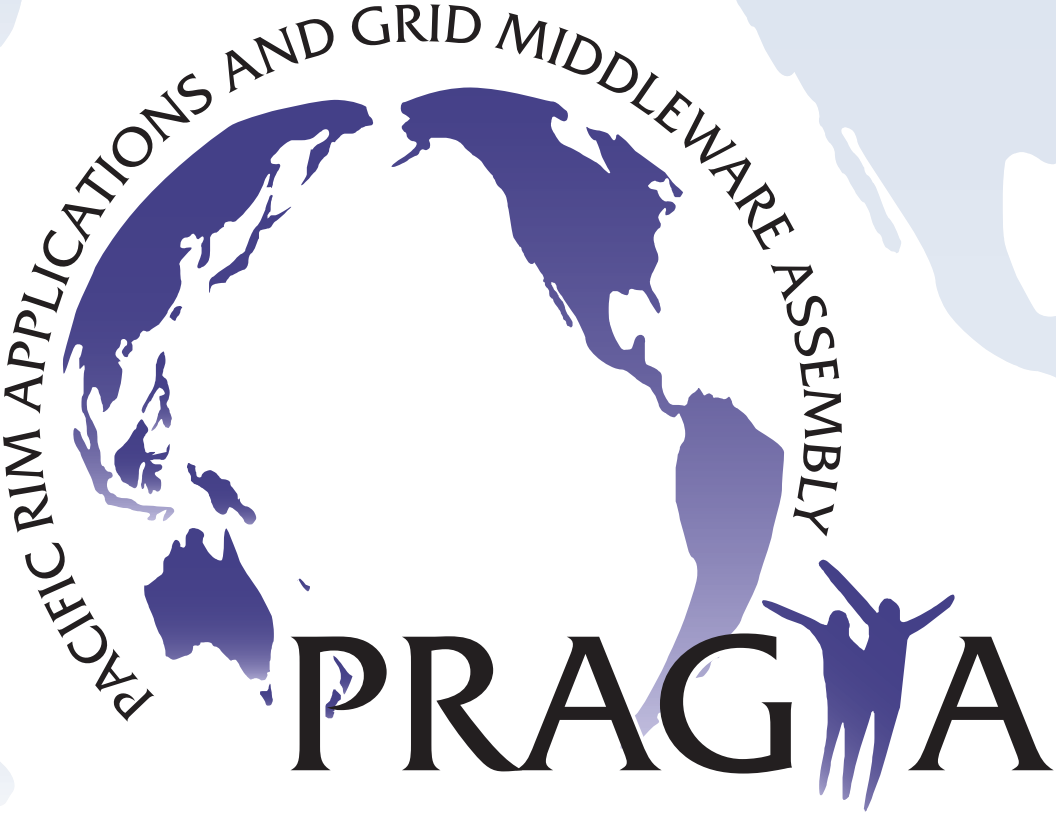
PACIFIC RIM APPLICATIONS AND GRID MIDDLEWARE ASSEMBLY



Collaboration Overview

www.pragma-grid.net

PRAGMA Institutions & Contacts

PRAGMA is an institution-based organization governed by a Steering Committee. Below is a list of member institutions & key contacts. Steering Committee members are noted with an asterisk (*).

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PRAGMA: An International Model of Collaboration

In the 21st century advances in science and engineering (S&E) will, to a large measure, determine economic growth, quality of life, and the health of our planet. The conduct of science, intrinsically global, has become increasingly important to addressing critical global issues…Our participation in international S&E collaborations and partnerships is increasingly important as a means of keeping abreast of important new insights and discoveries in science and engineering [National Science Board 2000]

The Pacific Rim Application and Grid Middleware Assembly (PRAGMA) is an open, institution-based organization, founded in 2002, to establish sustained collaborations and to advance the use of grid technologies in applications among a community of investigators working with leading institutions around the Pacific Rim. PRAGMA was founded based on the following premises: the conduct of science is global and more examples arise that point to the challenges that must be faced internationally; the grid promises to revolutionize science as much as networking has done to our daily activities; and the grid is yet too difficult to use by most researchers. Finally, PRAGMA recognizes that constructing and using the grid to promote e-science is inherently a global, collaborative undertaking. No one institution or economic entity has all of the talent or all of the resources to do this. Yet, each needs to participate in building the future scientific, social, and economic global infrastructure.

PRAGMA accomplishes its mission primarily by conducting joint projects that develop grid middleware to advance applications and by sharing resources to create a testbed, and addressing scheduling and allocation issues across institutional and international boundaries. In addition, PRAGMA is committed to disseminating the results of its efforts to the broader community and to work with regional and international groups to enhance the overall grid infrastructure and to promote global collaboration.

This brochure highlights accomplishments attained by working together across political and disciplinary boundaries, with a common focus and shared principles underlying the collaborations. These accomplishments illustrate the concept that the grid brings remote resources (observational equipment, computers, data, and people) together to one's local work environment. The examples range from controlling a microscope in order to understand cell processes in the brain to monitoring the environment in national parks, from distributing computations that can lead to insights into drug discovery to moving files essential to high-energy physics experiments, and from conducting a global structural genomic experiment to rapidly deploying technology to assist the world in fighting the SARS outbreak.

PRAGMA is a model of how to collectively build upon international scientific needs such as constructing and deploying a grid. It is premised on the principles that the grid must be developed and deployed by international efforts, that a focus on application will produced those developments, that an open organization of institutions committed to this goal is a viable approach, that open access to software and data are essential, and that attribution of our individual and identifiable contributions will ultimately benefit the larger effort.

During the next year we will continue to demonstrate the value of application-focused collaboration in building the grid. We expect to diversify the areas of applications, to expand the institutions and geographic regions involved, and to develop vehicles and resources to train and exchange participants.

We hope that PRAGMA will inspire other international collaborations and promote new means to nurture, sustain, and expand those collaborations in order that we as a global society can address critical global issues and improve economic growth, quality of life, and the health of our planet.

1. National Science Board. Toward a More Effective NSF Role in International Science and Engineering, National Science Board Interim Report, NSB-00-217 (Dec. 2000). *www.nsf.gov/nsb/documents/2000/nsb00217/nsb00217.htm*

"National Science Foundation support for the PRAGMA partnership has led, most importantly, to the development of strong human trust and a cooperative spirit among the sites."

—William Chang, NSF program manager in the Office of International Science and Engineering

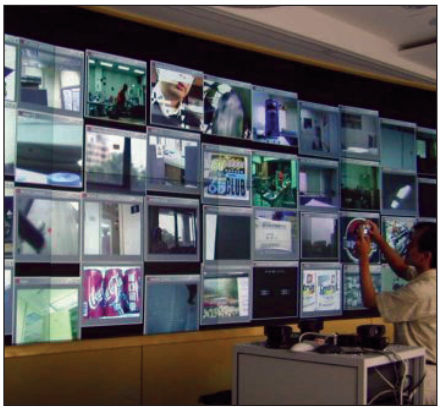
PRAGMA

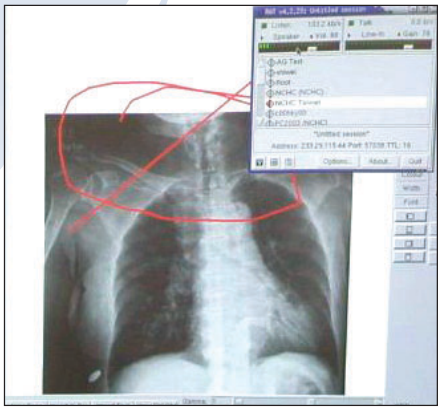
PRAGMA Science & Partnership Successes

PRAGMA participants have successfully demonstrated the value of international collaborations in conducting applications on the grid. The following vignettes, science successes from PRAGMA's first year, illustrate the grid concept of supplying researchers' local work environments with remotely distributed resources such as microscopes, computers, data, and, ultimately, people. The applications demonstrate the potential of working together on the grid and reveal the barriers that need to be overcome to make the grid more accessible. Knowing where the difficulties lie will help focus the broader grid community efforts, and lead to the development and deployment of improved infrastructure.

