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**Joshy Joseph • Craig Fellenstein**



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# Grid Computing



**On Demand Series**

**Joshy Joseph  
Craig Fellenstein**



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# Preface

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**T**he Grid Computing discipline involves the actual networking services and connections of a potentially unlimited number of ubiquitous computing devices within a “grid.” This new innovative approach to computing can be most simply thought of as a massively large power “utility” grid, such as the one that provides power to our homes and businesses every day. This delivery of utility-based power has become second nature to many of us, worldwide. We know that by simply walking into a room and turning on the lights, the power will be directed to the proper devices of our choice at that moment in time (on demand). In this same utility fashion, Grid Computing openly seeks, and is capable of, adding an infinite number of computing devices into any grid environment, adding to the computing capability and problem resolution tasks within the operational grid environment, and at the exact time it is needed (on demand).

## WHAT IS THE IMPORTANCE OF THIS BOOK?

The last few years we have witnessed the emergence of Grid Computing as an innovative extension to distributed computing technology, for computing resource sharing among participants in a *virtualized* collection of organizations. This technology leverages a combination of hardware/software virtualization, and the distributed sharing of those virtualized resources. These resources can include all elements of computing, including: Hardware, software, applications, networking services, pervasive devices, and complex footprints of computing power. Grid Computing is one technology enabler for some of the most innovative and powerful emerging industrial solution approaches, including the IBM On Demand strategies,<sup>1</sup> HP utility computing,<sup>2</sup> and Sun N1 technologies.<sup>3</sup>

The emergence of open standards has a great influence on this computing technology, especially in providing seamless Grid interoperability and Grid integration facilities. We could find that technologies of Grid Computing are still evolving; however, the alignment with industry-wide open standards, and the commercial interests, quickly placed this technology into a forerunning



state for infrastructure and technology development. The most notable standard we have seen in this area of Grid is the Global Grid Forum's<sup>4</sup> Open Grid Services Architecture (OGSA) initiative.

Until today, most of the work in Grid Computing has been concentrated at the academic, and standards level discussion and building custom solutions. However, the emergence of commercial utility services and the requirement for alignment with the rest of the organizational computing infrastructures hasten the development of open standards and interoperable commercial Grid solutions. This book is a detailed discussion on all aspects of Grid Computing, technology, applications, disciplines, and infrastructures. In this book we provide full treatment to covering the evolution of Grid Computing, existing Grid infrastructure components, emerging Grid service standards, and Grid architectures. In addition, we will explore detailed discussions on many prominent Grid middleware solutions.

## WHAT YOU CAN EXPECT FROM THIS BOOK

We, the authors of this book, hope that you will find reading this book, an interesting and thought-provoking experience. In this book, we are introducing you to the basic Grid Computing principles, and to the emerging technology standards for Grid Computing. Readers will find this discussion interesting with a progressive evolution of technologies, discussed in this book in a concise, hard-hitting, and to-the-point fashion. We believe this will help the readers clearly understand the basic Grid Computing principles, the existing/emerging Grid standards, and their various usages models. We must be aware that the Grid standards are complex with a number of interrelations among themselves and other emerging standards such as XML and Web services. As we will see, this is a fast moving target and we should try to focus on this fact, early, so that we won't miss the opportunity to create Grid services and infrastructures suitable for each of our respective organizations or Grid initiatives.

In general, this book will explore:

- *The basic concepts of Grid Computing:* Grid Computing discipline has been evolving over the past few years as a means of immense computing power and distributed data sharing facilities. We will discuss the many core aspects of these infrastructure components, and the high-level services built upon the Grid infrastructure as networking services.
- *How the Grid Computing is evolving as an open standard for resource sharing:* The Grid Computing discipline is evolving. The focus is now on seamless interoperability and integration among participants of the Grid for better resources sharing. This is exceptionally challenging and a number of organizations are working collectively to provide an open and extensible standard and test beds for the Grid.
- *The influence of emerging technology standards on Grid infrastructure:* Computing is always involving some process and form of evolution. New software standards and architectures are continually evolving to meet the requirements of global industries. The most notable and latest in this row are the Service Oriented Architecture (SOA) and the

XML/Web services standards. These architectures and standards, as the reader will soon see, have tremendous influence in the emerging open Grid Computing standards.

