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NII Today

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[Special feature] Grid×e-Science
Connecting Data, Harnessing Data

Competitive, Cooperative Massive Computation Network Construction

The Fourth Science Methodology, Led by Grid Computing

The New World of Research and Development Being Created by Linking Computational Resources

Formulating International Standard Specifications

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Grid × e-Science

Connecting Data, Harnessing Data

There has been a keen interest in "grid computing", connecting multiple computing resources and data, and "e-science", using the grid to make new scientific discoveries, for some time now. Research and development in Japan have been steadily ramping up in order to provide functional grid services. What issues will they face in the future, and what does that future hold for them?

NII Interview

Competitive, Cooperative Massive Computation Network Construction

Kenichi Miura

Director, Center for GRID Research and Development, Professor, Information Systems Architecture Science Research Division

Popular Commercial Clouds Are Not a Good Fit for Large Scale Scientific Computing

Takahashi The world of computing moves incredibly quickly. The "cloud" concept has become popular recently, and it feels like the expression "grid computing" has been heard less frequently .

Miura Clouds and grids really aren't that different. Their central concepts, being able to input information, process it, and obtain solutions, without needing to be aware of the location of the computational resources being used, is the same. The image of cloud computing varies from person to person, which is a bit of a bother, but what we're working with are grids, which are the trunk lines of cyber- framework, while clouds are a layer above that, positioned closer to users. In fact, I'd say the two are complementary.

Takahashi Grids are primarily used for scientific and technical computations. Are there any cloud services used in the scientific field?

Miura They're just starting to be rolled out. Right now, there are very few usage limitations from the cloud provider's viewpoint. In other words, the clouds are theoretically available for any applications. In practice, commercial cloud services being started up are mainly focused on routine business-related work, such as accounting ledger calculations and salary calculations. This format, however, is not a good fit with large scale scientific computing. When people have tried using these cloud services for scientific purposes, they've found that they don't offer near the necessary performance, or that while they expected low prices, the actual costs were ten times as high as expected. There has been a multitude of studies and evaluations of this kind around the world, and improvements are being made toward their use in scientific applications.

Takahashi You were active for many years in Fujitsu's computer divisions, moving to NII when the NAREGI (National Research Grid Initiative) project (*1) was started in 2003, with the goal of connecting supercomputers in Japan, right?

Miura Attention turned increasingly to grid computing while I was at Fujitsu, and I was engaged in investigating and reporting on the current state of grid computing, when I was invited to NII to work with the new NAREGI project. I had always wanted to create a grid which could be used like water from a faucet, flowing just by turning the tap.

Takahashi The NAREGI project ended in 2007. To what degree is the middleware that project produced been used?

Miura Right now, 7 nationwide computing and communications centers, and the computing centers at the University of Tsukuba, and the Tokyo Institute of Technology are connected. We also have been provided some computational resources and participation from younger generation researchers. However, we're still not in full operation, so the scale of grid adoption varies from one center to another. The grid installations also include the High Energy Accelerator Research Organization (KEK) and the National Astronomical Observatory of Japan, and is being used by the Institute for Materials Research at Tohoku University, the Institute for Molecular Science, and more.

Takahashi What about overseas expansion?

Miura There are a few places which have downloaded the NAREGI software. I think around 10, mainly in Europe.

Takahashi What about Asia?

Miura China, Korea, and Taiwan have been dominated by the EGEE, a European grid.

Overcoming "Not Invented Here" Syndrome

Takahashi What's the difference between EGEE and NAREGI?

Miura EGEE started in order to distribute CERN's (*2) experimental data to collaborating research organizations around the world. That means that KEK, which works in the same field as CERN, must be connected to the EGEE grid. At the same time, as a Japanese research body, they also need to connect to NAREGI, so we're working together on interoperation between the two grids. It's simply impossible for everyone to join a single grid. There's an expression in our field: Not Invented Here syndrome (*3). Everyone wants to keep the things that they themselves have developed, so when something else comes along, they reject it, since they weren't the original developers. That's both unfortunate and understandable, so we're considering ways to overcome such situations and to connect various grids. That's interoperation.

Takahashi Why don't China or Korea join NAREGI?

Miura That's somewhat difficult...

Takahashi It would be impossible without marketing.

Miura Probably so. We've been dedicating our efforts to development, and haven't had the time to sell the project to others.

Takahashi Minimal marketing is something of a hallmark of Japanese R&D.

Miura Yes, unfortunately, there is a large gulf between our marketing manpower and that of Europe and America.

Takahashi If you were to market NAREGI, what would you say its sales points are?

Miura It can be used to construct vertically integrated grids connecting different types of computing systems. NAREGI isn't the only one to do so; Europe has UNICORE. UNICORE is the current core middleware for the European supercomputer grid, and vertical integration of different computer systems is possible with it as well. It's also possible with America's large scale TeraGrid, but while large, internally it is less structured.

Takahashi　NAREGI is more along the European lines?

Miura　That's right. Europe has been working steadily on its grid since around 2001, and at one point we were incorporating their technology as well. However, our development phases didn't precisely match theirs, and we ended going off in a bit of a different direction, so the two aren't exactly the same. In terms of interoperation, we're now at a stage where it is experimentally possible to exchange computation information between Europe's UNICORE and NAREGI. It will probably take another one or two years before the international standard becomes mature and complete.

Takahashi　Will NAREGI become an international standard?

