



Prospects for e-Science in Korea : The role and impacts of Korea-UK collaboration

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<Summary>

The Korea · UK e-Science Collaboration project has been aimed at supporting research and collaboration between Korean and UK researchers. Its goal is to benefit the nation by reducing cost and time in constructing the National e-Science Research Environment' by studying and benchmarking the cases in countries that have already procured advanced technologies in the area. Two joint workshops were held in a year where researchers from the two countries had the opportunities to share their research results with each other. Also, the project has supported exchanges of researchers fostering expertise in the field. In the course of the project, the e-Science Centre in the UK and KISTI have signed MoU(Memorandum of Understanding) in 2006. Moreover, there have been active research collaboration between Korea and the UK. The University of Southampton will share the BioSimGrid data

with the Korean counterpart, and the University of York has provided the AURA software. In the future, KISTI and the UK NGS(National Grid Service) will organize a working group at OGF that will work mainly on the standardization of Parameter Sweep and bring it to lead the global standard. KISTI will include its own AURORA system into OMI-UK software stack, which will enable access to NGS resources through AURORA user application. The collaboration with the UK has opened up more opportunities for collaboration with other countries as well. KISTI and HLRS in Germany have agreed to share the COVISE and will have research exchanges. As such, it is expected that Korea will play a major role in e-Science research by building strategic and systematic collaborative relations with its international partners.

1. Introduction

e-Science research environment has been promoted as a national vision for building the nation's global competitiveness in science and technology. The United States, the United Kingdom, and other countries including China are carrying out e-Science projects in order to strengthen the national competitiveness through convergence of science and information technology. Korea, with its world leading internet infrastructure, supercomputing and other experimental resources, has a firm basis where e-Science can be successfully carried out.

e-Science is a new research paradigm based on grid computing and large scale data sharing technologies. It supports the use of research resources that are required by big sciences such as aerospace science, bioscience, high-energy physics and meteorology, by enabling collaborative and interdisciplinary researches. In fact, many researchers around the world in computing and application fields are carrying out researches that are aimed at sharing research resources such as computing infrastructure, application software and data. For example, computational fluid dynamics in aerospace science requires the use of as much computing power as possible in order to lessen the time spent for the research. If the large amount of data produced in the course of researches are put into a database, future researches on various analyses of fluid dynamics may benefit from easy access to the data without having to go through the same research processes that were already carried out by other scientists. If this is extended to

global level collaboration, e-Science through integration of computational grid and data grid will open up new possibilities for various researches within the mid to long term period in aerospace science.

In the national e-Science project, more than 60 researchers from around 20 organizations including KISTI are participating and collaborating with overseas counterparts. Also, collaboration between researchers in Seoul and Daejeon has been better supported with a web service technology which has been developed to control jobs submitted to shared resources from remote sites. For the development of the technology, KISTI has collaborated with the Cardiff University in the UK, Louisiana State University in the US and Max-Planck Institute in Germany. However, KISTI was first to apply it to aerospace science.

In order to bring the national e-Science project to contribute to advancing global e-Science, it is important to actively participate in global science and technology activities with openness, as well as to lead the construction of the next generation environment of global standard.

Thus, the Korea-UK e-Science Collaboration project has been aimed at supporting research and collaboration between Korean and UK researchers. Its goal is to benefit the nation by reducing cost and time in constructing the National e-Science Research Environment' by studying and benchmarking the cases in countries that have already procured advanced technologies in the area. Two joint workshops were held in a year where researchers from the two countries had the opportunities to share

their research results with each other. Also, the project has supported exchanges of researchers fostering expertise in the field.

2. Technology development trends for e-Science

2.1 Domestic trend

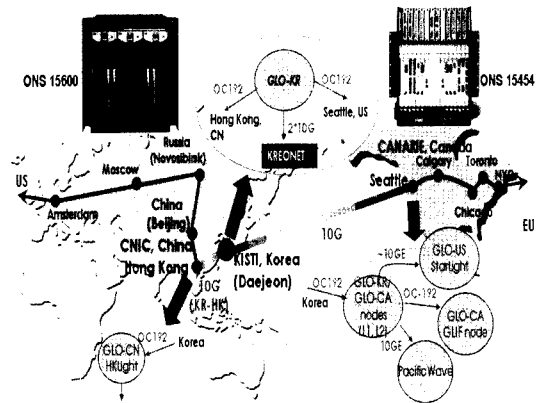
2.1.1 High performance Research Network Infrastructure

