GEONGrid Portal: Design and Implementations

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SUMMARY

We have developed the GEONGrid system for coordinating and managing naturally distributed computing, data, and cluster resources on the cyberinfrastructure. At the present state, since the use of Grid technology is still very complex for researchers and scientists, the area of Grid Portals has made excellent progress. Grid portal system is emerging open grid computing environments that promises to provide users to uniform seamless access to remote computing and data resources by hiding the complexity of more sophisticated Grid technologies. In this paper, we present our initial efforts of design and implementations of service components in the GEONGrid portal. These service components may be implemented as Web services that follow the conventions of service oriented architecture design. In this approach, service components are self-contained, have a well-defined programming interface defined in WSDL, and communicate using SOAP messaging. In building GEONGrid portal, we also present a portlet-based architecture as clients to component based user interface. Portlets provide the desired component model for user interfaces in the same way like Web services. Using this approach which allows grid portals to be built out of reusable components has obvious advantages of reusability and modularity.

KEY WORDS: Grid portal; service-oriented architecture; portlet; Web service; geosciences

1. INTRODOCTION

The word "cyberinfrastructure" often connotes advanced scientific computing as well as a more comprehensive infrastructure for research and education based upon distributed, federated networks of computers, information resources, on-line instruments, and human interfaces [1]. For building this geographically distributed computing infrastructure to support multi-disciplinary and multi-institutional organizations of scientists and engineers, the use of Grids technologies has become much more attractive and popular [2]. Many useful services, such as secure, seamless access to remote compute and data resources on the cyberinfrastructure can be built on top of this core infrastructure. With the advent with the OGSA [3], recent advances in Grid computing have aligned itself with Web Service standard which is gaining wide acceptance for the scientific computing because of the desire for a loosely coupled, communication services. Web Services are the distributed system which follows a Service Oriented Architecture (SOA) principles discussed by the World Wide Web Consortium's Web Service Architecture working group [4]. Thus, this service-oriented approach to science offers

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the general architecture for accomplishing distributed networks of interoperating services.
GEON (GEOsciences Network) is the cyberinfrastructure project that is bringing together information technology and geoscience researchers from multiple institutions in a large-scale collaboration [5]. The aim of GEON is to build data-sharing frameworks, identify best practices, and develop useful capabilities and tools to enable dramatic advances in how geoscience is done. The GEONGrid infrastructure is naturally distributed with users and resources spread across 16 different partner sites in US. For utilizing the GEONGrid system, the GEONGrid portal system provide user-friendly science environments for access to scientific tools and data and vastly broaden the scope of scientific questions that can be answered [6]. Scientists or researchers are able to discover data, tools, and models via distributed GEONGrid portals, using advanced, semantics-based search engines and query tools, in a uniform authentication environment that provides controlled access to a wide range of resources. The main challenge of the GEONGrid portal is to provide the partner sites with increased control and management of how their resources, tools, and data are accessed and integrated into the end-user's environment while maintaining the properties of a virtual organization: interoperability, security, location independence, etc.
In building GEONGrid portal, specifically we consider two things. First, the service-oriented approach is very appropriate and applicable like other science grid projects [7][8]. A diverse set of services as a "kit" of service components can be easily composed in various ways in different science applications. This is also the rationale for the "plug-and-play composable services" vision for Grid middleware in UK e-science program. Next, portal services that contain a different set of service interfaces include allowing access to all metadata, the management of system deployments, and data information, which is provided by other GEON partner sites. Additionally a portal service may aggregate a set of services and provide a domain specific view of the state of these services. Thus, we are also adopting a portlet based architecture which is allowed to be built out of reusable portal services. This portlet approach allows the user and/or administrator to choose which content providers to display and what portion of the display real estate they will occupy that may be controlled through the portlet container as well as allows each partner site to plug and play the portlet component among them for GEON community. Furthermore, portlets may be reused between different containers through the way of the JSR 168 portlet specification [9] as aspect of the portal interoperability.

2. PORTAL ARCHITECTURE

We have implemented the portal system in the traditional three-tier architecture, based on the service-oriented model. These tiers separate functionality and responsibility, allowing us to develop services independently as illustrated in Figure 1. Users are able to connect to portlet components or services through either a web browser, stand-alone client application, or both using the over-the-wire connection protocols. The middle tier consists of two basic sections: the user interface server running a portlet engine and a distributed Grid/Web Service-based middle tier. The web server runs a portlet engine which contains portlet components. These components as described in Section 3 may compose specific local service interfaces with integrating a variety of distributed GEON services. In addition, this user interface server running the portlet container is also responsible for aggregating and customizing the various components on the GEONGrid portal. This portlet container defines how user interface components can be plugged in and managed by portal administrators and users. For example, gridsphere portlet framework [10] which we are using currently in GEON portal framework is open source portlet container system that provides this capability. Service components as described in

Section 4 consists of a distributed Web/Grid Services that can provide access to remote back end services, such as HPC computers running PBS or other queuing system, data storage devices, mapping tools, and visualization toolkits.

