Fujitsu's Activities in Grid Computing

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(Manuscript received August 27, 2004)

Fujitsu has been actively involved in the research and development of Grid computing: a technology that enables the integrated and collaborative sharing of resources across administrative boundaries. Research on Grid computing was initially carried out in scientific computation projects, and Fujitsu has been participating in a number of such projects in Japan and Europe. As the technology became more mature, Fujitsu's R&D focus expanded to include business applications of Grid computing, with interoperability as a key issue. Therefore, Fujitsu has been increasingly involved in the standardization of Grid computing, especially technologies relating to commercial Grid systems. In addition to working on standardizing essential technical specifications, Fujitsu also holds a number of key posts in the Global Grid Forum, which is the premier standard-setting organization for Grid technology. Fujitsu has also been promoting the establishment of important standards in other bodies, for example, OASIS. In this paper, we describe key Grid computing projects that Fujitsu has been engaged in and some current technology-development activities. We also outline the technical fields that are expected to become significant in Grid computing in the future.

1. Introduction

Grid computing emerged from technology developed to enable effective use of distributed supercomputers for large-scale scientific computations. The technology has been extended and can now handle various types of computer resources and applications. Recently, the application of Grid computing to business has attracted a lot of attention and many major information technology (IT) vendors are competing to research and develop business solutions.

This paper introduces Fujitsu's activities in Grid computing and outlines Fujitsu's major technological developments. More detailed descriptions of individual projects are given in other papers in this special issue.

2. Grid projects in scientific fields

Grid computing was initially developed and used for scientific computation. Fujitsu has been involved from an early stage in the development of Grid computing technology by participating in scientific computation projects. Some of the major projects are described below.

2.1 Information Technology Based Laboratory (ITBL) project[1),2)]

ITBL is a Grid computing project under the e-Japan Priority Policy Program. In this project, the Japan Atomic Energy Research Institute is in charge of platform software development and the Institute of Physical and Chemical Research is in charge of high-capacity, high-security networking technologies development. Other participating organizations are handling the development of application software.

Fujitsu has supplied servers to ITBL and has also been contracted to develop ITBL platform software in a joint venture with Hitachi East Japan Solutions, Ltd., starting in fiscal 2001. The platform software is intended to establish an environment that enables transparent use of heterogeneous supercomputers installed in multiple institutions.

ITBL has capabilities such as single sign-on authentication using client certificates, firewall traversal, and file resource sharing and job execution by linking heterogeneous supercomputers. ITBL also supports joint research by providing collaborative visualization environments (Advanced Visual Systems [AVS] and Parallel Tracking Steering [PATRAS]) to enable remote users belonging to the same research community to share computation results and other research data. ITBL sites are linked using Super SINET (Science Information Network), which provides the required high-performance network infrastructure.

2.2 Super SINET project[3)]

Super SINET is an ultrahigh-speed research network. It uses 10 Gbps optical communication technology to connect research institutes and universities formerly under the control of the Ministry of Education, Culture, Sports, Science and Technology. The project was started under the e-Japan Priority Policy Program.

Super SINET is intended to provide the networking infrastructure needed by leading academic researchers to increase the global competitiveness of their activities. For example, research in high-energy science, nuclear fusion, genetic information analysis, space astronomy, nano-technology, and Grid computing can benefit from access to this network.

Fujitsu has ported Grid middleware (e.g., Globus Toolkit) to Fujitsu VPP supercomputers and has installed it on VPPs at three universities.