International research network infrastructure is comprised of GLORIAD and TEIN: the Global Ring Network for Advanced Application Development (GLORIAD) connects the US, Europe and Asia with 10 Gbps Fiber Ring. The Trans-Eurasia Information Network (TEIN) connects Europe and Asia. The GLORIAD is a global collaborative research network for which six countries-Korea, US, China, Russia, Canada and Netherlands-are closely collaborating. On this network, researchers can freely access and share large amount of information and high-end research instruments. Approximately 200 research organizations in Korea are participating and making use of the GLORIAD, especially in the areas of high-energy physics and biotechnology, as well as in the e-Science based projects such as International Thermonuclear Experimental Reactor project and OptIPuter.

2.1.2 National e-Science Project

A. Overview of the Project

The National e-Science Project aims to build and advance the e-Science environment that will significantly enhance research productivity by 2011. Korea seeks to bring its capacity up to the level of the leading countries such as US,



(Figure 1) GLORIAD

UK, Germany and Japan. The main activities include development of 12 e-Science generic software for visualization services and other scientific fields, as well as remote sharing of search resources. Also, collaborative projects in 5 application areas including biotechnology and aerospace science have been carried out.

B. e-Science technology development

• Generic software development(4 types)

Visualization Service: Skeletal Function
Service Framework: System Language
Support Service Framework: Utility function
Service Framework

• Deployment and improvement of generic software (8 types)

Generic SW API, Collaborative Work Environment, Portal Toolkit, Fault Management, Work Management, Information Service, Resource Management, Data Management

• Scientific workflow technology

e-Science workflow enactment service, Resource connecting component for integrated e-Science service workbench, workflow language for e-Science service based process modelling, e-Science workbench, e-Science

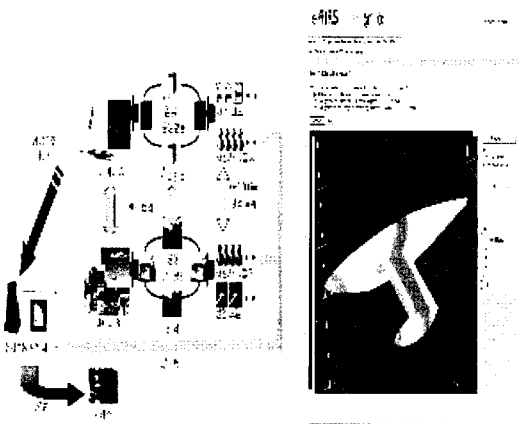
service repository, e-Science workbench actor client applications.

- Data farm technology

Setting up of ALICE Tier2 Center, International technology development for WISDOM(World-wide In Silico Docking On Malaria)

C. Application projects for construction and implementation of e-Science environment

- Construction of e-Science test environment using High-voltage electron microscope (HVEM)
- Construction of e-Science environment for meteorological information system
- Development of e-Science based aerospace numerical wind tunnel
- Development of e-Science environment for HG2C(Human Genome to Chemicals for Drug Discovery), based on a service oriented structure
- Development of Molecular simulation e-Science research infrastructure and e-Glycoconjugates



(Figure 2) Development of e-Science based aerospace numerical wind tunnel(e-AIRS)

2.2. Overseas trend

2.2.1 United States

◆ NSF(National Science Foundation)¹⁾

A. Major activities

- Development of CI(Cyberinfrastructure) for human(meaning researchers, students, public, etc) centered science and technology researches and education opportunities
- Provision of world-class CI tool and services to science and technology communities
- Construction of peta-scale high performance computing environment
- Data, data analysis and visualization
- Virtual organization for integrating dispersed communities
- Education and human resource development
- Promotion of CI for strengthening national competitiveness in all areas of science and technology
- Provision of CI which will evolve into a national infrastructure essential for science and technology researches and education with high level of security, efficiency, reliability, applicability and interoperability
- Development and provision of stable and scalable CI environment for research and education community that will contribute to realizing NSF's mission

B. Project period

- 2006 ~ 2010(5years)

C. Organizational structure

- NSF recognizes CI as a core field for the next

1) Summary of Cyber Infrastructure Vision for 21st Century Discovery(NSF, 2007)

generation research environment, and has established the Office of CyberInfrastructure (OCI) in 2005. The OCI carries out national strategies in the field.

