Overview and Major Goals of PRAGMA

The Pacific Rim Application and Grid Middleware Assembly has an overarching goal of enabling small distributed teams of researchers to work together across international boundaries. PRAGMA is an international-scale organization, a technology development and testing vehicle, and a venue for training the next-generation of researchers who can operate in an international collaborative environment. A key organizing principle of PRAGMA are scientific expeditions that bring domain scientists and technology specialists together to work on common scientific goals. The scientific expeditions for this past year have been

* Lake ecology and Lake Eutrophication (the artificial enrichment of nutrients in lakes that can, for example, potentially cause catastrophic algae blooms)
* Biodiversity expedition focusing on data from Mt. Kinabalu in Sabah, Malaysia and the University of Kansas Lifemapper system for modeling species diversity.
* The PRAGMA Experimental Network Testbed. An international scale testbed that utilizes the AL2S service from Internet2 and international networks like Japan’s JGN to investigate software-defined network technologies and their applicability to expeditions.

PRAGMA researchers develop and deploy technologies in support of the scientific expeditions. Two underlying classes of technology work together to build capability in sharing: *system virtiualization* and *overlay networking* to create trusted communication envelopes for sharing data and software. The major goals have been to

* Further develop the *PRAGMA boot* for transporting virtualized compute clusters pre-configured with specific domain science applications between different virtualization systems (e.g. between OpenNebula an Rocks)
* Improve I-POP overlay networking technology that uses peer-to-peer trusted network envelopes, even for hosts behind NAT firewalls
* Create a mechanism called the *personal cloud controller* that provides a much more understandable interface for end-users to utilize the underlying tools needed to created distributed computing environments.
* Extensive porting and packaging of Lifemapper with two related goals: enable Lifemapper to operate in other data centers and provide some of Lifemapper’s functionality in a virtual machine suitable for deployment on in-field laptops. This second part is very useful for researchers who are in the field but disconnected from the Internet.

PRAGMA Engages students with the goals of providing opportunities for both undergraduate and graduate students to contribute to the research goals, fundamentally drive aspects of the organization itself through the Student’s association and to participate in training opportunities.

Finally, PRAGMA must function as a cooperative international organization that adapts as realties of some organizations ability to participate and natural priorities change over time. As a group, PRAGMA as meetings twice per year to serve as a natural focal point for all members. The steering committee meets in person as part of the larger group meeting.

I. Details of Major Goals of specific PRAGMA activities

I.A. Scientific Expeditions

***PRAGMA Lake eutrophication expedition***: To gain understanding and predictive ability of the impact of eutrophication on lake ecosystem services, we need to understand, for example, how phytoplankton community structure and biomass respond to drivers operating at different time scales, such as short-term weather patterns, multi-year climate cycles, and long-term climate trends, and how easily measured indicators of phytoplankton communities, such as in-situ pigment fluorescence, allow us to predict ecosystem-scale wax and wane of phytoplankton blooms. This PRAGMA expedition, led by Paul Hanson (UW), in collaboration with Renato Figueiredo (UF) and Cayelan Carey (Virginia Tech), and involving the GLEON lake modeling working group, has an over-arching goal of discovering the controls over the wax and wane of lake phytoplankton communities. By connecting the scientific community with data and model resources, this expedition enables advanced simulation of lake hydrodynamics and water quality to address research questions. The expedition focuses initially on three CI challenges: Organizing and structuring heterogeneous data from multiple data providers; tracking/managing the collection of resources so that all stakeholders can participate in some meaningful way; tracking/ managing attribution for stakeholders. One activity in the expedition is the deployment of an IPOP overlay virtual network and HTCondor across participating GLEON/PRAGMA institutions to enable aggregation and sharing of computational resources and models by a distributed group of collaborators.

