Architectural Design for GRID Clearinghouse Service

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Abstract

Grid Computing provides advanced feature for computer resource sharing, distribution over the Internet. Large-scale collaboration and engineering development for GRID Computing has been initiated around the world. The vigorous momentum of the technology capture business attention. The resources management in such large-scale distributed environment becomes a great challenge, and will be the critical concern before GRID deployed into production operation while resource allocation and use need to be properly managed in realistic and economic justification.
This study aims to elaborate a new business model regarding service trading and billing. The Grid Architecture for Computational Economy (GRACE) framework can be the fundamental framework which reveals resource trading behavior. This paper explored the resource trading models and the way to integrate them into a uniform computing environment. Thereby the concepts and Architecture is to be investigated and extended with Economic Service Architecture (ESA). Last but not least, this paper carries out necessary Service Interfaces and Service Data Entities.

Keywords: Grid Services, Economic Model, Chargeable Grid Service (CGS), Grid Payment System (GPS)

1. Introduction

With the advance of new Internet technologies and with an increasing number of potential users, software and hardware firms face new challenges in ultra-performance and scalability design of computing systems. Grid computing, as one of the emerging technologies, brought the new approach of computing technology and evolved new paradigm of computing services.

In this sense, Grid Technology enables the virtualization of distributed computing and data resources such as processing, network bandwidth and storage capacity to create a single system image, granting users and applications seamless access to

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vast IT capabilities. Just as an Internet user views a unified instance of content via the Web, a grid user essentially sees a single, large virtual computer (IBM Grid Computing, 2004).

One of the ambitious cases on Grid Computing is Oxford University's Centre for Computational Drug Discovery's project that utilizes more than one million PCs to look for a cancer cure. Participants donate a few CPU cycles from their PCs through "screensaver time." The project eventually will analyze 3.5 billion molecules for cancer-fighting potential. More than 50,000 years of CPU power (based on a 1.5 gigahertz chip) have been put to work so far.

Institutions nationally and worldwide are using the Grid to conduct large simulations, analyze data and coordinate experiments in disciplines that require high-end computing resources, databases or equipment at widely distributed locations. The scientific and business community accessing these resources also will be highly distributed, often worldwide.

The resources in the Grid are heterogeneous and geographically distributed. Availability, usage and cost policies vary depending on the particular user, time, priorities and goals. Resource sharing has inevitably become an appropriate approach to leverage computing resources largely existed in different regions and various research institutions. Nevertheless, without economic considerations and mechanisms, Grid services, with whichever good intention to facilitate collaboration and resource sharing, could not find their place in real-life applications.

This research is thus meant to work out a distributed computational economy framework as an effective metaphor for the management of resources and application scheduling. For this purpose, we elaborate the potential economic-based Grid Clearinghouse service for wide-area parallel and distributed computing.

The Service Framework as well as the economic consideration will be further investigated and extended on the basis of the Economic Services Architecture (ESA) from OGSA. Last but not least, necessary mechanisms such as CGS, GPS, Service Data Entity and interface etc. will be carried out.

2. *Grid Computing Technology and Economic-based Grid Resource Management*

Grid computing allows geographically distributed organizations to share applications, data and computing resources. Being a new model of computing, GRIDs are clusters of servers joined together over the Internet, using protocols provided by the open source community and other open technologies, including Linux. Grid protocols are designed to allow companies to work more closely and more efficiently with colleagues, partners, and suppliers through:

Resource aggregation, allowing corporate users to treat a company's entire IT infrastructure as one computer through more efficient management.

Grid and Peer-to-Peer computing platforms enable the services regarding sharing, selection and aggregation of geographically distributed heterogeneous resources for solving large-scale problems in science, engineering, and commerce.

Database sharing allows companies to access remote databases. This is particularly useful in the life sciences community, where researchers need to work with large volumes biological data from a variety of sources. Engineering and financial firms also could benefit significantly. Collaboration is in its nature to enhance widely dispersed organizations to work together on a project with the ability to share everything from engineering blueprints to software applications.