2.2.2 United Kingdom

◆ UK e-Science

A. Overview

- In the UK, Grid is considered as part of e-Science Programme, which will serve as an infrastructure and tool for the realization of e-Science

- e-Science Programme aims to integrate the infrastructure required by industry and research institutes in the UK

B. Structure

- The National e-Science Centre(NeSC) in Edinburgh administers the "National Grid" of computing/data resources

- All the projects in the UK uses Globus Toolkit

- The Center operates seminar programs that focus on international collaborative researches in various fields.

a) Manages network for grid technology

b) Organizes meetings between UK and OGF

c) Coordinates collaboration among different Grid centers and e-Science testbed

- There are 8 regional centers which collaborate with industry and provide physical resources and information to the Grid application developers

- The UK e-Science Programme has supported more than 270 projects

C. Core programme

- Technical area of e-Science Programme

- Currently focusing on development of data grid using OGSA-DAI software included in various grid toolkit

- Main function

- National e-Science center coordinates activities around regional grid centers

- Supports community activities in the UK

- Operate OMII (Open Middleware Infrastructure Institute)

- Operates DCC (Digital Curation Centre)

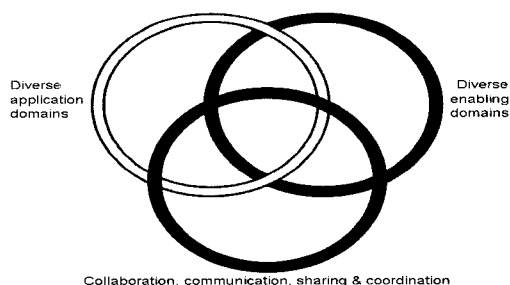
a) Responsible for secure management of and services with science related digital data and documents in the UK

- Performs successful model of e-Science

- Active participation in international grid projects and activities

D. 2007 UK e-Science

- Provides vision for research environment for enabling collaborative researches in various application areas by sharing information and resources, which will lead to an advancement of future e-Science



(Figure 3) Strengths of e-Science

3. R&D activities and successful outcomes

3.1 Korea · UK collaboration

3.1.1 Visiting research at an e-Science Regional Center, University of Southampton

- Time : December 19, 2007
- Correspondents: Professor Simon Cox, Dr. Steven Johnston
- Objectives: To learn about and collaborate with BioSimGrid's current community activities and construction of data sharing system for 'Building e-Science environment for bioscience'
- Discussion
 - Introduction to inner organizational structure of BioSimGrid
 - Current activities of BioSimGrid
 - Around 60 scientists from 5 universities including Oxford, York and Southampton are participating in the BioSimGrid activities. More than 300 data for molecular simulation pathway are being produced. Among the 300, about 100 data are considered as reliable. The average size of pathway data is approximately 18GB, while mmCIF data format is used for saving the data. They are currently seeking for possible collaboration with the European Bioinformatics Institute(EBI).
 - Not all data are open to public as researchers have the property rights of data. However, it could be accessible through a selective process.
 - Outcomes : Agreement on sharing data with BioSimGrid (Professor Simon Cox at the University of Southampton)

3.1.2 Meeting with IT Center at the University of York

- Time : December 20, 2007
- Correspondents: Professor Jim Austin, John McAvoy
- Objectives: To discuss possible collaboration, especially the employment of AURA (Advanced Uncertain Reasoning Architecture) technology for the construction of e-Science

environment

- Discussion
 - Introduction of AURA, inner structure and applicability of the technology
 - Outcomes : DAME (Distributed Aircraft Maintenance Environment), which has been developed for diagnosing aircraft engine cannot be provided to KISTI as it is under the property of Rolls-Royce. However, AURA software can be provided for research purposes, and research collaboration is possible.