2.3 VizGrid project[4),5)]

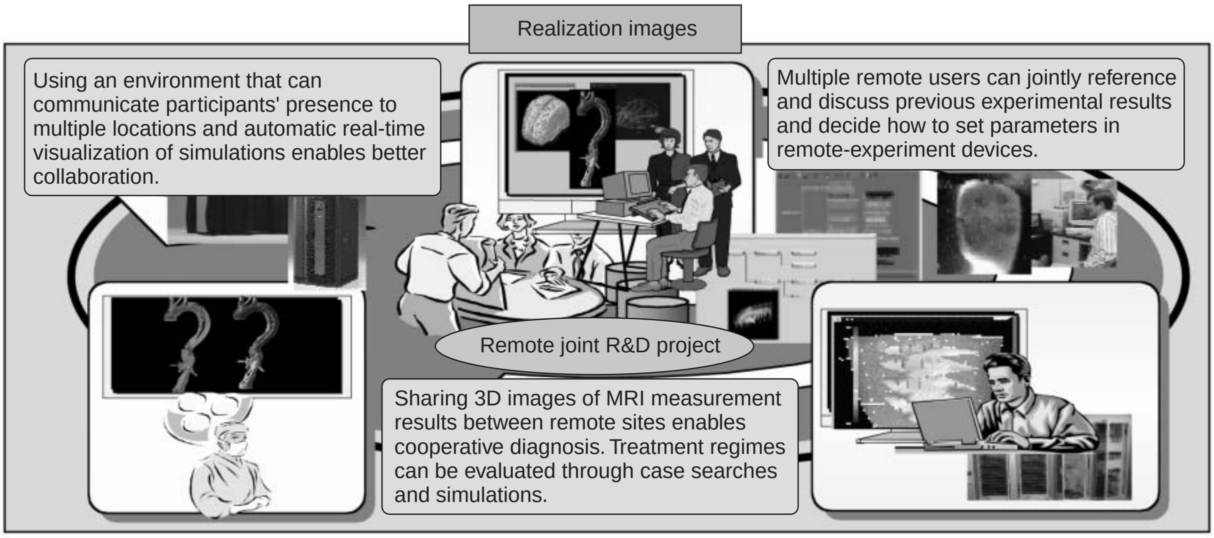
The VizGrid project aims to realize an advanced collaboration environment that can support remote collaborative research and development (**Figure 1**). VizGrid is an e-Science implementation project of the Ministry of Education, Culture, Sports, Science and Technology. The project is headed by Professor Matsuzawa of the Japan Advanced Institute of Science and Technology, Hokuriku. Research and development is carried out by the Japan Advanced Institute of Science and Technology, Kyoto University, Hiroshima University, Japan Atomic Energy Research Institute, Kanazawa Medical University, and Fujitsu.

2.4 Uniform Interface to Computing Resources (UNICORE) project[6),7)]

The UNICORE project developed technologies for transparent access to supercomputers and other computing resources without requiring changes to the operational policies of vendors and computer centers. It was sponsored by the German Government and ran from 1997 to 2002 as part of the EUROGRID project.

The German Meteorological Bureau, Pallas GmbH (in Germany), and Fujitsu Laboratories of Europe (FLE) participated in the UNICORE project. The UNICORE system is currently in operation at supercomputer centers in Zurich, Karlsruhe, Stuttgart, Munich, Berlin, Paderborn, and Dresden.

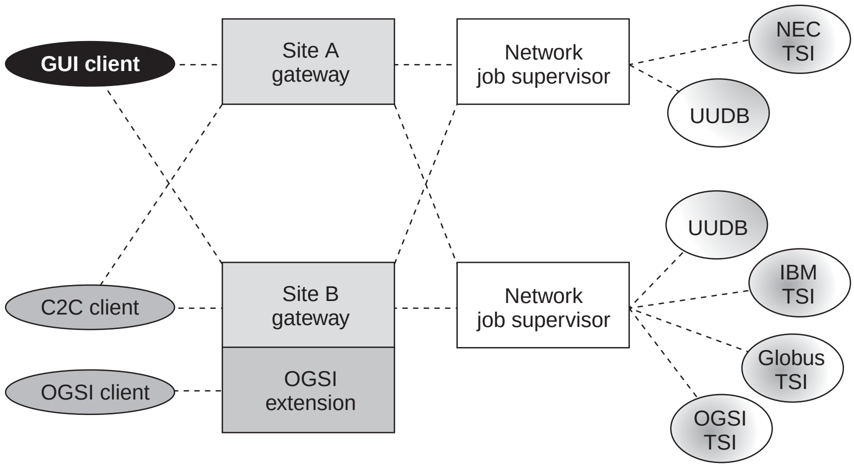
FLE and Pallas (now part of Intel Corporation) shared the software development of the UNICORE project. FLE developed the UNICORE architecture (**Figure 2**), protocols, and server software. Pallas developed the UNICORE client, an easy-to-use graphical application that can be used to prepare, submit, and monitor jobs across multiple sites.



MRI: Magnetic Resonance Imaging

Source: VizGrid Symposium 2002. Realization of real-experimental environment on supercomputer networks

Figure 1
Remote collaboration on VizGrid.



GUI : Graphical User Interface
C2C : Consumer to Consumer
OGSI: Open Grid Services Infrastructure
TSI : Target System Interface
UUDB: UNICORE User DataBase

Figure 2
UNICORE architecture.

2.5 Japanese Virtual Observatory (JVO)[8),9)]

The JVO system is intended to integrate astronomical observation data accumulated around the world so it can be used more effectively. Fujitsu has been developing and evaluating a prototype of the system since 2002 in association with the National Astronomical Observatory of Japan. The JVO system was built using the Globus Toolkit and Data Grid technology. Users of JVO can reference distributed, accumulated observation data regardless of where it is stored and make observations of a virtual digital universe independently of time and location (**Figure 3**).