- *The new Grid architecture and infrastructure:* Based on the experience drawn from earlier Grid infrastructures, implementations, and the influence of the emerging open standards and technologies, the Grid computing standards organizations are designing an Open Grid Service Architecture (OGSA), and Open Grid Service Infrastructure (OGSI) for Grid computing. These important contributions will soon become the core platform for all the next generation Grid Computing technologies.
- *The most prominent toolkits and middleware solutions that will impact the Grid adoption:* These open standards and technologies are not enough; we need real middleware solutions and high-level services using these standards and technologies. The most prominent middleware technology that exists today is Globus Toolkit.<sup>5</sup> We will explore the details on this toolkit's robust architecture, and programming model capabilities to enable the latest Grid standards on the OGSI. In addition, we will explore some architectural concepts of the OGSI.NET<sup>6</sup> toolkit, another notable implementation of the OGSI standard.

## HOW THIS BOOK IS ORGANIZED

This book contains 15 chapters, which are organized into five parts.

### Part I—Grid Computing

Part 1 consists of Chapter 1. Chapter 1 provides a detailed but high-level introduction to the Grid Computing evolution, the applications, and the infrastructure requirements for any Grid environment. In addition, this chapter discusses Grid Computing disciplines, and the factors developers and service providers must consider during the implementation phases.

### Part 2—Grid Computing Worldwide Initiatives

Part 2 consists of Chapter 2, Chapter 3, and Chapter 4. This part is more on defining Grid Computing, its evolution, the factors that are affecting these evolutions and the organizations that are influencing/deciding the adoption of this new technology. In addition, we will see a general-purpose architecture solution for the emerging Grid Computing infrastructure and a road map for Grid Computing technology initiatives.

Chapter 2: “Grid Computing Organizations and Their Roles.” There are a number of organizations from various industry sectors including scientific research, commercial, and standards organizations that are affecting the Grid Computing adoptions, infrastructure development, testing, standardization, and guideline developments. This chapter introduces us to the major plays in the Grid world.

Chapter 3: “The Grid Computing Anatomy.” This chapter defines the problems of coordinated resource sharing, the concepts of virtual organization formation, and a protocol architecture



solution for the Grid problems. In addition, this chapter examines the Grid in relation with other distributed technologies such as Web, object-oriented, distributed technologies, service provider's frameworks, clusters, and peer-to-peer computing.

Chapter 4: "The Grid Computing Road Map" is a brief. Here we will be discussing the current and prominent technology initiatives that are affecting the recent Grid Computing revolution. Some of the prominent technology initiatives that are acting as catalysts to the evolution are Business On Demand environments, autonomic computing, service oriented architectures and semantic Grid.

### Part 3—The New Generation of Grid Computing Applications

Part 3 consists of Chapter 5. In this part we will explore the technology constructs of the Service Oriented Architecture (SOA) that will set the stage for the new generation of Grid Computing applications.

Chapter 5: "Merging the Grid Service Architecture with the Web Service Architecture." This is an extensive chapter, which defines the Service Oriented Architecture (SOA) and its respective implementations, Web and Web services. Our discussion on Web services covers the details on extensible Markup Language (XML), Simple Object Access Protocol (SOAP), and Web Service Description Language (WSDL 1.1/1.2). In addition, we will explore the details of Global XML Architecture (GXA) and some emerging standards (WS-Security, WS-Policy, WS-Addressing). Another notable area covered in the chapter is the Web service interoperability (WS-I) basic profile and the tools to assert the interoperability validations. We will end the chapter with a detailed discussion on Web service state management, the concepts around stateful interactions/applications, and how Grid networking services relate to stateful Web services.

### Part 4—The Grid Computing Technological Viewpoints

Part 4 consists of Chapter 6, Chapter 7, Chapter 8, Chapter 9, and Chapter 10. This part introduces the concept of Open Grid Service Architecture and the motivations that drive OGSA standardization. In addition to this, we will describe the OGSA architecture and the core infrastructure components for this architecture. This discussion will align Grid Computing with the other emerging technologies. In addition, we will define some of the core base services defined by the OGSA platform.

Chapter 6: "Open Grid Services Architecture (OGSA)." This chapter will introduce the new OGSA architecture defined for Grid Computing. This is based on open standards and a Global Grid Forum initiative. This discussion introduces us to the architectural layers as defined by OGSA. This chapter will then set the stage for the forthcoming discussions on OGSA.

Chapter 7: "Some Sample Use Cases that Drive the OGSA." Any well thought-out architecture is driven from a set of use cases, which captures the scenarios, involved parties, and the solution

requirements for the architecture. This chapter will introduce some representative sample use cases from various industry sectors to illustrate this process of requirements gathering.

Chapter 8: “The OGSA Platform Components.” This is a simple chapter with an illustration on IBM vision for OGSA. This chapter enhances the OGSA architecture with more detailed layering and relationship with the other existing application and system components.

