Grid Middleware Center is a university research institute affiliated to ITRC (Information Technology Research Center). ITRC is a support program that establishes centers in universities specialized in IT (education) and promotes training of highly-capable specialists in IT field, the engine of our nation’s development. Since 2001 when the center was selected as the ITRC institute, we have strived to produce cutting-edge researches on Grid computing technology and to educate excellent minds in the field of Grid computing technology.

During the first stage of our research ended in August 2005, our center produced studies and made significant advancements in optimal resource management and application platforms in Grid computing technologies through joint-researches conducted by exceptional domestic and overseas research team. As a result, the center invented middlewares such as PQRM (Policy Quorum based Resource Manager) and DOVE-G, and a variety of grid applications including Bio-Grid, Nano-Grid, Physio-Grid. In addition, the research also accomplished other remarkable successes, which are 193 (published) technical papers, 13 cases of domestic and overseas patents, and 26 cases of software registrations. We have also invested our efforts in training excellent experts, producing 68 Masters and 13 PhDs. We are now at 7th year of 8-year long research project, leading Korea’s computing technology, and exceptional national universities including Kangwon National University, Korea University, Gwangju Institute of Science and Technology, Daejeon University, Ajou University, foreign research teams from MIT, BUPT, and research teams from domestic and overseas institutes such as KISTI and AIST have participated in the research.

Since the beginning of the second stage, our center is concentrating at developing a world-standard Grid computing middleware platform, training highly-qualified IT experts through the ITRC program, and creating Grid application service system such as Physio-Grid and PACS-Grid that allows multidimensional visualization and 3D interface. At this stage, we are striving to combine application platforms such as PACS-Grid, Nano-Grid, Bio-Grid using already developed Policy Quorum based Grid Resource Management System and Semantic information technology, and to develop a revolutionary cyber computing control system such as Augmented Reality and tangible computing that enables virtualization and 3D interface. Also based on the center-developed information technology, a highly-collaborative networking technology for interconnecting each lab computer, which would allow conducting virtual experiments and sharing virtual graphics, is under development. Grid Middleware Center has also accomplished 300 research technical papers, which includes several exemplary SCI papers with impact factor higher than 5, 40 cases of domestic and overseas patents, and 6 cases of commercialization of its projects. We are also a leading participant of OGF-KR, an annual Korea-Japan symposium, and have continuously strived to vitalize global cooperation and human resources exchanges.

Our center will continue to be the hub of advancement and sharing of knowledge and information on Grid technology. In addition, we will fulfill our role as the pioneer in Grid technology and in related fields of its architecture, middleware, and application. We will also dedicate our best efforts to create new internet businesses and train highly-competent experts in the field. Lastly, We appreciate MKE, IITA, KISTI, ETRI, OGF-KR, collaborating companies and especially all faculties and students at GMC for their continued supports and cooperation.
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Introduction to Grid Middleware Center

Grid Middleware Research Center

| Center Objective and Research Contents |

Government
RITA

Institute
ETRI, IITI

Universities
KAIST, GIST, Ajou University, Kangwon National University, Korea University, Daegu University

Overseas
MIT(USA), AIST(JAPAN), BUPT(CHINA)

Standardization
OGF, GGF, EGI, W3C

Industry

Grid Solution Users
Academic Medical Group

- Lead the standard technology through the OGF and GGF
- Lead the OGF and GGF technology through standardization
- Establish testbed between hospitals
- Identify user’s requirement and apply to our system
- Interchange people resource for commercializing grid solution
- Research on marketing of grid through regular meeting

Development of semantic business grid technology and its application platforms

- High performance grid computing middleware platform
- Grid application service for high quality heart diagnosis
- Grid application service for integrating remote PACSes at hospitals

Technology transfer and business cooperation
- Technology transfer of PQRM and Physio-Grid (KMH corporation)
- Promotion of building medical grid service network Training IT human power and research accomplishment

Training IT human power and research accomplishment
- High class IT human power (13 doctors, 94 masters, employment at national research institutes)
- Publication : about 35 SCI papers, a large number papers over impact factor 5

Grid international cooperation and activating interchange of students
- International cooperation through Korea-Japan symposium
- Exchange students with AIST(Japan), BUPT(CHina), and INT(France)

Promotion of building global grid test-bed
- Promotion of Korea and Japan grid testbed
- Promotion of Korea and China grid testbed

| Main Research Achievement |

- Development of Business Grid Platform and Its Application Prototype System
  - Develop PQRMPLUS (Policy Quorum-based Resource Management System Plus)
  - Grid application service for high quality heart diagnosis
  - Grid application service for integrating remote PACSes at hospitals