3.1.3 UK e-Science All Hands Meeting 2006/2007

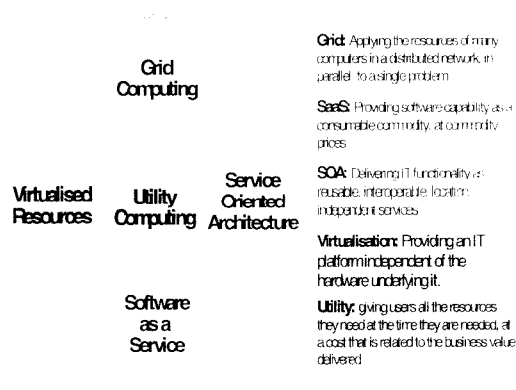
A. Memorandum of Understanding between Korea and UK e-Science

The Korea Institute of Science and Technology Information(Direcotr of 2006 National e-Science Project, Jysoo Lee) and the UK e-Science Center (Malcolm Atkinson, the UK e-Science envoy) signed MoU at the UK e-Science All Hands Meeting (Nottingham, UK).

B. Activities at All Hands Meeting

- UK e-Science communities
 - NGS(National Grid Service) 2007
 - a) Launch of NGS2
 - b) Introduction of new members (Queens University Belfast, University of Southamton, and Imperial College)
 - OMII-UK Community
 - a) Virtual lab for e-Science
 - b) Secure access to census data
 - c) Development of applications to be run on the NGS
 - d) Support pen source software
 - e) WHIP(Workflow Hosted in Portals)

- Grid computing
- Interoperability
- Various middlewares such as gLite, Globus Toolkit 4, UNICORE and CROWN have each of their own way of approaches to application description, work submit language, security and others.
- Various projects have been implemented in order to achieve interoperability among different infrastructures such as OMII-Europe, gEclipse, GridSAM, and GridWay.



(Figure 4) e-Science IT Infrastructure

C. R&D in UK e-Science regional centers and IT Center

• BioSimGrid

Molecular dynamics simulation enables comparative analysis of biomolecular structure and amends experimental methods. However, lack of database is being a barrier towards advancing simulation. Protein Data Bank(PDB) only admits structures produced by experimental methods and excludes those done through theoretical methods. Thus, the aim of the BioSimGrid is to enlarge the scope of the PDB to include the molecular dynamics simulation trajectory. The database will then be useful to both theoretical and experimental

scientists.

• AURA

AURA(Advanced Uncertain Reasoning Architecture) consists of various technologies that support high-speed search and matching computation. The core of the system is relatively simple, but it is based on a binary neural network called CMM(Correlation Matrix Memory). The CMM enables efficient and high-speed computation. AURA provides other various useful functions as well such as searching and storing of wide range of data, and communications between external and internal representations from a wide range of data types.

3.2 Theme-specific workshops

3.2.1 2007 Korea-UK e-Science Workshop

At the UK All Hands Meeting in September 2007, KISTI and Dr. Malcolm Atkinson agreed upon holding Korea-UK e-Science Workshop during the Supercomputing Conference 2007 (SC'07). Due to changes in Dr. Malcolm Atkinson's schedule, Dr. Neil Chue Hong, Director of OMII-UK organized the 2007 Korea-UK e-Science together with KISTI.

The workshop began with Dr. Ok Hwan Byeon's welcome address, who is in charge of the Korean e-Science project. 4 researchers from each country gave presentations on the introduction of e-Science project, high-energy physics, GeoScience and software development.

There were around 20 participants from the two countries: 8 people including 4 researchers from the UK, and about 10 people from Korea. The workshop took place at KISTI booth, and there were more participants than had been

expected, which led the workshop quite successful.

3.2.2 2007 International aerospace e-Science Workshop

Aerospace science is being considered as a killer application in e-Science as it provides a new research area where computation, experimentation, and theory can be used in an integrated form. Various researches are being carried out at national level in the EU, US, UK, Germany and others. The research has wide range of impact as it incorporates studies from basic to applied science through interdisciplinary researches in fluid, structure, control, and so on.

In Korea, e-AIRS R&D projects and various other projects related to e-Science are being carried out in industry, universities and research institutes.

2007 International e-Science Aerospace Workshop has been a collaborative meeting providing opportunities for international collaboration which is key to e-Science.

The Workshop was held during December 5-6, 2007 at KISTI, Daejeon, Korea. More than 50 people from universities, industry and research institutes, and e-Science professionals from the UK, US and Germany participated in the Workshop. Dr. Tom Jackson, DAME project leader from the UK also attended the workshop. e-Science activities of aerospace field in Korea and other countries were introduced, and discussions regarding international collaboration were held.

