PACIFIC RIM APPLICATION AND GRID MIDDLEWARE ASSEMBLY

COLLABORATIVE OVERVIEW

2019

INTRODUCTION

Shava Smallen and Shinji Shimojo, PRAGMA Steering Committee Co-Chairs

The Pacific Rim Application and Grid Middleware Assembly (PRAGMA) is an open, grass-roots, international organization that makes cyberinfrastructure accessible, easy to use, and useful for long-tail-of-science communities to advance their science. These communities, often international in composition, are addressing societally important problems and are frequently unable to access, fully utilize, or keep pace with rapidly evolving cyberinfrastructure (CI) technologies and approaches. Through active participation and contributions of all members, PRAGMA focuses on how to make these new and rapidly changing CI technologies usable by these communities of scientists within a trusted envelope of shared, easy-to-use computer and data resources.

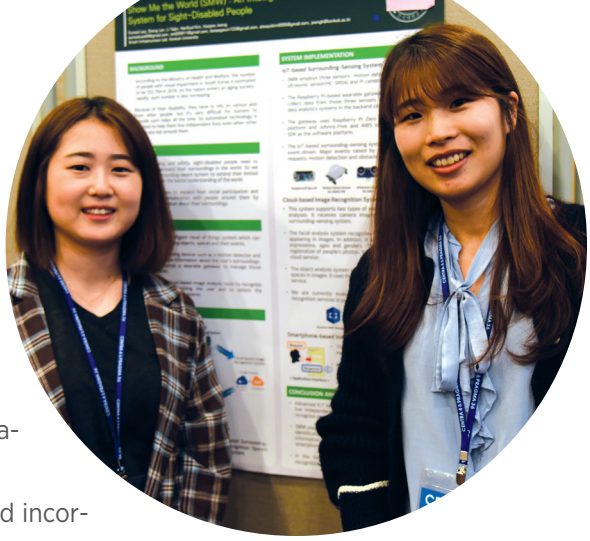
Since its inception in 2002, PRAGMA, through its workshops, projects, and students, acts as

- A **conduit of ideas** among members, for example by pushing the envelope of AI research through the recent deployment of the National Center for High-performance Computing's (NCHC) Taiwania 2 resource for AI research and development, and the previous year's deployment of the National Institute of Advanced Industrial Science and Technology's (AIST) AI Bridging Cloud Infrastructure, and between members and the broader community of CI researchers;
- An **enabler of multi-disciplinary, multi-institutional, international collaborations,** exemplified by our expeditions in water quality, biodiversity, and experimental network research, resulting in new knowledge that often transforms fields of research;
- An **experimenter with new technologies and approaches,** often on shared, jointly-constructed testbeds, such as PRAGMA's Experimental Network Testbed (PRAGMA-ENT) and the PRAGMA cloud, for pre-production testing, measurement, and research, in some cases leading to incorporation of approaches in national infrastructure, e.g., NSF's production virtualization resource Comet;
- A **producer and refiner of community software** driven by specific applications, but generalizable to others, for example GRAPLEr, Lifemapper, and PRAGMA's cluster virtualization suite, including PRAGMA boot and Cloud Scheduler GUI; and
- A **forum for students and researchers** to build the trusted people networks of inter-disciplinary scientists for long-term successful collaborations and careers.

The PRAGMA organization actively marries application needs with technology capabilities to advance science and infrastructure, both in short-term experiments and long-term expeditions. It actively seeks and engages new participants, promotes opportunities for development of students, and works to build and maintain increasing levels of trust among its community. It promotes collaborative and individual partner accomplishments and, as appropriate, migrates tools experimented with (or developed by) PRAGMA to national and international infrastructures.

PRAGMA Evolves

This year we welcomed a new steering committee member, Lilian Chan (University of Hong Kong), a new co-chair for Mentoring, Prapaporn Rattanatamrong (Thammasat University), and a new co-chair for Membership, Ruth Lee (Korea Institute of Science and Technology Information (KISTI).



Looking Forward

In the coming years, we will build on our current activities and plans described in this Collaborative Overview. PRAGMA's success will be weighted by

- New science from the expeditions and new insights from our experimentation and measurements;
- Use of tools and other PRAGMA products by the broader community and incorporation of some into national and international infrastructures;
- New collaborations generated by PRAGMA and new communities able to use these new cyberinfrastructure technologies;
- Student opportunities for research and professional development; and
- Publications that share the results of our work with the broader community.

PRAGMA's future is bright thanks to its strong people-network, partners working together to make CI technologies useful to new scientific communities and their challenges, and its investment in people who will be future leaders in their fields.

References

For more about PRAGMA, its past accomplishments, and software, please see:

Arzberger, P. (2017) A reflection on the origins, evolution, and future of PRAGMA. *Concurrency Computat: Pract. Exper.* e4136. doi.org/10.1002/cpe.4136.

We would like to highlight a recent publication highlighting the lessons learned from PRAGMA's successful collaboration with GLEON:

Carey, C. C., Ward, N. K., Farrell, K. J., Lofton, M. E., Krinos, A. I., McClure, R. P., Subratie, K. C., Figueiredo, R. J., Doubek, J. P., Hanson, P. C., Papadopoulos, P., and Arzberger, P.. 2019. Enhancing collaboration between ecologists and computer scientists: lessons learned and recommendations forward. *Ecosphere* **10**(5):e02753. 10.1002/ecs2.2753

PRAGMA Collaborative Overview: www.pragma-grid.net/overview

PRAGMA Software: www.pragma-grid.net/products

AT A GLANCE

PRAGMA was established in 2002 to enable the long tail of science through scientific expeditions and infrastructure experimentation for Pacific Rim institutions and researchers.

