The Accounting Information Sharing Model for ShanghaiGrid [1]

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Abstract. The ShanghaiGrid, as a Grid Computing Environment, is an information Grid to serve the public in the city, and all resources are regarded as Grid Services in Open Grid Services Architecture (OGSA). The primary goal of ShanghaiGrid is to build a general shared information grid platform. Charging and accounting is an important part of grid computing system in computational economy environment. An accounting procedure based upon a computational economy model is a promising way of solving the problem of resource allocation in a grid environment. The aim of this paper is to propose an accounting information sharing model to be used within the ShanghaiGrid project. In this paper, we introduce firstly an overview of ShanghaiGrid. Then we describe architecture of charging and accounting system and its key technologies. Afterward, we discuss mechanisms of the grid charging and accounting in ShanghaiGrid.

1 Introduction

Grid computing, which are able to harness distributed resources for solving large-scale computationally intensive problems, has been widely accepted as a promising paradigm for large-scale distributed systems in recent years [1,2,3], and the main goal of it is sharing large-scale resources and accomplishing collaborative tasks [2] in science, engineering, and commerce. In the past few years, the main application of grid computing was mostly academic or exploratory in nature and did not enforce the grid economy mechanisms. However, with the emergence of Web Services technologies and the Open Grid Services Architecture (OGSA) [4,5], Grid infrastructures move increasingly towards a multi-institutional production scale and need infrastructure that supports various services: security, uniform access, resource management, scheduling, application composition, computational economy, and accounting. Therefore grid economy and accounting is becoming increasingly important.

A charging and accounting service to be functional in a grid environment will

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manage the cost of usage of grid and support the economic activity according to the computational economy. It needs to be decentralized, scalable and flexible. An accounting system is responsible for carrying out several functions: metering, data collection, pricing, charging and payment.

Charging and accounting for grid has been taken into account for some grid projects and researchers. DGAS [6] presented a accounting system for European DataGrid project; GridBank[7] was introduced as a grid accounting services architecture for computational grids; IBM 's 'Extreme Blue' grid accounting project proposed a grid accounting framework GSAX [8] with dynamic pricing strategies independent of economic model. The problem of the accounting on a computational resource can be faced in many different ways. Different grids have different accounting structure and technologies to adapt to their own Grid Computing Environment. The aim of this paper is not to describe analyze the details of all these approaches but to propose our vision of the problem, and present an accounting model for ShanghaiGrid.

The paper is organized as follows. In Section 2, we introduce background and architecture of the ShanghaiGrid. Then, we present the grid accounting model and key technologies of ShanghaiGrid in Section 3. In Section 4, we briefly describe accounting and charging mechanism in ShanghaiGrid. Finally, we give the conclusion of this paper and the future work in Section 5.

2 An Overview of ShanghaiGrid

The ShanghaiGrid is an ongoing Grid Computing Environment based on the Grid Service standards and the Open Grid Services Architecture, which funded by the Shanghai Science and Technology Development Foundation. As a City Grid, the ShanghaiGrid is to provide a general shared information Grid platform for various Grids. The primary aim of ShanghaiGrid is to develop a set of system software for the information grid and establish an infrastructure for the grid-based applications [9], and promote Shanghai become one of the most advanced information cities in the world. The subjects to be researched in the project cover a wide range, including infrastructure, standard protocol, software, and collaboration platform [10].

The first stage projects of ShanghaiGrid have drawn the investment of ￥28 million. Participants are Shanghai Jiaotong University, Tongji University, Fudang University, Shanghai University, Shanghai Supercomputer Center, Shanghai Transportation Information Center, East China Institute of Computer Technology, IBM, Intel, etc. The nearest goal of ShanghaiGrid is to going to connect all supercomputers in this metropolis together to form a sharing environment for massive storage and grid computing [9].

Fig.1. [10] shows architecture of the ShanghaiGrid. It consists of the following components [10]: Resource Management, Data Access and Transfer, Resource Discovery and Grid Monitoring, Data Sharing and Integration, Grid Service Middleware, Security Service, which are organized according to the requirements of the OGSA.