SARS Grid Participants: *National Center for High-performance Computing; Univ of California, San Diego; Argonne National Lab; & many other organizations*

Grid Community Pulls Together to Battle SARS in Taiwan





Left to Right: *1) A test of the SARS Grid constructed by the NCHC SARS Combat Task Force with assistance from PRAGMA members. A series of Access Grid points were assembled within record time, allowing quarantined hospital staff to communicate with the outside world. 2) A preliminary map of the SARS Grid proposed by NCHC and Taiwan CDC, in May 2003, extends over 10 medical centers & 12 SARS-dedicated hospitals. 3) The SARS Grid permits remotely located doctors to perform real-time diagnoses.*

Because quarantine and isolation are the primary means of slowing the spread of SARS, Taiwan's hospitals faced a communication logjam during the 2003 SARS epidemic. Physicians in quarantined hospitals were unable to consult with specialists at other institutions, and on a more personal level, hospital staff and patients had limited contact with their families. As of May 13, 2003, the World Health Organization reported that the respiratory illness had infected 7548 people worldwide, killing 573, and that the outbreak was still on the rise in Asian countries.

On May 15, 2003, in search of expertise for setting up Access Grid sites, Taiwan's National Center for High-performance Computing (NCHC) sent a request for help to PRAGMA members. Within hours, offers to assist poured in from around the world, with volunteers ready to provide gear, remote expertise, and Chinese-speaking support staff.

Grid computing researchers around the Pacific Rim quickly mobilized to fight the SARS epidemic, helping establish a cutting-edge communication grid among quarantined hospitals across Taiwan within two weeks. In addition to linking the hospitals to each other, the grid connects doctors to global sources of health information.

"National Science Foundation (NSF) support for the PRAGMA partnership has led, most importantly, to the development of strong human trust and a cooperative spirit among the sites," said William Chang, NSF program manager in the Office of International Science and Engineering. "PRAGMA shows that NSF's investment in cyberinfrastructure will transform not only scientific research and learning but also the handling of global episodic events such as SARS."

The Access Grid, a network-based collaboration environment, goes beyond standard video- and teleconferencing and allows physicians to share detailed X-ray images, patient data, and other information in online meetings among several sites. The Access Grid can also host private virtual rooms for patients or hospital staff to visit with family members.

"Thanks to PRAGMA, the alliance has been formed," said Fang-Pang Lin, director of the NCHC's grid computing division. "NCHC has a responsibility to assist in handling this arduous task, and with assistance offered from the international grid community," he said. "We believe that we can adequately contribute to the nationwide call to assist in fighting the disease, relieving the epidemic, and ultimately save many lives."

Merging Grid Technology and Computational Chemistry

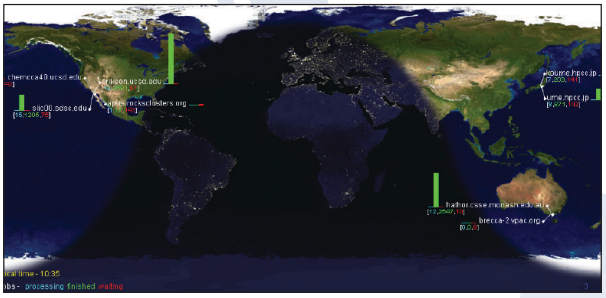
The ability to theoretically model biological and chemical processes is an important key to understanding nature and to predicting experiments. This type of computational modeling, which is data and computation extensive, can take advantage of a worldwide computing grid to provide the necessary resources. Coupling the GAMESS quantum chemical code to the Nimrod/G grid distribution tool within a collaboration initiative by PRAGMA demonstrated that researchers can use the grid not only to do calculations more quickly, but also to open doors to new types of questions. The results of this coupling were first shown in an overnight run at the PRAGMA 4 Workshop in June 2003.

"These results allow us to explore many more parameter combinations than we had been able to do in the past," said Wibke Sudholt, a postdoctoral researcher at the San Diego Supercomputer Center (SDSC). "Future applications of this technology could range from understanding complex biochemical reaction, to design of new drugs, to basic structure-function relationships in materials. This international example of collaboration has opened up a new field of inquiry."

In particular, the Nimrod/G system simplifies the creation of large parameter sweep and search applications by scavenging compute cycles from a wide variety of platforms, ranging from simple workstations to high performance clusters and vector supercomputers. It also incorporates quality-of-service metrics that make it possible to set deadlines and budgets for computation. The aim was to couple Nimrod to GAMESS for parameterizing a quantum chemical pseudo-potential.

Future applications of this technology could range from understanding complex biochemical reactions, to design of new drugs, to basic structure-function relationships in materials. This international example of collaboration has opened up new avenues for research.

This demonstration drew on resources at Monash University, Victorian Partnership for Advanced Computing, Kasetsart University, the National Institute of Advanced Industrial Science and Technology, Cray Inc., the University of California, San Diego, and SDSC.



Computational Chemistry Methods Participants: *Monash Univ; Victorian Partnership for Advanced Computing; Kasetsart Univ; National Inst of Advanced Industrial Science & Technology; Cray Inc.; San Diego Supercomputer Center, Univ of California, San Diego*

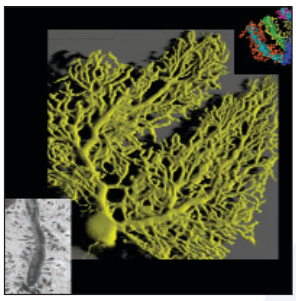
Left: *Researchers used a tool called Nimrod/G to distribute task of processing a quantum chemical modeling code, GAMESS, to six clusters in three countries.*

Telescience Marshals Rich Network of Technologies at iGrid2002

Telescience technologies provide worldwide access to unique scientific instruments and facilitate research collaborations. At iGrid2002, held in Amsterdam in September 2002, PRAGMA Telescience collaborators successfully demonstrated the ability to use a high-quality, low latency digital video to navigate a specimen in a microscope over a global grid of heterogeneous resources located at five institutions worldwide.

Researchers from the National Center for Microscopy and Imaging Research (NCMIR) at the University of California, San Diego, in collaboration with Osaka University and the National Center for High-performance Computing (NCHC), utilized a native IPv6 network to provide the highest possible video quality.

In addition, data was transferred to and from distributed storage resources, intensive distributed computational jobs were completed, and data-intensive visualizations performed—all utilizing a global grid composed of heterogeneous resources located at NCMIR, the San Diego Supercomputer Center, NASA Ames' Information Power Grid, NCHC, and Osaka University. This example illustrates an ideal collaboration where each site contributed its unique expertise, to the benefit of both the project and all of its participants.