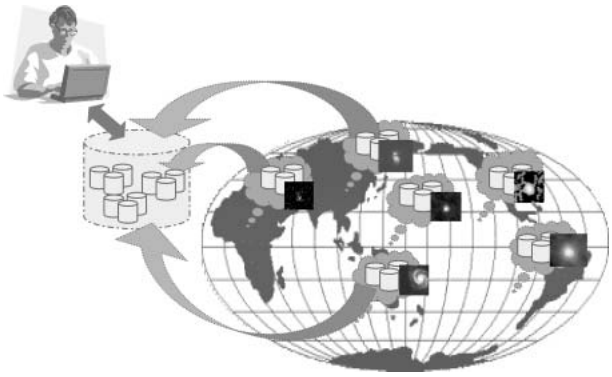


Figure 3
JVO virtual digital universe.

2.6 National Research Grid Initiative (NAREGI) project[10),11)]

The NAREGI project is a national project that is developing a new-generation computing system to enhance Japan's global competitiveness in information and communication fields. It will establish a Grid computing environment that can perform computations at speeds as high as 100 tera FLOPS and can be used for scientific research in fields such as nano-technology. To enable users without Grid computing knowledge and skills to use its capabilities, a problem-solving environment (PSE) and a super-scheduler for controlling Grid job execution are being developed. The initial phase of the project will establish a prototype Grid, based on UNICORE, as a research and development environment. The architecture of the prototype Grid will gradually be changed to the Open Grid Services Architecture (OGSA) as OGSA is further refined by the Global Grid Forum (GGF).

Details of the NAREGI project are given in another paper in this special issue.

3. Expansion of Grid computing technology to business

This section discusses how Grid computing is being adopted internally by companies to address rising infrastructure costs. Two use cases are presented and solutions are discussed.

As a result of hardware improvements and ever falling hardware prices an increasing number of companies have large numbers of high-performance servers, desktops, and laptops in their offices. These machines are often underutilized. Companies would like to harness all the high-performance hardware they own to perform computationally intensive tasks, for example, design simulations in manufacturing, risk analyses in the financial industry, and genetic analyses in the biotechnology industry. The main stumbling blocks are the potential software complexity and the operational costs.

Data centers typically own many servers that are used to execute a large number of small-to-large-scale business applications for a variety of customers. Typical allocation mechanisms over-provision resources to business applications to protect against worst-case scenarios, for example, failures or the highest expected load. Over-provisioning leads to lower utilization rates. Therefore, data centers would like to increase the average utilization rates of their servers to reduce costs. Also, data centers would like to reduce their administration costs, because management of resources increasingly makes up the largest part of overall cost. At the same time, data centers must ensure flexible and reliable job execution.

Various Grid computing technologies are being developed to solve these management and utilization problems. For example, Computing Grid technology aims to share and maximize computing power; Data Grid technology aims to virtualize distributed data and provide new integrated methods of using it; Collaboration Grid technology aims to share distributed information, technical knowledge, and resources to enable advanced collaborative work; and Data Center Grid technology aims to integrate IT resources located both within a data center and across different data centers and provide consistent management of the infrastructure in addition to optimizing the use of IT resources and enhancing the overall reliability.

As an example of a Computing Grid, Fujitsu has internally constructed a Simulation Grid system using existing servers and personal computers to simulate the error rates of LSIs for mobile communication systems. This system simplified the execution of large jobs and shortened the simulation phase from 16 to 4 months, thereby contributing to quicker development of products. In addition, the system reduced the time needed for job submission and management from 33 to 10 person-months, resulting in a dramatic reduction in the total cost of ownership (TCO).

The Business Grid national project, promoted by the Ministry of Economy, Trade and Industry, was started in fiscal 2003. The project is developing infrastructure software (Business Grid middleware) that allows companies to manage and fully exploit a large variety of IT resources and provide highly reliable services. The project also promotes the international standardization of Business Grid technology. For details, see the paper "Business Grid Computing Project Activities" in this special issue.

4. Research and development of Grid computing technology

Fujitsu's approach is that an IT infrastructure based on Grid computing technology can provide a robust environment that can quickly adapt to emerging business needs. Such an infrastructure can utilize a large number of distributed IT resources to flexibly and reliably deliver the computing power and data needed by the demanding business applications of customers. The core part of Fujitsu's Grid computing technology is Fujitsu's TRIOLE[12] IT infrastructure.