Members: 27 Institutional Members.

Governance: Steering Committee and PRAGMA's Operating Principles and Procedures

Steering Committee Co-Chairs: Shinji Shimojo (Osaka University) and Shava Smallen (UC San Diego)

Chairs of other steering committee Functional Area Roles:

Membership: Fang-Pang Lin (National Center for High-performance Computing, NCHC), Ruth Lee (Korea Institute of Science and Technology Information, KISTI)

Workshop Engagement: Kohei Ichikawa (Nara Institute of Science and Technology, NAIST)

Communications: Heru Suhartanto (Univ. of Indonesia)

Mentoring: Jason Haga (National Institute of Advanced Industrial Science and Technology, AIST), Prapaporn Rattanatamrong (Thammasat University)

Collectively, the PRAGMA Steering Committee Co-chairs and the Functional Area Role (FAR) chairs constitute an executive committee of the steering committee.

Workshops of Participants: Workshops are held twice a year to share progress and plan future activities. Open to all, workshops are hosted by PRAGMA members, often in conjunction with other activities.

2019 WORKSHOPS

PRAGMA 36: April 25–27, 2019. Hosted by the Korea Institute of Science and Technology Information (KISTI). Held in Jeju, Korea in conjunction with the 4th annual CENTRA meeting (April 22–24, 2019). For more information please see: **www.pragma-grid.net/pragma36**.

PRAGMA 37: September 11–13, 2019. Hosted by UC San Diego, La Jolla, California, USA. For more information please see: **www.pragma-grid.net/pragma37**.

2020 WORKSHOPS

PRAGMA 38: March 11–13, 2020. To be hosted by the University of Hong Kong, Hong Kong, China.

Overlay Virtual Networks and Applications in Lake Modeling, Forecasting, and Beyond

The PRAGMA Lake Expedition is an interdisciplinary collaboration between computer scientists and lake modelers and scientists affiliated with the Global Lake Ecological Observatory Network (GLEON). This effort advances current understandings of the effects of climate change and eutrophication (i.e., increased nutrient pollution of nitrogen and phosphorus, leading to increased plant growth) on harmful algal blooms in lakes. Lake expedition researchers and students have embarked on several activities this year and spun off collaborations with other PRAGMA members, leveraging team software and expertise. On the lake science side, the team has used PRAGMA cyberinfrastructure to complete hundreds of thousands of lake model runs to investigate (1) the impact of variability in climate warming scenarios on cyanobacteria bloom estimates in lakes, and (2) ecosystem-scale changes in water column total nitrogen and total phosphorous concentrations due to incremental changes in air temperature in both an oligotrophic and an eutrophic lake. On the cyberinfrastructure side, the focus has remained on the IP-over-P2P (IPOP) overlay virtual network software and on applications in sensor gateways and GRAPLEr, a high-throughput computing distributed system tailored for the execution of large batches of the General Lake Model (GLM). The GRAPLEr effort has enabled model runs in support of two publications under review, and the team has applied their lessons learned from working at the intersection of computer science and ecology into a practical guide for other collaborative teams.

PARTICIPANTS: *Virginia Tech:* Cayelan Carey, Kait Farrell, Arianna Krinos (student); *Univ. of Wisconsin:* Paul Hanson; *Univ. of Florida:* Renato Figueiredo, Ken Subratie (student), Vahid Daneshmand (student)

COLLABORATORS: *Thammasat Univ.:* Prapaporn Rattanatamrong, Yootana Boonpalit (student), Siwakorn Suwanjinda (student); *NAIST:* Kohei Ichikawa, Keichi Takahashi, Kundjanasith Thonglek (student); *UC San Diego:* Shava Smallen; *Universiti Sains Malaysia:* Nurul Hashimah Ahamed Hassain Malim

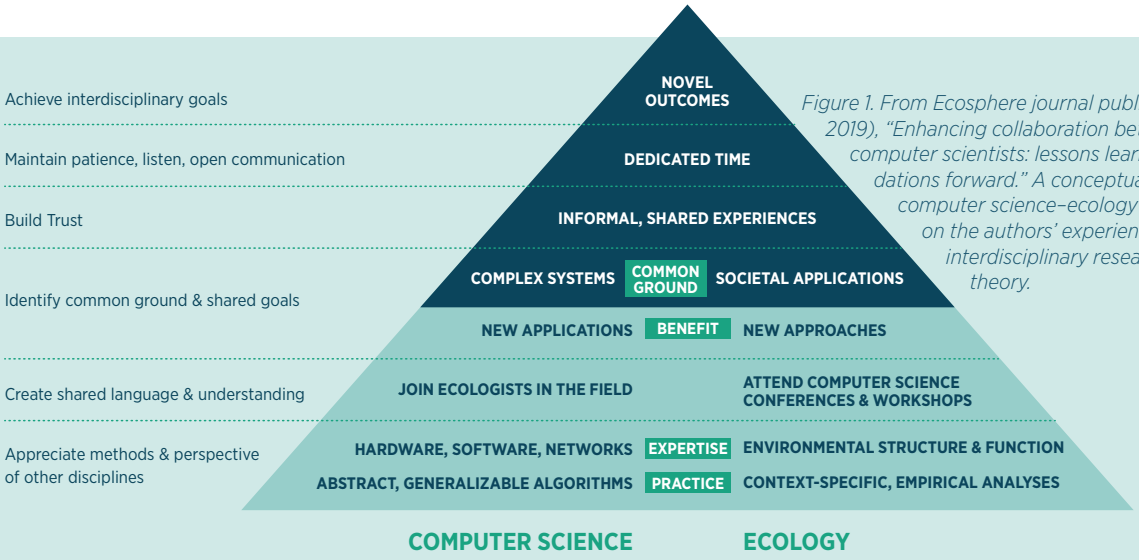


Figure 1. From Ecosphere journal publication (Carey et al. 2019), "Enhancing collaboration between ecologists and computer scientists: lessons learned and recommendations forward." A conceptual framework for computer science–ecology collaborations, based on the authors' experiences and informed by interdisciplinary research and team science theory.