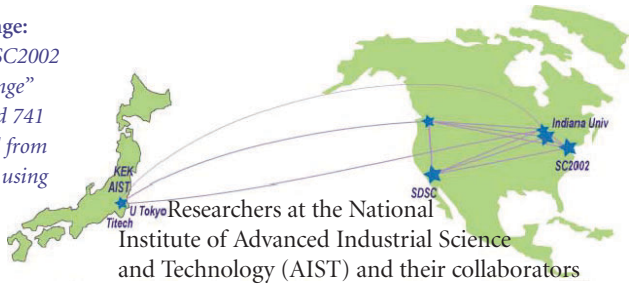


iGrid2002 Participants: *National Center for Microscopy & Imaging Research, Univ of California, San Diego; National Center for High-performance Computing; Research Center for Ultra-High Voltage Electron Microscopy; Cybermedia Center, Osaka Univ*

Left: *The central image is a 3-D reconstruction of a Purkinje neuron from a series of light microscopic images. The lower left image is an electron micrograph showing the dendritic spines at higher resolution. The reconstruction in the upper right is a 3-D reconstruction of a portion of a Purkinje cell dendrite showing the main dendritic branches & their dendritic spines, created using electron tomography at NCMIR & Osaka Univ.*

PRAGMA

Grid Demo Sets US to Japan Data Speed Record



Bandwidth Challenge: *Participants in the SC2002 "Bandwidth Challenge" pushed data a record 741 Megabits per second from Baltimore to Japan, using both clusters & networks provided by PRAGMA participants.*

Grid Demo Participants: *National Inst of Advanced Industrial Science & Technology, TransPAC, San Diego Supercomputer Center, Tokyo Inst of Technology, Univ of Tokyo High Energy Accelerator Research Organization (KEK)*

Researchers at the National Institute of Advanced Industrial Science and Technology (AIST) and their collaborators worldwide set a transpacific data transfer record using the Grid Data Farm Data Grid Middleware, pushing data from a high-energy physics experiment at an average speed of 741 Megabits per second over 10,000 kilometers from Baltimore to Japan. The record was set in the course of participating in the "Bandwidth Challenge," a networking contest held as part of SC2002, the annual conference of high performance computing.

High-energy physics experimental data generated by Monte Carlo simulation was distributedly stored on the Gfarm file system (Grid virtual file system) which consisted of seven clusters (190 PCs) via a number of high-speed networks, including two associated with PRAGMA member TransPAC. In addition to AIST, clusters were located at Japan's High Energy Accelerator Research Organization (KEK), the Tokyo Institute of Technology, University of Tokyo, Indiana University, San Diego Supercomputer Center, and at SC2002 in the Baltimore Convention Center.

By conducting parallel data replications between the clusters and sharing the data between high-speed networks, the researchers were able to boost the overall data transfer rate. Additionally, it was the first time that clusters in the US and Japan had been integrated and a single application used to send multiple terabytes of data via multiple TCP streams across the Pacific Ocean

"An important thing to note about this 'speed record' is that it uses the network & attached clusters in a manner very similar to the way scientists will actually use these resources," according to the TransPAC website. "[It] is an example of how grid computing & high performance networking will be intimate partners in the future of scientific computation."

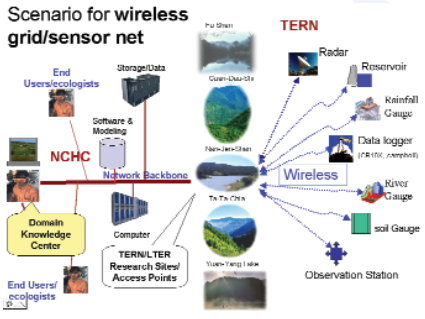
More information may be found at: *www.aist.go.jp/aist_e/aist_today/2003_08/2003_08_p07_09.pdf.*

EcoGrid: Scientists Use Grid Technology to Study Ecosystem

EcoGrid Participants: *National Center for High-performance Computing; Taiwan Ecological Research Network; San Diego Supercomputer Center, Univ of California, San Diego; Asia-Pacific Advanced Network; Cybermedia Center, Osaka Univ; National Agricultural Research Center; North temperate Lakes LTER; Virginia Coast Reserve LTER; Andrews Forest LTER*

Right: *The Ecology Grid project at Taiwan Forestry Research Institute's Fushan Research Station will collect data & share it, via the grid, with the international research community.*

At the northeastern end of Taiwan lie nearly 1,100 hectares of pristine rainforest, a haven where rare muntjacs and endangered birds wander among trees that are hundreds of years old. Throughout that forest, along pathways and atop mountains, a network of high-resolution cameras monitor the movements of those animals and capture slowly forming patterns of soil erosion and river flow.



Those sensors are part of an Ecology Grid (EcoGrid) project in the Taiwan Forestry Research Institute's Fushan Research Station, a collaboration between the Taiwan Ecological Research Network and PRAGMA member, the National Center for High-performance Computing, under the National Science Council. The data collected through the EcoGrid is then made available through a computational grid, facilitated by PRAGMA, to the international research community.

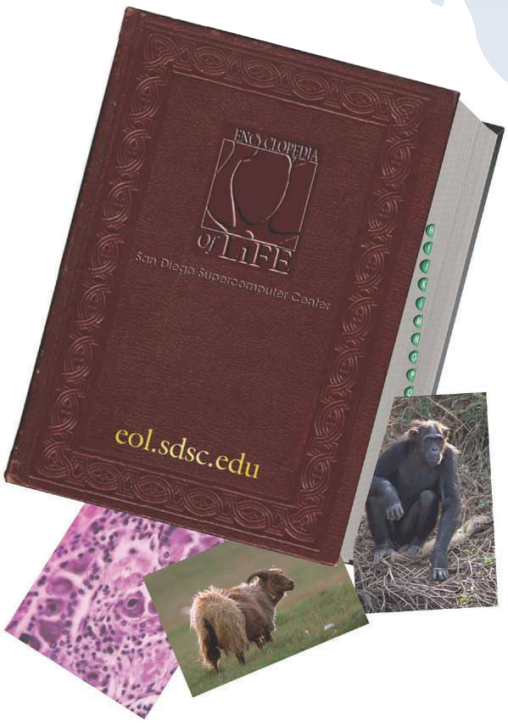
Connecting with the worldwide community of ecologists and biodiversity researchers will allow scientists to perform comparative studies between Fushan's environment and the rest of the world. However, sustaining an international grid environment will depend on the cooperation and collaboration of a larger, global community. PRAGMA provides access to that community, both in terms of computing resources and overseas collaborators.

A system modeled on the well-established telescience efforts between the US and other countries will give scientists access to research instruments in remote locations. Planting wireless monitors, including cameras, deep within the forests of Fushan will allow researchers to access to observations without requiring them to travel to that actual location, saving time and expense, and without disturbing the local environment. Representatives of one-third of Taiwan's species inhabit Fushan, making it a significant example of biodiversity.

Encyclopedia of Life

Scientists in an open collaboration led by the San Diego Supercomputer Center (SDSC) are building a system, the Encyclopedia of Life (EOL), that will automatically marry the enormous amount of genomic data currently available (about 1000 full or partial genomes) with the latest knowledge of proteins through the largest biological computation ever completed.