- Technology transfer and business cooperation
  - Technology transfer of PQRM and Physio-Grid (KMH corporation)
  - Promotion of building medical grid service network Training IT human power and research accomplishment

- Training IT human power and research accomplishment
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- Grid international cooperation and activating interchange of students
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- Promotion of building global grid test-bed
  - Promotion of Korea and Japan grid testbed
  - Promotion of Korea and China grid testbed
The 1st Activity Research
Grid Middleware Research Center

| Overview of the 1st Activity |

We’ve been researching and developing a business Grid and its application platform including overall technologies for commercializing Grid. In order to commercialize Grid technology, we need a variety of circumstantial technologies such as accounting, user management and session managing for single sign on, utility computing, virtualization of distributed computing resources, and others. We have been especially focusing on a Grid application in many IT-integrated technological subjects to enhance its commercial prosperity. Especially, medical IT and bio IT convergence was out leading target field in this group.

In the first stage of Grid Middleware Center, our group developed a Grid resource management system which is core middleware component for a commercial Grid. Based on the efforts of first stage, we are studying and developing Physio-Grid and PACS-Grid as the business Grid application platform.

Physio-Grid is an e-Health service platform, in which patient can easily get a cardiac diagnosis service at home, and doctor can diagnose using grid-supported disease identification service. This group covers methodology to detect, transfer and store the massive medical data, methodology to diagnose heart disease by ECG, grid workflow technology for the service control, and medical collaboration environment. In addition, PACS-Grid is a single virtual system and a framework that consists of the services to support it, in which distributed picture archiving servers over a DICOM network are integrated by Grid technology. Storing and sharing huge amount of medical data based on Data-Grid and security mechanism in PACS-Grid system have been a major concern in this group. Synchronization of basic PACS and PACS-Grid, integration of legacy PACS and PACS-Grid, and advanced remote diagnosis are circumstantial research topic.

Along with these tangible achievements, we have published about 50 journal papers including 22 SCI papers, 106 conference papers, and registered 8 patents since 2006.

The 1st Activity Research
Grid Middleware Research Center

| The 1st Activity |

Development of Business Grid Middleware and Application Platform Goal

- Goal
  - Development of Business Grid Integrating both technology and business
  - Medical Information Integration Technology based on Grid technology
  - Technology to anticipate Disease based on Grid technology
  - Physio-Grid Platform and establishment of its testbed
  - PACS-Grid Platform and establishment of its testbed

Research Goal and Area
(Business Grid)
**Objective**
- Development of SOWFAM integrated PQRMPLUS supporting various applications
- Enabling a real-time combination of Grid tasks and managing each task efficiently
- Supporting dynamic distributed environment by implementing Loosely-Coupled System and improving system scalability
- Real-time workflow management

**Overview**
- Development of service oriented workflow application management integrated PQRMPLUS
- Controlling flow between tasks without a hitch through scheduling and maintaining combined Grid services
- Grid-Testbed for Physio/PACS/Nano/Bio-Grid applications

**Core Technology**
- Providing optimum Resource Quorum based on monitored real-time resource information and Service Level Agreement to guarantee QoS
- BPEL and Kepler workflow transaction tool to create MWA (Manageable Workflow Application)
- Status Information Transmitter for indicating status information of workflow execution for users
- RIA (Rich Internet Application) based workflow execution environment
- Supporting various PSE (Problem Solving Environment) with Web Service
Development of Grid Platform and e-Health Grid Technology for Cardiovascular Disease Detection

Research & Development Team

- Prof. Chan-Hyun Youn’s Lab., KAIST (http://lans.kaist.ac.kr)
- Prof Chae-Woo Lee’s Lab, Ajou University (http://mnlab.ajou.ac.kr)
- Prof Eun-Bo Shim’s Lab, Kangwon National University (http://cc.kangwon.ac.kr/~ebshim)
- Prof Ho-Jin Cha’s Lab, KAIST (https://iser.kaist.ac.kr)

Main Research Area

- Methodology to conveniently sense, store, and transfer medical data from smart home to server
  - Multi-Hop based Zigbee technology
  - QoS Control on Wireless ECG Data Transfer
- Methodology to diagnosis heart related disease based on ECG signal
  - Bradycardia, Tachycardia, and Atrial Fibrillation Detection Algorithm
  - Virtual Heart Simulation for Arrhythmia Detection
- Ontological diagnosis supporting system
- Service Control based on Grid Workflow Technology
  - Workflow visualization tool to monitor & identify the steps of heart disease diagnosis
  - Workflow management to guarantee SLA (Service Level Agreement) between Service Use and Service Provider
- Collaboration Environment
  - Tiled-display based video conferencing technology
  - Medical Data Integration & sharing technology