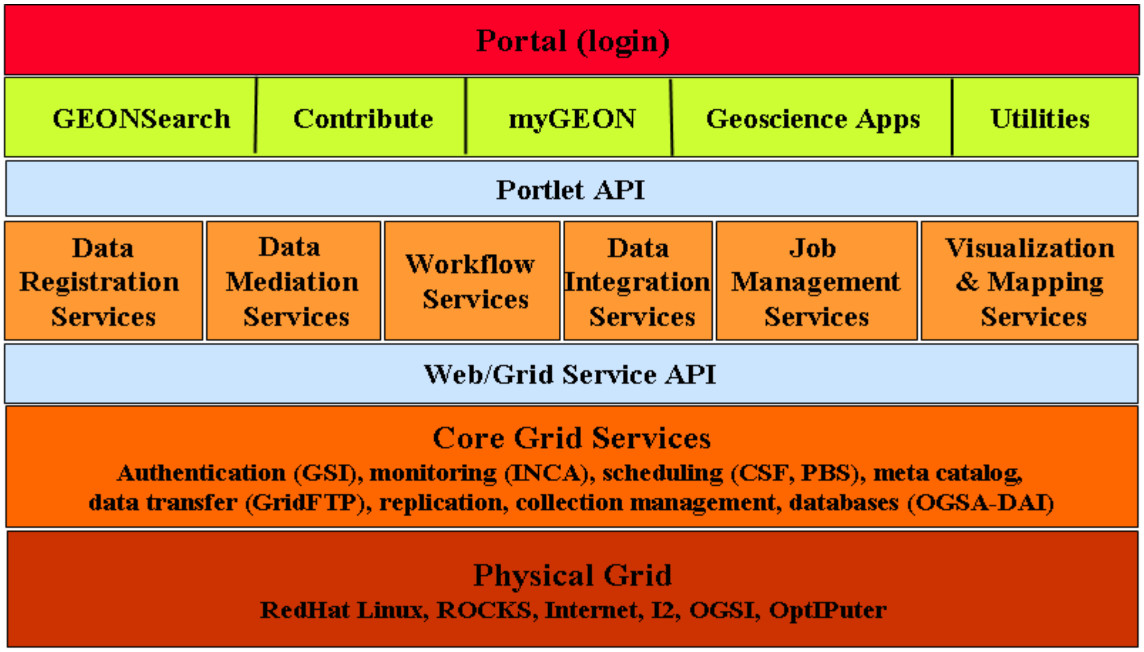

Figure 1. GEONGrid portal is implemented in a multi-tiered architecture

The main task of the GEON user interface is to allow users to register and discover the data for the geoscience, organize their work into the workbench place, called “myGEON”, and do the map integration with the geoscience data. For example, users can search the GEON data resources, e.g. shapefiles, databases, WMS (Web Map Server) service, and GeoTIFF, collect their data and integrate them into “myGEON” portlet from the “GEONSearch” portlet and then visualize the shapefile data using a mapping service embedded in the “myGEON” portlet. And in the computation area of “myGEON” portlet, users can also review and analyze SYNSEIS (a synthetic seismogram calculation tool) ouputs that are generated by job running as the user archival service, and resubmit the job into the computational resources.

Basically, the portlet component maintains several client stubs that provide local interfaces to various remote services. These remote services are described in WSDL and are invoked via SOAP over HTTP(S). These services are invoked on various service-providing hosts, which may in turn interact with local or remote databases, data repositories, or remote queuing and system environments via grid services. So, this service-oriented approach allows the portal developer to browse the remote service on a particular host easily into their applications to build up.

In this architecture, to address uniform access to resources among partner sites, portlets are key point. These pluggable user-interface components for processing requests and generating dynamic content can be replicated on the partner sites to provide a standard interface to the GEON community. So, the distributed portal architecture and the software that enables this architecture will be valuable to partner sites. It will allow experts at partner sites to develop individual IT solutions that are compatible and that can be leveraged by other partners in a seamless integrated way.