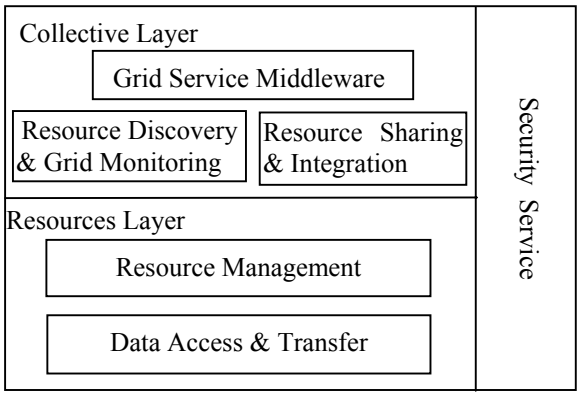


Fig. 1. Architecture of the ShanghaiGrid

3 Accounting Model

The accounting model is the basic services for any practical Grids. Accounting model that we designed for ShanghaiGrid is based on Architecture of the ShanghaiGrid, which is able to support accounting of resource and service usage, and is generic enough to be used for resource trading.

3.1 Accounting Life Cycle

Fig. 2 shows an accounting life cycle, which is divided into the following phases: submission, negotiation, implementation, charge, payment and deinstallation.

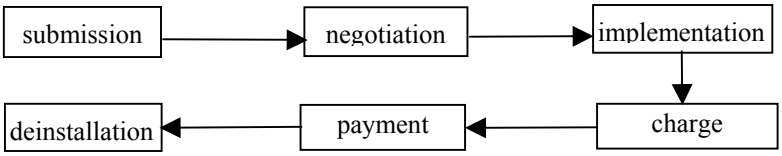


Fig.2. accounting life cycle

The accounting life cycle starts with the ***submission*** of application. User submits a job with specification of the needed functionality and possible QoS parameters, and then selects suitable resources and estimates the application cost.

Afterwards, the provider and user start the ***negotiation*** phase. This phase deals with the process of service negotiation between provider and user, which contains detail about functionality, QoS, and pricing mechanism. The negotiation phase ends with signing an agreement.

During the ***implementation*** phase, the provider provides resources to user, and then the user job is executed, as well as meters the resources consumed.

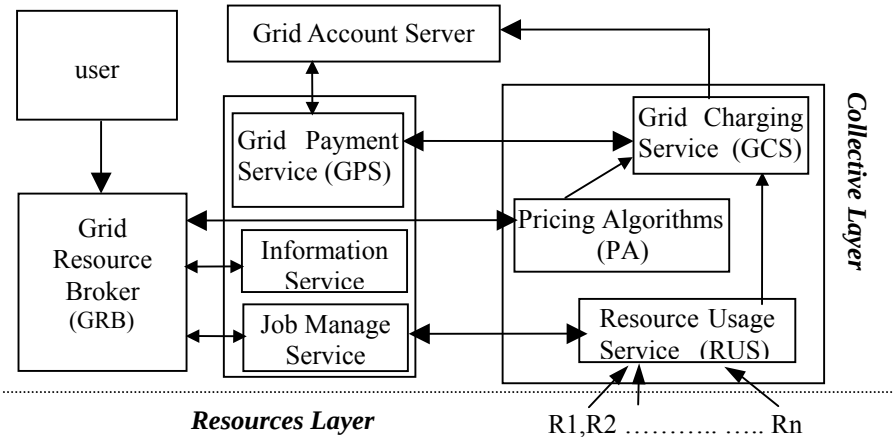
The ***change*** phase combines changing service functionality, which calculates total

cost based on the resource usage and the resource price. Whereafter, in the ***payment*** phase, user pays charge the user resource usage.

Finally, the accounting life cycle ends with the ***deinstallation***. In this phase, the implementation's resources are released.

3.2 Accounting Processes

The accounting processes can be separated into several phases that already mentioned above. In the following, we will give a brief description of the accounting processes that are shown Fig. 3.



