DESCRIPTION OF THE JPL PLANETARY WEB MAPPING SERVER.

L. Plesea[1], T.M. Hare[2], E. Dobinson[1], and D. Curkendall[1], [1]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, California 91109-8099, [2]U.S. Geological Survey, 2255 N. Gemini Dr., Flagstaff, AZ, 86001, Lucian.Plesea@jpl.nasa.gov

Introduction: JPL's Web Map Server (WMS) which hosts the two planetary data servers called OnMars and OnMoon is a very high performance implementation of the ISO Standard WMS. The specific technologies used for this work are the existing open methodologies defined by the Open Geospatial Consortium (OGC) [1], which we have extending and generalizing for the planetary case. In 2007, the development of OnMars and OnMoon servers is under way; we continue to add functionality for more complex data services such as 3D, anaglyph generation, larger datasets as well as support for high traffic applications. This abstract describes the history, hardware, and software behind the servers.

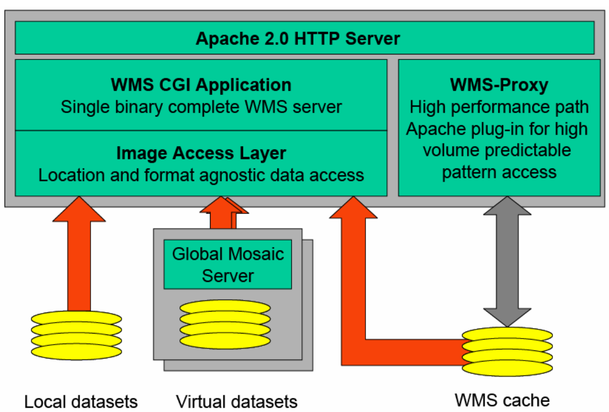

Figure 1. WMS Server Architecture

Timeline: In 1997, the JPL High Performance Applications group assembled a multi-spectral 30m Landsat mosaic of the continental US. The twenty million pixel dataset contained more than two hundred gigabytes of data and represented the largest single assembled at that time. In 1999, a decision was made to release this mosaic for open public use, and the basic mechanism chosen was an emerging web based mapping standard which was to become WMS. The NASA Geospatial Interoperability Office was tasked to support and participate in the efforts of the newly formed OGC. In this context, access to the JPL CONUS Landsat Mosaic was made possible via collaboration between JPL and MIT, resulting in the implementation of the JPL WMS server, a combination of a JPL developed map server and the MIT WMS parser/server.

Between 2003 and 2004, many more datasets and features were added, the server being upgraded to full compliance with WMS 1.1.1, including support for the OGC Style Layer Descriptor (SLD). This was done in conjunction with the assembly of the WMS Global Mosaic, a 15m per pixel global multi-spectral mosaic of the Landsat 7 GeoCover 2000 dataset.

Adaptation of the server to the planetary domain was started in 2005. Several pre-existing planetary datasets were added to the server in 2005 and 2006 [2]. In 2006, the OnMars and OnMoon servers were virtually split from the OnEarth server to begin testing new planetary reference system encodings that have been proposed to the OGC community [3,4].

Significance and Relevance: The JPL's web mapping server, in both its earth and planetary instantiations is a very significant web resource for many mapping applications. For many WMS and SLD features, the JPL server is the only known implementation; the combination of datasets, features, availability and open access is unmatched.

- ***Access to planetary data***. OnMars and OnMoon have continuously tried to expose as much data as possible [4]. The choice of a simple yet flexible access API such as WMS, backed by a high performance and feature reach server implementation, greatly increases the ease of data access.
- ***Innovative use of datasets***. As new datasets are being added, new applications become possible, which in turn require new features to be added to the server. This loosely coupled development model generates many innovative applications, such as the creation of MOC Narrow Angle mosaic [4].
- ***Web Based Supercomputing***. The classic view of supercomputing relies on very large computers or clusters, where a user gets an account, learns the environment, ports or installs the applications, transfers the data in and out, and relies on a scheduling system for sharing the resources with other users. This is a slow process, only suitable for a limited set of applications. The JPL WMS server was developed to propose and demonstrate a new type of supercomputing application, in which significant data and computational resources are available to a user within milliseconds via a web interface. The dataset and type of operations are indeed limited, but this is primarily due to the lack of resources. This type of supercomputing also solves, in a very simple way, a number of security issues inherently present in classical supercomputing.