Miura　No, I meant that proposals which participating members submitted for international standardization are being discussed and implemented as the final standards. Right now, the current versions of the standards do not fit 100% with any of the grid middleware being tested, and there are still functions which are lacking. Everyone is engaged in discussions and working out the details. I think this is excellent. About 4 or 5 years ago, everyone was making their own grid, but it has been gradually recognized that this results in poor international collaborations.

Takahashi　Japan has been involved in these international standardization efforts from the start, right?

Miura　Yes. It has mainly been handled by the researchers who were involved since the NAREGI project era. I think that long term association with the grid community is essential, and that our grid research is being advanced in the right direction from an international perspective as well. You might assume that the situation could be taken care of by just distributing UNICORE or EGEE in Japan, but that isn't quite true. For one thing, there's the problem of language, and also one never knows what pitfalls there might be when riding on someone else's back. For example, until now, EGEE grid middleware has been offered for free, but they suddenly announced this spring that they would only offer maintenance support for countries that pay, which is causing confusion to many participating countries.

Undervaluing National Infrastructure, Leading to Weak Basic Science in Japan

Takahashi　How much does maintenance cost?

Miura　For our grid R&D center, something over one hundred million yen. Our center also has full-time staff. The e-Science project which succeeded the NAREGI project will continue until 2011, and will deliver a newly developed light-weight grid middleware, but after that things aren't so clear. The national government isn't that interested in infrastructure and operations, and in a worst case scenario, all the work could be for naught, as the grid that has been built up gets no support. That happens with quite a few Japanese projects.

Takahashi　That's one of the problems that leads to weakness in the basic science in Japan. What do future prospects look like?

Miura　We are working in the e-science RENKEI (Resources liNKage for E-sclence) project at a layer above NAREGI, closer to users, trying to create something easy to use.

Takahashi　Researchers who use grids are more interested in how effective grid use is in their own research rather than in the computational technologies themselves.

Miura　Exactly. Another NII group is conducting research on education clouds. The approach of connecting clouds to the NAREGI environment, dividing work up into pre-processing, main computation, and post-processing, and performing pre- and post-processing in-house, with clouds, and using the grid for the heavy workload of main computation, is also being worked on. From the users' perspective, the only difference is whether the jobs in a workflow (*4) are processed on the local resources or on the grid, but there are no differences in the human interface. Without grid technology, users would have to use different methods for each computer system – that is, they'd have to learn different protocols (*5), data handling methods, and submission methods, which would make them reluctant to use them. The RENKEI Project develops technologies to overcome such difficulties.

Takahashi　That will be ending in March 2012, right?

Miura　That's why we're moving towards having RENKEI project technologies tested by actual end users. In March 2011, we'll be holding an open symposium, introducing the results of our work to people, reporting the experiences of some of our early adopters, and looking for people who want to use what we've developed. The key to the survival of our project is what kinds of research communities are making use of it, and how. In that sense, we're very grateful to KEK and the National Astronomical Observatory of Japan for already using the NAREGI grid middleware. Right now, people are focusing less on computational processing and more on data intensive computing, searching for scientific data which matches their objectives from large volumes of data. There are many more ways the grid can be utilized, and I think this is just the beginning.

*1 NAREGI (National Research Grid Initiative) Project: National project whose objective was the development of an academic grid to support cutting edge research and educational activities.
*2 CERN: Research organization which uses a massive particle accelerator to research elementary particle physics. It receives 90% of its operating funds from 20 participating countries. Its current official English name is the European Organization for Nuclear Research, but its acronym comes from its former French name, the Conseil Européen pour la Recherche Nucléaire.
*3 NIH (Not Invented Here) Syndrome: Avoiding the use of technologies, ideas, products, etc. because they were produced by other people, organizations, or countries.
*4 Workflow, job: A workflow consists of a sequence of connected steps, carried out in the execution of computer programs. "Jobs" are the individual processes which make up a workflow.
*5 Protocol: Rules used by computers when transmitting data via a network. Also known as communications procedures. HTTP and IP are also types of protocols.

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News Bureau
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Comment from the Interviewer

Recently, grids have come to be almost exclusively associated with the smart power grids. Grid computing had only a faint presence. However, I discovered that this powerful behind-the-scenes force which supports large scale scientific computing has made significant strides in recent years, with international standardization increasingly underway. What will determine the future direction of grid computing will be the amount of support it enjoys from users. If a grid is truly easy to use, though, it will be transparent to users. Perhaps grids need to be advertised to their end users, as with the ubiquitous "Intel Inside" stickers found on computers.

[Special feature]
Grid × e-Science

Connecting Data, Harnessing Data

The Fourth Science Methodology, Led by Grid Computing

"Grid computing" has been a keyword in computer science since its appearance in the mid 1990's.
In the grid concept, multiple supercomputers and computers are networked to perform large scale, high performance data processing.
In recent years, grids have been extended from just computers to also include storage equipment, experiment devices, sensors, and more, creating virtual communities and expanding the borders of scientific knowledge.
In this issue, we will look at the cutting edge of this research.