PUBLICATIONS: www.pragma-grid.net/publications/lake-expedition

SOFTWARE: www.pragma-grid.net/software/grapler and www.pragma-grid.net/software/ipop.

Virtual Biodiversity Expedition and Lifemapper

Lifemapper, an open-source modeling environment created at the University of Kansas, allows researchers to pursue species distribution and macroecological modeling for biogeographic and biodiversity analyses of terrestrial species. The Virtual Biodiversity Expedition (VBE) is utilizing unique Lifemapper installations for PRAGMA sites using species occurrence data of local interest or specified by a researcher and phylogenetic (evolutionary) data derived from DNA sequencing studies to explain the ecological and evolutionary contributions to observed spatial patterns of species diversity. This year, biodiversity researchers enabled Lifemapper to more efficiently utilize all available resources from small virtual cluster installations designed for individual researchers to the XSEDE Comet supercomputer. In collaboration with CENTRA, they adapted the visualization client into a SAGE2 (Scalable Amplified Group Environment) application, a collaborative software that allows local and remote participants to visualize data on large, high-resolution displays. The Lifemapper SAGE2 client frees users to choose and arrange linked data displays to best visualize data properties and allows multiple, remotely-located users to interact with the data and application. Future versions will allow direct comparisons of datasets computed with different species, environmental layers, regions, spatial resolutions, or parameters. The SAGE2 client was built to facilitate user interaction, data exploration, and training in PRAGMA's "Distributable Lifemapper" installations and workshops.

PARTICIPANTS: *Univ. of Kansas:* James Beach, Aimee Stewart, C.J. Grady; *UC San Diego:* Nadya Williams; *NCHC:* Fang-Pang Lin, Hsiu-Mei Chou; *Univ. of Florida:* Michael Elliott (student)

PUBLICATIONS: www.pragma-grid.net/publications/biodiversity-expedition

SOFTWARE: www.pragma-grid.net/software/lifemapper

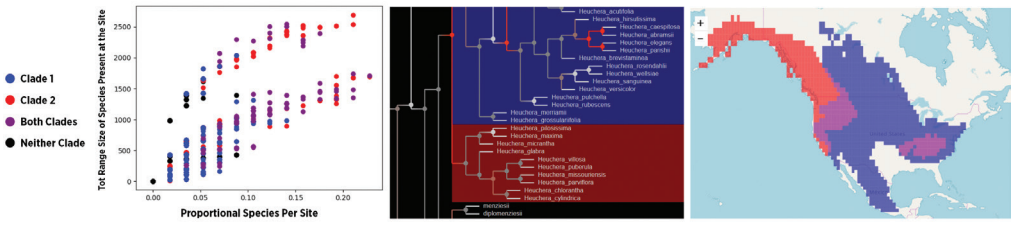


Figure 2. Linked windows showing 1) center image: two clades of species data, illustrating evolutionary relationships, colored as red and blue; 2) right image: predicted species distributions of two clades of species, areas of purple show predicted presence of both clades; and 3) left image: scatterplot of sites colored by clades present, illustrating the relationship between species range size in a site vs. number of species in a site. Purple points denote sites where both clades are predicted present; black points denote sites where species not highlighted are present.