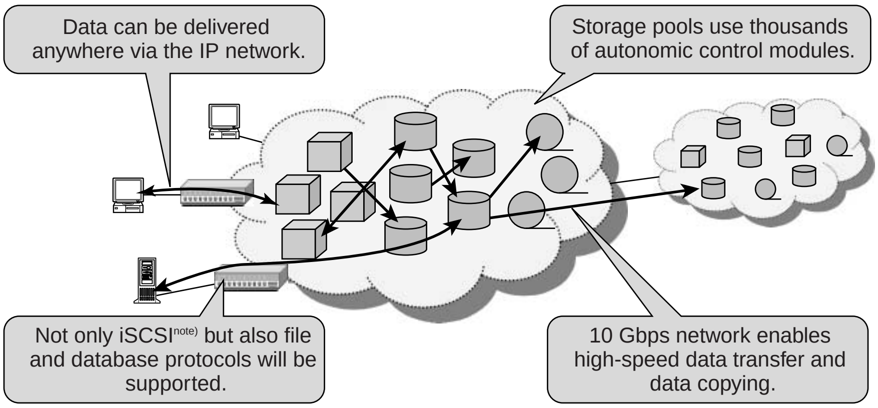
In addition, Fujitsu is researching and developing IT resources that can provide advanced functionalities based on autonomous technology. Two examples of such resources are the organic server and organic storage. The organic server has autonomous control functions: it can detect the current system status (self-detection), analyze it (self-analysis), and perform actions to optimize its operation (self-optimization). Organic storage provides the advanced functionality required to build Data Grids. It uses a scalable architecture to deliver high-performance data-transfer rates and a high level of manageability. Organic storage can quickly and efficiently deliver data in a variety of formats (**Figure 4**).

5. Standardization activities

Grid computing is a technology for sharing a wide variety of distributed IT resources. Interoperability is a critical factor for the success of this technology, so it is very important to achieve technological standardization. The standardization of Grid computing technology is being led by the Global Grid Forum (GGF)[13] and is promoted through the cooperation of multiple standards organizations, for example, the Organization for the Advancement of Structured Information Standards (OASIS), World Wide Web Consortium (W3C), Internet Engineering Task Force (IETF), and Distributed Management Task Force (DMTF).

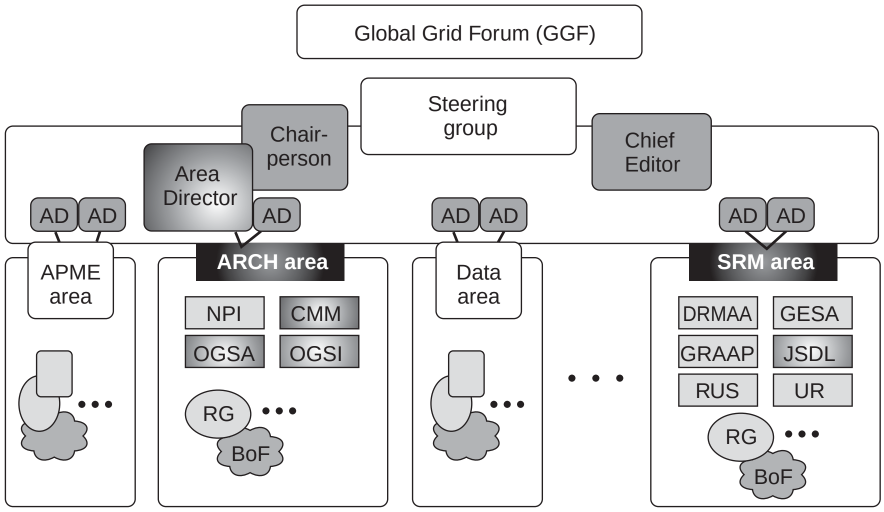
The GGF is the main standards organization focusing on Grid computing. More than 400 universities, research laboratories, and companies and over 5000 researchers and engineers are participating in the GGF (**Figure 5**). It was founded in 2001 as an alliance of regional organizations that operate in the U.S., Europe, and the Asia-Pacific region. Since its founding, it has held eleven meetings (three each year), the seventh of which (GGF7) was held in Tokyo in March 2003.

The GGF is managed by a Steering Group (GFSG). Working groups are organized into "areas" and each area is managed by two members of the GFSG. (Currently, there are seven areas). Fujitsu has made substantial contributions in standardizing technical specifications relating to commercial Grid systems, mainly in the areas of Architecture and Scheduling and Resource Management.



note) Protocol used for communication between computers and storage devices on the IP network

Figure 4
Organic storage.



Area Director (AD): Manages an area made of working groups

RG : Research Group
BoF: Birds of Feather
(preparation for WG formation)

ARCH area: Architecture area
CMM (Common Management Model): Resource management model
OGSA (Open Grid Services Architecture): Overall architecture
OGSI (Open Grid Services Infrastructure): Basic function interface
SRM area: Scheduling and resource management area
JSDL (Job Submission Description Language): Job description language

Figure 5
Structure of GGF.

6. Conclusion

This paper outlined Fujitsu's Grid computing activities. Fujitsu has been advancing the development of this technology and its application in various scientific fields and more recently has been pursuing business uses for this technology. Fujitsu will continue to advance the development of Grid computing technology and contribute to international standardization.

As Grid computing becomes more widely known, we expect that it will be applied to more and more areas. In particular, we anticipate that business customers will demand a more diversified range of services. To satisfy the emerging customer needs, we plan to provide flexible, reliable TRIOLE-based solutions.

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