The EOL is an ambitious project to catalog the complete complement of proteins from every living species in a flexible, powerful reference system available via the web. The project draws on the skills of experts in biology, data and knowledge systems, and grid computing, and some of the world's most powerful computational resources, potentially up to 2416 processors when counting clusters at the three PRAGMA EOL sites, including SDSC's Blue Horizon and the TeraGrid.



"The genome projects have led to a lot of new questions, most importantly, 'How can we best use this sequence information?'" said Philip Bourne, UCSD professor of pharmacology and co-director of the Protein Data Bank.

"The Encyclopedia of Life is part of the answer to those questions. The EOL will permit comparative proteomics—comparison of proteins within and between species. This will lead to identification of new functions for these proteins and in the best case highlight potential new drug targets," he said. "At the very least we will have an encyclopedic reference of existing proteins that will educate a broad community in the role of these proteins in living systems."

In February 2003, the Bioinformatics Institute, Singapore, became the first international site to use protein annotation software developed at SDSC to completely process the genome of an organism, the Tiger Pufferfish or Takifugu rubripes, an organism prized by sushi eaters for its delicate taste and by scientists for its compressed genome, which contains the same number of genes as a human in one-eighth of the space. Since then, the Tokyo Institute of Technology has joined the project. As of September 2003, the EOL contained the annotated proteomes of 140 species out of a potential 1000.

EOL Participants: *San Diego Supercomputer Center, Univ of California , San Diego; Bioinformatics Institute of Singapore; Global Scientific Information & Computing Center, Tokyo Inst of Technology*

Left: *The Encyclopedia of Life is an open collaboration to catalog the complete complement of proteins from every living species.*

PRAGMA Working Groups

The working groups below reflect the interests of current PRAGMA members. Each group has a lead or co-leads who coordinate the activities of that group at and between meetings. The groups have projects that bring a focus to their activities, providing milestones and demonstrations at PRAGMA workshops and other meetings. This structure allows for the inclusion of new applications as well as new areas of interest. New working groups are being considered in activities of middleware and training.

Telescience

Telescience Working Group Participants: *F. Lin & S. Shimojo, Co-chairs, S. Kato, T. Akiyama, Osaka Univ; National Center for High-performance Computing; M. Lee, Korea Inst of Science & Technology Information; B. Pailthorpe, N. Bordes, Univ of Queensland; D. McMullen, Indiana Univ; K. Mikami, Cray Inc.; B. Durnota, Complexibotics; M. Ellisman, S. Peltier, A. Lin, D. Lee, T. Molina, National Center for Microscopy & Imaging Research, Univ of San Diego*

Electron tomography is a powerful technique that draws on advanced instrumentation, networking, and grid computing to derive three-dimensional structural information from biological specimens. Telescience, developed by the National Center for Microscopy and Imaging Research (NCMIR), focuses on a web-based solution for end-to-end electron tomography that centralizes applications and seamlessly interfaces with the grid to accelerate the throughput of data results.

The Telescience Working Group assists NCMIR with evolving Telescience by developing collaborations among experts in grid architecture and integrating scientific devices such as ultra-high voltage electron microscopes, magnetoencephalography, and synchrotron facilities to the grid. By incorporating the Cybermedia Center at Osaka University's expertise in IPv6 networking, and NCMIR's advances in Telescience Infrastructure, telemicroscopy systems for both the ultra-high voltage electron microscope in Osaka and the intermediate-high-voltage electron microscope at NCMIR at the University of California, San Diego have been enhanced through the use of digital video over end-to-end IPv6 networks, this new technology provides end-users with dramatically improved visual feedback during remote microscopy experiments.

Researchers from the National Center for High-performance Computing have contributed their expertise in visualization, advanced volume segmentation, and web-based visualization tools, which have been integrated into the Telescience Portal environment and coupled to Storage Resource Broker-enabled automated data management tools.

At iGrid2002, held in Amsterdam in September 2002, PRAGMA Telescience collaborators demonstrated the ability to use a high-quality, low latency digital video to navigate a specimen in a microscope over a global grid of heterogeneous resources located at five institutions worldwide. The working group has facilitated the future addition of a 1.2 MeV electron microscope at the Korea Institute of Science and Technology Information to the Telescience effort and has expanded the Telescience application model to Taiwan's Ecology Grid project.

Biological Sciences (including Chemoinformatics)

Biological Sciences Working Group Participants: *L. Ang, Chair, A. Krishnan, F. Tang, A. Shahab, Bioinformatics Inst, Singapore; Karp Joo, Jeoung, Sun Tae, Hwang, Kun Kuk Univ; Jysoo Lee, Keebum, Kee, Kum Woo, Cho, KISTI, Korea; W. Li, A. Birnbaum, J. Hayes, P. Bourne, K. Baldridge, R. Byrnes, P. Arzberger, M. Miller, SDSC/UCSD; Shoji Hatano, Qin Ye, Zhang Er, Chinese Academy of Sciences; S. Shimojo, S. Date, S. Takeda, Osaka Univ*

Over the past few years, bioscience researchers have increasingly turned to computing resources, which has led to a transformation of science in areas such as systems and structural biology, and molecular modeling. Compute-based biosciences are now poised to move from clusters to a larger venue, computational grids. The Biological Sciences Working Group focuses on grid applications development, porting and tuning code, and enabling bioinformatics software for use in a grid computing environment.

The working group aims to forge research collaborations among researchers within the PRAGMA community through a number of activities. During PRAGMA workshops and meetings the working group shares its research and reviews opportunities for collaboration. The working group also organizes mini-symposia in collaboration with other meetings such as the Global Grid Forum.

Some of the highlights of the working group activities include the Encyclopedia of Life project, the MSGrid-GridX project, and the Grid Network for Life Sciences that links the Osaka University BioGrid and the Chinese Academy of Sciences. As part of the Encyclopedia of Life project, the San Diego Supercomputer Center at the University of California, San Diego, has been working with the Bioinformatics Institute, Singapore, and Global Scientific Information and Computing Center at the Tokyo Institute of Technology to solve problems in structural biology. The MGrid and GridX collaboration involves a close collaboration between the Korea Institute of Science and Technology Information, Konkuk University, and the Bioinformatics Institute, Singapore, to develop and use middleware for molecular simulation.

Data Computing

The Pacific Rim region generates and harbors large-scale data that covers a diversity of fields, information about climate, water, culture, spatial data, ecology, pollution, physics, chemistry, bioinfomatics, medical, astronomy, and earthquakes. The Data Computing Working Group aims to facilitate and foster the demand for sharing and analyzing such large-scale data, introducing data grid technologies and an international testbed in collaboration with researchers within the PRAGMA community.

In 2002, the working group established a PRAGMA Grid Datafarm testbed consisting of 3 clusters in the United States and 3 clusters in Japan, which made it possible to share 18 terabytes capacity of a wide-area virtual file system and 6 gigabytes/sec of parallel disk I/O performance using the Grid Datafarm Data Grid Middleware. High-energy physics experimental data was generated by Monte Carlo simulation, which was replicated between the United States and Japan at the record speed of 741 Mbps during the SC2002 high-performance bandwidth challenge.

The data computing working group encourages collaborations around data computing in the Pacific Rim region, expanding the testbed to several hundreds of terabytes of high-performance shared virtual file system. Current activities include Belle Data Grid (high energy physics), which includes the University of Melbourne, National Institute of Advanced Industrial Science and Technology (AIST), and the High Energy Accelerator Research Organization; the Spatial Data Grid, which includes the National Center for High-performance Computing and the San Diego Supercomputer Center; and Virtual Observatory Grids, which includes AIST and the Australian National University.