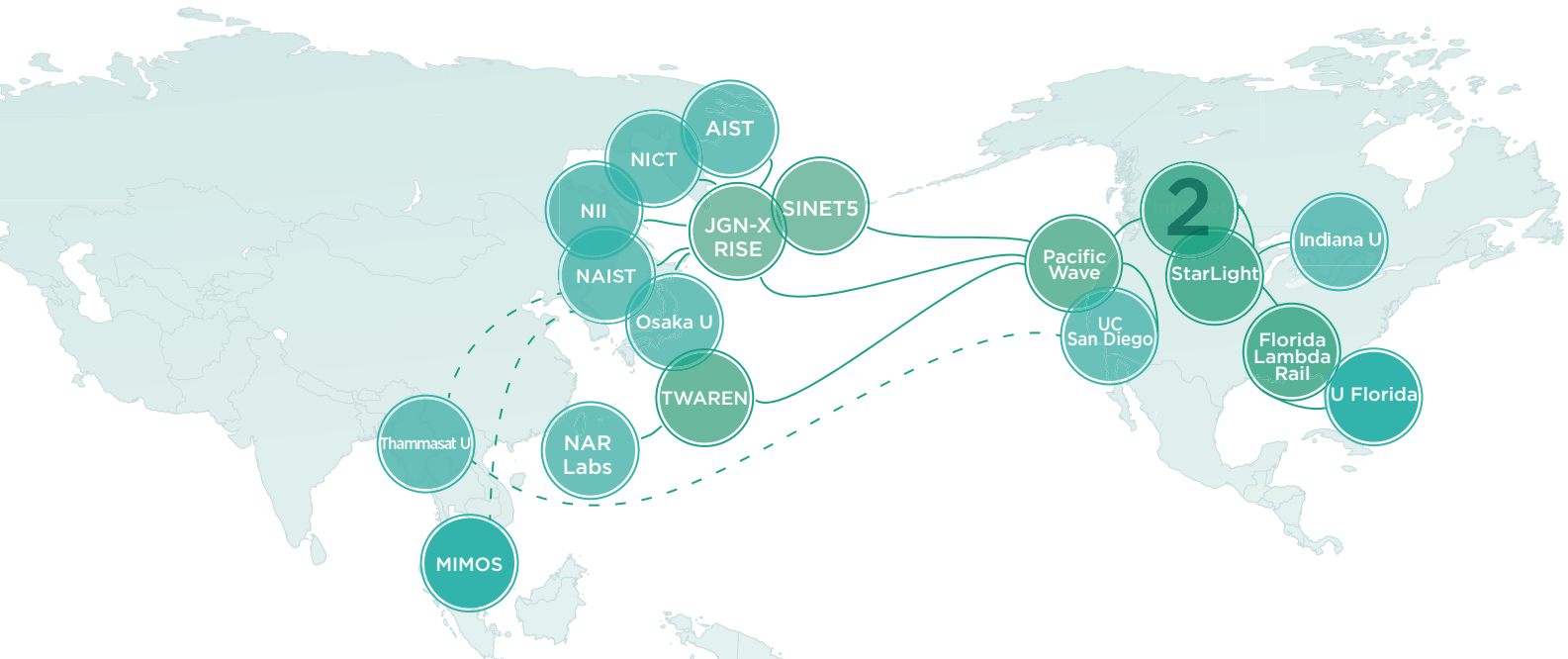


Figure 3: PRAGMA- L2 Backbone. High-speed research networks (FLR, Internet2, JGN-X, SINET, TWAREN, PacificWave, and StarLight) interconnect OpenFlow-enabled hardware switches in the United States (Univ. of Florida, UC San Diego, and Indiana University), Japan (Nara Institute of Science and Technology, National Institute of Information and Communications Technology, Osaka University, National Institute of Advanced Industrial Science and Technology, and National Institute of Informatics), Taiwan (National Applied Research Laboratories), Thailand (Thammasat University), and Malaysia (MIMOS). The solid and dashed lines indicate physical connections and virtual connections, respectively.

PRAGMA Experimental Network Testbed

The PRAGMA Experimental Network Testbed (PRAGMA-ENT) is an international Software-Defined Networking (SDN)/OpenFlow testbed for use by PRAGMA researchers and collaborators. The testbed offers complete freedom for researchers to access network resources to develop, experiment with, and evaluate new ideas without concerns of interfering with a production network. This will expose SDN to the broader PRAGMA community and facilitate the long-tail of eScience by creating new collaborations and infrastructure among institutes in the Pacific Rim area. Currently, five countries and 11 institutions provide their networking and computing resources for this testbed, and various researchers have been conducting many networking experiments, including high-performance networking, multipath routing, and Network Function Virtualization (NFV).

PARTICIPANTS: *NAIST:* Kohei Ichikawa, Wassapon Watanakeesuntorn (student); *Univ. of Florida:* Renato Figueiredo, Jose Fortes; *NICT:* Hiroaki Yamanaka, Jin Tanaka; *UC San Diego:* Shava Smallen, Nadya Williams *(now UC Irvine),* Philip Papadopoulos *(now UC Irvine); Osaka Univ.:* Juan Sebastian Aguirre (student), Yoshiyuki Kido, Susumu Date, Yasuhiro Watashiba, Shinji Shimojo; *AIST:* Jason Haga, Ryosei Takano, Yoshio Tanaka; *NII:* Atsuko Takefusa; *NARLabs* and the *NCHC:* Li-Chi Ku, Fang-Pang Lin, JenWei Hu, TeLung Liu; *Indiana Univ. Bloomington:* Quan (Gabriel) Zhou, Beth Plale, Jennifer Schopf, Rick McMullen; *Internet2:* John Hicks; *Kasetsart Univ.:* Putchong Uthayopas; *Thammasat Univ.:* Wanida Putthividhya, Prapaporn Rattanatamrong; *MIMOS:* Luke Jing Yuan

PUBLICATIONS: www.pragma-grid.net/publications/ent

SOFTWARE: www.pragma-grid.net/products/#ent

Monitoring the PRAGMA Cloud and IoT Testbed Infrastructures

The PRAGMA Cloud testbed provides a persistent set of resources for researchers to run their applications. Through a GUI interface, a researcher can select from a set of images and launch a virtual cluster at one or more PRAGMA sites for their application experiment. This past year, work has been focused on monitoring the infrastructure as well as the applications running on it. First, a GRAPLEr testbed was deployed on PRAGMA Cloud as well as a set of Raspberry PI boards that represented GRAPLEr IoT gateway nodes. Then, an initial performance monitoring environment based on the open source Telegraph, InfluxDB, and Grafana (TIG) stack was deployed to monitor it. A server was deployed with InfluxDB and Grafana, and each application node of the GRAPLEr testbed was installed with a monitoring agent, Telegraf, that collected runtime system performance metrics, including power consumption on the Raspberry PI boards. A module was also written to report basic job statistics for the GRAPLEr scheduler. To measure the overhead of monitoring, experiments were run to vary the monitoring frequencies and number of metrics. The results showed that Telegraf had a minimal impact on CPU, memory, disk I/O, and power consumption. To facilitate the deployment of this system in different clusters of application nodes, automated deployment scripts were created to install the software stack with basic configurations and will be used to deploy the monitoring to the production environment.