The move toward providing IT services as a utility, similar to the telephone and power, has begun to emerge. While application service providers (ASPs) were probably the first harbinger of this emerging service, computing utility offerings are beginning to populate the landscape of offerings and those competitors, application infrastructure providers (AIPs) have launched utility-based IT offerings.

This move to computing utility is expected over a long period of time to ultimately supplant the traditional outsourcing model in which the services providers manage customer-owned infrastructures and generally take control of the customer's IT and network staff. On a worldwide level, the USA is the most advanced regions for this future generation of IT computing, followed by Europe and then Asia/Pacific.

The implications of this model will be felt across not just the IT industry but also across the telecommunications, hardware, software, and other IT services sectors. Hereby SOA may be the famous product aroused within the evolution. Thus, the impact of Grid computing is moving from technological aspect to business aspect. The economic value of Grid computing is captured significant high-tech business attention. The value should be evaluated through economic measurement and justification.

However, resource management and scheduling in these environments is a complex task. The geographic distribution of resources owned by different organizations with different usage policies, cost models and varying load and availability patterns is problematic. The producers (resource owners) and consumers (resource users) have different goals, objectives, strategies, and requirements.

To address these challenges of resource management, this paper applies Grid Architecture for Computational Economy (GRACE) framework (Rajkumar Buyya, 2002), for resource allocation and to regulate supply and demand of the available resources. This economic-based framework offers an incentive to resource owners for contributing and sharing resources, and motivates resource users to think about trade-offs between the processing time (e.g., deadline) and computational cost (e.g., budget), depending on their QoS requirements. It is believed that this approach is essential for promoting the Grids as a mainstream computing paradigm, which could lead to the emergence of new service-oriented computing industry.

3. Clearinghouse Service Framework Introduction

To use GRID resources, there are several steps needed to complete these tasks. First of all, for a user to access the GRID, there must be a way where the user can identify what's available, and how various services are created. Thus information directory service, e.g. UDDI, is needed to locate resources, data banks, market registry for resource pricing. Metadata for resource capabilities is also needed. Second, user must be able to interact with & submit jobs to the Grid, which requires low-level service API's, authentication and trust mechanisms, and mechanisms for parallel processing. Finally, user must know how and where to obtain computed data, which needs secure file transfer protocols, file directory catalogs, enabling efficient retrieval and storage of data.

There are available tools and software to help Grid system designers in their tasks. For example, the Globus toolkit provides a peer-to-peer architecture for users to access remote resource using a set of APIs. The toolkit also provides a bag of service for resource discovery (Monitoring & Directory Service), secure resource access (Grid Security Infrastructure) and data transfer (GridFTP). Due to its widely deployment and way of distribution (opensource), The Globus has emerged to become a *de-facto* standard for Grid computing. Another competing standard comes from co-called Web Services that is initiated and leading by UN/CEFECT and OASIS, for e-Business uses.

As illustrated above, Grid Clearinghouse service is foreseeable to fulfill the market demand. A Clearinghouse can be identified as a middleware for integrating mandatory Grid services. A Clearinghouse provides central access for user authentication, enable dynamic resource sharing policies, and maintain accounts of participating enterprises/organizations. The clearinghouse will make the final decision of how to create resource suppliers and debit resource consumers. Finally, Clearinghouse should provide Grid market for resource trading. We can assume the clearinghouse is a regulating body of how suppliers would charge for their resources.
The basic functions of the Clearinghouse consist of:

(1) Job submission and management
(2) Resource trading between enterprises
(3) Resource usage monitoring (Grimshaw and W. Wulf, 1997).

The projected GRID Clearinghouse service framework is illustrated in Figure 1.

