Preface

Grid computing is an emerging computational field with a great impact in compute-intensive endeavors. As an offshoot of distributed computing, the grid can be harnessed to solve a single scientific or technical problem at the same time by deploying jointly computational resources such as computers, networks, data archives and instruments. It is cost-effective as organizations can share or pool together computing resources among geographically dispersed groups in a virtual environment.

Historically, the term grid computing stemmed from Ian Foster's and Carl Kesselman's seminal work in the nineties that liken the grid to electric power grid. The term has since been popularized by such academic works as SETI@home (that exploited cycle-scavenging networks or networked PCs) and other applications to grand challenge problems. Grid computing is becoming popular in the enterprise world after its origin in the academic and research communities, where it was successfully used to share resources, store data in petascale, and ultimately lower IT costs. There are several reasons for the embrace of the enterprise grids. In the nineties, the IT world was confronted with the high cost of maintaining smaller, cheaper and dedicated servers such as UNIX and Windows. There was the problem of application silos that lead to underutilized hardware resources; huge and ungainly systems that are costly to maintain and transform; and patchy and disintegrated information that cannot be fully exploited by the enterprise as a whole. Various surveys put the average utilization of servers in a typical enterprise to often much less than 20 percent. But with the increasingly available cheaper, faster and affordable hardware such as server blades, and operating systems like the open source Linux, the IT world embraced grid computing to save money on hardware and software.

The grid has since grown with the demand for more computational resources for problems in engineering, biology, military, climate or weather research. Complex simulations cause long runtimes or overtax modern computer systems and pooling computational resources together have proven to minimize runtimes. Such simulations can be efficiently executed in parallel or distributed across many nodes or processors in a grid environment. Even ad hoc or pro-active grids have emerged that are suitable for short-term collaborations or small-scale computations.

The growing importance of grid computing has been accompanied by numerous researchers around the world focusing on accumulating knowledge in this discipline. Therefore, to keep educators, students, researchers and professionals abreast of changes in the ever-evolving grid concepts, protocols, applications, methods and tools, I decided to launch a handbook project where researchers from all over the world would assist me in providing some necessary coverage on topical issues in the discipline.

The *Handbook of Research on Grid Technologies and Utility Computing: Concepts for Managing Large-Scale Applications* provides a comprehensive coverage of terms, concepts, processes, acronyms, important issues and trends in grid technology. With contributions from diverse experts, the handbook shares new ideas and best approaches among researchers, scholars and industry practitioners. The handbook is organized in five distinct sections, covering wide-ranging topics such as: (1) Introduction (2)

Grid Scheduling and Optimization (3) Grid Security (4) Grid Architecture, Services and Economy (5) Grid Applications and Future Tools. These sections are summarized as follows:

Section I, *Introduction,* provides an overview of grid computing and discusses issues like grid evolution, potential users, trends and advances in grid infrastructure, web and grid services, international collaborations and emerging standards. The chapter "*Overview of Grid Computing*" by Emmanuel Udoh, Frank Zhigang Wang and Vineet R. Khare, presents an excellent framework in which to understand the fundamental concepts of grid computing as contrasted from distributed computing and peer-to-peer computing as well as the current challenges.

Section II, *Grid Scheduling and Optimization*, deals with an important research topic in grid computing. In scheduling, one or more user jobs can be processed without knowing where the resources are or the owner of the resources. The efficiency and quality of service of job's execution must be guaranteed as resource management is determined by many and different organizational administrative policies. Several chapters are presented in this section mirroring the intensity of research on this topic. Eric Aubanel in "*Resource-Aware Load Balancing of Parallel Applications*" reviews the wide range of solutions proposed for parallel applications and the need for performance comparisons, while Tevfik Kosar in "*Data-Aware Distributed Batch Scheduling*" addresses challenges and trends in data-aware scheduler with a focus on Stork case study. Chapters such as "*Assisting Efficient Job Planning and Scheduling in the Grid*" by Enis Afgan and Purushotham Bangalore discuss work that offers individual users alternative job options in terms of cost and time tradeoffs in which a new layer of scheduling includes application parameter selection and parameter value optimization, while the chapter "*Effective Resource Allocation and Job Scheduling Mechanisms for Load Sharing in a Computational Grid*" by Kuo-Chan Huang, Po-Chi Shih and Yeh-Ching Chung, evaluates site selection policies and feasible load sharing mechanisms in a series of simulations. The section ends with two chapters on quality of service in grid computing from Ming Wu and Xian-He Sun as well as researchers Zhihui Du, Zhili Cheng, Xiaoying Wang and Chuang Lin.

Section III, *Grid Security*, which deals with authentication and authorization for use of grid resources, is a critical component for extending the grid technology beyond the academic realm. Due to the heterogeneity of the grid environments such as the different operating systems, policy decisions, software and hardware, security issues are a major source of concern for use and adoption of the grid virtualization solutions in the enterprise. It is therefore necessary to develop solutions to address these issues. The chapter from researchers Kris Bubendorfer, Ben Palmer and Ian Welch, "*Trust and Privacy in Grid Resource Auctions*," offers a look at the privacy preserving and verifiable auction protocols for secured electronic auctions and the implications of adopting them on grid architecture.