3. PORTLET COMPONENTS

The main portlet components in GEON are grouped into three areas: account management for the portal administrator, resource management and science applications for geosciences, and utility services for the portal user.

3.1 Account Management Portlets

For controlling access to remote resources in a GEONGrid infrastructure which use Grid Security Infrastructure (GSI) based security system, GEON account management system is developed. We have identified three classes of users: public users (i.e., non-registered users), local users (i.e., users restricted to a particular GEON partner site), and "grid" users that will receive special privileges, e.g., ability to register data and execute compute intensive jobs. The current set of global services for GEON partner sites is focused on user account management and security. The account management services are provided by GAMA (Grid Account Management Architecture) [11] developed specifically to support GEON. GAMA provides a central GSI certificate management system where “grid” users are approved, and credentials are created for them based on global policies. Grid users have a single login credential and password that can be used at any portal site that has that account enabled. The partner portals can query GAMA and synchronize the grid accounts either automatically or selectively. In addition to grid accounts, each partner portal can create purely local-user accounts with no GSI credentials. These accounts may be used by developers to build the local services, or by users that wish to access the local resources, but who are not members of GEON. The global GEON services and applications will generally not support local users, or it will provide reduced level of service for non-grid users.

3.2 Resource Management Portlets

- **GEON Ontology Portlet** [12][13][14] facilities OWL (Web Ontology Language) ontologies registration and visualization. For each OWL ontology uploaded into the GEON system, the system validates that all the imported ontologies are registered in the GEON system, and assigns a unique name space to the ontology, and then generates web based documents for browsing the ontology.
- **GEON Resource Registration Portlet** supports to register resources into GEON. The resources registered to GEON can be classified as hosted and non-hosted resources. The hosted resources are physically sent and installed into the GEON repository and served from the GEON system. Shapefiles and GeoTIFF files are two typical hosted resources. Non-hosted resources are the resources served from the machines outside GEON, and their information is saved in GEON, for instance, relational databases and web services are usually non-hosted data resources.

  A registered resource can be annotated by ontologies at item level and item detail level. At the item level, a resource is annotated by some classes in a selected ontology. GEON Search uses such information to find resources related to some specified concepts. At the item detail level, a resource is annotated to make the GEON system completely understand how the resource and the ontology are connected. The GEON system supports automatic data integration based on the item detail level ontology annotations.

- **GEON Search Portlet** provides a search engine to find resources registered to GEON. Users can search based on metadata, spatial coverage, temporal coverage, ontologies or any combination of these.
- **GEON Workbench (myGEON) Portlet** supports bookmaking and integrating many different type resources. For example, multiple shapefiles can be integrated through a map; multiple databases and shapefiles can be integrated as a virtual relational resource. It also provides tools to manage submitted resources.
- **Map Integration Portlet** drives spatial data mapping and visualization on the portal. It is composed of different components, which support on-the-fly visualization and analysis of geoscience datasets, stored in shapefile format. Its development, theory and evolution are covered in great depth in [14], [15] and [16].

  First, in mapping integration, assigning proper colors to maps requires *knowledge about* the data, and *knowledge about* the standard coloring scheme. GEON already maintains semantic descriptions of datasets (by annotating data elements with concepts in one or more ontologies represented as OWL files). Thus, this existing framework is used for managing coloring rules as well. Ontology owner is given an option to provide a text file which defines a mapping between ontology concepts and RGB color values, thus mapping data values to color values indirectly. Once such a mapping is generated, the color-aware ontologies are used to generate composite thematic maps instead of randomly colored images.

  Next, this service was the facility to query all GEON-hosted shapefiles to generate data fragments instead of map images. The portlet designed on top of the map integration service allows the users to download subsets of data, which were generated as result of the query. As these derived resultsets are regular datasets themselves, they can be registered with the GEON system and thus can be shared with the community. If the user doesn't want to download and register the resultset, he/she can still work with it by adding it to his/her personal workspace and eventually integrating it with other datasets. Development of such a service required a solution for the problem of semantic heterogeneity among homogeneous information. For example, while integrating geologic data from multiple sources, different shapefiles may contain same data, such as geologic age, but it may appear under different columns. In some other case, different authors may even use different terms for same geologic age (e.g. Jurr for Jurassic).

  This problem is also resolved by the use of ontologies i.e. the users are allowed to query datasets for concepts, instead of actual values stored in the personal geo-database. An ArcIMS-based query service first converts concepts into data values for each of the queried datasets and then queries each dataset for given values. This results in the generation of derived datasets. The portlet also enables users to visually analyze the results by displaying a map of generated data fragments, where different colors symbolize the query results.