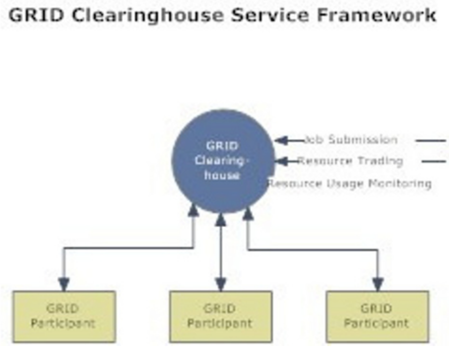

Figure 1 Grid Clearinghouse Service Framework

Clearinghouse service flow can be structured as the following steps:

Creation of the Application Service Agent (ASA)

Application service agent can be seen as a process that is dynamically created by the clearinghouse service host. The clearinghouse delegates the responsibility of user request management to the application service agent. The service agent acts on behalf of the user to find and acquire suitable resources to schedule jobs submitted by the user. The service agent also tracks the status of jobs submitted by the user, and negotiates with services providers, the price for resource consumption.

Submission of Job Application

The clearinghouse identifies the specification of the nature of the job. Locating or uploading of actual binaries to run the application. Feeding input data to server process and indicating paths or URL for output data then, exceed.

Application Service Agent accesses the Clearinghouse for the following information when submitting a job

When submitting a job, application service agent need to know the location of resource & capabilities, paths to application services on remote sites, URLs to obtain input data and output data. Resource consumption price proposed by enterprises is needed.

4. Economic Considerations

The Grid Clearinghouse service framework can be seen as a trading model from business perspective. From economic considerations, cost issue can be the major concern for resource consumers and suppliers.

The Clearinghouse organizes enterprises as consortium for sharing resources and enforces sharing by resource trading. Resource trading is about how enterprises go about exchanging their computing resources with each other. To trade resources in the Clearinghouse, users of the clearinghouse must belong to exactly one domain or enterprise. Exchange of resources occurs when a user consumes resources from another enterprise. When this happens, the clearinghouse will compute the cost of consumption so that debit and credits can be made to the accounts of the consuming enterprise and the supplying enterprise respectively. The Clearinghouse resource trading model is shown in Figure 2.

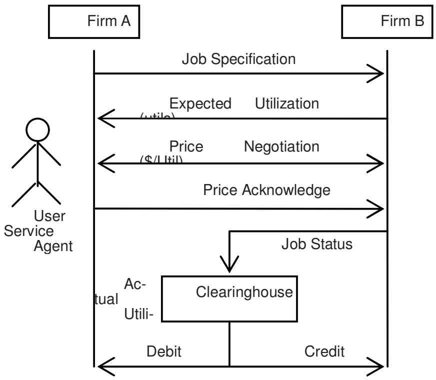

Figure 2 Resource Sharing Model (Percival Xavier, 2003)

For resource trading to occur, the following must exist; Resource contribution must first be quantified. Quantification of resource usage is termed utilization. A pricing strategy for enterprises is able to sell their resource as profitable as possible yet maximizing utilization. Accounting mechanisms must be implemented to charge users for using remote resources registered to the clearinghouse.

Resource pricing are negotiations performed between consumers and suppliers There are generally 3 modes of interactions for resource pricing, viz. one consumer - many suppliers, many consumers- one supplier, many consumers - many suppliers.

In the case of one consumer - many suppliers: suppliers compete to lower their prices until it is no longer feasible. Once price equilibrium is established the consumer will select a supplier and acknowledge the price established. For the case of many consumers, one supplier: Consumers must bid a price as high as possible to acquire a resource. Once the auction ceases, the consumer that provides the highest bid will obtain the resource. For the last scenario of many consumers, many supplier; Consumers may form alliances for resource consumption so that they can share the total cost of acquiring similar resource.

5. Grid Economic Service Architecture Introduction

The concepts and procedures we formulate as above need operational mechanism to realize in certain details, e.g. make the services chargeable. Economic Service Architecture (ESA) Architecture initiated by OGSA serves a reference model.