GRB is a mediator between the user and grid resources by using middleware services. It is responsible for discovers resources, negotiates for service costs, performs resource selection, and so on.
GPS provides a service to a payment infrastructure.
GCS provides a basic infrastructure that has been enabled to support economic interaction.
RUS [11,12] provides a basic infrastructure to support the auditing and monitoring capability for the resources consumed by OGSA services.
PA define the prices that resource provider would like to charge users.
Information Service provides a complete list of resources
Job Manage Service deals with job submission to grid resource provider.
Grid Account Server provides a service to manage and maintains accounts and resource usage records

Fig. 3. The Accounting Processes

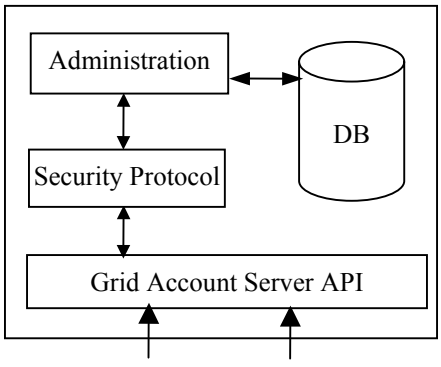
- **The submission phase:** the user submits their applications with some parameters including budget and deadline to GRB so that GRB may correctly choose resources, and estimation the application cost. The Information Service provides a complete list of resources to GRB, and then GRB selects suitable resources according to different scheduling criteria.
- **The negotiation phase:** GRB interacts with PA to consult acceptable price of

services for both grid resource provider and user. If they come to an acceptable price, PA informs GCS about accepted price. The GRB, having received the job description and select suitable resources for the given job, estimate the overall cost of the job.

- **The implementation phase:** GRB submits user job to grid resource provider via Job Manage Service. Grid resource provider provides the service by executing the user job and RUS meters the resources consumed while processing the user job. After the job finished, RUS will obtain the usage statistics of the grid resources, and then generates a standard Resource Usage Record (RUR) [12].
- **The charge phase:** GCS receives the price from PA, which negotiates with resource users, and the data from RUR. Then It calculates total cost based on the resource usage and pricing algorithms that the mutually agreed. Afterward, GCS sent the total service cost and the resources usage statistics to Grid Account Server.
- **The payment phase:** GCS contacts GPS with a request to charge the user account. User will pay resource usage charge by using payment strategies of GPS.
- **The deinstallation phase:** GRB returns the results to the user, and resources are released.

3.3 Grid Account Server

Grid Account Server was designed to store and manage accounting information about provided resources. When a job is done, accounting information of resources usage is sent to Grid Account Server who then transfers an amounting of "money" from the user's account to the resource provider's account. Fig. 4 shows Grid Account Server architecture.



API provides a Grid Account Server interface to other services.
Security Protocol performs authentication and authorization of users. Authentication process uses Generic Security Services (GSS) API, which is implemented by Globus Toolkit I/O [13].
Administration provides basic account operation and management such as open account, update account, close account, deposit, transfer, etc.
DB is a database that stores account and resources usage information.

Fig.4. Grid Account Server Architecture

An authorized manager creates user accounts, called initial account, at the Grid Account Server. An amount of "money" and a credit value are stored to Grid Account Server according to the credit rating of the user. When a user starts a request for an application, the server checks and charges the user's account for its application in

order to determine whether the user can afford the job to be computed or not. In order to execute a submitted job, the user needs to have an account at Grid Account Server with a positive amount of money.

Communication between user and Grid Account Server must relate to security and access protection. User isn't able to change his identification, and isn't trusted to manipulate server's central storage. An authentication server should be implemented, which handles login and logout procedures. Once clients are authenticated, the client is authorized to establish a connection between client and server. Clients cannot send any requests if a connection is refused. Clients will be checked for their identification every time when they request an accounting service and communicate with server. Clients will be able to access only their own data, unless they have special administration privileges.

