AstroPortal

Harnessing Grid Resources to Enable the Dynamic Analysis of Large Astronomy Datasets
http://people.cs.uchicago.edu/~iraicu/research/AstroPortal/

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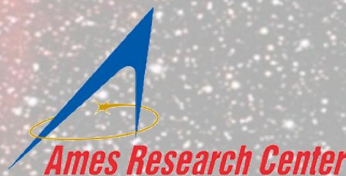University of Chicago
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Grid computing has emerged as an important new field focusing on large-scale resource sharing and high-performance orientation. The astronomy community has an abundance of imaging datasets at its disposal which are essentially the "crown jewels" for the astronomy community. However, these astronomy datasets are generally terabytes in size and contain hundreds of millions of objects separated into millions of files—factors that make many analyses impractical to perform on small computers. The key question we answer is: "How can we leverage Grid resources to make the analysis of large astronomy datasets a reality for the astronomy community?" Our answer is "AstroPortal," a gateway to grid resources tailored for the astronomy community. To address this question, we have developed a collection of Web Services-based systems that use grid computing to federate large computing and storage resources for dynamic analysis of large datasets. Building on the Globus Toolkit 4, we have built a prototype consisting of various systems (AstroPortal, DYRE – Dynamic Resource pool Engine, 3DcacheGrid – Dynamic Distributed Data cache for Grid applications, and CompuStore – Computational Scheduler) to enable a "stacking" analysis; the analysis sums multiple regions of the sky, a function that can help both identify variable sources and detect faint objects. We have deployed AstroPortal and the related systems on the TeraGrid distributed infrastructure and applied the stacking function to the Sloan Digital Sky Survey (SDSS), DR5, which comprises more than 320 million objects dispersed over 1.5 million files, a total of 3.5 terabytes of compressed data, with promising results. AstroPortal gives the astronomy community a new tool to advance their research and to open new doors to opportunities never before possible on such a large scale.
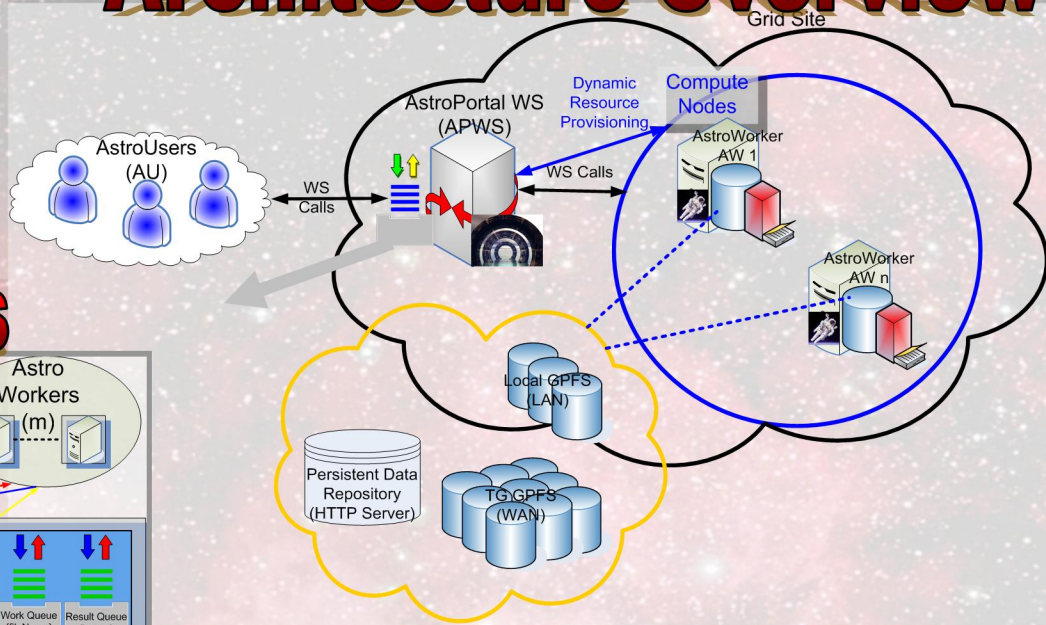
Time (sec)	Queued Stackings	Active Stackings	Completed Stackings	Submitted Stackings	Completed(%)	Global Queued Stackings	Global Active Stackings	Global Active Resources
6.808	1328	672	0	2000	0%	1328	672	32
9.068	1328	567	147	2000	7%	1328	546	32
10.151	1328	420	315	2000	15%	1265	357	32
10.735	1265	189	630	2000	31%	1265	105	32
11.898	1097	315	672	2000	33%	1097	231	32
12.048	1076	336	672	2000	33%	1076	252	32
13.27	845	567	672	2000	33%	845	483	32
13.431	803	609	672	2000	33%	803	525	32
14.68	698	714	672	2000	33%	698	630	32
14.832	677	735	672	2000	33%	677	651	32
16.143	656	609	819	2000	40%	656	525	32
17.56	656	378	1071	2000	53%	656	273	32
19.131	509	336	1281	2000	64%	509	231	32
20.509	257	504	1344	2000	67%	257	399	32
21.93	68	693	1344	2000	67%	68	588	32
23.368	0	656	1449	2000	72%	0	551	32
24.849	0	420	1685	2000	84%	0	315	32
26.325	0	189	1916	2000	95%	0	84	32
26.486	0	147	1958	2000	97%	0	42	32
27.767	0	105	2000	2000	100%	0	0	32