The architecture of the Grid Economic Services Architecture infrastructure is illustrated in figure 3, showing how the grid service that is to be sold as a Chargeable Grid Service (CGS) interacts with the Grid Payment System (GPS) and the resource usage services. (Daniel Minoli, 2005)

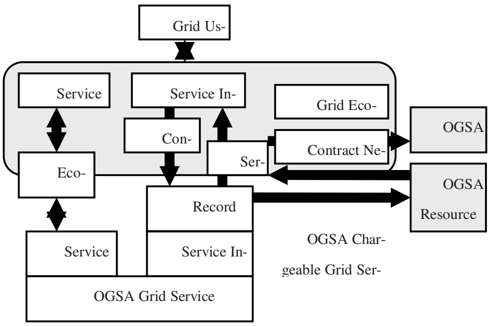

Figure3: Computational grid service being sold as a Chargeable Grid Service (Daniel Minoli, 2005)

Discussions identified one key requirement, e.e, that the underlying Grid service interface has not to be changed, but only be extended, by the wrapping of a grid service as a CGS. This would allow existing clients to interact with a CGS even if the client interface had been generated for the underlying GRID service.

This basic architecture exploits the transient nature of a grid service to encapsulate the cost of using the service within its Service Data Elements (SDE). All changes in state of the grid service (from the initial advertisement, establishing the cost of its use, to the acceptance of this cost, through to its eventual use) are encapsulated through the creation of new services.

Job Submission and Scheduling

According to the typical user workflow of computing, user interact Grid from UI to submit job, match make the best resources, check job status, and retrieve job results. Job match-making and distributing is in charged by the resource broker (RB) and the workload manager. The problem is that there is no standard way to submit job, this work is fully depend on the job scheduling system deployed. Resource brokering and job dispatching mechanism are also different by systems.

Our focus is based on the generic portal of economic/chargeable Grid applications, by employing a job wrapper for common job descriptions and virtual queuing system for the dynamic job execution management. The whole management should still base on workload management, resource broker and charging services such as contract negotiation. We have developed the mechanism (Figure 4) as a decision tool by price negotiation and integrated the Clearinghouse applications as described in section 3 into the Grid service system. Hereby, the price negotiation becomes a function of costs, workload and time, where the fuzzy functions can be employed when a rapid decision is needed.

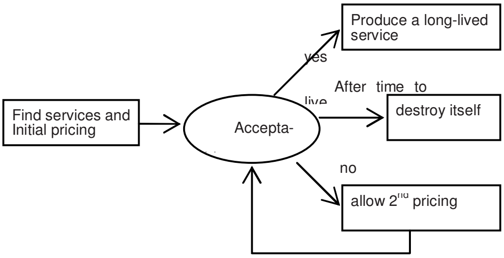

Figure 4 The price negotiation process supporting service sharing

The process shown in Figure 4 illustrates the negotiation how the user finds a service and requests a price through the Request-Pricing operation. The pricing is encapsulated in a short-lived service that is not acceptable to the user and the chosen economic model supports a second call to the Request-Pricing operation to produce a section short-lived service. The user has only two choices: to reject the price and let the service destroy itself after given time or to accept the pricing, which produces a long-lived service specifically created for the user. The pricing of this service may have two stages, a single stage or many stages. The detailed protocols need to support this form of interaction can be described as Figure 5.

The Chargeable Grid Service (CGS)

The CGS represents the abstraction of a grid service that has been enabled to support economic interaction. SDE includes pricing, usage, price liability and testimonial.

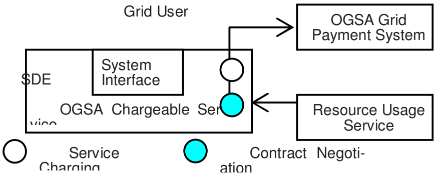

Figure 5 Price-negotiation-centric Chargeable Grid Service

The SDEs provided by the CGS are in addition to those defined within the OGSI Specification. These contain static and dynamic metadata relating to the economic use of the service. This list of SDE is not exhaustive and should be expanded and adapted as the requirements from the economic models develop. For example, instead of using real currency within the refund or compensation SDE, a service may choose to give credit. This could be represented as a currency exchangeable only with the services run by a specific service provider. The SDE constitute a service –specific advertising element and some of these SDEs may only be relevant at different stages of the CGS lifetime.

Service Interface Definition: It is proposed that the Grid Economic Service Interface (GESI) should support a number of operations to facilitate the GESA. The first of these is a *factory operation* to allow the creation of new instances of this particular CGS. It is envisaged that many of these CGSs will have a multistage process to define the final cost of the service to the user, for example, negotiation, auctioning, and so on. To enable each mode of interaction, the initial act of any CGS on being contacted by a user will be to create a new service instance to deal with the requested interaction method.

