Interoperability between UNICORE and ITBL

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Abstract. The interoperability among different science grid systems is indispensable to worldwide use of a large-scale experimental facility as well as a large-scale supercomputer. One of the simplest ways to achieve the interoperability is to convert message among different science grid systems without modifying themselves. Under such consideration, the interoperability between UNICORE and ITBL (IT-Based Laboratory) has been achieved without modifying these grid systems by adopting a connection server which works as a mediator. Until international standardization is established, the method of message conversion among different science grid systems is promising as a way to establish the interoperability.

1 Introduction

Recently, there are some scientific global projects such as International Thermonuclear Experimental Reactor (ITER) as well as Conseil Europeen pour la Recherche Nucleaire (CERN). As the increase of global projects, the worldwide science grid environment which enables worldwide use of such a large-scale experimental facility becomes more necessary. To construct such an environment, the interoperability among different science grid systems is indispensable. A worldwide science grid environment is also expected to worldwide use of a large-scale supercomputer. In Japan, the national project (hereafter peta-scale supercomputer project) to develop and utilize the leading edge and multipurpose supercomputer begins in April 2006, where a 10 PFlops supercomputer is planned to be available around year 2010. The development and improvement of grid middleware is also situated in this project.

So far, as the most promising way to achieve international interoperability among different science grid systems, research and development of international standardization of grid systems have been promoted. The establishment of standardization makes it easier to interoperate different science grid systems. It also contributes to the enhancement of a grid system because each component of different grid systems can cooperate more flexibly with each other. However, since different types of grid system have already constructed by adopting various architectures in all the world, the standardization of all these systems demands their modification, which prevents users from continuing the development of their applications on these grid systems.

It is critical to keep operating existing science grid environments in which the users continuously develop and execute their applications. One of the simplest ways to achieve the interoperability with keeping their operations is to convert message among different grid systems without modifying themselves. Under such consideration, the interoperability between UNICORE and IT-Based Laboratory (ITBL) [1] has been tried.

ITBL project is a national project placed as one of the e-Japan Priority Policy Program to realize the e-Japan Strategy which sets goals to make Japan the world's most advanced IT nation. ITBL project was launched at April 2001 by six institutes: the National Institute for Materials Science (NIMS), the National Research Institute for Earth Science and Disaster Prevention (NIED), Japan Aerospace Exploration Agency (JAXA), the Institute of Physical and Chemical Research (known as RIKEN), Japan Science and Technology Agency (JST), and Japan Atomic Energy Agency (JAEA) and has been carried out to March 2006 as 5 years' plan. The objective of ITBL project is to establish virtual laboratories in which researchers in various disciplines can collaboratively develop highly sophisticated simulation systems by fully utilizing computer resources located in high-speed network. To achieve this, ITBL project has been classified roughly into 4 activities; development of applications, development of system infrastructure software, maintenance of shared facility including a supercomputer, and promotion activity.

Center for Computational Science and E-systems of Japan Atomic Energy Agency (CCSE/JAEA) has developed ITBL middleware as ITBL system infrastructure software and has operated it since April 2003. Tools of ITBL middleware enable secure communication among plural supercomputers via internet (STARPC: Seamless Thinking Aide Remote Procedure Call), parallel computation between different types of supercomputer (STAMPI: Seamless Thinking Aide Message Passing Interface), job control on distributed computational environment (TME: Task Mapping Editor), parallel and distributed visualization (AVS/ITBL) and so on [1]. Researchers can use these tools on the Web browser.

Figure 1 shows the overview of the ITBL environment. At the end of the project (March 2006), 600 researchers from 77 organizations participate in ITBL project and ITBL middleware integrates about 1/5 (45 TFlops) of all the computer resources owned by the institutes and the universities for scientific research in Japan. These resources consist of 25 computers from 13 sites (10 organizations and 3 areas of JAEA). CCSE/JAEA keeps operating ITBL middleware to maintain the ITBL environment and contributes to the establishment of a backbone grid environment in the peta-scale supercomputer project launched at April 2006.

Uniform Interface to Computing Resources (UNICORE) [2] is one of the representative grid middleware. It has been developed in UNICORE project and

UNICORE Plus project [2] of Germany and improved in EUROGRID project [3] and GRID project [4] of EU and now further improved in UniGrids project [5]. And UNICORE is used in High Performance Computing Center in Stuttgart (HLRS), Germany with which CCSE/JAEA has collaborates since 1999. Thus we have selected UNICORE as a first step towards international interoperability with ITBL.