Resources Working Group

Improving the interoperability of grid middleware in the Pacific Rim and throughout the world will lead to an increase the productivity and effectiveness in the use of the grid for research. As a step in this direction, the Resources Working Group over the next year has set the goal of constructing a PRAGMA Grid test bed.

To realize this goal, sites participating in the testbed have committed equipment, agreed to install a minimum set of common software (Globus 2.2.x with job submission to local scheduler), with standardized procedures for exchanging certificates, and identified a set of additional preferred software that provides support for certain applications and to aid in monitoring of the PRAGMA Grid. MPICH-G2 and Ninf-G are both recommended for application support, and SCMSWeb and Ganglia are both recommended for grid monitoring.

A secondary goal of the working group is to promote, deploy, and test grid middleware developed by PRAGMA members. Of the additional preferred grid software components, Ninf-G, SCMSWeb, and Ganglia are developed by PRAGMA members and their partners.

For a site to be considered part of the test bed, every other site should be able to reach and interact with it, for example, run a job, do a handshake, do a "hello world." Until that happens, a site is not considered part of the testbed. Leading to these agreements, a metric for quantifying the degree to which a site is available, the goodness index, was developed.

The working group, in conjunction with ApGrid, helped secure resources for the data computing Gfarm demo as part of the SC2002 bandwidth challenge. Following the philosophy of PRAGMA, the Resource Working Group interacts closely with ApGrid, to test software more broadly, to share experience, and to adopt best software.

With an instantiation of a testbed, future challenges will include seeding new grid-aware applications, pushing deployment of software environments better tuned to applications, coupling distribution of software from various PRAGMA sites into a single release, and installing accounting systems to track use of the testbed and barriers to sharing resources internationally. This experience will help inform all funding agencies interested in understanding how the global grid will be used and benefit researchers within "funding" boundaries to really link together national and regional production grids.

Data Computing Working Group Participants: *O. Tatebe, AIST, Co-chair; P. Papadopoulos, SDSC/UCSD, Co-chair; J. O'Callaghan, APAC; J. Smillie, Australian Nat'l Univ; L. Winton, S. Melnikoff, Univ Melbourne; P. Coddington, Univ Adelaide; M. Sato, T. Boku, D. Takahashi, Univ Tsukuba; A. Takefusa, Ochanomizu Univ; F. Lin, R. Sheng-Ming Wang, NCHC; E. Yen, H. Chen, A. Chen, Academia Sinica; R. Chitradon, P. Srichaikul, S. Vannarat, NECTEC; B. Yan, K. Nan, K. Wu, Y. Ma, H. He, CNIC, Chinese Acad of Sci; W. Chen, ISOC/CAS; D. McMullen, J. Hicks, Indiana Univ; K. Kumar, Inst of HPC*

Resources Working Group Participants: *M. Katz, Co-chair, SDSC/UCSD; K. Sakharkar, Co-chair, BII Singapore; Y. Tanaka, Co-chair, AIST; P. Papadopoulos, SDSC/UCSD; R. Buyya, Univ Melbourne; J. Lee, KISTI; F. Lin, NCHC; K. Mikami, Cray; K. Nan, CNIC, Chinese Acad of Sci; K. Shirose, Tokyo Inst of Tech; S. Shimojo, Osaka Univ; O. Tatebe, AIST; P. Uthayopas, Kasetsart Univ; H. Wahab, Univ Sains Malaysia; J. Williams, D. McMullen, J. Hicks, Indiana Univ; E. Yen, Academia Sinica Computing Centre; A. Agarwal, Univ Hyderabad*

PRAGMA Member Grid Activities & Resources

Academia Sinica Computing Centre, www.ascc.net, www.twgrid.org

ASCC is one of the major high performance computing and communication centers in Taiwan. ASCC provides service and support for academic computing at Academia Sinica and its collaborating institutes. ASCC began investigating and deploying grid technology in 2000. Since then, ASCC has established grid-based infrastructure for research and education in Academia Sinica and other institutes, and has conducted several grid-related training workshops. PRAGMA will enable ASCC to work with other leading institutions in building and maintaining an advanced production grid environment for various applications.

ASCC is in charge of the information technology and infrastructure support for the National Digital Archive Program and National Research Program for Genomic Medicine. This has included introducing and deploying grid technology in as part of a support and service role for these two national programs. ASCC is also one of the two Large Hadron Collider Computing Grid regional centers for High Energy Physics in Asia. ASCC staff are participating in middleware development, resource management, and certification and testing. Grid technology development at ASCC includes: PC Cluster and grid system, middleware, certification authority, and grid applications in high-energy physics, bioinformatics, digital archive, biodiversity, eLearning, and the Access Grid.

ASCC would like to both share its expertise and enlarge the scope of its grid activities by participating, through PRAGMA, in the following areas: grid application development, grid middleware development and deployment, cross-grid integration and validation, grid operation and monitoring, and hosting future PRAGMA meetings.

Key contacts: Simon Lin, Eric Yen

Asia-Pacific Advanced Network, www.apan.net

APAN is a consortium that provides an international high performance network infrastructure for research and educational activities in the Asia-Pacific region. Currently 15 countries and regions, including the European Union, are connected through APAN's high-bandwidth links. As an example of the bandwidth available, the link between the United States and Japan operates at 11.8 Gbps.

APAN's working groups promote projects that utilize the infrastructure. The Natural Resource Area of APAN has working groups in agriculture. Earth observation and Earth systems have been pursuing grid-orientated applications under the collaboration with the grid working group of the Application Technology Area. Examples of these application include a data grid for satellite image achieves, a high performance computing grid for climatic prediction, a middleware and web-service grid for heterogeneous weather databases, and a high-density grid for wireless field sensors.

In addition to PRAGMA, APAN maintains close relationships with active grid organizations in the Asian region such as APBioNET, ApGrid and GGF. Recently APAN initiated a committee to coordinate both APAN's grid-related activities and its links with external organizations.

Key contacts: Seishi Ninomiya, Kento Aida

Australian Partnership for Advanced Computing, www.apac.edu.au

APAC and its partners provide advanced computing facilities to the Australian research community and industry. It is estimated that over 1300 researchers use these resources. APAC plans to integrate these facilities into a grid over the next three years. The grid will support national and international research collaboration.

APAC is a consortium member of GrangeNet *(www.grangenet.net)* which has installed a multi-gigabit network between Melbourne, Canberra, Sydney, and Brisbane for research and education purposes. Five of the APAC partners are participating in GrangeNet projects to deploy and demonstrate grid and advanced communications services. These demonstrations involve collaboration with international research communities in high-energy physics, gravitational wave astronomy, bioinformatics, astronomy, & environmental sciences.

APAC has representation on APAN, is a core member of APGrid, and is a silver sponsor of the Global Grid Forum. Representatives of APAC have attended the PRAGMA workshops and APAC co-hosted the fourth PRAGMA workshop held in Melbourne, Australia.

Key contacts: John O'Callaghan, David Abramson, Bernard Pailthorpe

Bioinformatics Institute, Singapore, www.bii.a-star.edu.sg

BII scientists and engineers are involved in application, middleware and Biomedical Grid (BMG) activities with the aim of leveraging grid computing technology to build a scalable, secure, and easy-to-use national grid resource. The BMG serves the new integrated biomedical research park called the Biopolis, which houses BII and four other sister institutes. The BMG research and development work is completely meshed in with the research objective of BII to model the flow of information in living systems.