The Grid Payment System

The GPS provides a service to a payment infrastructure that is itself defined outside the GESA document. The purpose of this section is to define the interaction between the GPS and other entities within the GESA. No implementation details are specified within the GESA. However, the GPS could be implemented by any infrastructure with an account-based abstraction. This could include systems based around electronic cash, credit cards, accountancy packages with periodic reconciliation, prepaid accounts, service tokens, and so on. The “currency” sued in these transactions need not be recognized or supported by a large community. A currency could relate to service tokens allocated within a specific service centre or virtual organization. If the CGS is willing to accept more than one currency to pay for service usage, then this may be specified within its economic SDEs.

SDE hereby includes Currency, Banker Payment/Method, TrustedUser, PrivilegedUser (3P service)

Interface definition: The GPS supports the following operations. As the current authorization model for GridServices has yet to be defined, one uses the following classification for these operations:

1 Unprivileged：A normal GSI authenticated client connection is sufficient.

2 Trusted：A GSI authenticated client whose DN is registered as an account holder in the GPS or is contained in the TrustedUser SDE.
3 Privileged：A GSI authenticated client whose DN is contained in the PrivilegedUser SDE

GPSHold Service

This service instance encapsulates the duration and amount of money being held on behalf of the client. OGSI standard lifetime management tools can be used to extend the length of service. The hold on the currency ends when this service instance expires or is terminated by the client. The service can only be terminated by the declared owner—the entity requesting the hold.

SDE：The current OGSI specification does not deal with any form of access control within SDEs.

Interface Definition：This service's primary function is to encapsulate the "reservation" of money from a specified account. The amount encapsulated by the reservation is immutable. Therefore, the only operations =that may be performed on the service instance are effectively related to the lifetime management of the reservation, and this may be restricted by the GPS during service creation.

T*he Grid CurrencyExchange Service*

The Grid CurrencyExchange Service provides a service to a currency exchange infrastructure that is itself defined outside this document. The purpose within this section is to define the interaction between the GCES and other entities within the GESA. The GCES could be implemented b any infrastructure with a currency-based abstraction. This could include systems based around electronic cash, credit cards, service tokens, and so on.

The "currency" used in these transactions need not be recognized or supported by a large community. A currency could relate to service tokens allocated within a specific service centre or virtual organization.

1 Service Data Elements：exchangeRate, Exchange Commission

6. Results and Summary

A rational pricing and billing mechanism for realizing GRID in business environment has been addressed. This paper explores the potential clearinghouse-like service for Grid Computing. We have decomposed Grid system architecture, identified potential design issues in IT service environment. The result is to transform an abstract utility concept into concrete service collaboration.

The resources that are coupled in Grid computing environment are distributed and different individuals or organizations own each one of them and they have their own access policy, cost and mechanism. The resource owners manage and control resources using their favorite resource management and scheduling system and the Grid users are expected to honor that make sure they do not interfere with resource owners' policies. They may charge different prices for different Grid users for their resource usage and it may vary from time to time.

The economic-based Grid Clearinghouse service framework is proposed in this paper. When the user submits an application for execution, they expect that the application be executed within a given deadline and cost. There is no single perfect solution that meets all user requirements; hence this promotes the need for tailored Grid schedulers for each class of applications.

The concepts brought by CleaningHouse can be realized by means trading and billing services after ESA. This paper points out the mechanisms necessary for the economic services, viz. ChargeableService, GridPaymentSystem and GPSHoldService. The CurrencyExchange is important for international business services. The effects of perceived issues and potential Clearinghouse services are worthy of further investigation.

As a whole, the outcome of this paper includes:

1 A Cleaninghouse-like Framework for Economic GRID Services
2 A method for managing the resource trading behavior and economic services needed for GRID and SOA platforms
3 Useful Software packages (interfaces) to facilitate the economic services, including billing and payment.
4 Solutions for GRID/Web Service Providers to do resource trading and to integrate them into a uniform computing environment.

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