Also in Japan, UNICORE has been used in National Research Grid Initiative (NAREGI) project [6]. This project has been carried out from April 2003 to March 2006, aimed at developing infrastructure software of sufficient quality to become an international standard. This infrastructure software is also expected to contribute to the development and improvement of grid middleware in the peta-scale supercomputer project. Therefore, the interoperability between UNICORE and ITBL is also meaningful to enhance the Japanese science grid environment.

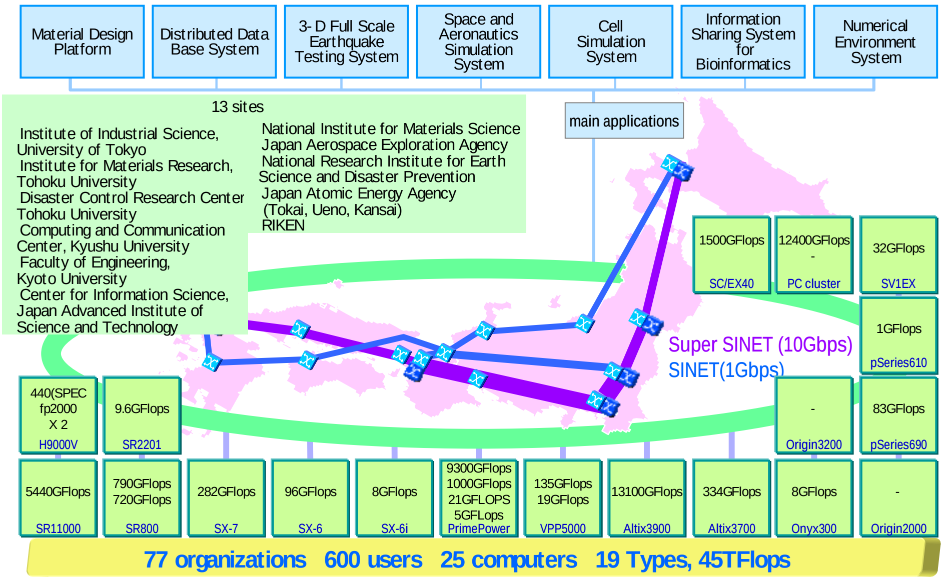

Material Design Platform
Distributed Data Base System
3- D Full Scale Earthquake Testing System
Space and Aeronautics Simulation System
Cell Simulation System
Information Sharing System for Bioinformatics
Numerical Environment System
main applications
13 sites
Institute of Industrial Science, University of Tokyo
Institute for Materials Research, Tohoku University
Disaster Control Research Center Tohoku University
Computing and Communication Center, Kyushu University
Faculty of Engineering, Kyoto University
Center for Information Science, Japan Advanced Institute of Science and Technology
National Institute for Materials Science
Japan Aerospace Exploration Agency
National Research Institute for Earth Science and Disaster Prevention
Japan Atomic Energy Agency (Tokai, Ueno, Kansai)
RIKEN
Super SINET (10Gbps)
SINET(1Gbps)
1500GFlops SC/EX40
12400GFlops - PC cluster
32GFlops SV1EX
1GFlops pSeries610
440(SPEC fp2000 X 2 H9000V
9.6GFlops SR2201
- Origin3200
83GFlops pSeries690
5440GFlops SR11000
790GFlops 720GFlops SR800
282GFlops SX-7
96GFlops SX-6
8GFlops SX-6i
9300GFlops 1000GFlops 21GFLOPS 5GFLops PrimePower
135GFlops 19GFlops VPP5000
13100GFlops Altix3900
334GFlops Altix3700
8GFlops Onyx300
- Origin2000
77 organizations 600 users 25 computers 19 Types, 45TFlops

Fig. 1. Overview of the ITBL environment. 600 users from 77 organizations share 25 computers containing 19 types ones from 13 sites (11 organizations and 3 areas of JAEA). Main applications developed in ITBL project are also shown.

2 Main Function

As a main function of the interoperability between UNICORE and ITBL, we have achieved a job submission with each other. Namely, ITBL users can submit a job to any computer under UNICORE (Vsite) by using Task Mapping Editor (TME) [7, 8] which is a work flow tool on ITBL middleware. And UNICORE users can submit a job to any computer under ITBL (ITBL computer) by using a client graphic user interface (GUI) of UNICORE.