PRAGMA provides BII with a platform for research collaborations to develop biomedical applications and middleware. BII researchers are involved in all workshops and also provide suitable cluster to the PRAGMA testbed. BII collaborations with PRAGMA member institutes include the Encyclopedia of Life project with the San Diego Supercomputer Center and other partners at the University of California, San Diego and a project called "Grid Workflow Enactment Engine" with the Korea Institute of Science and Technology Information and Konkuk University in Korea.

Key contacts: Larry Ang, Santosh Mishira

Center for Computational Physics, University of Tsukuba, www.rccp.tsukuba.ac.jp

The Center for Computational Physics is a research institute for computational physics, science and high-performance computing technology. We expect that the grid will open new areas and methodologies of discovery and analysis in computational science. Currently, we are working on several grid projects, both in Japan and internationally. We have strong ties with PRAGMA partners in Japan, including AIST, Tokyo Institute of Technology (Titech) and University of Osaka, in Japanese grid projects and ApGrid.

Researchers at the Center for Computational Physics have developed several grid middleware tools such as a grid RPC system, OmniRPC, for parallel programming, the HMCS-G (Grid-enabled Heterogeneous Multi-Computer System) for sharing a special purpose computer, GRAPE-6, on the grid, and computational chemistry applications for the grid. We are also involved in the International Lattice Data Grid Project (ILDG) to develop an international data grid for the lattice field theory community.

The Center for Computational Physics shares computing resources with AIST and Titech through a grid testbed on the Japanese SuperSINET and Tsukuba-WAN. Joining PRAGMA will be beneficial to our grid research by providing a forum for exchanging ideas and resources through the promotion of broader collaborations with PRAGMA partners. The Center for Computational Physics has offered several PC clusters to a PRAGMA as a computing resource.

Key contacts: Mitsuhisa Sato and Taisuke Boku

Computer Network Information Center, Chinese Academy of Sciences, www.cnic.ac.cn

CNIC is a founding institutional member of PRAGMA and has been an active participant in PRAGMA activities. CNIC researchers are involved in application and resources working groups within PRAGMA, providing an 8-node cluster for the testbed and organizing some science applications in disciplines such as astronomy, biology, and chemistry in China. Also, CNIC is helping to develop collaborative training among PRAGMA members.

CNIC is a leading institute in grid computing and applications in China. It is involved in key projects such as the Scientific Data Grid (SDG) and China National Grid (CNGrid). CNIC researchers have been developing a set of grid middleware to support data access and integration, in particular, for distributed, heterogeneous, and multi-disciplinary scientific data. The software will be initially released at the beginning of 2004 and will be available to PRAGMA members.

CNIC researchers have been involved in all workshops except the fourth one due to the SARS crisis. CNIC will host the sixth workshop in Beijing in May 2004.

Key contacts: Baoping Yan, Kai Nan

Cray Inc., www.cray.com

Cray Inc. is the first Industrial Affiliate member of PRAGMA. In addition to participation in PRAGMA meetings and workshops, Cray will contribute to the organization by providing its expertise in high performance computing and demonstrating how grid technologies can be used to provide access to scarce HPC resources to the scientific community.

Cray is actively involved with the Resources Working Group of PRAGMA, providing access to a grid of Cray series supercomputers, including a Cray SV1™ system located in the Cray-Japan office. This grid is aimed at supporting middleware and application porting activities. Working with PRAGMA members, Cray demonstrated benefits of the grid on scientific applications such as molecular dynamics at the PRAGMA 4 Workshop in June 2003.

Cray has also been working closely with Japan's National Institute of Advanced Industrial Science and Technology (AIST) and the Grid Technology and Research Center (GTRC) in Japan to port grid middleware such as the Globus Toolkit, and a grid-based Remote Procedure Call (RPC) tool, Ninf-G. These efforts resulted in the development of a grid-based finite element structural application that executes over multiple Cray SV1 systems. The ability to utilize Cray systems for specific kernel computations as a remote library system call from a local desktop system proved to be an efficient method for executing computationally-intensive simulations.

Cray plans to continue efforts to place Cray systems into large-scale supercomputing grids and verify that the approach can be used effectively to handle computationally challenging scientific problems.

Key contacts: Richard Russell, Mikami Kazunori

Global Scientific Information & Computing Center, Tokyo Institute of Technology, www.gsic.titech.ac.jp

Titech is one of the premier universities in Japan, specializing in advanced fields of science and technology. Its Global Scientific Information and Computing Center (GSIC) was established in April 2001. Being responsible for deploying advanced supercomputing infrastructure, GSIC's major emphases are to research and to develop grid computing for high-end scientific computing, and to replace traditional costly and centralized supercomputers with commodity and distributed supercomputing infrastructure. GSIC's pilot grid deployment research is called the " Grid," actually seeding the entire campus (15 sites) with over 800 processors of high-performance PC blade servers, in addition to the existing supercomputers, and interconnecting them with a campus Gigabit backbone to construct a large production-level testbed.

The Titech Grid was initiated in April 2002, and has deployed various grid middleware, including the Globus Grid Toolkit, the Ninf GridRPC middleware, jointly developed with AIST and the SCore cluster operating system. This effort has been recognized internationally, winning several awards for itself as well as its industrial partners, including the IBM "SUR (Shared University Research)" award, and the Nikkei IT Product award for partner NEC.

Key contacts: Satoshi Matsuoka, Hidemoto Nakada

Grid Technology Research Center, National Institute of Advanced Industrial Science and Technology, www.gtrc.aist.go.jp

The GTRC of AIST is dedicated to the research and development of the state-of-the-art grid programming tools, international verification experiments, grid-building technologies, and ultra-high speed networks, as well as studies on requirements for a reliable grid.

Six teams at the GTRC cover every facet of research and development (as of 2003). The mission of the GTRC is: 1) to share the activities of international standardization in collaboration with research organizations in Asia-Pacific countries, 2) to make research and development results into deliverable forms and provide them to users in demonstrable manner, and 3) to accelerate the commercialization of grid technology through the industrial, academic and government collaboration.

The GTRC, founded on January 1, 2002 with a limited term of 6 3/4 years, has 68 members, as of July 2003, including regular, postdoctoral, visiting, and temporary staff. At the Tsukuba Central 2 and the Ueno Office, GTRC is pursuing efforts aimed at making a quantum leap in sophistication and systematization of grid technology.

PRAGMA provides opportunities to encourage the use of AIST-developed grid middleware such as Ninf-G and Grid Data Farm. In addition, PRAGMA is a venue for sharing resources, knowledge, experiences; building new grid technologies via collaborations; interacting with experts in applications and grid middleware; linking PRAGMA member institutions with international grid communities; and helping developments of grid-enabled applications.

AIST researchers have been involved in all workshops. AIST hosted the third PRAGMA workshop in Fukuoka and continues to provide three clusters as a part of the PRAGMA testbed. PRAGMA projects selected the Grid Data Farm as a challenge of PRAGMA Applications. Satoshi Sekiguchi and Yoshio Tanaka are PRAGMA Steering Committee members. Osamu Tatebe is one of the leaders of the Data working group.

