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Denver, CO, USA, November 2001
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Preface

The term "grid computing" is based on an analogy with the electrical power grid: computing capabilities should be ubiquitous and easy to use. While the development of what we now call grid computing is, in many ways, part of a natural progression of work done in the last decade, what's special about it is that all of its enabling technologies are converging at once: (1) a widely deployed, network infrastructure will connect virtually every device in the world, (2) an interface technology is widely understood and embraced by virtually every segment of science, technology, commerce, and society, and (3) there is a widespread, and growing, understanding of the properties, capabilities, and services that are necessary and *possible* to utilize this infrastructure. Information services and resource brokers will allow the dynamic sharing of resources for applications large and small and enable virtual organizations. These properties, capabilities, and services will be used in different contexts to enable different styles of computing such as Internet computing and Peer-to-Peer computing. To facilitate the adoption of standard practices, the Global Grid Forum (www.gridforum.org) was formed to identify common requirements and push for eventual standardization.

The phenomenal growth of grid computing and related topics has created the need for this workshop as a venue to present the latest research. This year's workshop builds on the success of last year's. Grid 2000, chaired by Rajkumar Buyya and Mark Baker, was held in conjunction with HiPC 2000, in Bangalore, India, and attracted participants from 15 countries. This year's workshop was held in conjunction with Supercomputing 2001, the world's premier meeting for high-performance computing. We sincerely thank Sally Haerer, David Culler, and Ian Foster for making this happen.

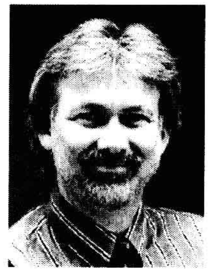
This year's Program Committee represented 12 countries on 4 continents and authors submitted papers from 7 countries on 3 continents. This certainly attests to the wide-spread, international importance of grid computing. We heartily thank all of the authors and the members of the Program Committee. It is the contribution of their valuable time and effort that has made this workshop a success. A very special thanks is extended to Dennis Gannon for his stimulating keynote address. Dennis has a long history of identifying the important issues and clearly elucidating them.

We thank our sponsors, the ACM, the IEEE, the IEEE Computer Society, the IEEE Task Force on Cluster Computing, and also Supercomputing 2001 for making the workshop and these proceedings possible. We are very grateful to Prof. Cauligi Raghavendra and Prof. Viktor Prasanna for allowing Grid 2001 to host its web site at the University of Southern California. Using WIMPE from Dartmouth College for managing the workshop through the web site from wherever I was proved to be invaluable. (Just make sure no other project fills up the disk partition with `/tmp`. ;-) We also wish to thank Jan van Leeuwen of Utrecht University (LNCS Series Editor) and Alfred Hofmann of Springer-Verlag

(Executive Editor) for publishing the proceedings. A special thanks goes to Anna Kramer of Springer-Verlag (Computer Science Editorial Assistant). Her prompt help made prefecting these proceedings as easy as `\addtocounter{one}{2+3}`.

Finally we wish to thank all who attended Grid 2001 in Denver. We now invite you to study these proceedings and their contribution to the further development of grid computing.

August 2001



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Grid Application Design Using Software Components and Web Services

Dennis Gannon

Indiana University
Bloomington, Indiana

Abstract. Software Component systems are widely used in the commercial world for designing desktop applications and multi-tier business systems. They have not been widely used in large scale scientific computation. However, as our computing platform has evolved into Grid systems, a distributed component architecture is gaining support as a programming model for building heterogeneous, wide-area application. There are several interesting Grid component architectures that are currently being used. Some are derived from the Corba component model and others are based on EJB or other object systems. The DOE CCTTSS organization has developed a model that supports parallel applications as well as distributed computation called CCA. Components in CCA are defined by public interfaces called "ports" which define the endpoints in the communication channels that link an application's components together.

Over the past year a number of companies have defined another approach to designing distributed application based on a concept called "Web Services." A Web Service is a process that provides a network-accessible interface of "services" that is described by an XML specification called WSDL (Web Services Description Language). The Grid Forum is currently working on several projects which allow Grid services to be defined and accessed as webservices.

In this talk we will describe the simple duality that exists between component-based programming and web services. We will also discuss the difficult problems of integrating web services protocols like SOAP into high performance distributed systems.

Design and Implementation of a CORBA Commodity Grid Kit

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Abstract. This paper reports on an ongoing research project aimed at designing and deploying a CORBA Commodity Grid (CoG) Kit. The overall goal of this project is to explore how commodity distributed computing technologies and state-of-the-art software engineering practices can be used for the development of advanced Grid applications. As part of this activity, we are investigating how CORBA can be integrated with the existing Grid infrastructure. In this paper, we present the design of a CORBA Commodity Grid Kit that provides a software development framework for building a CORBA "Grid domain." We then present our experiences in developing a prototype CORBA CoG Kit that supports the development and deployment of CORBA applications on the Grid by providing them access to the Grid services provided by the Globus toolkit.