Core Technology

- ECG based heart disease detection system
  - Providing ECG analysis algorithm for detection of Tachycardia and Bradycardia
  - Providing services for sensing, transferring and getting medical results in home environment
- Simulation of Patient Heart based on virtual heart model
  - Function to identify concrete area of heart disease which is not possible through ECG
  - Generation of three dimensional heart model for each user by using CT image
- Providing Collaboration Environment
  - Share HD quality visual image (Maximum 1280x720 resolution)
  - Providing Group-to-Group Communication among multi-user without quality loss
- Computing Middleware (PQRM) for providing huge computing power
  - QoS guaranteed job execution based on SLA (Service Level Agreement)
  - Providing real-time information about execution status and processing node

Main Research Achievement

- Providing E-Health platform to support cardiac disease detection with high performance and high accuracy based on adaptive policy-based grid workflow.
- Development of virtual heart to find the several causes of an arrhythmia and to diagnose it for electrophysiological aspect using grid computing.
- Constructing medical ontology can be reused into other applications and system developments and applied and managed with semantic grid computing environment
- Design and implement the Sensor-grid Gateway based on Embedded System and test-bed including Sensor-grid Database Server and real-time web monitoring system for uhealthcare Service
The 1st Activity Research
Grid Middleware Research Center

PACS-Grid: Grid-based Medical Imaging and Collaboration Platform

Research & Development Team
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- Prof. Desok Kim’s Lab, KAIST (http://vega.icu.ac.kr/~kimdesok)
- Prof. Bong-Hwan Lee’s Lab, Daejon University (http://comnet.dju.ac.kr)

Objective
- Research on core Data-Grid technology and security protocol on Grid
- Design and Implementation of PQRMPLUS-based PACS-Grid middleware and service modules
- Applying PACS-Grid to business/commercial Grid domain
- Design and implementation of next PACS-Grid platform oriented to chronic diseases
- Designing unified medical information processing platform for diverse services

Overview
- The PACS-Grid is a unified virtual system and a framework for supporting medical collaboration to for distributed picture archiving servers over a Grid network are interoperable.
- Storing and sharing huge amount of medical data are supported.
- Research and implementation on security mechanism in PACS-Grid
- For chronic disease care, extensible medical information processing platform is proposed.
- Federation of distributed information, medical image processing, and data processing are managed in the platform.
- The platform provides user friendly service composition tools and management tool based on SOA

Core Technology
- Management technology for Data/Application resources and Compute resources with users’ QoS guarantee
- Medical information synchronization technology for supporting clinical collaboration
- Role-based access control technology among the Grid VOs (Virtual Organization)
- Service management technology for unified operating services in the platform
- Supporting workflow tools for easy composition and extensions of services
- Visualization technology for chronic-disease care in mobile-wire network environment

Main Research Achievement
- Building medical Grid platform for collaboration between clinical institutions
- Building SOA-based medical information platform
- Developed FAS model for establishing trust based on digital certificates in Grid security framework
- Design and implementation of a web application for dental image analysis software system functions as a dental image database
- Success in commercialization of PACS-Grid

Overview Diagram

Diagram showing the components and interactions of the PACS-Grid system, including various services and data management processes.
The research topic of the 2nd activity is developing semantic grid middleware and applications. For semantic grid middleware, we developed web service based semantic grid middleware system. This middleware system consists of two sub-systems: Semantic Grid Management System (SGMS) and Semantic Information System (SIS). SGMS provides grid application scheduling and monitoring services so that users can control their grid applications easily. SIS provides various information services such as resource matching, resource allocation, application analysis, and others. We also developed web service based grid portal system that grid application user can use these two semantic grid middleware systems easily.

A bioinformatics application has been taken for the semantic Grid. In this research, we have constructed grid based bioinformatics analysis procedures to accelerate usage of grid technologies in bioinformatics field. In addition, Semantic Application Management System is constructed to provide more advanced bioinformatics analysis environment. We show how information of application programs is handled and managed for the grid operation and how it can be used to increase user’s convenience and analysis efficiency based on the system.

