Astronomy and Computing 7–8 (2014) 71–80

Contents lists available at ScienceDirect

Astronomy and Computing

journal homepage: www.elsevier.com/locate/ascom

Full length article

Planetary Science Virtual Observatory architecture

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ARTICLE INFO

Article history:
Received 30 April 2014
Received in revised form
18 July 2014
Accepted 18 July 2014
Available online 1 August 2014

Keywords:
Virtual Observatory
Planetary Science
Solar System
Data services
Standards

ABSTRACT

In the framework of the Europlanet-RI program, a prototype of Virtual Observatory dedicated to Planetary Science was defined. Most of the activity was dedicated to the elaboration of standards to retrieve and visualize data in this field, and to provide light procedures to teams who wish to contribute with on-line data services. The architecture of this VO system and selected solutions are presented here, together with existing demonstrators.

1. Introduction

After more than 10 years of development, the astronomical Virtual Observatory (VO) has reached a point of maturity, and some of its tools are now routinely used in research activities. For historical and organizational reasons, Planetary Science was only marginally involved in this process. However, in the recent years several Planetary Science oriented projects were started, with various scopes and objectives: PDS (Planetary Data System, the NASA Planetary Science data archive) has developed several data access systems, and the PDS4 system is explicitly oriented towards easy user access; the IPDA (International Planetary Data Alliance, gathering most space agencies) has started the definition of a VO system to inter-connect space-borne data archives more generally. The planetary plasmas community also organized itself around specific data handling tools, such as AMDA at CDPP, Toulouse. In parallel, several programs funded by the European Union focused on data services and data processing related to Solar System studies: HELIO, IMPEx, VAMDC, CASSIS, and Europlanet-RI.

Among many activities, the Europlanet-RI program included a data access activity called IDIS. One of its topics was to study the Planetary Science VO and to produce a demonstrator of such a data system. The architecture of this project was defined in a Joint Research Activity (JRA) and the first data services were implemented in a Service Activity (SA), globally referred to as IDIS (Integrated and Distributed Information Services). The main actors in this process were VO-Paris Data Centre (a structure of the Observatory of Paris involved in Virtual Observatory activities (Le Sidaner et al., 2013b)), CDPP (the planetary plasma data center in Toulouse), IAPS (an INAF laboratory in Rome), IPAG (a laboratory in Grenoble involved in spectroscopy in solid phase, also partner of the VAMDC program), and IWF in Graz. The overall infrastructure defined in Europlanet-RI is described here, with a stress on the solutions adopted and possible developments to be implemented in the future Europlanet_2020-RI program (currently under definition).

The aim of the activity was to facilitate searches of Solar System related data in big archives and sparse databases, to make on-line data access and visualization possible, and to allow small data providers to share their data in an interoperable environment with minimum effort. This system makes intensive use of previous studies and developments led in Astronomy (IVOA) and by space-borne data archive services (IPDA, PDS), as well as in solar

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http://dx.doi.org/10.1016/j.ascom.2014.07.005
2213-1337/