Kento Aida
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Osamu Tatebe
Associate Professor
Department of Computer Science, Graduate School of Systems and Information Engineering, University of Tsukuba

Grid Computing as a Method for e-Science in Addition to Large Scale Computation

The grid concept has gained a secure foothold in the information science and IT business fields. Professor Kento Aida of the NII Center for GRID Research and Development, whose work is focused on putting the grid into practical use, explains: "In the information science field, keywords often come first, followed by content, as with the Internet. The grid is another example of this. At first, grid computing referred to connecting multiple supercomputers and computers via the Internet to perform large scale calculations. The word 'grid' itself came from power grids, as the goal was to be able to obtain information and services as needed, just like power can be obtained when needed by plugging a device into an outlet.

In more recent years, the word grid has come to include not only to computers, but also geographically scattered file servers, data bases, storage devices, experiment equipment, and the like, connected into frameworks which can be used as if they were single systems, creating virtual communities. Connecting massive quantities of experimental data and experiment devices such as high-voltage electron microscopes is already underway."

In other words, there are two needs which grids satisfy: increased performance through interconnecting computers, and data analysis by connecting not only computers but geographically scattered databases, experiment equipment, and the like.

"I think the need for the former is on the decline. This is because the capabilities of individual computers have risen greatly, so there is less need to go through the trouble of networking them for computation purposes except in the cases of extremely large amounts of calculations. However, recently, grid computing technologies have become the primary force in implementing e-Science, networking information scattered across servers in different operating environments and data generated in differing locations, and applying computing to them in order to create new knowledge. There is a lot of expectation regarding the new multidisciplinary and interdisciplinary knowledge this will bring forth," says Professor Aida.

"e-Science", Linking Different Types of Data to Produce New Knowledge

The objective of e-Science is to gather together varied research data from research organizations into massive single virtual collections of knowledge, using them to create new knowledge. e-Science (data centric science), in which massive amounts of data are linked for high level processing and utilization, is being called the fourth science methodology, joining experimental science, theoretical science, and computational science, and is drawing attention as the newest trend in science.

Senior Research Scientist Isao Kojima, who is engaged in

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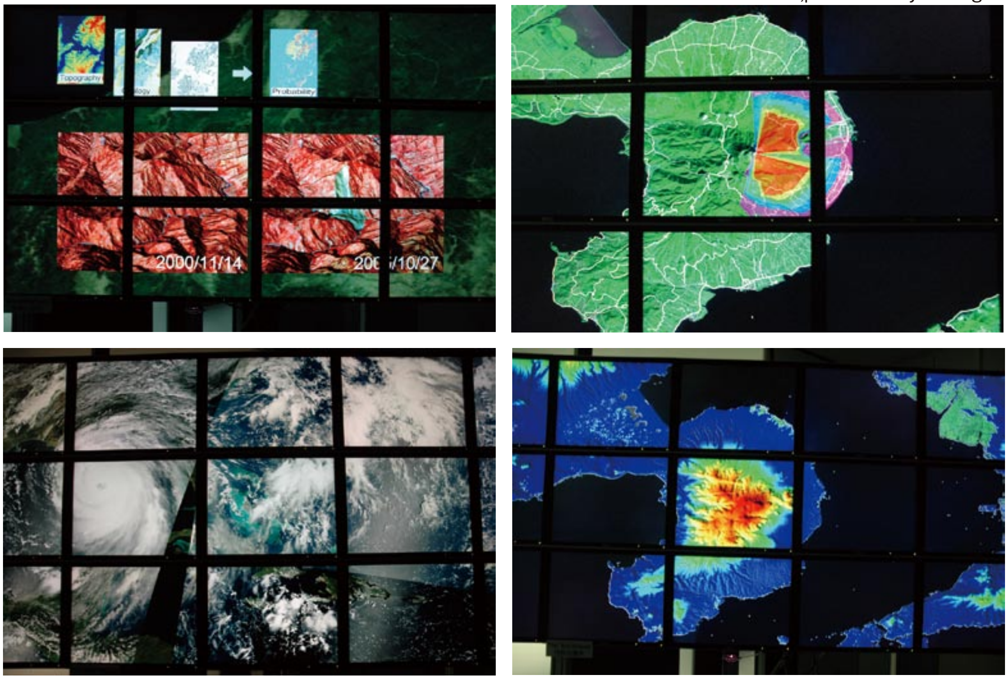

Figure 1 GEO Grid processing results shown on a high resolution display.
Top left: Earthquakes and landslides Top right: Mount Unzen Fugendake peak pyroclastic flow simulation
Bottom right: Mount Unzen Fugendake area elevation map Bottom left: Hurricane

researching grid technologies at the National Institute of Advanced Industrial Science and Technology Information Technology Research Institute, gave the following example of specific research results.

"For example, the project we're working on is GEOGrid (Global Earth Observation Grid). This project is at the leading edge of e-Science, fusing geological data such as remote sensing data obtained from satellites or geological maps in a massive, easy-to-access online earth measurement database (Fig. 1).

The ability to work with all these different types of data within a single system has made it possible to create a wide range of new knowledge. For example, e-Science is starting to be used in environmental and disaster applications. We can overlay the high resolution CO_2 data obtained from sensors on flux towers erected in Southeast Asian tropical rain forests for measurement purposes with wide area CO_2 data measured by satellites, discovering how they correlate with each other, and using that knowledge to correct data and create global high resolution CO_2 absorption and emission volume maps. We can also combine rainfall data from AMeDAS with geological inclination and soil firmness data obtained from satellite images, creating landslide hazard maps."

This is one of the benefits of the e-Science being made possible by the grid: obtaining higher resolution information on both the global and local scales through the worldwide linkage and complementary utilization of massive quantities of data.

