THE GRID PROBLEM

Grid Computing has evolved as an important field in the computer industry by differentiating itself from the distributed computing with an increased focus on the resource sharing, coordination, and high-performance orientation. Grid Computing is trying to solve the problems associated with resource sharing among a set of individuals or groups.

These Grid Computing resources include computing power, data storage, hardware instruments, on-demand software, and applications. In this context, the real problems involved with resource sharing are resource discovery, event correlation, authentication, authorization, and access mechanisms. These problems become proportionately more complicated when the Grid Computing solution is introduced as a solution for utility computing, where industrial applications and resources become available as sharable. The best example of this is in the IBM Corporation's Business On Demand resource implementations in Grid Computing.

This commercial on-demand utility concept spanning across Grid Computing services has introduced a number of challenging problems to the already complicated grid problem domains. These challenging problems include service-level management features, complex accounting, utilization metering, flexible pricing, federated security, scalability, open-ended integration, and a multitude of very difficult arrays of networking services to sustain. It is key to understand that the networking services can no longer be taken for granted, as these very important services now become the central nervous system for the enablement of all worldwide Grid Computing environments.

The Concept of Virtual Organizations

The concept of a virtual organization is the key to Grid Computing. It is defined as a dynamic set of individuals and/or institutions defined around a set of resource-sharing rules and conditions (Foster, Kesselman, & Tuecke). All these virtual organizations share some commonality among them, including common concerns and requirements, but may vary in size, scope, duration, sociology, and structure.

The members of any virtual organization negotiate on resource sharing based on the rules and conditions defined in order to share the resources from the thereby automatically constructed

resource pool. Assigning users, resources, and organizations from different domains across multiple, worldwide geographic territories to a virtual organization is one of the fundamental technical challenges in Grid Computing. This complexity includes the definitions of the resource discovery mechanism, resource sharing methods, rules and conditions by which this can be achieved, security federation and/or delegation, and access controls among the participants of the virtual organization. This challenge is both complex and complicated across several dimensions.

Let us explore two examples of virtual organizations in order to better understand their common characteristics. The following describes these two examples in simple-to-understand terms.

1. Thousands of physicists from different laboratories join together to create, design, and analyze the products of a major detector at CERN, the European high energy physics laboratory. This group forms a "data grid," with intensive computing, storage, and network services resource sharing, in order to analyze petabytes of data created by the detector at CERN. This is one example of a virtual organization.
2. A company doing financial modeling for a customer based on the data collected from various data sources, both internal and external to the company. This specific virtual organization customer may need a financial forecasting capability and advisory capability on their investment portfolio, which is based on actual historic and current real-time financial market data. This financial institution customer can then be responsive by forming a dynamic virtual organization within the enterprise for achieving more benefit from advanced and massive forms of computational power (i.e., application service provider) and for data (i.e., data access and integration provider). This dynamic, financially oriented, virtual organization can now reduce undesirable customer wait time, while increasing reliability on forecasting by using real-time data and financial modeling techniques. This is another example of a virtual organization.

With a close observation of the above-mentioned virtual organizations, we can infer that the number and type of participants, the resources being shared, duration, scale, and the interaction pattern between the participants all vary between any one single virtual organization to another. At the same time, we can also infer that there exist common characteristics among competing

and sometimes distrustful participants that contributed to their virtual organization formation. They may include (Foster, Kesselman, & Tuecke) some of the following items for consideration:

1. Common concerns and requirements on resource sharing. A virtual organization is a well-defined collection of individuals and/or institutions that share a common set of concerns and requirements among them. For example, a virtual organization created to provide financial forecast modeling share the same concerns on security, data usage, computing requirements, resource usage, and interaction pattern.
2. Conditional, time-bound, and rules-driven resource sharing. Resource sharing is conditional and each resource owner has full control on making the availability of the resource to the sharable resource pool. These conditions are defined based on mutually understandable policies and access control requirements (authentication and authorization). The number of resources involved in the sharing may dynamically vary over time based on the policies defined.
3. Dynamic collection of individuals and/or institutions. Over a period of time a virtual organization should allow individuals and/or groups into and out of the collection; provided they all share the same concerns and requirements on resource sharing.
4. Sharing relationship among participants is peer-to-peer in nature. The sharing relation among the participants in a virtual organization is peer-to-peer, which emphasizes that the resource provider can become a consumer to another resource. This introduces a number of security challenges including mutual authentication, federation, and delegation of credentials among participants.
5. Resource sharing based on an open and well-defined set of interaction and access rules. Open definition and access information must exist for each sharable resource for better interoperability among the participants.

The above characteristics and nonfunctional requirements of a virtual organization lead to the definition of an architecture for establishment, management, and resource sharing among participants. As we will see in the next section, the focus of the grid architecture is to define an interoperable and extensible solution for resource sharing within the virtual organization.