3.4 Dynamic Account Manager

To access grid resources, each user will request a local account. However, it is neither desirable nor feasible to allocate an account for each user and accurately maintain a great deal accounts of user. Therefore, we use dynamic or template accounts to manager account, which can meet the requirements of accounting and system management. System administrator will check the user's membership during authentication, and authorize the user as a dynamic account if she does not have a static account. The dynamic account is chosen from the pool of template accounts [14]. Each dynamic account is a local system account created on the pool of template accounts, but without a permanent user associated with it.

A dynamic account bound to a user is temporary. When a user submits some application to resource provider, one of the template accounts from the pool of template accounts will be dynamically assigned to user. To bind of current user to a template account, user's Certificate Name is temporarily mapped to the account. At the termination time, the processes running and all files with this account as owner will be killed and deleted. Finally, the template account is relaxed, and returned to the pool.

3.5 Accounting Protocols

Accounting protocols can be distinctive the following two types: Security Protocol and data Transfer Protocol.

***Security Protocol*:** It is developed an architecture for authentication and authorization of clients. The architecture is client-server architecture. Authentication is based on Public Key Infrastructure (PKI) using X509v3 certificate [15], and certificates can be issued by certificate authority (CAs). The clients send authentication request to server, and server decides whether the user is authorized to use grid resources.

***Data Transfer Protocol*:** TCP-based transfer protocols such as SMTP, FTP, or HTTP can be used to transfer information of payment and charge between user account and provider account. These protocols is reliable, efficient, and security.

4 Accounting Mechanisms

The accounting mechanism describes the accounting policies, and determines the resources exchange rates during the performance of accounting, which maximize benefits of grid resource provider and consumer. The accounting mechanism should be simple enough to be understood by all resource providers and users.

***Accounting Items*:** It is necessary to decide for which resource elements one should pay. Any services invocation will consume a wide range of resources. However, a services provider may only be interested in a relatively small subset of these resources for the purposes of deciding a price to use a service. The consumption of the following resources may be accounted and charged [11]: CPU, Memory, Disc, Wall Clock Time, Node Count, Network, Processors, Software and Libraries accessed.

***Book and Estimate*:** After the job description was received and select suitable resources for the given job, user need book a portion of resources to execute job. Then, resource consumption should be estimated, which has two constituents: rate of consumption, and estimated maximum durations. The overall estimated resource consumption would then be (rate of consumption) $\times$ (expected duration).

***Resource Pricing*:** Pricing schemes should base on the supply and demand for resources and the QoS requirements. GBR was requested to mediate resources price by grid resource producers and users. GBR sets firstly a price for a resource and then queries both producers and consumers whether or not accept that price. With time elapsing, GRB increases or decreases the price by a small amount ε after each negotiation, namely $P(t) = P \pm \varepsilon \Delta t$, until producers and users come to an acceptable price.

***Accounting Checking*:** The overall cost of the job is estimated by multiplying resource price with estimated resource consumption. The user's account is checked whether there is a positive amount of "money" to pay. If the estimated overall cost of the job exceeds the user's funds, the resource provider may provide a loan for user according to the credit rating of the user.

***Accounting Policies*:** Account policies concern is how to charge for resource usage in some particular situations. We propose the following system policies: 1. If user job is cancelled during execution because of user action, resource provider will charge for resources already used; 2. If user job is suspended because of resource provider action, resource provider don't charge to the user; 3. If the resource usage expectations is underrated, resource provider provide a loan to user so as to complete whole job; 4. If the expected resource usage is overrated, the job is executed.

5 Conclusions and Further Work

Charging and accounting is an important part of ShanghaiGrid. In this paper, we describe briefly the background and framework of the ShanghaiGrid. Then, we have shown that an account sharing model for ShanghaiGrid, which is a complex system that involves many services interaction, and is a standard architecture for supporting

generation and distribution of accounting information. Afterward, we give an introduction to accounting mechanisms of ShanghaiGrid.

Other work needs to be considered and need further investigation. The next steps will study reliability and fault tolerance of accounting model, increase security mechanisms, selects suitable payment policies, analyze the related economic model that suitable for ShanghaiGrid.

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