Key contacts: Satoshi Sekiguchi, Yoshio Tanaka

Kasetsart University, www.ku.ac.th

Researchers from KU have been working in collaboration with PRAGMA members to achieve the goals of promoting and using the grid. KU has been actively involved in the testbed activities through providing a dedicated cluster for PRAGMA use. The intention is to provide a stable environment for advanced grid applications being developed under PRAGMA effort.

In addition, KU researchers are now working with a team from the University of California, San Diego, to deploy GAMESS software under the grid environment. This will enable KU scientists to utilize the power of the grid for applications such as drug design and industrial applications for quantum chemistry. KU researchers have customized the KU-developed SQMS scheduler to distribute GAMESS jobs in a grid environment.

In addition, there is a work underway to port the OpenSCE cluster environment (ww.opensce.org) built by KU to run on the ROCKS system. This is a collaborative effort to build a strong fabric layer for the next-generation grid system.

Data-intensive applications are also an important driving force for the grid. KU is now working with the National Institute of Advanced Industrial Science and Technology in Japan on the Grid Data Farm project. The goal is to explore the viability of building wide area data intensive application using grid technology. The target applications are GIS, remote sensing, and large data and knowledge management.

Key contacts: Surasak Sanguanpong, Putchong Uthayopas, Sornhep Vannarat

Korea Institute of Science & Technology Information, www.kisti.re.kr, www.supercomputing.re.kr

KISTI is the leading edge organization of N*Grid project which is constructing the Korean national grid infrastructure, including grid middleware and application research. KISTI is also carrying out the Asia Pacific Grid Implementation Project for the construction and operation of Asia Pacific Grid, which was endorsed by APEC TEL. It also operates the secretariat of Grid Forum Korea that is the grid organization in Korea, and actively participates in other grid organizations such as GGF and APAN.

KISTI has actively involved in PRAGMA since its inception. It has participated in all five PRAGMA workshops, and hosted the second workshop in Seoul, Korea, where over 60 members from 9 countries were present. In terms of resources, KISTI is contributing a 80-node cluster to be used by PRAGMA members.

KISTI researchers have been involved in several PRAGMA projects such as, MGrid, which will develop a cost-efficient and reliable grid computing system for simulations of biomolecules, application of Ninf to simulations of nano-material, application of Active Measurement Protocol (AMP) for Korea Research Environment Open NETwork (KREONET).

Key contact: Jysoo Lee

National Center for High-Performance Computing, National Applied Research Laboratories, www.nchc.org.tw

NCHC researchers are involved in application and grid activities of interest to PRAGMA, such as the Taiwan Advanced Research and Educational Network, Knowledge Innovation National Grid, Asthma and SARS Grids, EcoGrid, World Wide Metacomputing, National Initiative in Hazard Mitigation and Emergency Response, National Biodiversity Program, National Science and Technology Program for Nanoscience and Nanotechnology and various outreach efforts for grid applications.

NCHC researchers are involved in all PRAGMA workshops, hosted the fifth PRAGMA workshop and provided a dedicated cluster to the PRAGMA testbed. PRAGMA projects involving NCHC researchers include: Telescience, EcoGrid/EcoInformatics; and the PRAGMA Testbed.

PRAGMA provides a platform for sharing resources between its members; establishing a testbed for grid applications; understanding practice and policy issues of sharing resources; advancing science via collaborations; linking current projects with international collaborations; interacting with experts in applications and grid middleware and increasingly wireless extensions to the grid; and for sharing in experiences and lessons learned.

Key contacts: Whey-Fone Tsai, Fang-Pang Lin

National Center for Supercomputing Applications, University of Illinois at Urbana-Champaign, www.ncsa.uiuc.edu

NCSA is a national high-performance computing center that develops and deploys cutting-edge computing, networking and information technologies to foster cyberinfrastructure. NCSA serves as the leading edge site for the National Computational Science Alliance (Alliance), and also for the NSF-funded TeraGrid.

NCSA researchers enable exemplary scientific research in various disciplines through the Alliance and TeraGrid partnerships. As such, NCSA researchers are involved in a variety of activities of interest to PRAGMA in cluster computing, grid computing, and applications research. NCSA leads the Network for Earthquake Engineering Simulation initiative, and also co-leads the National Laboratory for Applied Network Research network measurement monitoring, and the NSF National Middleware Initiative, and is involved with the National Virtual Observatory, a data grid for astronomy.

NCSA works with several PRAGMA member institutions through its International Affiliates Program. PRAGMA provides an international venue to interact, communicate, and collaborate, and to share, beta test, and deploy infrastructure currently in development by NCSA and PRAGMA partners. As a new member of PRAGMA, NCSA has participated in the Resources Working Group and has provided access to its high-performance computing environment to the PRAGMA testbed. NCSA anticipates being an active participant in all of the other PRAGMA working groups. At PRAGMA5, a subset of researchers associated with the Virtual Observatory activities from the countries of several institutions affiliated with PRAGMA participated virtually in a forum to discuss the current status.

Key contacts: Radha Nandkumar, Dan Reed, Danny Powell

Cybermedia Center & The Research Center for Ultra-High Voltage Electron Microscopy, Osaka University, www.cmc.osaka-u.ac.jp, www.uhvem.osaka-u.ac.jp

OSAKA UNIVERSITY

biogrid

Osaka University has been contributing to PRAGMA through providing computational resources, including highly advanced scientific devices, and expertise and experience in advanced networking and high-performance computing CMC co-hosted the third PRAGMA workshop with AIST in January 2003.

As a PRAGMA member, Osaka University is intensively involved in the research and development of two application categories (telescience and biological science) and grid middleware (IPv6-based Grid technology). In the telescience field, Osaka University is integrating scientific devices such as ultra-high voltage electron microscopes, and magnetoencephalography to the grid. Through this activity we have explored a new research method based on seamless data management from data acquisition to visualization. In the biological sciences field, Osaka University has been developing the federation of various bio-related databases using OGSA-DAI and the establishment of BioPfuga platform for multi-scale Bio simulation. In addition, a secure file system GSI-SFS and a portal system named GUIDE have been developed as Grid middleware for life-science applications. Furthermore, development and testing has involved IPv6-based grid technologies including IPv6-based Globus toolkit with PRAGMA research community and testbed.

Key contacts: Shinji Shimojo, Susumu Date, Toyokazu Akiyama, Seiichi Kato

STAR TAP/StarLight Initiative, www.startap.net/starlight

STARLIGHT

As the foremost 1Gbps-to-10Gbps optical exchange in North America, StarLight supports the high-performance computing experiments of a global community of researchers. As an advanced optical infrastructure, StarLight is a proving ground for network services optimized for high-performance applications.

PRAGMA members, in partnership with colleagues worldwide, can share techniques to exploit and control optical networks; develop new LambdaGrid tools to schedule both the computing resources as well as wavelengths; develop new visualization and data mining middleware techniques; put forth new methodologies for collaborative problem solving over very-high-speed networks; and participate in biennial international grid (iGrid) demonstrations.

As Pacific Rim research networks approach the multi-gigabit range, the StarLight facility exists as a permanent infrastructure where PRAGMA e-scientists, computer scientists and networking engineers may plug-in networks, co-locate equipment and directly peer with their colleagues in Canada, the U.S., South America, Europe and Asia.