1. Introduction

The past decade has seen the emergence of computational Grids aimed at enabling programmers and application developers to aggregate resources[1] scattered around the globe. However, developing applications that can effectively utilize the Grid still remains a difficult task. Although, there exist Grid services that enable application developers to authenticate, access, discover, manage, and schedule remote Grid resources, these services are often incompatible with commodity technologies. As a result, it is difficult to integrate these services into the software engineering processes and technologies that are currently used by application developers. Recently, a number of research groups have started to investigate Commodity Grid Kits (CoG Kits) to address this problem. Developers of CoG Kits have the common goal of developing mappings and interfaces between Grid services and a particular

[1] In this paper we use resources to collectively refer to computers, data stores, services and applications.

commodity technology (such as Java platform [1] [2], Java Server Pages [3], Python [4], and Perl [5]). We believe that CoG Kits will encourage and facilitate the use of the Grid, while at the same time leveraging the benefits of the commodity technology.
Recent years have also seen significant advances in commodity distributed technologies aimed at easing application development in distributed environments. One such technology is the **C**ommon **O**bject **R**equest **B**roker **A**rchitecture (CORBA) [6] defined by the Object Management Group (OMG). CORBA specifies an open, vendor independent and language independent architecture for distributed application development and integration. Furthermore, CORBA defines a standard interoperability protocol (i.e. GIOP and IIOP) that enables different CORBA implementations and applications to interoperate and be portable across vendors. CORBA has emerged as a popular distributed computing standard and meets the necessary requirements to be considered by application developers as part of the Grid infrastructure. It is therefore natural to investigate the development of a CoG Kit that integrates CORBA with the Grid such that CORBA applications can access (and provide) services on the Grid. Such an integration would provide a powerful application development environment for high-end users and create a CORBA "Grid domain".
This paper presents the design and implementation of a CORBA CoG Kit that provides CORBA application with access to Grid services provided by the Globus toolkit [7]. In this paper we first give a brief overview of the Grid and its architecture and introduce the services and protocols that we intend to integrate within the CORBA CoG Kit. We then briefly outline requirements, advantages and disadvantages of CORBA technologies from the point of view of Grid application developers. Next, we present the architecture of the CORBA CoG Kit, and describe the design, implementation, and application of a prototype. Finally, we conclude our paper and identify the directions of ongoing and future activities.

2. The Grid

The term "Grid" has emerged in the last decade to denote an integrated distributed computing infrastructure for advanced science and engineering applications. The Grid concept is based on coordinated resource sharing and problem solving in dynamic multi-institutional virtual organizations [8]. Grid computing not only provides access to a diverse set of remote resources distributed across different organizations, but also facilitates highly flexible sharing relationships among these resources, ranging from client-server to peer-to-peer. An example of a typical client-server relationship is the classical model where a remote client submits jobs to batch queues for resources at a supercomputer center. An example of peer-to-peer relationship is the collaborative online interaction and steering of remote (distributed) high-end applications and advanced instruments [9].

Grids must support different levels of control ranging from fine-grained access control to delegation and from single user to multi user, and different services such as scheduling, co-allocation and accounting. These requirements are not sufficiently addressed by the current commodity technologies, including CORBA. Although sharing of information and communication between resources is allowed, it is not easy to coordinate the use of distributed resources spanning multiple institutions and organizations. The Grid community has developed protocols, services and tools, which address the issues arising from sharing resources in peer communities. This community is also addressing security solutions that support management of credentials and policies when computations span multiple institutions, secure remote access to resources, information query protocols that provide services for obtaining the configuration and status information about the resources. Because of the diversity of the Grid it is difficult to develop an all-encompassing Grid architecture. Recently, a layered Grid architecture representation has been proposed [8] that distinguishes a

- ***fabric layer***, that interfaces to local control including physical and logical resources such as files, or even a distributed file system,
- ***connectivity layer***, that defines core communication and authentication protocols supporting Grid-specific network transactions,
- ***resource layer***, that allows the sharing of a single resource while using a
- ***collective layer*** that allows to view resources as collection,
- and an ***application layer*** that uses the appropriate components of each layer to support applications.

Each of these layers may contain protocols, APIs, and SDKs to support the development of Grid applications. This general layered architecture of the Grid is shown in the left part of Fig. 1.

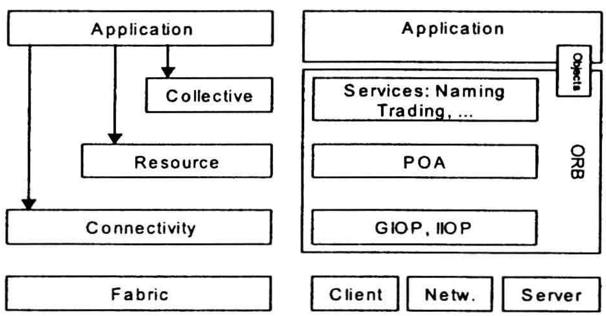

Fig. 1. The Grid Architecture and CORBA (The figure on the left shows the Grid architecture. The figure on the right shows how CORBA fits into the Grid Architecture).

3. CORBA and Grid Computing

CORBA provides advanced capabilities and services for distributed computing and can support the Grid architecture as shown in Fig. 1. Features of CORBA that makes it a suitable candidate for a CoG Kit include its high-level modular programming model, availability of advanced services (e.g. security, naming, trading, event, transaction, etc.) and readymade solutions, interoperability, language independence, location