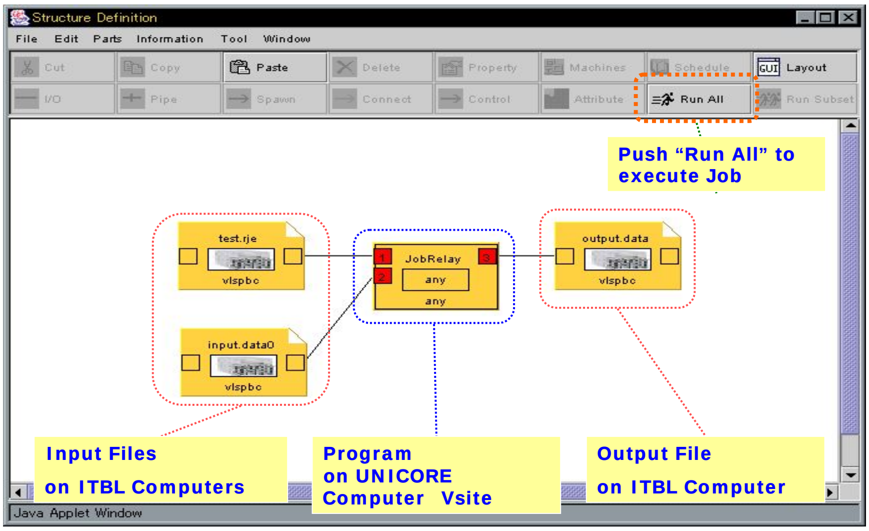
TME has a function to define, execute and monitor a scenario of job submissions, program executions and input/output file transfers over ITBL computers. Most of the applications developed on ITBL use the function of TME. Therefore, most of ITBL users can use any Vsite in the same manner. We have installed the following functions.

- Conversion of request from TME into Abstract Job Object (AJO)
- Submission of converted AJO into UNICORE
- Mutual transfer of input/output file
- Monitoring a program execution

Here, AJO is the Java object created when the job is submitted from the client GUI of UNICORE.

TME has the GUI to define programs and input/output files as an individual module and to connect them to be one scenario. Using the module which defines the program (program execution module), users can specify the computer to execute the program. In the same manner, users can specify the Vsite and execute the program (executable software) on it. Figure 2 shows an example of the work flow using the Vsite. Here, data on the ITBL computer is an input file (the module at the lower left in figure 2), the program is executed on the Vsite (the module in the middle) and data is output as an output file on the ITBL computer (the module on the right).

It should be noted that users have to set the input file which defines the program execution on the Vsite as a module (the module at the upper left).



Push "Run All" to execute Job

Input Files on ITBL Computers

Program on UNICORE Computer Vsite

Output File on ITBL Computer

Fig. 2. The GUI of TME. A program (executable software) executed on UNICORE computer (Vsite) is defined as a module of TME

Inversely, UNICORE users can use any ITBL computer. We have installed the following functions.

- Recognition of ITBL site as an UNICORE site (Usite)

– Conversion of AJO into ITBL’s request
– Mutual transfer of input/output file
– Monitoring a program execution

Figure 3 shows an example of the work flow using the ITBL computer from the client GUI of UNICORE. Here, data on the Vsite is an input file (the module at the upper in figure 3), the program is executed on the ITBL computer (the module in the middle) and data is output as an output file on the Vsite (the module at the bottom).

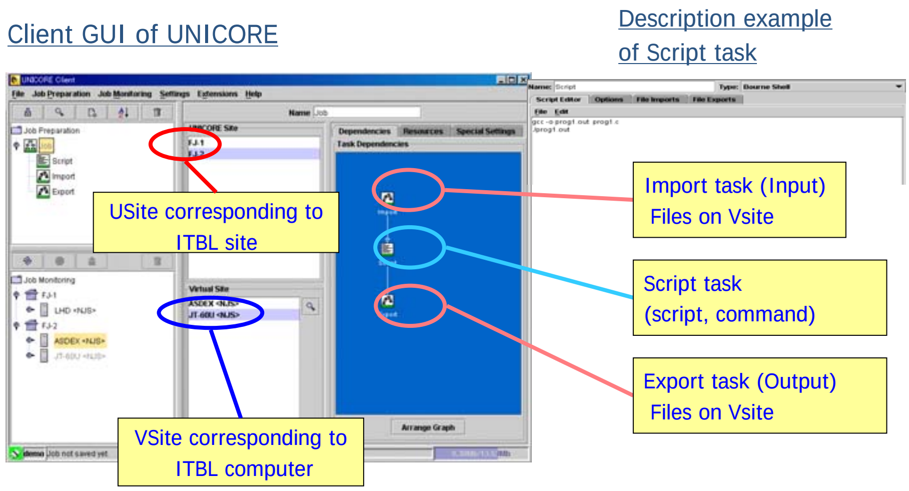


Fig. 3. The GUI of UNICORE client and the description example of script task.