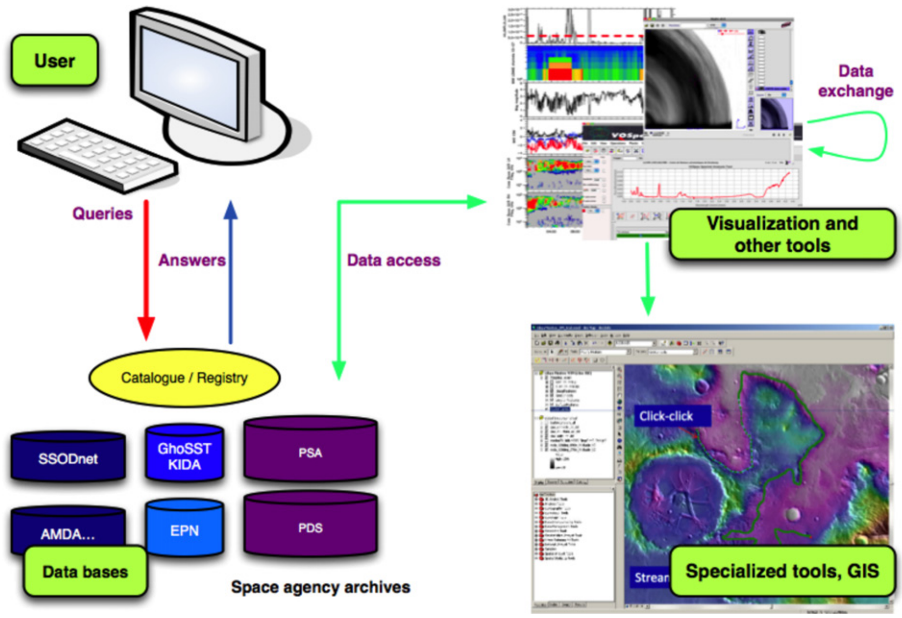

Fig. 1. Overall scheme of the Planetary Science VO.

Physics (HELIO program) and spectroscopy (VAMDC program). In particular, it remains consistent with extensions of IVOA standards.

The global architecture involves existing data services accessible through IVOA protocols (Cone Search, TAP, etc.) or the IPDA protocol (PDAP) whenever relevant. However, a more general standard has been devised to handle the specific complexity of Planetary Science, e.g. in terms of measurement types and coordinate frames. This protocol, named EPN-TAP, is based on Table Access Protocol (TAP) and includes precise requirements to describe the contents of a data service [see companion paper: Erard et al. this issue]. The data services are declared in the extended IVOA registry based at VO-Paris, which is queried by a web-based client handling both EPN-TAP and PDAP protocols. Since the original funding was European, some priority targets are related to European research activities—however, the system is not proprietary and is intended to fulfill the needs of the community in a broad sense.

The client itself and some demonstrators are available from the VO-Paris Europlanet node at http://voparis-europlanet.obspm.fr/ (acronyms and web links are provided in Appendix).

2. Proposed architecture

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

3. Data scope

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

- Data bases produced by various work packages during the Europlanet program (JRA4/task4).
- A selection of space-borne data from planetary missions. This includes data from European space missions, i.e. access to ESA's Planetary Science Archive (PSA) (Heather et al., 2013), but also calibrated or reduced data sometimes available only in instrument teams.
- Specialized data services and tools related to participants of the Europlanet/IDIS activity are also linked to the system, e.g. GhoSST (Grenoble Astrophysics and Planetology Solid Spectroscopy Thermodynamics) at IPAG, AMDA (Automated Multi Dataset Analysis) at CDPP/Toulouse or SSODnet (Solar System Open Database Network) at VO-Paris. This also includes services designed in the frame of related European programs, such as HELIO and IMPEx.
- Big data repositories that include Planetary Science data and predate Europlanet are other natural targets to expand this system, e.g. the ESO and HST archives.
- Datasets directly published in a compliant form by data providers, typically as end product of a research activity, after scientific publication.

The Planetary Science VO is required to be open so as to allow external data providers to include their databases in the system with minimum efforts. This includes not only observational data derived from space missions or ground-based telescopes, but also reference data acquired in the laboratory, and simulations.

The VO system is therefore intended to provide access to a variety of data related to planetary surfaces, atmospheres, and interiors, laboratory samples (including meteorites), Solar System plasmas, and possibly solar data, etc. It is stressed that there is a high level of heterogeneity in these data, in particular with respect to astronomical data:

- Formats: although most data formats are readily handled, PDS3-formatted data from space missions are difficult to read due to the lack of standard/versatile software, and require a special input process. Many specific formats are also in use, e.g. CDF in plasma physics.
- Coordinate frames: sky images exist, but in contrast with astronomy the targets are moving and can be identified from their coordinates only at a given time. Most data are located on planetary surfaces, atmospheres, or interiors, and are described using specific coordinate frames.
- Data are also extremely diverse in nature: 1D/2D/3D/4D, bitmap vs vectorial, local vs event-related, observational vs laboratory vs modeling, celestial vs HR orbital images, remote sensing vs in-situ (or electro-magnetic vs particles). Some of those call for particular display modes, in particular observations in reflected light or transmission, and particle measurements, have few counterparts in Astronomy.