The Grid and the Cloud: A Single Concept

So how does this grid computing differ from the cloud computing which has been in the limelight of late? Principal Research Scientist Yoshio Tanaka, who like Senior Research Scientist Kojima is also involved in grid research at the National Institute of Advanced Industrial Science and Technology, says, "The name 'cloud' was first used by Google's Eric Schmidt in 2006, but the goals of cloud and grid computing are the same." "In both, users can use resources or services which are out there, without having to be aware of where they are, or how they are offered. The grid concept, though, was born in the academic research field, and involves bundling computers and servers to provide high level calculations, so it presents many technological hurdles, such as calculation capabilities and security. The cloud concept comes from the business field, and one of its features is that the services and functions offered are narrowed down, as in the cases of Gmail or Google Maps, making it easy to use by anyone. In other words, both grid and cloud computing are oriented in the same direction, but their backgrounds and approaches differ."

It is eminently possible that the two will merge in the future, with grid technologies used in cloud computing, and cloud technologies used in grid computing.

Isao Kojima
Leader,
Senior Research Scientist
Grid Service-ware Research Group, Information Technology Research Institute, National Institute of Advanced Industrial Science and Technology

Yoshio Tanaka
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Connecting Data, Harnessing Data

Grid Middleware, the Key to the Advancement of the Grid

Practical use of grid computing still faces many obstacles. The biggest of the technical issues facing the grid is the development of software called "grid middleware". Link assets and creating virtual organizations over the network requires a wide range of services, such as those used to ensure security, share information over the network, allocate and assign calculations (scheduling), share data over the network, and provide programming environments. Grid middleware is responsible for delivering those services.

"For example, there are many operating systems, such as Windows, Mac, and Linux, but regardless of the OS, computers can send e-mail. This is because common interfaces have been designed for handling e-mail. Grid middleware has the same role, making it possible for existing supercomputers, computers, and databases to work together. Middleware acts as an intermediary between operating systems and applications, connecting the two. Needless to say, middleware also includes security, authentication, and permission related functions. Another one of our research topics is how to reduce the overhead produced by having to create and log into accounts on supercomputers," explains Professor Aida.

Another one of middleware's major roles is maximizing the ability to access networked resources and provide simple, unified interfaces for the safe coordination of varied, heterogeneous databases throughout a distributed environment.

Senior Research Scientist Kojima says, regarding these technical issues, "In order to list the many various types of data stored using different storage methods, they must be placed into uniform containers. For example, data may consist of Excel tables, Word files, or the like. New, easy to use interfaces must be developed which collect those disparate data types."

Principal Research Scientist Tanaka points out, "In addition, there are also societal issues involved in handling data. For example, for satellite image data alone, data is owned by individual research institutions, such as AIST, JAXA, NASA, and the like, as well as commercial data owned by companies for business purposes. Coordinating and linking this data is not easy. Gathering and using data requires operation policies and consensus formation. Security related grid technologies for authentication and permission have been developed, but it is impossible to manage how data which has been retrieved is used. Another issue is how to provide security for data requiring privacy considerations, such as data used in the bio and life science fields. There are still many things to be considered, such as, for example, not releasing what keywords are used in data searches."

Developing Grid Middleware: The RENKEI Project

Against this backdrop, NII's Professor Aida, AIST's Mr. Kojima and Mr. Tanaka, the University of Tsukuba Graduate School of Systems and Information Engineering's Associate Professor Osamu Tatebe, and others have been working on the RENKEI Project, part of the "Research and Development of Software for System Integration and Collaboration in Order to Implement e-Science" next generation IT infrastructure creation research and development spearheaded by the Ministry of Education, Culture, Sports, Science and Technology. The objective of this project, started as a four year research project in 2008, is the development of middleware for linking and sharing resources distributed across multiple organizations, such as research labs, computing centers, and international grids. Professor Aida of the NII leads the project, and development of the middleware's abilities to connect distributed databases (Senior Research Scientist Kojima) and abilities to safely use connected databases using a safe framework (Principal Research Scientist Tanaka) are led by AIST. University of Tsukuba's Associate Professor Tatebe's efforts are focused on technologies for fusing data on an individual file basis.

"Originally, the concept was for everything to be handled by a single middleware, but in reality, America, Europe, and Japan were all using different middleware, making coordination difficult. We decided to decide interface standards for transmissions between different middleware, and to develop many types of middleware, such as middleware that connects different level systems, such as supercomputers and the computers found in research labs. We couldn't just create our own specification and expect others to use it, so we've joined the Open Grid Forum (OGF), an international standards body, and are using an open standard development approach (see P10-11 for details). By simultaneously going forward with development, demonstration testing, and standardization, we hope to produce something which is actually usable," says Professor