Configuration details: The JPL WMS server architecture is influenced by both the hardware and software configurations. Each is the result of a long series of changes, leading to a very well integrated and scalable software/hardware system. In addition to the server itself, the same software system and hardware is used to generate, improve and maintain the datasets.

Software: There are three layers of software in the current JPL WMS server architecture, plus a WMS cache system. The layers are separated by well defined interface levels, making it possible to run the server itself in a distributed fashion. The WMS cache module, the WMS server and the image server can operate as individual applications, and are commonly being used as such in the development process.

- ***Bottom Layer.*** The first layer is represented by an image server developed as a high performance data access subsystem. The same data access layer was used for the production of the 5TB Landsat mosaic and the MOC Narrow Angle mosaic. In the WMS server configuration, the image server is used for dataset virtualizations, enabling uniform resolution access to the WMS Global Mosaic. For reasons of performance there are four copies of the image server, running on the two of the Linux storage systems.
- ***Middle Layer.*** The second layer is the WMS server itself. It is a single binary C++ implementation which includes the WMS protocol layer and the map data processing kernel. It is an in-core, multithreaded application implemented using the SGI Image Library with custom extensions and has direct access to local data and virtual image server datasets.
- ***Top Layer.*** The top layer is represented by the Apache HTTP Server. This top layer provides access control and deals with the HTTP protocol itself. Apache 2.0 is used currently.
- ***Cache.*** The cache system is a very high performance WMS specific cache system implemented as an Apache core module. It represents a fast path alternative to the full WMS server, and can operate independently. It recognizes and serves specific WMS requests matching a predefined access pattern, greatly accelerating applications using a deterministic tiled access. WorldKit, WorldWind, osgPlanet, Google Earth and the ESRI ArcExplorer are some of the applications that can use the cache system. Support for KML is integrated; the WMS cache module can create KML wrappers for the existing WMS access patterns. The cache datasets can be pre-built using the WMS server code or the user access can be used to generate a cached dataset on-the-fly. The existence of the cache system greatly increases the performance of the WMS server, reducing access latencies in the range of seconds to tens of millisecond. It also helps to lower the server computation load, improving server availability. The cache system was able to sustain more than twelve million requests per day, while the normal WMS server on the current hardware only supports about one million requests.

Hardware: The JPL's web mapping server is built around a Gigabit Ethernet server subnet. Computer nodes connected to this subnet can be classified in three categories: storage, web server, and support

- ***Storage.*** The storage system is a cluster of 10 Linux machines, each with 4 TB of internal, hardware RAID5 disks. It serves as both main and backup storage for the massive datasets. Some of the storage servers are running the image server, providing specific virtual dataset access to the WMS servers.
- ***Web servers.*** The main data server hosts the virtual servers OnEarth, OnMars, OnMoon, WMS and other unrelated web servers. The machine itself is an SGI Origin 300 with 8 CPUs and 8GB of RAM. The WMS caching modules uses a direct attached 1TB high performance RAID.
- ***Support servers.*** A public bulk data server complements the WMS functionality. A second Origin 300 is used as a development server.

Conclusion: The planetary JPL WMS servers OnMars and OnMoon are in service and the planetary reference systems encodings are in place for testing. Adoption of these planetary encodings by other parties are slow but progressing. OnMars and OnMoon are quickly shaping up as some of the most data and function rich WMS servers for planetary as well as Earth-based systems.

References:

[1] OGC, http://www.opengeospatial.org/, accessed January 2007. [2] Dobinson, E., et. al., Adaptation & Use Of Open Geospatial© Web Technologies for Multi-Disciplinary Access to Planetary Data, (2006), LPSC XXXVII, abs. 1463. [3] Hare, T., et. al., Standards Proposal to Support Planetary Coordinate Reference Systems in Open Geospatial Web Services and Geospatial Applications, (2006), LPSC XXXVII, abs. 1931. [4] Hare, T., et. al., Advanced Uses of Open Geospatial© Web Technologies for Planetary Data, (2007), LPSC XXXVIII, abs. 2364.

Additional Information: This work is funded under the NASA AISR Program. The website portal can be found at http://webgis.wr.usgs.gov/ogc.