3.3 Research exchange

3.3.1 Development of CFD solver through Cactus

framework and international collaboration

A. International collaborative research

Cactus is one of the major open source codes which has been developed since 1990s with an aim of unifying numerical analysis codes in astrophysics area. However, as its development was intended for wide use, basic frame can be applied to other areas that share similar structures of numerical analysis codes such as computational fluid dynamics, chemistry, and quantum mechanics. Since 2000 Cactus has been actively developed to meet the needs for multidisciplinary collaborative researches.

KISTI has been developing Cactus problem solving environment for computational fluid dynamics. KISTI researchers have made improvements in the problem solving environment of Cactus which has allowed numerical analysis of 3D coordinates of an object such as a wing of an aeroplane. On the basis of this research, KISTI has been collaborating with the Louisiana State University and Cardiff University in the UK to generalize and improve the structure of a problem solving environment for fluid dynamics research. In 2005, a Korean researcher as a visiting scholar in the US has carried out improvements in compressible fluid flow analysis as well as basic research for solving problems in incompressible and abnormal grid conditions. Such work has been enhanced through collaboration with the researchers in the UK and the US who have also paid visits to KISTI in 2006. Through the collaborative researches, analysis of actual application model has been carried out, and interactive roles for the research groups in each country could be

assigned. KISTI and the Cardiff University have collaborated on making improvements in compressible fluid flow analysis, and they are currently together working on computational fluid dynamics analysis around a Smart UAV(Unmanned Aerial Vehicle) which is currently under development. The Louisiana State University in the US and Max-Planck Institute in Germany have focused on the development of a module for incompressible fluid flow analysis, and dealt with problems of cavity flow and vortex around rectangular cylinders.

B. R&D

KISTI has led the application of Cactus toolkit for compressible fluid flow analysis on 3D compressible fluid flow analysis since 2003. Since 2005, the research has been extended to include the Cardiff University and the Louisiana State University as collaborators. For the computation, compressible 3D Navier-Stokes equation and $k-\omega$ SST 2-equation model have been used. AUSMPW+ scheme was used in spatial discretization while LU-8G8 was employed for time integration.

KISTI has also developed coordinate transformation module for flexible application to both fixed coordinates and body coordinates, which had not been possible with Cactus. As a result, it has enabled complex fluid flow analysis in aerospace in addition to its function for computational analysis using rectangular coordinates in astrophysics.

IV. Conclusion

4.1 Contribution to related fields

4.1.1 Leadership role in OGF standardization and collaborate with OMII-UK

As a follow-up from the Korea-UK e-Science Workshop, KISTI and Dr. David Meredith from UK have agreed to continue the collaborative efforts in research. Dr. David Meredith has worked on the NGS Application Repository Portal. NGS Job Portal does not yet support Parameter Sweep Application, although it plans to. KISTI's AURORA system, on the other hand supports the Parameter Sweep Application, which provides a positive outlook for further collaboration between KISTI and STFC(Science and Technology Facilities Council). NGS has the infrastructure and application where Parameter Sweep can be run, while KISTI has an experience in developing a prototype system that supports Parameter Sweep Application, where JSDL(Job Submission Description Language) is extended in order to provide better support for parameter sweep. As such, it is expected to produce a synergetic effect through the collaboration.

Parameter Sweep Application is one of the major applications, and many e-Science systems have been developed to support the application. However, since there is no standard for supporting the Parameter Sweep Application, supporting systems have been developed independently, lacking interoperability as a result. Therefore, interoperability needs to be sought with standardization efforts at Grid and e-Science standards related organizations such as OGF. There is no working group currently working on this standardization process. It is hoped that KISTI and NGS will form an OGF

working group in the near future that will lead to advancement of a Parameter Sweep international standard. Michel from Fujitsu Europe in the UK has written a draft for the OGF standardization of JSDL Parameter Sweep Extension. There could also be further positive impacts, if a collaborative work with Michel could be achieved.

OMII-UK is a collaboration between e-Science centers at Southampton, Edinburgh and Manchester. Its goal is to provide stable and interoperable open source Grid middleware in order to bring about successful results in the UK e-Science project. OMII-3 which was launched in July 2006 provides an infrastructure that enables collaboration among users, grid resources, and application providers. The OMII-3 can be described in short as having two standard components: Web Service and Grid Service. KISTI will seek collaboration with OMII-UK as well as NGS, and thus include AURORA system developed by KISTI in the OMII-UK software stack. On successful collaboration, researchers may access NGS resources by using AURORA user application. Issues regarding future collaboration have been discussed with Dr. Neil Hong, Director of OMII-UK during the 2007 Korea-UK e-Science Workshop.