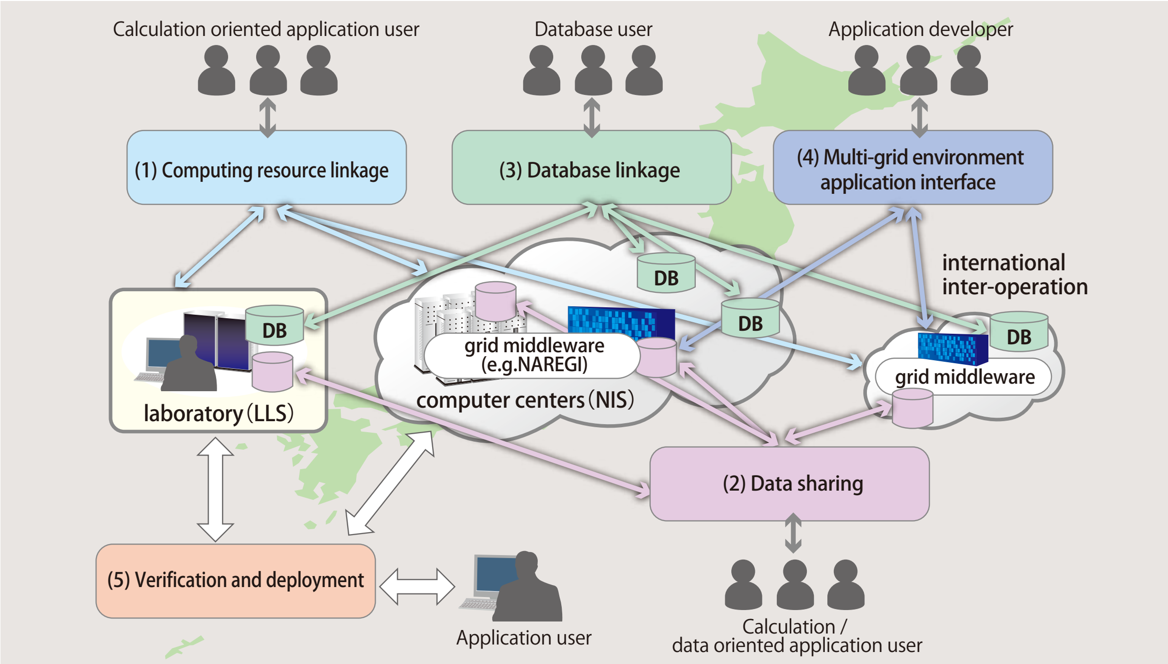

Figure 2 Overall view of the RENKEI Project. Individual members are charged with separate responsibilities, from computing resource coordination and linking to verification and deployment.

Aida. Prototype development has already been completed, and research efforts will be accelerated in order to perform demonstration testing and deploy the research results in the form of actual grid middleware.

"Database connection work is progressing smoothly. For example, geographically separated researchers, concentrated in Austria are working together on breath analysis research. We're providing their project with middleware we've designed, and have created a distributed database for them. We're getting improvement requests from them, and providing them with feedback. A major issue going forward is ensuring that ease of use and search speed do not suffer even if the amount of data balloons in the future," explains Senior Research Scientist Kojima.

The distributed file system developed by Associate Professor Tatebe is already in actual use, and software for it has already been released.

"When sharing data between machines in different organizations, such as machines in research labs and supercomputers in computing centers, files have conventionally been sent and copied. When copies are made, information such as which copy is the most current, and where the most current copy has been copied to, must be manually managed. In order to resolve this problem, I'm researching and developing the Gfarm wide-area file system (*1) for sharing data between organizations. It might be simple to envision by imagining the popular Dropbox service. With Gfarm, the same folder can be viewed by both research lab computers and computing center supercomputers, meaning that programs can be executed anywhere in the same environment. This is wonderful. RENKEI is particularly making advances in system reliability improvement. It's now possible for file access to remain possible even when some systems experience faults. What's important is to fundamentally avoid creating single points of failure, and in the event of failures at single points of failure, to block data until the failure is restored, avoiding the failure from affecting applications. We've performed performance evaluations through past astronomical data analysis workflows and the MapReduce (*2) applications, but I hope that in the future even more researchers will take advantage of e-Science."

We are at a crucial point in the actual adoption and implementation of e-Science. When grid computing becomes a widespread technology, it will be interesting to see what new discoveries and knowledge people will uncover, through e-Science as well, and what kinds of services will be available to us.

(Written by Madoka Tainaka)

*1 Gfarm File System: Software which can be used in multiple computers and clusters as a large scale, high performance shared file system. It is open source software, primarily being developed by Associate Professor Tatebe.
*2 MapReduce: Software framework introduced by Google for parallel distributed data processing.

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The New World of Research and Development Being Created by Linking Computational Resources

**Progress is underway in the creation of an "Academic Grid", networking together precious research resources such as the computers and databases in universities and research organizations across Japan.
When realized, this grid will make it possible for academic fields handling massive volumes of computation data to link a wide range of computational resources and perform computational processing.
This system will be a flexible one, which prioritizes the convenience of researchers.
We talked with three researchers who are working to make this system safer and more convenient for users.**

Creating Japan's First Academic Grid

"If only I could use that university's computation system, I could do much more in-depth research..." Not a few researchers have thought the same. The Cyber Science Infrastructure Grid (CSI Grid) project was started in order to satisfy this need. NII provides operation support for the project, in which 9 universities with supercomputers – Hokkaido University, Tohoku University, the University of Tokyo, Nagoya University, Kyoto University, Osaka University, Kyushu University, University of Tsukuba, and Tokyo Institute of Technology, are collaborating on research.

Professor Kento Aida of the NII Center for GRID Research and Development explains the new possibilities that will be opened up by the construction of this large scale grid.

"With this system, when users want to use computation systems, they will be able to utilize systems at other universities via the grid. What's more, the grid will make flexible workflows possible, such as performing simulations on ones own system, while performing graphic based visualization processing on a different system."