Section IV, *Grid Architecture, Services, and Economy*, looks at a host of research directions in architecture, service and grid economy. The grid architecture defines the basic and interacting components for managing cross-organizational resource sharing. It focuses on the interoperability among the resource providers and users as well as the protocols at each layer of the architectural model. Currently, there are efforts to merge the grid architecture with service-oriented architectures (SOAs), autonomic computing and other open standards platforms. This will aid the construction of dynamic applications that leverage virtualized resources, as users of applications are now only concerned with the operational description of the service. For instance, the Web services architecture (WSA) enables and defines SOA, where services interact by exchanging XML (Extensible Markup Language) messages. Furthermore, concepts defined in grid economy help effective management of resources and application scheduling as cooperative and competitive trading of resources such as CPU cycles, storage, and network bandwidth leverage various grid resource allocation.

There are a couple of chapters in this section. Researcher Sandro Fiore and colleagues described a grid database access service in "*An Architectural Overview of the GRelC Data Access Service*," while

Man Wang, Zhihui Du and Zhili Cheng discuss a mechanism based on multidimensional grid QoS in "*Adaptive Resource Management in Grid Environment*." In chapters "*Bio-Inspired Grid Resource Management*" and "*Service Oriented Storage System Grid*" Vineet R. Khare, Frank Zhigang Wang, Yuhui Deng and Na Helian address biologically inspired grid resource management techniques that are decentralized and self organized in nature as well as challenges involved in building a service oriented storage (SOS) grid. Rosario M. Piro in "*Resource Usage Accounting in Grid Computing*" and Kurt Vanmechelen, Jan Broeckhove, Wim Depoorter, and Khalid Abdelkader, in "*Pricing Computational Resources in Grid Economies*" focus on new approaches in grid economy. Maozhen Li and Man Qi, in "*Service Discovery with Rough Sets*" present ROSSE, a rough sets based search engine for grid service discovery. In "*On the Pervasive Adoption of Grid Technologies: A Grid Operating System*" by Irfan Habib, Ashiq Anjum and Richard McClatchey, the researchers emphasize the need to simplify the learning curve of grid technology (thus promote easy adoption) by integrating the grid system in an operating system environment.

Section V, *Grid Applications and Future Tools*, offers a way to solve challenging problems such as earthquake, climate/weather, financial and protein simulations. Grid technology can also be applied as a utility for commercial and noncommercial user. This last section of the handbook showcases the flurry of activities in applying the grid technology to various domains such as nuclear physics, biomedicine, image processing, e-science, simulation, business, global terrorism and national platforms.

In chapters "*Grid-Based Nuclear Physics Applications*" by Arickx Frans and "*Simulated Events Production on the Grid for the BaBar Experiment*" by Daniele Andreotti, Armando Fella and Eleonora Luppi, the researchers discuss MPI-based cluster computing in a self-scheduling paradigm and a batch-computing paradigm as well as the grid approach to the BaBar production framework using the INFN-GRID network respectively. Gerald Schaefer and Roger Tait present how a blackboard paradigm can be used as an efficient and effective vehicle for distributed computation in "*Distributed Image Processing on a Blackboard System*." In the chapter "*Developing Biomedical Applications in the Framework of EELA*," Gabriel Aparicio and colleagues apply grid to studies of oncological analysis, neglected diseases, sequence alignments and computational phylogenetics. Diego Liberati proposes a framework that creates, uses and communicates information over a distributed cooperative enterprise in public environments or open source systems, in "*A Framework for Semantic Grid in E-Science*."

In this final section, there are other chapters that capture the research trends in the grid realm. Roberto Barbera, Valeria Ardizzone and Leandro Ciuffo described a fully working grid test-bed devoted to training and dissemination activities in "*INFN virtual Laboratory for Dissemination Activities (GILDA)*." In the chapter "*Grid Enabled Surrogate Modeling*" Dirk Gorissen, Tom Dhaene, Piet Demeester and Jan Broeckhove present a framework that can leverage the use of compute clusters and grids in order to decrease the model generation time by efficiently running simulations in parallel. Patrik Skogster describes in "*GIS Grids and the Business Use of GIS Data*" the business use of geographic data (business intelligence) and geographic information system (GIS) grids. To further demonstrate the applicability of the grid concept to global security, Gokop Goteng, Ashutosh Tiwari and Rajkumar Roy in "*Grid Computing: Combating Global Terrorism with the WWW*" develop grid architecture and implementation strategy on how to connect the dots between security agents such as the CIA, FBI, police, custom officers and transport industry to share data and information on terrorists and their movements. Finally, Jyotsna Sharma in "*Grid Computing: The Technology and The Indian Initiatives*" and researchers Hai Jin, Li Qi, Jie Dai and Yaqin Luo in "*Dynamic Maintenance in ChinaGrid Support Platform*" describe the major efforts in grid platforms initiated in India and China respectively.

In conclusion, the capability of the web to link information over the Internet has popularized computer science to the public. But it is the grid that will enable the public to exploit data storage and computer power over the Internet analogous to the electric power utility (a ubiquitous commodity). In this vein, the handbook is a contribution to the growth of grid technology as a new IT infrastructure that allows modular hardware and software to be deployed collectively to solve a problem or rejoined on demand to meet changing needs of the user.

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