Also, we have been researching and developing a parallelized optical device and an x-ray generation simulator based on various numerical methods and the portal site based on the web-based user interface architecture for easy access to the Grid computing resources and the use of the parallel simulator. One of our research goals is simplifying the procedure to use the Grid computing resources by encapsulating the Grid environment using a web interface. For this goal, we have developed the FDTD simulators called Bigboy and GIST Maxwell Equation Solver (GMES). Another our research goal is the Web-based User Interface (WUI) architecture for easy access to the Grid computing resources and the portal site based on the architecture. By using these services, scientists can smoothly communicate or interact with each other and perform interdisciplinary research.
The 2nd Activity Research

Grid Middleware Research Center

| Semantic Grid Middleware System |

- **Research & Development Team**
  - Prof. Chang-sung Jeong Lab., Korea University (http://supercom.korea.ac.kr)

- **Overview**
  - Agent-based semantic grid management system
  - Semantic information system with semantic web technology
  - Grid portal system supporting for various grid applications

- **Core Technology**
  - Grid resource management and control
  - Resource matching service based on semantic information service for efficient grid application execution
  - Dynamic grid resource pool construction model
  - Easy application executing and monitoring through grid web portal

- **Main Research Achievement**
  - Agent based grid management system and semantic information system
  - Lightweight semantic grid management system environment and flexible and extensible semantic service environment
  - Providing web serviced based grid portal system for user friendly interface

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The 2nd Activity Research

Grid Middleware Research Center

| Grid-Based Nano-Technology Applications and Tools |

- **Research Team**
  - Prof. Youngjoo Chung’s Lab., Gwangju Institute of Science and Technology (http://ontl.gist.ac.kr)

- **Outline**
  - GIST Maxwell’s Equations Solver (GMES): A highly applicable optical device simulation program which supports parallel calculation environment
  - Nano simulation portal: Web-based User Interface (WUI) based on GMES

- **Core Technology**
  - GMES is a widely applicable Finite-Difference Time-Domain (FDTD) implementation based on the Object-Oriented Programming (OOP) Paradigm
  - GMES is provided as a Python package for good usability and extendibility
  - GMES supports the parallel calculation environment through the Message Passing Interface (MPI)
  - Nano simulation portal enables users to access to simulation program easily by using the WUI architecture
  - WUI architecture is a layered structure where the layers interoperate with each other, and is flexibly applicable to various simulations
  - WUI architecture is independent of the programming languages by using the web service technology

- **Main Research Achievement**
  - Development of the parallel simulator based on a finite-difference time-domain method
  - Development of the simulation platform based on the FDTD method: GMES
  - Building of the nano simulation portal site based on the WUI architecture and GMES
  - Promotion of the growth of the nano-technology field throughout the web-based user interface (WUI) architecture for easy access to the Grid computing resources
Developing Bioinformatics Applications on Semantic Grid

**Research & Development Team**
- Prof. Gwan-su Lee's Lab, KAIST (http://csbio.kaist.ac.kr)

**Objective**
- Adapting grid technologies to solve various bioinformatics problems
- Developing semantic application management system to provide more advanced bioinformatics analysis environment based on the grid

**Core Technology**
- Construction the application ontology based on OWL
  - Program Ontology, Analysis Ontology, Data Ontology
- Ontology Data Information Extraction and Inference
- Resource and job state monitoring
- Appropriate nodes selection based on application’s requirements
- Resource requirement prediction based on input data and execution option
- Provide bioinformatics analysis environment based on web service

**Main Research Achievement**
- Increase user’s convenience
- Provide real examples of grid based bioinformatics analysis procedure to accelerate usage of grid technologies in bioinformatics field
- Enable understanding and managing information of application software in a well-defined structure based on application ontology and semantic application management
- Enable grid middleware to support more appropriate job management by accepting information of applications
Applications for Grid-based Nano Computing Services

Research & Development Team
- Prof. Mincheol Shin's Lab., KAIST (http://cnl.kaist.ac.kr)

Overview
- Development of in-house nano-electronic device simulators and integration to the Grid environment
- Deployment of the developed tools through web-based Grid portal service

Core Technology and System Architecture
- In-house nano-electronic classical/quantum device simulators: 2D/3D MOSFET, nano-wire FET, carbon nanotube FET, bioFET
- Various front/back-end tools and middleware for Grid nano-computing
- Web-based Grid portal service platform using VNC/Rappture/PQRM

Main Research Achievement
- Development of in-house nano-electronic device simulators and integration to the Grid environment and Web-based Grid portal service platform using VNC/Rappture/PQRM
- In-house nano-electronic classical/quantum device simulators: 2D/3D MOSFET, nano-wire FET, carbon nanotube FET, bioFET
- Maximizing the research and development capabilities through research and prevention of duplicate resources
- Optimal utilization of resources in grid environment via Nano Portal