Assistant Professor Manabu Higashida of the Osaka University Cyber Media Center Applied Information Systems Division, who works on the project together with Professor Aida, explains the need for the development work he is involve in, saying, "Computation systems are replaced with new equipment every four or five years. Many users utilize the systems immediately after they're updated, resulting in a heavy usage concentration. When other institutions set up new computing environments, obviously, users want to immediately make use of the new systems. If we were back in the days when computational scales were on the order of floppy disks or hard drives, this wouldn't be a problem, but the amount of data involved in research and development has mushroomed, and just moving data takes time. Given this background, there is an increasing need for grid coordination, allowing users to take advantage of separate, physically distant computation systems from the comfort of the systems they are accustomed to using."

Approaching Grid Creation from Two Directions: Deployment and Operation

In August, 2008, NII and the 9 universities inaugurated the "Grid Deployment and Operation Task Force" in order to accelerate the construction of a grid connecting the computation systems of the universities. The task force is involved in research at each university, tackling the issues of "deployment technologies" and "operation technologies". On the deployment technology end, the primary issue is how to manage the system. On the operation technology end, it is the creation of a framework for coordinating user accounts.

First, let's look at the deployment technology issue. Currently, the CSI Grid is using the "NAREGI" middleware (*1). However, when the project was started, installation and deployment of NAREGI during grid construction was seen as difficult, making package and installer improvements a high priority. One of the greatest problems was that it presumed that an organization which managed the grid would manage the entire grid. This problem was tackled by Specially Appointed Associate Professor Taizo Kobayashi of the Kyushu University Research Institute for Information Technology. "The grid is composed of valuable computational resources managed by individual universities. The management of computational resources at any individual university, then, would of course be the domain of that university. Given this

Kento Aida
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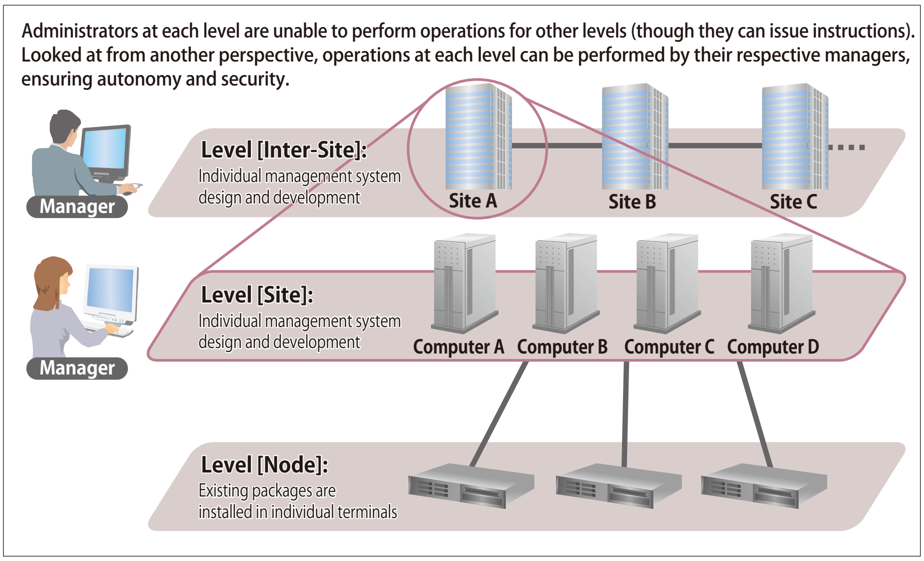


Figure New Approach of Dividing Network Into Three Levels in Order to Perform Management

background, it would be out of the question for a single organization to manage everything, including internal computational device information."

The Grid Deployment and Operation Task Force set nodes, the elements which make up the network, as the minimum management unit. We have clearly divided the system into three hierarchical levels – intra-node, inter-node = intra-site, and inter-site – and are designing and constructing systems for managing each, in order to resolve this problem (Figure).

This is one of the completely original research results of the CSI Grid. To explain in brief: package system software is responsible for managing integrity between the different software installed within each node. Integrity between nodes within a site, and higher level management of site interoperation, are managed by other systems. By doing this, we've organized the information which needs to be managed at each hierarchical level, making it possible to ensure integrity at each level, and to manage the entire grid."

Improvements are also underway on the operation technology end. In the 1980s and 1990s, there was already a system in place for sharing user accounts to computational resources in Japan connected by dedicated network connections. Common accounts were used at the time for system management, but with the rise of the Internet in the 1990s, there was an increasing view that "the age of users taking a proactive role in selecting computational resources with open connections to the Internet", and the common account management approach was temporarily abolished. However, due to Internet security problems, the hoped for open system approach was never realized. "To rectify this situation, we deployed a service which uses the 'Shibboleth' middleware (*2)" explains Assistant Professor Higashida, regarding their new approach. The Shibboleth-based system links IDs on the grid once IDs and passwords have been acquired, making it easy to acquire electronic certificates, promoting the use of grid services offered by each university. "It wouldn't be possible to offer services with a single certificate application and publishing contact for approximately 10,000 users. This is another of the advantages of coordinating IDs from individual universities over the network," explains Assistant Professor Higashida.

In addition to the activities above, the Grid Deployment and Operation Task Force is also considering security technologies and billing systems. They are surmounting the obstacles to real-world implementation, one obstacle at a time.