Figure 4. Screenshot of Grafana dashboard showing sample job statistics from the GRAPLEr testbed deployed on PRAGMA Cloud.

PARTICIPANTS: *UC San Diego:* Shava Smallen; *Thammasat Univ.:* Prapaporn Rattanramrong, Ayuth Mangmesap (student), Nitipat Wuttisasiwat (student), Yutthana Boonpalita (student), Siwakorn Suwanjindal (student); *AIST:* Jason Haga; *Univ. of Florida:* Renato Figueiredo, Vahid Daneshmand (student)

PUBLICATIONS: www.pragma-grid.net/publications/resources-data

SOFTWARE: cloud.pragma-grid.net and www.pragma-grid.net/products/#cloud

PRAGMA Data Infrastructure

PRAGMA continues to explore issues of identity and transparency for data. Building on previous work of how and when to assign persistent IDs (PIDs) for application datasets, this year's work has focused on implementing a concept called the global Digital Object Architecture (DOA). DOA implements the FAIR (findable, accessible, interoperable, and reusable) principles by provisioning an overlay that allows machine discovery of data. PRAGMA has developed an interoperability mapping between the DOA layer for sensor data residing in a network storage system called UNIS and demonstrated that it can recreate the logical objects in the face of failures in the network storage system. The DOA service that we developed (called Lakes Integrative Digital Object service or LIDO) utilizes the Research Data Alliance's (RDA) PID Kernel Information Working Group recommendation for knowledge management, and the Enhanced Robust Persistent Identification of Data (E-RPID) testbed (NSF #1839013) for test Handles.

PARTICIPANTS: *Indiana Univ.:* Yu Luo (student), Beth Plale, Martin Swany, and Jeremy Musser (student); *Airbox Project, Academia Sinica:* Ling-Jyh Chen

PUBLICATIONS: www.pragma-grid.net/publications/resources-data

SOFTWARE: cloud.pragma-grid.net and www.pragma-grid.net/products/#cloud

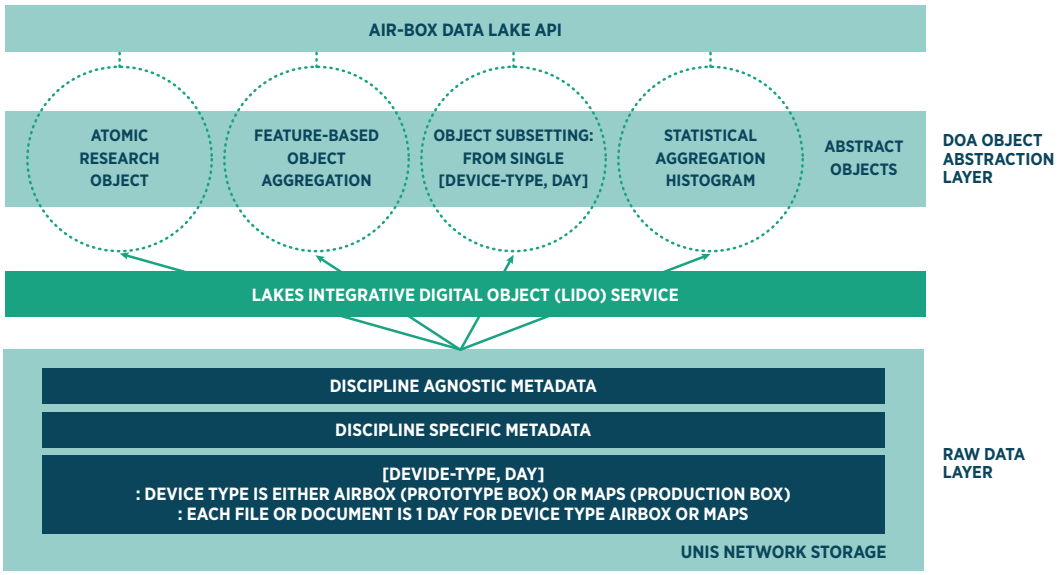


Figure 5. Architecture of the Lakes Integrative Digital Object (LIDO) service

Visualization Infrastructure and Activities: Improving Understanding through Visualizing Multiple Integrated Data Sources

The use of large format tiled display walls for immersive visualization and analytics continues to be an active area in PRAGMA and builds on the organization's strong ties with CENTRA and the University of Hawaii, Manoa. The application areas for immersive visualization using SAGE2 (Scalable Amplified Group Environment 2), LAVA (Laboratory for Advanced Visualization and Applications) at the University of Hawaii, Manoa, and the Electronic Visualization Laboratory (EVL) at the University of Illinois, Chicago continue to expand beyond disaster management. One new application area is in cybersecurity policy. A new collaborative project between the National Institute of Advanced Industrial Science and Technology (AIST) in Tokyo, Japan and Mahidol University in Thailand is developing a visualization workflow to provide decision support for understanding the requirements and deployment of different cybersecurity frameworks. The idea is to enable practitioners and policy makers to explore multiple security standards, usually consisting of hundreds of pages of text, in an interactive way, leading to better informed decisions when preparing to implement standards. A second application area is the development of a digital poster management tool. This application, also in a collaboration between AIST and Mahidol University, would enable exhibitors at conference booths to more easily manage the deployment of digital posters to multiple screens.

Figure 6. Screenshot of the security standards visualization application. This application creates a workflow that can be used to compare different security policies to make better decisions about choosing a standard.