***PRAGMA Biodiversity Expedition***: Facilitates the use of cyberinfrastructure to study the biodiversity, distribution and adaptation of organisms in extreme montane tropical environments, such as Mount Kinabalu (4095 m), in Sabah, Malaysia, a global biodiversity hot-spot and World Heritage Site. Located in the northern part of Borneo, Kinabalu is marked by numerous ultramafic (serpentine) outcrops where soil and substrates are high in iron, magnesium, nickel and other metals. These environments can be toxic to many plant and animal species, while other species are known to hyper-accumulate of nickel. An underlying goal is to understand how plants, animals, and microbes adapt to extreme environments, changing climate, and toxic conditions. The expedition also focuses on several CI challenges: PRAGMA expedition participants (A. Stewart, N. Williams) are working on portability and virtualization of clustered software (Lifemapper) where software can be moved to the data stored in participating PRAGMA nodes. Research collaborators also wish to share software and data across international boundaries in trusted, networked environments. Systems will need to provide sufficient metadata, usage tracking, and security to support distributed, collaborative environments, and Biodiversity Expedition plans to leverage PRAGMA-ENT to address specific needs. Remote sensing data capture using Unmanned Aerial Vehicles (UAVs) on Kinabalu has now been initially field-tested. Scaling up UAV data capture would present further CI challenges in data sharing and processing.

***PRAGMA Experimental Network Testbed (PRAGMA-ENT):*** established in October 2013 with the goal of constructing a breakable international software-defined network (SDN) testbed for use by PRAGMA researchers and collaborators. PRAGMA-ENT is breakable in the sense that it offers complete freedom for researchers to access network resources to develop, experiment, and evaluate new ideas without concerns of interfering with a production network. PRAGMA-ENT long term goal is to offer the necessary networking support to the PRAGMA multi-cloud and user-defined trust envelopes. To this end, research and development on several areas of networking will be conducted, including wide-area layer 2 (L2) connectivity, software-defined networks, overlay networks, and IPv6.

I.B. Technology Development

***Virtual Cluster Sharing*** To enable sharing of software platforms and allow running computational experiments across different sites, PRAGMA members have agreed on a common way to publish virtual clusters (VCs). Virtual clusters, like their real counterparts have two logical components: a frontend (or head node) and one or more compute nodes. Our goal is to use virtual clusters as a general way to capture complex software deployments and make them portable to other sites without reinstallation or significant porting effort. In essence we port the frontend and compute virtual machine images to a remote site and reconstruct the network topology to port a VC from one cloud deployment to another. This activity has led to the development of the Virtual Cluster Sharing technology so the groups may author their computing platforms (e.g., analysis software, load schedulers, web-services, scientific libraries and more) in any manner they prefer and then move their completed system to a remote site. With overlay networks (discussed further in this report), computing and access to remote data can more easily enabled across sites.

A PRAGMA Virtual Cluster is composed of virtual machine disk images and an XML file (vc-in.xml) describing how to connect the booted virtual machines in a computing cluster. This approach is different from other available cloud system because its smallest deployment unit is based on the concept of a cluster of machines connected together and not just on a single virtual machine. This self-contained description mechanism simplifies the creation of computational infrastructure and facilitates the creation of cluster appliance libraries. Libraries can contain different cluster images (application-centric or general) and can be hosted on various storage systems (from local shared file system to HTTP base web sites).

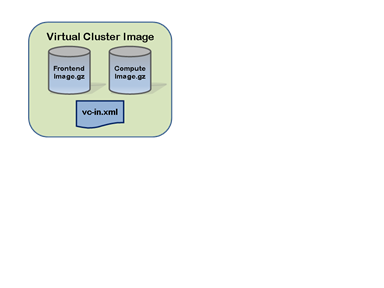


Figure - PRAGMA Virtual Cluster Images and Description file

**IPOP Network Overlay**

**Lifemapper Virtual Cluster Authoring** Biodiversity research uses species distribution modeling to understand how changes in climate and environment could affect the living organisms and how different species geographical distribution can change. A key software technology used in the biodiversity expedition is Lifemapper, which has been developed by the KU Biodiversity Institute since 2000 and today provides a collection of computational and web services that together with the software modules enable species distribution modeling and mapping over geographic ranges (http://news.ku.edu/2014/06/27/lifemapper-shows-where-earths-organisms-live-today-and-might-go-tomorrow).

