databases (VEX-MAG in collaboration with IWF Graz, Cassini-MAPSKP…) are currently done using a SPASE-based connector: http://cdpp-amda.cesr.fr
- Access to external databases in AMDA has also been implemented using webservices (e.g., CDAweb). Current studies concern possible connections of PDS webservices with AMDA.
- A service to support writing of XML data file descriptors is being developed by CDPP. An interactive mode produces the XML files from a user-friendly web interface (which can be bypassed for pipe-line processing)

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