Received results in 29508.0ms
Total number of images requested 2000
2000 actual images stacked
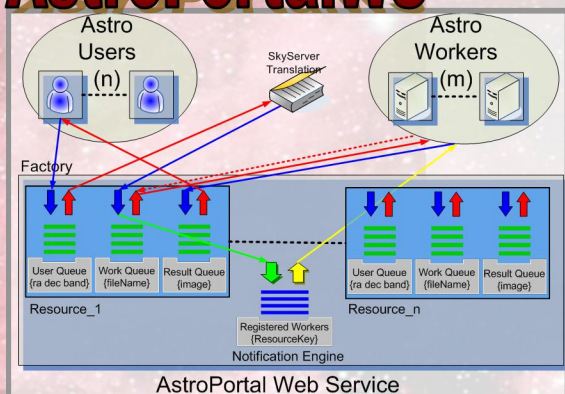0 requested stackings not performed

The "AstroPortal" is a gateway to grid resources; around the AstroPortal, we have developed a collection of Web Services-based systems that use grid computing to federate large computing and storage resources for dynamic analysis of large datasets. Building on the Globus Toolkit 4, we have built a prototype consisting of various systems (AstroPortal, DYRE – Dynamic Resource pool Engine, 3DcacheGrid – Dynamic Distributed Data cache for Grid applications, and CompuStore – Computational Scheduler) to enable a "stacking" analysis; the analysis sums multiple regions of the sky, a function that can help both identify variable sources and detect faint objects.
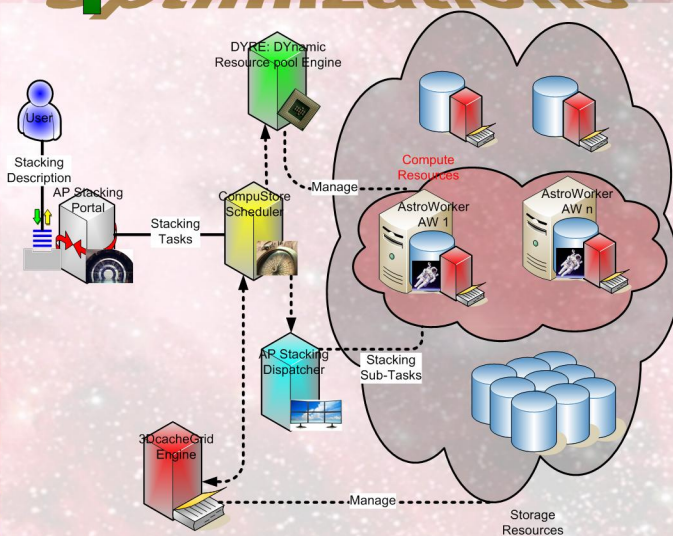
Architecture Overview

Grid Site

AstroUsers (AU)

WS Calls

AstroPortal WS (APWS)

Dynamic Resource Provisioning

Compute Nodes

WS Calls

AstroWorker AW 1

AstroWorker AW n

Local GPFS (LAN)

Persistent Data Repository (HTTP Server)

TG GPFS (WAN)

AstroPortalWS

Astro Users (n)

SkyServer Translation

Astro Workers (m)

