Preface

eScience is generally recognized as a complex of activities that require highly intensive computation on huge data sets in a large-scale networked distributed environment. It embraces such diverse disciplines as particle and high-energy physics, meteorology, astronomy, astrophysics, geo-science, and biology, just to mention a few. Another essential component of such activities is the capability of real-time interaction and collaboration among many scientists working on a specific problem or data set worldwide. However, there is a third major aspect that is sometimes less emphasized in this context, which is related with the use of specific instrumentation – the pieces of equipment physically producing the data that pertain to a certain experiment. Remotely accessing instruments, configuring their parameters, setting up a "measurement chain" – possibly distributed among different laboratories, running the experiment, generating and collecting the data are all preliminary actions to any further activities regarding data analysis and interpretation. System-level science and effectively running the complex workflows that modern science requires are made possible only by integrating instruments in the computing and data treatment pipeline.

In turn, large data sets and computationally intensive operations of eScience involve the use of Grid computing paradigms and their middleware. Bringing instrumentation into this framework raises new problems and challenges. What new middleware components and functionalities are needed to expose instruments as any other resources in the eInfrastructure? Which abstractions can better represent the multiplicity of scientific instruments and laboratory equipment? How and to what extent does the distributed environment affect measurement precision? These and other issues arise that require attention and answers. Even more than with other aspects in distributed systems, dealing with remote instrumentation to set up real and usable Remote Instrumentation Services (RIS) involves the multi-disciplinary interaction among computer science, networking, and metrology.

This is the third book in this series that attempts to put together such different points of view in the field of Remote Instrumentation. The first one (*Distributed Cooperative Laboratories: Networking, Instrumentation, and Measurements*, Springer, New York, 2006; ISBN 0-387-29811-8) was less focused on the integration of instruments and laboratories in the Grid and rather more concentrated on networking and measurement aspects. The second one (*Grid-Enabled Remote*

Instrumentation, Springer, New York, 2008; ISBN 978-0-387-09662-9) set forth the architectural and middleware aspects, though not neglecting the other relevant dimensions. In the present volume, we continue pursuing this point of view, with greater emphasis on the eInfrastructure in support of RIS and its features.

All books stemmed from a series of workshops on Distributed Cooperative Laboratories, which have converged under the name INGRID ("*Instrumenting*" the Grid), all held so far in Italy in different locations. The contributions in this book are extended and revised versions of presentations at INGRID 2008 (`http://www.ingrid08.cnit.it`), which took place in Lacco Ameno, Ischia, Italy, from April 9 to 11, 2008. Since the beginning, the INGRID Workshops were organized within the framework of a number of different European research projects. Among others, GRIDCC (Grid enabled Remote Instrumentation with Distributed Control and Computation), int.eu.grid (Interactive European Grid), g-Eclipse, CoreGRID, EDGeS (Enabling Desktop Grids for e-Science), EXPReS (Express Production Real-time e-VLBI Service), EGI (European Grid Initiative), DORII (Deployment of Remote Instrumentation Infrastructure), and RINGrid (Remote Instrumentation in Next-generation Grids) provided some of the results that are described herein.

The material in the book is organized in seven parts, each containing a number of articles. Part I, Remote Instrumentation Services, presents an overview of the activities of the RISGE (Remote Instrumentation Services in Grid Environment) Research Group (`http://forge.ogf.org/sf/projects/risge-rg`) of the OGF (Open Grid Forum), followed by a description of the Instrument Element (IE) – one of the main components to provide Grid-enabled instrumentation, and of some specific use cases in high-energy physics, telecommunication measurement equipment, and genomics.

Part II, Grid Infrastructure, Services, and Applications, after a short presentation of the structure and scope of the EGI, deals with Grid-specific functionalities that are relevant also to RIS, besides other services: automatic service deployment, job scheduling, Quality of Service (QoS) provisioning, resource management, global services across multiple Grids, desktop Grids, soft real-time constraints. The part presents also two applications in electron microscopy and simulation of a biophysical phenomenon.

Part III is entirely dedicated to Interactivity Services, an important aspect to provide the operator with the capability of online controlling the instrumentation and the experiment execution. Several aspects are considered, from the coexistence of parallel and interactive jobs to interactive data visualization, among others.

Part IV touches upon some Supporting Services. These include middleware independence, context-aware service composition, synchronization, resource discovery based on Specific Service Agreements (SLAs), QoS across multiple networking domains, and the use of portals in a specific application environment.

Part V addresses some large-scale instrumentation for radio astronomy, namely e-VLBI (electronic Very Large Baseline Interferometry) and Cosmic Rays Detection, treating both computational and networking aspects.

In Part VI, Metrology Issues are considered in some detail. They include wireless networking and synchronization in distributed measurement systems, as well as the description of some educational applications in remote instrumentation.

Finally, Part VII is devoted to Wireless Sensor Networks for Measurement. Wireless Sensor Networks (WSNs) are a fundamental component of Remote Instrumentation Services and constitute the basis for data acquisition in many distributed applications. The contributions in this part cover aspects in signal processing, data aggregation, energy saving, and integration of WSNs in the Service-Oriented Architecture.

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