The Path NII Should Take as an Inter-University Research Institute

The CSI Grid project has entered its 3rd year. What role will be required of NII in the future in order to provide steady management and real-world usage deployment of projects like this?

Professor Aida explains NII's aspirations: "NII, as an inter-university research institute, plans to coordinate with individual universities, and continue grid infrastructure construction. Looking outside Japan, there is a global organization called the International Grid Trust Federation (IGTF), which defines the operation standards which should be implemented by grid certification authorities. Certificates published by IGTF certified grid certification authorities are valid worldwide. We are approaching the IGTF in order to gain the ability to publish universally usable certifications. In this way, NII hopes to take a proactive approach to global measures which are not feasible for individual universities." Assistant Professor Higashida also holds high hopes for an increased overseas presence, saying "All attempts in Japan before to establish a central international certification authority have been broken off mid-way. If we don't coordinate internationally as we build our grid, though, we won't be recognized outside Japan even when the grid is completed. NII hopes to attract global attention." Specially Appointed Associate Professor Kobayashi hints at the possibility of lateral deployment to many fields, saying "It has often been said that the grid can be of great use to research in the fields which work with massive quantities of data, such as physics and astronomy. I think the time has come, though, for us to look for ways in which it can be used by other fields as well."

Japan's academic grid is gradually expanding its scope, to the global stage, and new academic fields. We stand at a critical time, and NII will come to hold an even greater significance as the driving force behind this expansion.

(Written by Junichi Morimoto)

*1 NAREGI: As explained earlier, NAREGI is the name of a national project, but in a more limited sense can also be used, as it is in this article, to refer to the middleware created by the "NAREGI" project.

*2 Shibboleth authentication: Middleware for exchanging authentication information between organizations, and performing cross-organizational access control. Shibboleth was developed by the Internet2 computer networking consortium.

Formulating International Standard Specifications

A major key in the modern advance of science will be to what degree the world's massive stockpiles of knowledge, and corresponding infrastructures, can be shared and effectively utilized. However, the specifications used in the grid middleware with which these infrastructures were built vary, making it difficult to share resources through grid federation. We delve here into the efforts underway to standardize international specifications for federating grids.

Federating Grids is Impossible Without Common Specifications

Computer calculations and simulations are essential to the advancement of modern science. However, for large scale research and development, small systems owned by researchers, and even large systems owned by single organizations, may sometimes be insufficient and expensive and special testing equipment may be required.

The technology that offers the solution to these problems is grid computing. In grid computing, multiple universities and research centers are connected using high speed networks, and share a variety of research resources.

Several large scale grid infrastructures have already been constructed around the world. In Japan, the CSI Grid, a science grid created by NII, links 9 universities, granting them mutual use of each others resources (the results of the 2003 to 2008 NAREGI project. See P8-9 for details).

Kazushige Saga
Senior Technical Staff Member, Center for GRID Research and Development

In this age of international collaboration, the need for resources to be federated across national borders is understandably growing. In Japan, the RENKEI Project for e-science, successor to NAREGI, is underway (See P6-7 for details). NII is leading the way in research and development, including grid middleware for federating research lab level resources and large-scale resources in grid infrastructures. Senior Technical Staff Member Kazushige Saga of the NII Center for GRID Research and Development is working on resource federation between different types of grids.

"The middleware specifications used in grids vary from country to country and region to region. Grid resources cannot be federated just by networking them together. In order to federate and share grid resources, specifications must be standardized.

The NAREGI project was involved in research with the objective of international federation of research resources from its inception. It took a proactive approach, using still uncompleted international standards in the middleware it developed, and in 2005, one of NAREGI's sub-leaders, Professor Matsuoka of the Tokyo Institute of Technology, together with the leader of America's TeraGrid, called on the grid project leaders of other countries to hold a conference regarding mutual operation between differing grids. Ever since that conference, the importance of grid interoperation has been recognized globally, and this marked the start OGF's grid interoperation activities."

The OGF is a global grid computing standardization organization which holds three meetings per year, gathering together academic organizations and corporate researchers from around the world in order to hold discussions with the aim of defining global standard specifications.

Why Isn't the Academic Field Moving to the Cloud?

There was once business interest in grid computing, but now it has become almost the exclusive domain of the academic field. What brought about this course of events?

"One reason is probably that businesses moved to cloud computing."

For much business processing, a large percentage of the time consists of waiting for input and output processing. Multiple virtual CPUs can be assigned to one physical CPU, and used without any appreciable drop in processing performance of each virtual CPU. In other words, one computer can act as multiple computers, so cloud services can be used to hold down operation costs.

"On the other hand, in academic fields, especially science, the ratio of input and output processing is low in many applications. The CPU is often used continuously in computations that don't result in the CPU being available for other tasks. If multiple virtual CPUs are assigned to a single physical CPU for calculations such as this, the processing performance would plummet. So single computers cannot act as multiple computers, meaning that costs don't vary much from having your own system. This is not conductive to business. Another major problem, which has been nearing resolution in recent years, is that it takes time to pass data between physical and virtual interfaces, so it is hard to get high performance in large-scale scientific calculations due to computational device data transfer speed bottlenecks. Because of these factors, scientific computation is currently seldom being performed using cloud computing."

There is another factor which makes business deployment of grids difficult: the structural aspect of grids, in which many academic organizations offer their resources and act as a single virtual organization.