Factory

User Queue {ra dec band}   Work Queue {fileName}   Result Queue {image}

Resource_1

User Queue {ra dec band}   Work Queue {fileName}   Result Queue {image}

Resource_n

Registered Workers {ResourceKey}

Notification Engine
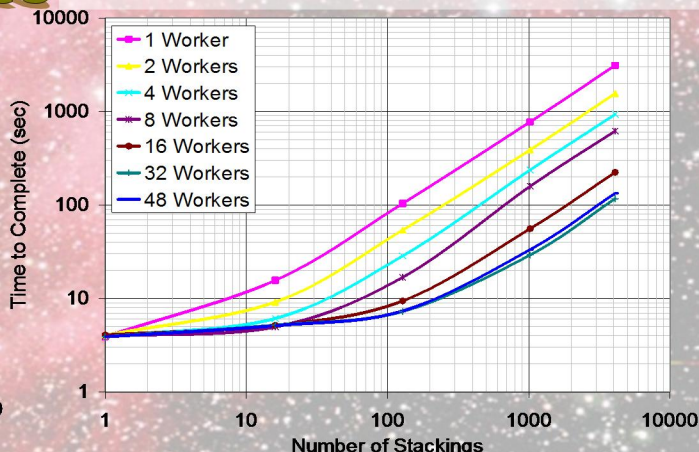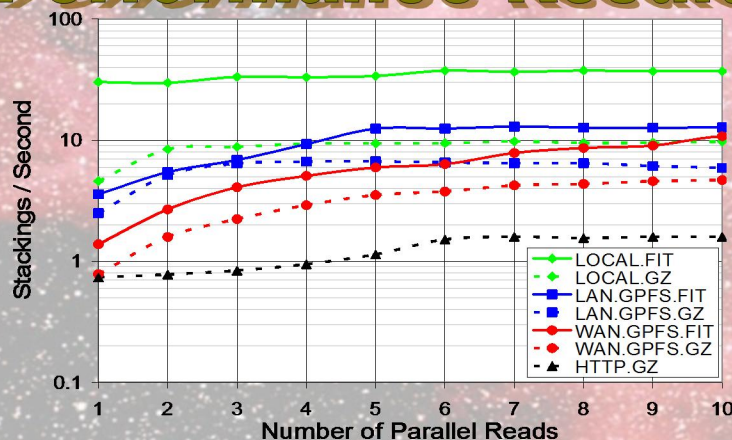
AstroPortal Web Service

We propose three different systems that can interoperate with each other in order to offer a complete storage and resource management solution to enable the efficient dynamic analysis of large datasets.

- DYRE, DYnamic Resource pool Engine, is an AstroPortal specific implementation of dynamic resource provisioning. DYRE essentially handles all the necessary tasks associated with state monitoring, resource allocation based on observed state, resource de-allocation based on observed state, and exposing relevant information to other systems.

- 3DcacheGrid, Dynamic Distributed Data cache for Grid application, allows applications to achieve a good separation of concerns between their business logic and the complicated data management task of large data sets. We utilize a tiered hierarchy of storage resources to cache data in faster but smaller data storage tiers.

- CompuStore, a work scheduler that uses both the storage and compute resource management systems 3DcacheGrid and DYRE; the goal of CompuStore is to make the best scheduling decisions given some work, the available compute resources (DYRE), and the available data caches (3DcacheGrid) which are stored on the compute resources.

Optimizations

DYRE: DYnamic Resource pool Engine

User

Stacking Description

AP Stacking Portal

CompuStore Scheduler

Stacking Tasks

Manage

Compute Resources

AstroWorker AW 1

AstroWorker AW n

AP Stacking Dispatcher

Stacking Sub-Tasks

3DcacheGrid Engine

Manage

Storage Resources

Performance Results

X-axis: Number of Parallel Reads (1–10)
Y-axis: Stackings / Second (0.1–100)

Legend:
- LOCAL.FIT
- LOCAL.GZ
- LAN.GPFS.FIT
- LAN.GPFS.GZ
- WAN.GPFS.FIT
- WAN.GPFS.GZ
- HTTP.GZ

X-axis: Number of Stackings (1–10000)
Y-axis: Time to Complete (sec) (1–10000)

Legend:
- 1 Worker
- 2 Workers
- 4 Workers
- 8 Workers
- 16 Workers
- 32 Workers
- 48 Workers

Ioan Raicu, Ian Foster, Alex Szalay, Gabriela Turcu. "*AstroPortal: A Science Gateway for Large-scale Astronomy Data Analysis*", TeraGrid Conference 2006, June 2006.
Alex Szalay, Julian Bunn, Jim Gray, Ian Foster, Ioan Raicu. "*The Importance of Data Locality in Distributed Computing Applications*", NSF Workflow Workshop 2006.
Ioan Raicu. "Harnessing Grid Resources to Enable the Dynamic Analysis of Large Astronomy Datasets", NASA GSRP Proposal, Ames Research Center, NASA, February 2006.