3.3 Science Applications Portlet

Using GEON computational and open grid computing environment, we have developed a domain-specific application tool (SYNSEIS – SYNthetic SEISmogram generation tool) [17] to help seismologists as well as any other researchers to calculate realistic and synthetic 3D regional seismic waveforms using a well-tested, finite difference code, e3d, developed by the Lawrence Livermore National Laboratory [28]. This system is also designed to be used in day-to-day activities of researchers, especially those of EarthScope scientists who will be accessing data from hundreds of

stations everyday and need to process the data in a timely fashion.
The SYNSEIS application has been implemented as the portlet object that can provide the hosting environments of interacting with the codes and the data retrieval, allowing the codes to be executed, submitted to batch queuing systems such as PBS, and monitored by users through the browser. As example of scenario, using interactive and dynamic graphic user interface which uses Macromedia Flash MX which was built from the ground up to provide a 'rich client' environment for Internet content and applications that will radically improve the quality of end-user applications, making the Internet more relevant and useful to businesses and consumers [29], with mapping tools and event/station/waveform extraction tools, users are able to interactively set their study region on the graphic map with zooming out and in, retrieve seismic event and station locations, extract waveforms on the fly for any selected event-station pair, and compute a synthetic seismic waveforms, the rendering of surface and volume data using built in tools.

3.4 Utility Portlets

In "UserProfile" Portlet, user information can be displayed and edited, and users are able to update the password depending on the account type. Users can do the customization of the layout using portlets which are registered into the portlet registry. For users with Grid proxy credentials, the Credential Manager portlet displays the credential information. Through other utilitiy portlets, users can provide information and suggestions into GEON community using GEON Forums portlet, and can download GEON softwares, toolkits, and documents via the CVS portlet.

4. GEON SERVICES

Actually, the main GEON services are divided into four categories: resource management services, job management services, mapping management services, and certificate management services. All GEON of services are defined as WSDL and can be accessed concurrently by multiple users, which is essential in a grid environment. Note GEON services are being developed and changed continuously.

4.1 Resource Management Services

- **Data model service** may load the whole US Moho or sediment data and then calculate the location using the bounding box data provided by the input parameters. The selected region's data for the data model is returned to the users to construct a 3D geologic model.
- **Data retrieval service** may be built on top of the Data Handling Interface (DHI) clients, which access the CORBA servers developed by IRIS. It provides the functionality for retrieving earthquake event point, station data, and seismogram waveform data from IRIS DMC.
- **GEON ID service** returns a list of public resource GEON IDs which satisfy some search conditions on metadata, spatial coverage, temporal coverage and concepts in a selected ontology. For a valid GEON ID of a public resource, "getMetaData" method returns its ADN metadata
- **Ontology query service** rewrites an ontology based simple query against shapefiles into SQL queries.

4.2 Mapping Management Services

- **“ATypeWorkflowService” service** provides visual map generation and analysis support for a workflow which aims at discovering a specific type (Plutonic Type) of rock in Virginia. This service also provides facilities such as querying an existing shapefile for above-mentioned rock-type and rendering maps for the derived results.
- **“TextToMap” service** is a collection of services which are designed to consume spatial data in ASCII or XML format. A typical example would be the point vector dataset that expresses each point as a combination of X,Y (in some cases X,Y,Z) along with a set of attributes with each record defined on a line, or expressed as XML elements. These services generate a shapefile as an output along with the creation of an Image Service and a mapping interface on the fly. Also, these services are used by Beachbaclls workflow in [18].
- **“ShapeToMap” service** converts shapefiles to interactive as well as static map images on the fly. It is the backbone for all visual analysis in GEON services architecture. For example, both ASCIIToMap and XMLToMap use ShapeToMap to create maps. This service also allows clients to create ArcIMS image services remotely, thus decoupling the applications from ArcIMS Server.
- **“ImageQueryService” service** facilitates applications/clients to query shapefiles to retrieve XML data or shapefile fragments. Technically, this service is a wrapper for ArcIMS query requests i.e. GET_EXTRACT and GET_FEATURES, once again decoupling applications and ArcIMS server.
- **Grid Monitor service** creates a map for the current state of GEONGrid nodes. A crone job periodically invokes a grid service that pings every node to extract the status in a XML file, which is then fed to the service to create the map with current status of the nodes with geographical location and other performance attributes.