3 Architecture

To achieve the above function without modifying architectures of UNICORE middleware and ITBL middleware, we have adopted a connection server which works as a mediator between these two systems. Both in UNICORE and ITBL, each site has one gateway server respectively. Thus, it is appropriate to prepare the virtual server to enable to change the way of accessing the computers.

The architecture to achieve the interoperability is shown in Figure 4. To control the job on any Vsite from the client GUI of ITBL (TME), we installed in the connection server "UNICORE collaboration tool" which consists of "Job Relay Servlet", "UNICORE Collaboration Interface" and "UNICORE Collaboration Module". Here is the brief process to submit the job from the client GUI of ITBL to the Vsite.

1. The request from the client GUI of ITBL to an Usite is received by the Job Relay Servlet.
2. The Job Relay Servlet calls the UNICORE Collaboration interface on the connection server by way of RMI (Remote Method Invocation) according to the request.

3. The ITBL certificate is connected with the UNICORE certificate.
4. The UNICORE Collaboration Module generates AJO according to the request information, the authentication using this UNICORE certificate is performed on the UNICORE server, and then the AJO is submitted to the Usite. After processing at the Usite, a result of the AJO request is returned to UNICORE Collaboration Module.
5. The result is relayed to Job Relay Servlet, and is returned to the client GUI.

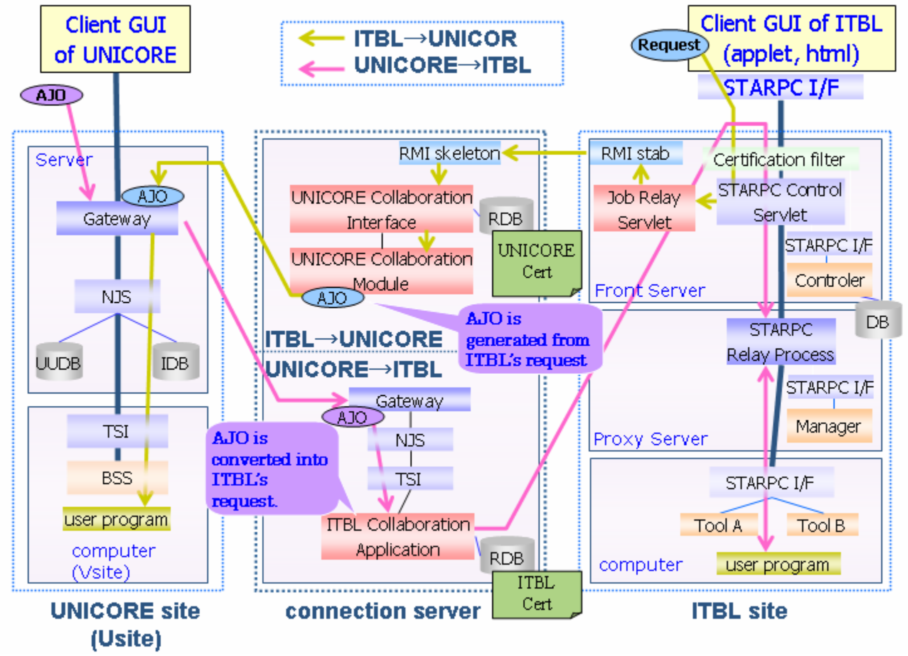


Fig. 4. Architecture of interoperability between UNICORE middleware and ITBLmiddleware.

Inversely, in order to control the job on ITBL computers from the client GUI of UNICORE, we installed in the connection server the similar system to the UNICORE and "ITBL collaboration application" that manages job submission, job cancellation and status acquisition on ITBL computers based on the information from TSI (Target System Interface).

As the process to execute the program on the ITBL computer, the following procedures are executed in the connection server:
1. Gateway checks the certification attached to AJO and transfers the request to NJS (Network Job Supervisor) which is located inside the firewall.
2. NJS receives AJO certified by Gateway, checks with UUDB (UNICORE User Data Base) whether it is possible to login to the computer resource, converts (embodies) AJO into the job executable on the computer and forwards the request to TSI.