4.1.2 Future collaboration following International Aerospace e-Science Workshop and expected impacts

It has been agreed that the DAME (Distributed Aircraft Maintenance Environment)'s search engine library shall be provided to KISTI for research use, and that KISTI will transfer e-AIRS technology to the UK

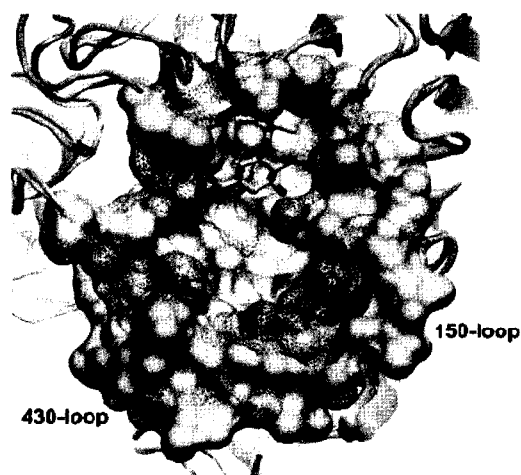
counterparts. Also, Korea will hold an international workshop and invite researchers from UK in 2009. The High Performance Computing Center Stuttgart(HLRS) has agreed to provide KISTI with COVISE (Collaborative Visualization and Simulation Environment) software so that KISTI will be able to use the source code in its research (In case of buying the software, it may cost around \$100,000). There will also be researcher exchanges, and KISTI will collaborate with German Aerospace Centre(DLR) as well as HLRS. They have also agreed to write a joint project proposal. Furthermore, KISTI will discuss further collaboration possibilities on visualization, Cyber Infrastructure and GeoScience with NCSA(National Center for Supercomputing Applications) in the US.

4.2 Future use of R&D results

Current projects at KISTI are focusing on bioscience, aerospace science, high-energy physics and meteorology in carrying out the 'Construction of National e-Science Environment' project. The results from the collaboration with the UK can be applied to bioscience area as will be explained in the following section.

4.2.1 Future use of BioSimGrid and AURA for biomolecular structure research

BioSimGrid can be used for molecular simulation aimed at new drug candidate discovery. The e-Science research projects in 2008 are focusing on the construction of research environment for developing a vaccine against bird flu virus as well as the medicine.



(Figure 5) Comparison of N1 inhibitor-binding pocket

BioSimGrid will be used at an *in silico* stage for supplementing docking tests. (Figure 5) shows the results from the molecular simulation of anti-virus medicine for a bird flu virus H5N1, which has been carried out at the University of California San Diego (UCSD). As molecular simulation allows sharing of path data, less experimental material is needed, and reduces time and cost for new drug candidate discovery.

The e-Science team at KISTI is planning to use AURA for new drug candidate discovery at an *in silico* stage, in order to build e-Science environment for biosciences. AURA carries out accurate pattern matching on large-scale data such as that of molecular path. AURA's pattern matching applies pipeline method and performs at two levels, which results in high cost effectiveness in molecular structure searching. In the UK, the Cardiff University is currently applying AURA in new drug candidate discovery.

4.2.2 Researcher exchanges and visits

A. Visits from the UK e-Science

Dr. David Meredith (STFC) and Mr. Geoff Williams (Oxford University) are paying a visit to KISTI from March 2-8. The main objective of the visit is related to the Parameter Sweep Application support. The AURORA development group at KISTI and Application Repository development team at NGS will further discuss the issues regarding the collaboration between the two. Also, organizing a follow-up meeting in Korea during September and November will be discussed. KISTI has applied for a financial support from the British Council through Korea-UK Bilateral Science and Innovation Programme which has been designed to promote Korea and UK collaboration.

B. International collaboration and future application in aerospace science area

The UK's DAME (Distributed Aircraft Engine Maintenance Environment) project is part of the e-Science pilot program which has been supported by EPSRC (Engineering and Physical Sciences Research Council) since 2000. It aims to develop remote monitoring system for aircraft engines. DAME develops Decision Support System on distributed conditions by using grid technology and OGSA based web service technology. By integrating computational resources and data placed at remote sites, it enables diagnosis of engine conditions as well as maintenance management by using an independent organization's decision making system.