Chapter 9: “Open Grid Services Infrastructure (OGSI).” This chapter discusses one of the most important aspects of the OGSA, the core infrastructure foundation for all Grid services. In this chapter we will cover the details on this infrastructure that will define the behaviors for all Grid services created for OGSA, including state management, instance naming, life cycle management, and fault handling. This chapter covers the core interfaces defined by the specification and their significance and usage patterns. In addition to this, we will define the relationship between Web services and Grid services, the similarities and differences of their description mechanisms, and the significance of the Grid Web Service Description Language (GWSDL). In this chapter, one will realize a tremendous amount of valuable information on the core infrastructure software.

Chapter 10: “OGSA Basic Services.” Based on the OGSI specification and the architecture requirements, a number of core services were developed in the Grid area. These services emerged from the requirements gathered from the use cases collected from various industry sectors. This chapter will introduce the readers to some of these prominent base services. This discussion covers the details on Grid services for resource management modeling, policy enforcement, service grouping, security, metering/accounting, logging, and distributed data management.

## Part 5—The Grid Computing Toolkits

Part 5 consists of Chapter 11, Chapter 12, Chapter 13, Chapter 14, and Chapter 15. In this part, we will learn about some of the prominent and emerging middleware solutions implemented using the Open Grid Service Infrastructure (OGSI) standard. The most prominent in this group is the Globus Toolkit. This part will cover the final release’s software framework, entitled “Globus Toolkit 3” or GT3. Our discussion includes the GT3 architecture, programming model, sample Grid service development, and high-level services. In addition to Globus GT3, we will see another most notable software framework called OGSI.NET, which is also a realization of the OGSI specification.

Chapter 11: “GLOBUS GT3 Toolkit: Architecture.” This chapter is dedicated to the Globus GT3 architecture model. We will discuss this layered architecture model provided by GT3. This software is built on Java, and enables a container model for the Grid service life cycle and instance management. This chapter introduces the reader to the architecture plug-ability of GT3 with Web service engines, and hosting capabilities in J2EE/J2SE containers. In addition, this chapter explains the GT3 security mechanisms and client side architecture details.

Chapter 12: “GLOBUS GT3 Toolkit: Programming Model.” This chapter provides a detailed and in-depth analysis of the programming model supported by the GT3 software. This discussion

will introduce the reader to the core service programming concepts, service data management, notification, and query processing. In addition we will discuss the service configurations, tools, and tracing options. The discussion on the client side-programming model in this chapter is also worth mentioning. Other aspects that will be discussed include security, and various message exchange models.

Chapter 13: “GLOBUS GT3 Toolkit: A Sample Implementation.” In this chapter we will explore a sample Grid service implementation using a top-down approach, starting with GWSDDL for a sample search service. Our discussion will provide a detailed look into each step of this service implementation, with the tools involved and the respective codes generated. In addition, the development is done in a phased manner with added complexities in each layer. Another most valuable discussion provided includes the traces of the SOAP messages exchanged during this service invocation. This helps the reader to understand the OGSi standards, and the GT3 in particular, and will provide better interoperability. In short, our sample will provide service data management, and notification. Finally we end with an EJB delegation model support provided in GT3.

Chapter 14: “GLOBUS GT3 Toolkit: High-Level Services.” These high-level services are for resource discovery and monitoring, including resource allocation and data management. The prominent services introduced in this chapter are Index services, Resource Information provider (RIP) services, Grid Resource Allocation and Management (GRAM) services, and data management services. In addition, this chapter introduces the component model for information services. This discussion includes provider components, service data aggregation components, and registry components.

Chapter 15: “OGSI.NET Middleware Solutions.” This chapter provides information on another OGSi specification implementation in the Microsoft .NET environment. The reader will find a detailed discussion on the architecture and programming model for developing Grid services for .NET.

## NOTES

1. For information on the IBM On Demand operating environment, go to <http://www-3.ibm.com/software/info/openenvironment/>.
2. For information on HP Utility services, go to [www.hp.com/products1/promos/adaptive\\_enterprise/us/utility.html](http://www.hp.com/products1/promos/adaptive_enterprise/us/utility.html).
3. For information on SUN N1 solutions, go to [www.sun.com/software/solutions/n1/](http://www.sun.com/software/solutions/n1/).
4. For information on the Global Grid Forum, go to [www.ggf.org](http://www.ggf.org).
5. For information on Globus Toolkit, go to <http://www-unix.globus.org/toolkit/>.
6. For information on OGSi.NET Toolkit, go to [www.cs.virginia.edu/~gsw2c/ogsi.net.html](http://www.cs.virginia.edu/~gsw2c/ogsi.net.html).

# Acknowledgments

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***From Craig Fellenstein...***

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