4.3 Job Management Services

- **Job submission service** [17] is a basic component required to integrate the computational grid with Web Services. This service may execute operating system calls directly or may interact with Grid services through client APIs. We implement this service with file transfer on top of Grid technologies using Java COG Kit [19] which is the Globus interface to run jobs on remote computational resources in a secure and authenticated manner.
- **Job monitoring service** [17] is implemented using Java COG Kit [19], like submitting the job for monitoring the execution of a job running in a remote queuing system. Basically, a job submission service returns a unique job identifier (Job ID from the job information) that can be used for enquiry about the job status. If the job is submitted to a batch scheduler it is in the pending state while sitting in the queue waiting to be executed. The job may become suspended due to pre-emption mechanisms. In case of normal completion the job status is “Done”, otherwise the job is “Failed”. In our case, once the user’s job is done, generated outputs are transferred to the data repository for allowing the user to access using the file transfer service.

4.4 Certificate Management Service

The certificate management service [20] for creating and managing GSI credentials provides a consistent interface to the various portal clients using basic account management and login/logout capability. Behind the scenes, this service manages the user’s certificate and private keys and interfaces with CACL (Certificate Authority Client) [21] which provides an implementation of a “certificate authority” that creates user and server certificates, MyProxy [22] that provides a centralized certificate repository with advanced features such as certificate renewal and CAS (Community Authorization Service) [23] that defines a set of roles, a set of access rights for each role, and maps users into roles within the GSI framework, as needed, depending on configuration and the type of account management system an organization wants to use.

5. SECURITY SERVICE

Security in a Grid environment is critical, since it often involves directly accessing a user's resources on a particular computer through delegation to a middle tier proxy. Grids require an extension of the traditional transport level security systems using SSL. Transport level security insures a safe transmission of messages between two endpoints. Grids on the other hand may need to pass messages through several intermediate hosts and may need to send messages to more than one endpoint. Grids thus require message-level security in addition to simple, point-to-point transport level security mechanisms.

In GEON portal architecture, there are two levels at which the authentication are performed: the portal interaction level and the Web Services level. The GEONGrid portal has GSI-based security infrastructure [24], called GAMA [11] which provides a central GSI certificate management system. The GSI for the mutual authentication across Grid services is based on the public key infrastructure which is used for X.509 certificates, and SSL communication protocol. Through the login portlet, the user portal authentication is performed with connecting to GAMA server. Users thus take the proxy certificate on the portal session. In order to communicate secure messages between the portal server and the targeted remote services, we set up the transport level security using GSI-based certificates for the authentication over SSL like the WSRF (Web Services Resource Framework) security infrastructure [25].

We are using the identity-based authorization system in GEON Web Services. This simple authorization mechanism to restrict GEON Web Services access is performed through the gridmap file which contains the user distinguished name and the local user name. Upon the authenticated call that arrives at certain service, the identity of the caller is checked against the owner of the application. If two identities match, the authorization for the Web service access is granted.

6. CONCLUSIONS

In this paper, we have presented design and implementations of GEON specific services that can be used for portlet components as the GEON user interface, centered into the service-oriented architecture. These services form the basis of Grid portal environments, and our emphasis has been on the development of reusable services and interchangeable portlet components among GEON partner sites that can form the basis for multiple problem solving environments. Based on this service-oriented computing architecture, the portal developer can construct specific implementations and composites of primitive service components and can also provide services that may be shared among different portals.

Currently, GEON services and user interfaces are still being developed and have a generic weakness in some service implementations. For example, job management service is designed to the particular queuing system, PBS for monitoring the job with file transfer and the job submission for running specific applications of SYNSEIS tool with file transfer.

Next, Users require the GSI-enabled authentication for using a variety of GEONGrid Web/Grid services. With the portal interaction, users get CAS (Community Authorization Service)-enabled proxy certificate for the authorization. The CAS proxy certificate is a GSI restricted proxy credential with an embedded policy giving the user the right to perform a set of actions granted by the resource provider to the community. Resource providers grant coarse-grained access to blocks of resource using SAML (Security Assertion Markup Language) standard [26]. SAML, an OASIS standard, is an XML-based security services framework for exchanging authentication and authorization information. Assertions are mechanism-independent, digitally signed information about authentication acts performed by subjects, attributes of subjects, and authorization decisions about whether subjects are allowed to access certain resources. Based on this assertion, GEON role-based authorization system is being developed.

To support the scientific workflow management system, GEON workflow services are being developed using Kepler [27]. The approach Kepler takes is based on actor-oriented model which allows hierarchical modeling and dataflow semantics. A form of actor proxy for each Web services and a set of Grid actors are used for Kepler system.

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