PARTICIPANTS: *AIST:* Jason Haga; *Mahidol Univ.:* Wudhichart Sawangphol, Assadarat Khurat, Nasorn Niampradit (student), Sirasit Prinyavitit (student); *Univ. of Hawaii, Manoa:* Dylan Kobayashi (student)

AI Research and Development on Taiwania 2

Preparing for the rising tide of artificial intelligence (AI) research in recent years, the National Center for High-performance Computing (NCHC) in Taiwan is positioned as the national cyberinfrastructure provider for AI activities of the country. Funded by the Ministry of Science and Technology (MOST), NCHC built a supercomputer, Taiwania2, that emphasizes AI capability and went into production October 2019. The facility serves as the major computing resource of the Taiwan Computing Cloud (TWCC), which supports the research and development of both academia and industry. Taiwania2 consists of 252 computing nodes with 9,072 Intel Xeon Gold CPU cores, 2,016 Nvidia Tesla V100 GPUs, Infiniband 100 Gbps interconnect, 193.5TB SSD (240GB SSD and 4TB of NVMe SSD per node), and 10 PB GPFS storage. The system is capable of executing AI tasks and conventional HPC simulations. With the Rmax for high performance Linpack (HPL) benchmark of 9 PFLOPS, Taiwania2 was ranked 20th on the TOP500, a list of the 500 most powerful non-distributed computer systems in the world, as of November 2018. By adopting arm water cooling and other mechanisms, the power consumption of Taiwania2 is as low as 11.285GF/W with a PUE of 1.2. The power efficiency was ranked #10 on the Green500 list of November 2018. Taiwania2 is the fastest and most efficient computer in Taiwan.

PARTICIPANTS: *NCHC:* Weicheng Huang, William Lee, Fang-Pang Lin, Hsiu-Mei Chou

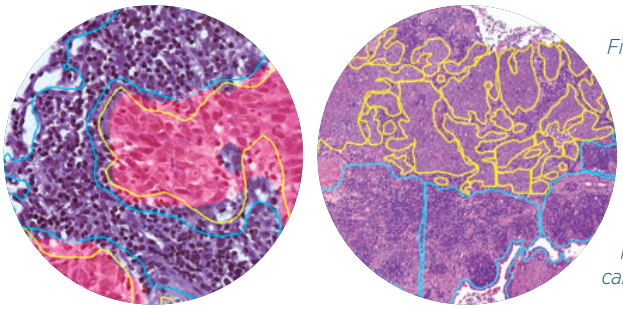


Figure 7. Identifying cancer cells on pathological tissue fragments using Taiwania 2. The resolution of the managed images is improved by 400 times, 100 million pixels, eliminating the need for a patch-based approach to imaging. The ResNet-50 with Unified Memory technology was used to train an AI model with 780 images and was validated with 68 images. The training performance is improved by 2.5 times. The process time of the whole digital AI pipeline is improved by 275 times, reduced from 690 days to 2.5 days, due to automatic annotation. The shadowed area of pink and red indicate the cancer predicted by AI, the cells marked by blue lines are normal tissues and the areas circled by yellow lines are the ground truth of cancer tissues.

EDISON for Computational Science and Engineering and beyond: Toward a Data Platform

EDISON is a well-known hub platform that supports various high-performance computing (HPC) simulation programs from multidisciplinary areas in computational science and engineering. Simple yet effective e-Science technologies such as EDISON WorkBench and WorkFlows have been improved to provide more powerful and convenient pre- and post-processing tools to conduct bulk simulations as well as analyze them. By adopting HTML5-based responsive CX-Learning contents, a lecturer can make cyber-learning contents via multi-faceted interactions such as lectures, YouTube videos, Webinars, or digital newsletters. With the growing trend toward AI, the EDISON platform can now be used for data analysis, AI modeling, and data sharing. EDISON-AI provides a GUI interface to develop machine learning models for novice users who want to learn about machine learning and AI applications. Example code is automatically generated for the user and then they can run the scripts on the web and modify the generated code for their needs. EDISON has been adopted as the official cyberlearning platform of PRAGMA for our international cooperation.

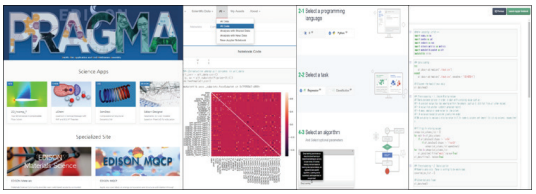


Figure 8. An example of EDISON-PRAGMA: Data analysis and GUI-based AI Modeling

PARTICIPANTS: *KISTI:* Ruth Lee, Junghun Shin, Jeonghyun Jerry Seo, Sunil Ahn, Namgyu Kim, Jeongcheol Lee

PUBLICATIONS: www.pragma-grid.net/publications/cyberlearning

SOFTWARE: www.pragma-grid.net/software/edison

UAV Applications for Rice Lodging Assessment

Recent extreme weather conditions in Taiwan have heavily impacted agriculture, especially in the northern and central areas where varying levels of flooding caused severe agricultural loss.

During mid-May 2019, two frontal systems caused heavy rainfall in Taiwan; on May 20th alone, the cumulative rainfall was more than 300 mm. The Taiwan central government reported more than 300 areas were affected by flooding, and agricultural damage amounted to $300 million US dollars. To detect the damaged areas where rice lodging (i.,e., bending over of the stems near the ground, making it difficult to harvest) occurred, images were taken from unmanned aerial vehicles (UAV), and machine learning techniques were applied to orthophoto and associated spectral characteristics to detect areas where rice lodging was observed. The rice lodging assessment report was provided to the township office and local government for disaster relief compensation reference.