Government Holds the Key to the Development of the Grid

Let's look, then, at the state of grid environments in different countries and regions. Japan has a top class Internet infrastructure, but when it comes to the grid...

"Europe and America are strong when it comes to grid computing. The EU is especially strong, home to the world's largest grid environment, called the EGEE, in which 54 countries, 280 sites, and 16,000 people are participating. There are other large scale grids as well, such as DEISA and NorduGrid. There is also research underway regarding interoperating these three grids. The EU has also been proactive in advancing joint projects in Asian countries and Australia in order to have EU grids used by other countries as well.

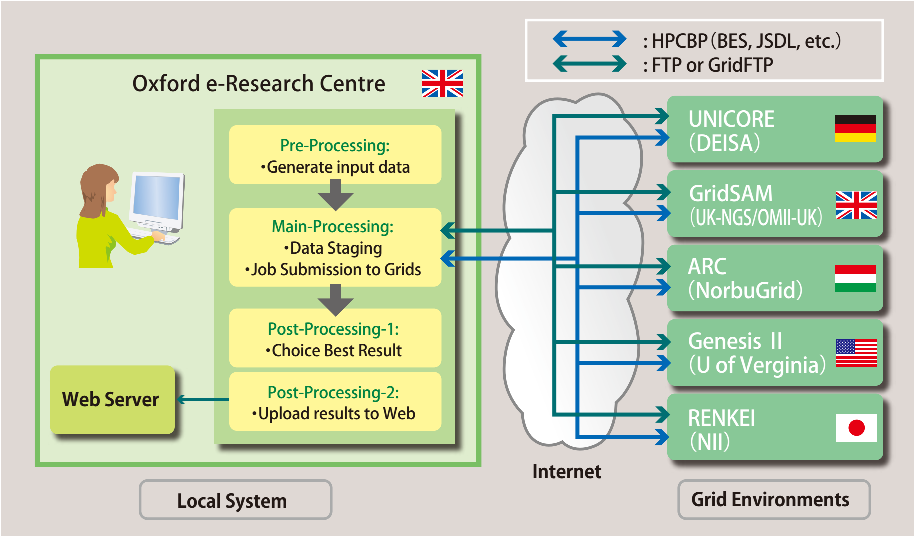
There is also a grid in America connecting major universities and national research institutes. It has fewer sites than EGEE, but resources in each individual site are quite large, and the grid is used by a large number of researchers."

As discussed earlier, Japan is home to grid created by NII and 9 universities, but it lags far behind Europe and America. Grid infrastructure creation requires not only computing centers and user awareness, but also the direction and support of the government.

"The primary reason for the EU grid's advanced position is that it is backed by a clear vision. In America, as well, large scale grid construction is underway by organizations such as the National Science Foundation (NSF), as well as the Department of Energy (DOE), and the Department of Defense (DOD), and they provide the funding necessary for building grid infrastructures and developing computational resources and operating costs."

In contrast, Japan is moving towards broadening its grid, but lacks the direction needed for effective utilization that matches the significant investment involved. One can only hope that the government gains a deeper awareness of the grid from the perspective of increasing international competitiveness.

Figure Experimental Verification of International Grid Federation UsingHPCBP Specification (Prototype)



Movements in the Standardization for Grid Interoperation

The size, and interest, in grids varies from country to country, but all countries now recognize the importance of international grid federation. How far along has grid federation come?

The OGF established working groups for grid interoperation in 2006. Last year, prototype implementations of a global standard specification (the HPCBP specification) were used to test the issuing of jobs from a UK grid to 5 other grids, including Japan's. The issued jobs were successfully processed by their respective grids, and the results were sent successfully back to the UK. The federation was structured as described below. On the UK side, a client supporting the HPCBP specification was used to issue jobs via the Internet to computational resources supporting the HPCBP specification in grids around the world. These resources performed the job's computations, and sent the results back to the UK client via the same route (Figure).

"However, problems were discovered with authentication and data staging (*1) in the current HPCBP specification. We confirmed that operation would have to be moved to the newly established PGI specification."

The OGF is currently developing the PGI specification, using what was learned from the results of the HPCBP experiment. The specification should have already been decided upon, but as there were diverse items to be considered, discussions are still underway as of mid-November.

Senior Technical Staff Member Saga has been active in discussions regarding specification formulation, and has submitted NAREGI and RENKEI requirements and test cases, as well as reporting on identified problems. This November, he was appointed co-chair of the GIN-CG (Grid Interoperation Now Community Group), which is responsible for carrying out testing such as interoperation testing. In the future, they plan on using the HPCBP specification prototype to test the issuing of jobs from RENKEI to other grid computational resources.

"In addition, I myself will continue middleware development at the practical level. To do that, the PGI specification needs to be finalized, so I will be taking an active part discussion, and help contribute to the prompt standardization of the specification."

Around the world, the development of exascale (*2) computers has become a topic of interest. The coordination of grids around the world, and mutual usage of their supercomputers, promises significant advances in fields requiring large scale computation, such as the high energy and bioscience fields. International coordination projects carry the seeds of our future discoveries. (Written by Yuko Sakurai)

*1 Data staging: Transferring of computational data and calculation results between computational resources, distributed storage, user environments, and the like.
*2 Exascale: In the computer field, this refers to processing speeds. The "exa" prefix means 10 to the 18th power. The fastest supercomputer in the world is "petascale" (peta: 10 to the 15th), so exascale refers to processing capabilities 1,000 times greater.