Key contacts: Maxine Brown, Tom DeFanti

Thai Social/Scientific Academic & Research Network, National Electronics & Computer Technology Center, www.nectec.or.th/thaisarn

NECTEC has been involved in Thailand's development of Cluster and Grid computing technology from the beginning. Through ThaiSARN, we are connecting and supporting grid collaboration among Thai research communities (known as Thaigrid) with international research networks and forums, PRAGMA being one. On the application side, NECTEC focuses in application aiming toward Agriculture and Natural Resources, Bio-informatics, and computational science and engineering. In addition, NECTEC participates in a number of international forums, which concern grid related activities such as ApGrid, Asia Pacific Advanced Network (APAN), Internet2, and PRAGMA.

PRAGMA provides a venue which NECTEC as well as Thai researchers can expand and share activities and resources in grid technology with Asia-Pacific colleagues. PRAGMA is a synergetic forum to the meaningful collaboration for the greater benefit. NECTEC is one of the PRAGMA founding members and has actively participated in all PRAGMA meetings.

Key contacts: Royol Chitradon, Piyawut Srichaikul

TransPAC, Indiana University, www.transpac.org

TransPAC is a high-performance network connecting scientists in the US with their counterparts in the Asia-Pacific region. TransPAC provides fundamental network infrastructure to support e-science collaborations between these researchers in a broad range of scientific disciplines.

Architecturally, TransPAC connects US research and education infrastructure to Asia, specifically to the Asia Pacific Advanced Network Consortium in Tokyo. Following the most recent upgrade (October 2003), TransPAC will provide an OC-48 from Tokyo to Los Angeles and 2xGE from Tokyo to Chicago, with additional GE connectivity to Europe possible via TransLight.

TransPAC was a founding member of PRAGMA and will be a co-host, along with UCSD of the PRAGMA7 meeting in San Diego. TransPAC actively supports e-Science and grid activity via its partnerships with PRAGMA, APAN, and APGrid. TransPAC also leads and participates in measurement and security partnership activities between Asia and the US.

Key contacts: James Williams, Donald McMullen, John Hicks

Universiti Sains Malaysia, www.usm.my

USM was invited to attend the first PRAGMA workshop and has since been actively involved in grid activities and applications in support of PRAGMA's missions and vision.

USM has been a contributor in the area of bioscience grid applications. Two molecular modeling packages have been ported, AutoDock 3.0 and AMBER 6. USM is also a participant in building testbeds for applications. USM researchers have communicated with other PRAGMA participants about experiences in understanding practice and policy issues of sharing resources and establishing collaborations with other PRAGMA institutions. Other grid projects that USM has undertaken in the area of grid computing include the E-science project, which is a collaboration of three different universities in Malaysia. PRAGMA projects involving USM researchers include Cheminformatics and the PRAGMA testbed.

Key contact: Habibah Wahab

University of California, San Diego, www.ucsd.edu

UC San Diego

CRBS

UCSD researchers are involved in application and grid activities of interest to PRAGMA, such as the NSF-funded TeraGrid and National Partnerships for Advanced Computational Infrastructure; the NSF Middleware Initiative, OptIPuter, Geosciences Network, National Laboratory for Applied Network Research network measurement monitoring, and the NIH-funded Biomedical Informatics Research Network and National Biomedical Computation Resource.

PRAGMA provides an international vehicle to share codes under development at UCSD such as ROCKS, clustering software, and GAMESS, a chemistry application; to establish a testbed for grid applications and understand practice and policy issues of sharing resources international; to advance science via collaborations; to link current projects with international collaborations; and in general to interact with experts in applications and grid middleware and increasingly wireless extensions to the grid, to share in experiences and lessons learned.

UCSD researchers have been involved in all workshops, including hosting the inaugural workshop, have provided a dedicated cluster to the PRAGMA testbed, and have provided leadership in various aspects of the organization. PRAGMA projects involving UCSD researchers include: Telescience with Osaka University, NCHC, and NCMIR; Cheminformatics, with Monash University, USM, KU; Workflows and the Encyclopedia of Life with BII and TiTech; EcoGrid/EcoInformatics with NCHC and the PRAGMA Testbed.

UCSD organizations involved in PRAGMA include the San Diego Supercomputer Center, the California Institute for Telecommunications and Information Technology, the Center for Research on Biological Structure, and the National Laboratory for Applied Network Research. UCSD looks forward to co-hosting, with TransPAC, the PRAGMA 7 workshop.

Key contacts: Peter Arzberger, Philip Papadopoulos, Teri Simas, Mason Katz

University of Hyderabad, www.uohyd.ernet.in

UoH researchers are involved in grid-related activities, such as biosciences, nanotechnology, drug design and discovery, I-GRID initiative, University Grants Commission (UGC) supported Centre for Modelling, Simulation and Design, proposal for setting up HPC centre with Department of Science and Technology (DST) and C-DAC support.

PRAGMA serves as mechanism through which information and resources can easily be exchanged. PRAGMA resource-sharing agreements will allow scientists and infrastructure researchers to concentrate on problem solutions without having to perform ad hoc resource collection, installation, and testing. PRAGMA will also play a catalytic role of promoting collaborations.

UoH is planning to add a dedicated cluster to the PRAGMA testbed. Other PRAGMA projects involving UoH include resource and middleware initiatives. UoH would like to be a potential host for the forthcoming PRAGMA meeting.

Key contact: Arun Agarwal

PRAGMA Schedule of Workshops

PRAGMA Workshops are working meetings held bi- or tri-annually to allow members to review accomplishments and plan for future activities. To ensure continuity between subsequent meetings, the Co-chair of one meeting is the Chair of the next.

PRAGMA 1: 11-12 March, 2002, San Diego, USA. Hosted by San Diego Supercomputer Center and Cal-IT2 at the University of California, San Diego. Held in conjunction with the NPACI All Hands Meeting. Chair, Philip Papadopoulos (UCSD/SDSC/Cal(IT)2/CRBS); Co-chair, Sangsan Lee (KISTI)

PRAGMA 2: 10-11 July, 2002, Seoul, Korea. Hosted by the Korea Institute of Science and Technology Information and held in conjunction with Grid Forum Korea. Chair, Sangsan Lee (KISTI); Co-chair, Yoshio Tanaka (AIST)

PRAGMA 3: 23-24 January, 2003, Fukuoka, Japan. Hosted by the National Institute of Advanced Industrial Science and Technology, Osaka University, and Monash University and held in conjunction with the Asia-Pacific Advanced Network Consortium Meeting. Chair, Satoshi Sekiguchi (AIST); Co-chair, David Abramson (APAC)

PRAGMA 4: 4-5 June, 2003, Melbourne, Australia. Hosted by Monash University and held in conjunction with ICCS2003. Chair, David Abramson (APAC); Co-chair, Fang-Pang Lin (NCHC)

PRAGMA 5: 22-23 October, 2003, Hsinchu/Fushan, Taiwan. Hosted by National Center for High-performance Computing. Chair, Fang-Pang Lin (NCHC); Co-chair, Kai Nan (CNIC)

PRAGMA 6: 16-18 May, 2004, Beijing, China. Hosted by the Computer Network Information Center, Chinese Academy of Sciences. Chair, Baoping Yan; Co-chairs: Mason Katz (UCSD) and Jim Williams (TransPAC)

PRAGMA 7: TBD September 2004, San Diego, USA. Chairs: Mason Katz (UCSD) and Jim Williams (TransPAC)

Student Opportunities

Please visit the PRAGMA website for the latest updates, *www.pragma-grid.net.*

PRAGMA Sponsors

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