PARTICIPANTS: *National Chung Hsing Univ.:* Ming-Der Yang, Hui Ping Tsai, Cloud Tseng, Yu-Chun Hsu

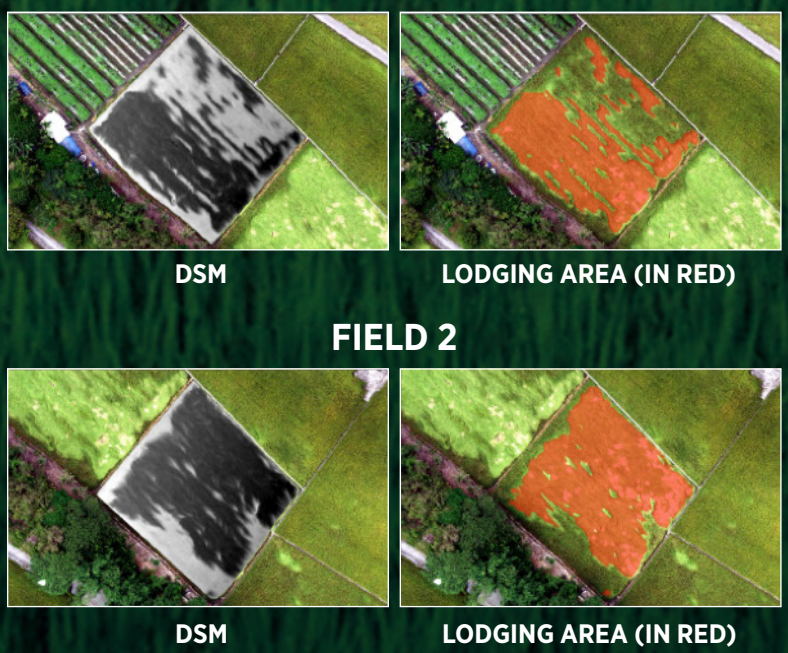


Figure 9. Based on the relative height information obtained from the digital surface model (DSM), orthophoto and associated spectral characteristics were used to detect areas where rice lodging occurred (marked in red). The proportions of lodging area for field #1 and field #2 are 55.59% and 71.67%, respectively.

Human Capacity Building for the International Research Enterprise: PRAGMA Students

PRAGMA's efforts to engage students are aimed at creating globally minded problem solvers for 21st century challenges. In particular, we want to inspire students to become research leaders who can function well in a collaborative, multidisciplinary, and multicultural world. Our approach focuses on two strategies: Enhancing professional experiences for and development of students at PRAGMA workshops and Providing students with research experiences throughout the PRAGMA network.

PRAGMA Students was formed in 2012 with the goal of helping students gain valuable professional experiences within PRAGMA's trusted social and technical networks. In order to provide leadership opportunities, this organization inside PRAGMA is led by a student committee and advised by senior PRAGMA researchers. To date, activities of PRAGMA Students include organizing PRAGMA-affiliated student presentation workshops and poster sessions as part of the biannual PRAGMA Workshops. During PRAGMA 36 in Jeju, South Korea, nine students presented their research and received feedback from PRAGMA mentors, and forty-two posters were presented. During PRAGMA 37, seven students presented during the student workshop, and 23 posters were presented. PRAGMA student activities have expanded to include professional development webinars that advise students on general presentation skills, for both posters and speaking, in a professional setting prior to our biannual workshops. In addition, four undergraduate students from Thammasat University had short-term residential research opportunities at AIST and the University of California, San Diego and worked collaboratively with researchers from the University of Florida. The students also form part of a unique model to build human capacity to solve problems in PRAGMA's collaborative scientific research.

We would like to note that one of the members of the PRAGMA Student Steering Committee, Chiao-Ning Chuang (NCTU), received a master's degree during this year. Congratulations!

PRAGMA STUDENT STEERING COMMITTEE: *NAIST:* Wassapon Watanakeesuntorn, Kundjanasith Thonglek; CAS: Can Wu; *Thammasat Univ.:* Suchanat Mangkhangcharoen, Yutthana Boonpalit, Yutthana Boonpalit; *Univ. of Florida:* Michael Elliott

PRAGMA STUDENT MENTORS: *AIST:* Jason Haga (FAR Mentoring co-chair); *Thammasat Univ.:* Prapaporn Rattanramrong (FAR Mentoring co-chair); *NAIST:* Kohei Ichikawa; *Indiana Univ.:* Beth Plale; *YARSI Universitas:* Sri C. Haryanti; *UC San Diego:* Peter Arzberger

CENTRA-PRAGMA Collaborations

The NSF-funded framework for Collaborations to Enable Transnational Applications (CENTRA) supports meetings, visits and other collaboration mechanisms needed for the creation of sustainable international collaborations. During its fourth year of existence, CENTRA activities included its all-hands annual meeting (CENTRA 4) in Jeju, Korea on April 22–27, 2019 as well as various researcher interactions needed to advance ongoing CENTRA collaboration projects. CENTRA 4 was held jointly with the PRAGMA 36 meeting, with CENTRA 4 sessions taking place on April 22–24 and PRAGMA 36 activities taking place on April 24–27. More than eight collaborative projects are now enabled and ongoing under the auspices of CENTRA. Eight additional collaborative efforts were proposed at CENTRA 4. Video recordings of CENTRA-hosted webinars on subjects at the intersection of software-defined systems, artificial intelligence and cyberinfrastructure are available for free viewing at https://vimeo.com/globalcentra. CENTRA webinars from both Spring 2018 and Spring 2019 have collectively been played more than 3,300 times.