The search engine of the DAME project which will be provided to KISTI allows fast

search of similar patterns while monitoring the condition of engine of a flying aeroplane at real time. The search engine incorporates a function of transforming large scale data to knowledge, which enables not only fast search but also management of the present data. Such function can be applied to software development for systematic management of a priori knowledge required by many areas of science including e-AIRS that deal with large amount of data.

The Memorandum of Agreement was signed between HLRS, Germany and KISTI in 2004 for 'Research collaboration for scientific visualization R&D and leading-edge grid project'. Since then, KISTI and HLRS have continued close collaboration. The MoU has been aimed at advancing supercomputing performance at each site, and at developing mutually complementary technologies. KISTI and HLRS have also collaborated on the development of user support program.

HLRS developed a distributed computing software COVISE (Collaborative Visualization and Simulation Environment) which integrates simulation, pre-processing, as well as visualization. COVISE is a visualization tool and supports Augmented Reality(AR) and Virtual Reality(VR). COVISE is used for visualizing data produced by application scientists at KISTI, and some visualization have been successfully carried out on tiled display.

HLRS has provided the source code of the COVISE to KISTI, which will enable various researches on visualization especially with its application to KISTI's visualization equipment. By collaborating with HLRS, KISTI will seek

to develop a core and additional module to the COVISE. In 2002, Korea Ocean Research & Development Institute (KORDI) announced the development of a small sized WIG(Wing In the Ground effect ship) vehicle. Recently, KORDI has been carrying out a project of which the aim is to develop 100-ton class large-scale WIG vehicle by 2011. If KORDI uses COVISE especially in developing large scale vehicles, DMU(Digital Mock Up) will not only reduce the time needed at design stage but will also allow better development and performance. DMU is a design process which adopts CAD/CAM for 3D solid modelling of all the components from the beginning stage of the development. Process of assembling, review, design, redesign, verification can all be carried out on simulation. Thus, it significantly reduces the cost and time for developing product prototypes and brings better quality to the product. The Physical Mock Up (PMU) had various problems related to detailed accuracy, time and cost for product development. Consequently, DMU is becoming a major tool used by the developers and it also performs as a Master Data. KISTI is currently seeking opportunities for contributing to enhancing efficiency and effectiveness of the process by signing an MoU with KORDI. It is presumable that such technological tools will also be required for development of vehicles with military purposes. Thus, KISTI may contribute to larger research communities by providing high quality services with a launch of a Digital Review Center at KISTI, which will invite other institutes and firms to use KISTI's visualization tools and equipments.

KISTI's collaboration with its counterparts in the US will lead to joint development and use of Aerospace Gateway. Professor Harry Hilton from NCSA, UIUC who participated in the Korea-UK e-Science Workshop at SC2007 is working on the development of Science Gateway and Cyber Environment at NCSA. In 2006 KISTI developed e-AIRS based Coaxsim portal which was run on TeraGrid for demonstration. This was acknowledge by the NSF as one of the good examples of collaboration. In 2007, KISTI participated in the NCSA Affiliation meeting and agreed on organizing a Aerospace Gateway working group. Also, KISTI and NCSA have discussed about various future collaboration including holding NCSA-KISTI joint workshop at NCSA. On the basis of these collaborations, KISTI e-AIRS technology and NCSA's Cyber Environment technology will together bring about successful results in various areas.

KISTI will collaborate with NCSA to develop e-Science based tools for analyzing UAV (Unmanned Aerial Vehicle) / MAV (Micro Aero Vehicle). KISTI will carry out fluid dynamics modelling of MAV/UAV using e-AIRS, and NCSA will work on the structural analysis. As a result, the collaboration will bring efficiency to the development of MAV/UAV. Certain shortcomings of MAEviz, a seismic risk assessment software developed through a joint effort between the Mid-America Earthquake (MAE) Center and the NCSA could also be amended by enhancing the use of e-AIRS with Cyber Environment. While NCSA has various visualization tools and technologies for the development of Cyber Environment, e-AIRS

needs to be linked to visualization. The collaboration between KISTI and NCSA will enable large-scale visualization by connecting grid computing, visualization equipment and TeraGrid.

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