3. ITBL collaboration application converts information from TSI in order to submit the job to the ITBL computer.
4. The UNICORE certificate is connected with the ITBL certificate, and then the authentication using this ITBL certificate is performed on the ITBL server.
5. The job is submitted to the ITBL computer.
6. The result is returned to the client GUI of UNICORE.

Here, procedures from 1 to 3 are the same as those when a program is executed in UNICORE.

Finally in this section, we mention the certification method. Both UNICORE and ITBL use X.509 certificate. As the realization of this interoperability, users can use two grid environments with single sign-on, if they are allowed to use both systems (namely they have to have both certificates). Shown in the previous procedures, when ITBL users access the Vsite, ITBL certificate is converted to UNICORE certificate by UNICORE Collaboration Module. On the other hand, when UNICORE users access the ITBL computer, UNICORE certificate is converted to ITBL certificate by ITBL Collaboration Application.

ITBL adopts HTTPS protocol when users access the ITBL (Front) Server located in DMZ (DeMilitarized Zone). The connection server is also located in the same DMZ. SSL protocol is adopted for the communication between UNICORE server and communication server. Consequently, the secure communication based on SSL encryption is guaranteed.

4 Examination

We evaluate the time for job submission between two systems. To evaluate that, we use the ‘date’ command described in a shell script as the executing job. In addition, we use the same machine for Vsite and ITBL computer. Table 1 shows the time from beginning the operation for job submission to getting the message of job completion for four cases. In case 1 (using only UNICORE), it takes 9 seconds totally. Since the time of job execution is less than 1 second (shown in case 3), it takes about 7 seconds to get the message of job completion. In case 2 (UNICORE to ITBL), it takes 56 seconds from job submission to beginning of job execution (procedure 1, 2, 3 and 4 mentioned in the previous section). This is mainly for the authentication to access ITBL (procedure 4 mentioned in the previous section). It is 72 seconds from the beginning of job execution to getting message of job completion. The reason why it takes longer is that the message of job completion got in ITBL is converted to AJO.

Tab. 1. Evaluation of the time for job submission between UNICORE and ITBL.

	Job submission	Beginning of job execution	Getting message of job completion
1. UNICORE only	00:01	00:02	00:09
2. UNICORE to ITBL	00:01	00:57	02:09
3. ITBL only	00:03	-	00:03
4. ITBL to UNICORE	00:10	-	01:08

It takes longer time for job submission from ITBL to UNICORE based on the similar reason. The reason why the case2 is longer than the case4 is that it takes longer time for ITBL to authenticate the certificate. Since these times are enough shorter than that of the usual job execution as well as the data transfer, these delays do not become the bottleneck. The huge data transfer caused by large-scale simulations via Internet is serious problem regardless of interoperability. This is beyond the scope of this paper and requires further study.

To further evaluate the constructed functions we have applied them into UNICORE of HLRS, Germany under the international cooperation between HLRS and CCSE/JAEA. As a result, the science grid environment enabling to interoperate SX-8 of HLRS and the 25 computers of ITBL has been constructed. Now we have been installing the assembled-structure analysis program (we call it ITBLFEM) in 4 computers: Altix3700Bx2 in Tokai Research and Development Center of JAEA, SX-6 and pSeries690 in CCSE of JAEA, and SX-8 in HLRS. ITBLFEM has been developed on ITBL environment to contribute to the safety of the nuclear power plant in case of extra large-scale earthquake. The results will be described in our future paper.

5 Related works

There have been the GRIP and the UniGrids as related works. The GRIP has been carried out for 2 years from January 2002 to December 2003. The UniGrids, which is placed as one of the 6th framework program Specific Targeted Research Project (STREP), has been carried out for 2 years from July 2004. These projects aim at the realization of the interoperability of UNICORE and Globus [9]. The research and development for standardization have also been addressed. Both projects enable UNICORE users to utilize computers managed by Globus. Here, the standardization of these systems (especially for UNICORE in the GRIP) demands their modification.

6 Summary

We have achieved the interoperability between UNICORE and ITBL by adopting a connection server which works as a mediator between these different grid systems. The advantage of this method is that both systems need not be modified. By realizing the interoperability, ITBL users can control a job on any UNICORE computer from the GUI of TME, which is the work flow tool of ITBL, and UNICORE users can control a job on any ITBL computer from the client GUI of UNICORE.

Applying this function to UNICORE in HLRS of Germany, we have constructed the science grid environment interoperating the SX-8 in HLRS and SX-6, pSeries690, and Altix3900 in JAEA. The method of message conversion among different science grid systems is promising as a way to establish the interoperability until international standardization is established.

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