PARTICIPANTS: *US-CENTRA at Univ. of Florida:* Jose Fortes; *NICT:* Shinji Shimojo; *CECEA:* Fang-Pang Lin; *INESC TEC:* Rui Oliveira; *KISTI:* Kum Won Cho

PUBLICATIONS: www.pragma-grid.net/publications/centra

CENTRA WEBSITE: For more information about CENTRA and its projects: www.globalcentra.org

Reviewing, Planning, and Organizing Activities and Introducing New Members

PRAGMA workshops are meetings of all members of the PRAGMA community. They are the major vehicle for information exchange between and among working groups, expeditions, researchers, and institutions; they also provide excellent opportunities to engage new researchers and students at the host sites. New participants bring new perspectives, applications, technologies, students, and resources to these events. These workshops are a critical opportunity to demonstrate progress on projects and to create action plans for accomplishing tasks prior to the next subsequent workshop.

Workshops are hosted by different organizations to provide a forum for PRAGMA members to meet and discuss research interests and ideally develop new collaborations with members of the hosting institutions.

The workshops are organized according to the activities of the following four working groups in PRAGMA:

- **RESOURCES AND DATA WORKING GROUP:** Working to make the distributed resources of PRAGMA useful to diverse applications via development and use of tools and technologies such as the PRAGMA Cloud Testbed, PRAGMA ENT, Open Data Platform, and others. Leader: Hsiu-Mei Chou (NCHC).
- **TELESCIENCE WORKING GROUP:** Focusing on a variety of activities that require access to, or use of, remote equipment, such as tiled-display walls (TDW) and sensors. Co-leaders: Shinji Shimojo (NICT and Osaka University) and Fang-Pang Lin (NCHC). This group also includes activities on disaster management.
- **BIOSCIENCES WORKING GROUP:** Focusing much of its efforts over the last several years on infrastructure development that enables virtual screening experiments and computational genomics analyses with an emphasis on combating infectious diseases and, more recently, on rice breeding. Leader: Jason Haga (AIST).
- **CYBER-LEARNING WORKING GROUP:** Focusing on the use of technologies to improve understanding in several areas of computational science through the use and improvement of EDISON. Co-leaders: Ruth Lee (KISTI) and Hsi-ching Lin (NCHC)

Active Members

A key component of PRAGMA is active involvement by participating in workshops, contributing resources, hosting workshops, and/or promoting and supporting student and researcher exchanges. The following institutions and members have contributed to PRAGMA activities in the past year *(* indicates Steering Comittee member)*:

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Networking partners provide access to improve the efficiency of the resource's groups in running distributed experiments and applications.

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TransPAC, INDIANA UNIVERSITY: Jennifer Schopf, *jmschopf@indiana.edu;* Andrew Lee, *leea@indiana.edu*

For more information about PRAGMA Members, visit www.pragma-grid.net/members-partners.php

ADDITIONAL ORGANIZATIONS

BIODIVERSITY INSTITUTE, UNIVERSITY OF KANSAS *(biodiversity.ku.edu)* participants conduct research on seven continents in biodiversity informatics, systematics and ecology and evolutionary biology. Contributions to the biodiversity expedition include participation in workshops and in the use and extension of the Lifemapper software.

NATIONAL APPLIED RESEARCH LABORATORY (NARL; *www.narl.org.tw/en*) was established in 2003 as a nonprofit organization to construct, operate and maintain the large-scale R&D facility and platform in support of academic research and foster the necessary manpower in various advanced fields focused on by the nation. NCHC is one of the laboratories in NARL. NARL can bring to bear several other laboratories at NARL for PRAGMA collaborations.

NATIONAL INSTITUTE FOR INFORMATION AND COMMUNICATION TECHNOLOGY (NICT; *www.nict.go.jp*) conducts general research and development on information technology supporting the ubiquitous society of the future. NICT supported PRIME students 2009–2015 and has participated in the activities of the Telescience Working Group through support of the high-definition video conferencing testing.

UNIVERSITY OF QUEENSLAND *(www.uq.edu.au)* become involved in PRAGMA through David Abramson's move there. David remains actively involved in PRAGMA Student activities.

VIRGINIA TECH Cayelan Carey and colleagues in Project EDDIE (Environmental Data-Driven Inquiry and Exploration; projecteddie.org, an NSF-funded project) have developed sensor-based and time series data analysis activities that can be integrated into classrooms to improve quantitative skills, reasoning, and increase student engagement. Carey is developing additional teaching modules that use the overlay network developed as part of PRAGMA to run lake simulations of climate change scenarios.

PARTNERS

GLEON (*www.gleon.org*) the Global Lakes Ecological Observatory Network, is a grassroots network of limnologists, ecologists, information technology experts and engineers who use GLEON's network of people, sensors and data to understand issues such as eutrophication or climate change at regional to global scales. GLEON, which was established based on an early PRAGMA expedition to place sensors on a lake in Taiwan in 2004, has grown to a network of more than 500 members.

NETWORK STARTUP RESOURCE CENTER (NSRC, *nsrc.org*), has longstanding experience in running hands-on networking training workshops and providing engineering assistance at both the campus and national network levels. They have worked in more than one hundred countries throughout the world over the past 20+ years. NSRC has been able to encourage participation in PRAGMA workshops, such as collocating a NSRC tutorial for MYREN (Malaysian Research and Education Network) concurrently with PRAGMA 35, and encouraging MYREN to provided a plenary talk at PRAGMA 35, bringing together these two communities.

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PRAGMA
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