Lifemapper is a computer infrastructure producing an archive of species distribution maps calculated from public specimen data and a suite of data and tools for biodiversity researchers. Lifemapper analysis and modeling tools include Species Distribution Modeling (LmSDM) which tries to predict the geographic distribution of species based on where they have been found and the environmental conditions in those locations and Range and Diversity Modeling (LmRAD) that supports Macro-Ecological modeling. The current infrastructure has a significant reliance on particular services deployed in the Kansas data center. A key goal has been to to progressively port the elements of Lifemapper into the Rocks cluster environment to make it more portable (and to remove dependency on specific servers physically located in Kansas

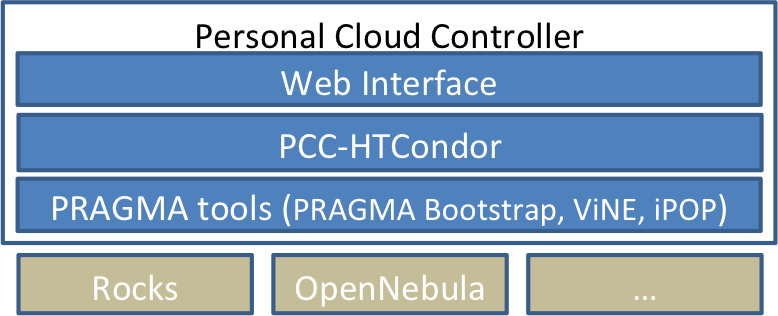
The infrastructure consists of four independent sub-systems that communicate with each other to process biological data: 1) LmDbServer for data management; 2) LmCompute for computations; 3) LmWebServer for communications and 4) client applications. The DbServer and WebServer components are the most complex software deployments in Lifemapper with a number of software subsystems and specific data that is loaded into a custom database schema running under Postgres.

For PRAGMA 25, three PRAGMA members (KU, IU and UCSD) built a framework for enabling Virtual Lifemapper Provenance Cluster (VLPC). The VLPC was instantiated at UCSD site, run Lifemapper species distribution modeling jobs created on the KU server and sent the jobs’ provenance information to the Provenance Karma server at UI site. For this distributed site approach we have: (1) streamlined and automated the build process for the LmCompute component to allow easy deployment of a virtual cluster at SDSC; (2) extended the Lifemapper code on the cluster to produce process-specific provenance logging; (3) enabled automated provenance collection for Lifemapper running jobs on SDSC's cluster.

## **Personal Cloud Controller**

A number of related technologies (virtual cluster boot, overlay network construction, identification of appropriate physical resources) must be assembled to enable our goal of resource and data sharing. The complexity can overwhelm non-specialists and this leads to our goal providing users with an easy-to-use interface for managing the lifecycle of virtual clusters from startup to status monitoring and shutdown, a higher-level control architecture activity was started during this report period. This activity led to the design of a Personal Cloud Controller (PCC) tool, a lightweight management tool that integrates various PRAGMA tools like PRAGMA Bootstrap with the well-known resource management tool called HTCondor. The architecture is shown in Figure 1 where the user views available virtual cluster images and submits a request through the Web Interface. The request is then forwarded to HTCondor, which utilizes a PCC extension (PCC-HTCondor) to invoke PRAGMA Bootstrap which, in turn, enables the virtual cluster on one or more physical resource and then constructs the virtual networking (i.e., iPOP or ViNE) overlay to connect the nodes together as a single cluster.

Figure 1: Architecture design of PCC.



I.C Student Activities Development

**PRAGMA Engagement the Pacific Rim Experiences for Undergraduates (PRIME)**: For the past 10 years, PRAGMA collaborators have actively participated in the Pacific Rim Experiences for Undergraduates program, otherwise known as “PRIME” (prime.ucsd.edu). Created in 2004 to provide a project-based, hands-on research internship program combined with an experience in international cultural awareness for science and engineering undergraduates at the University of California, San Diego. PRIME grew out of the [PRAGMA](http://www.pragma-grid.net) collaborative project framework and people network. PRIME’s projects are facilitated through collaborations between UC San Diego and international researchers within the Pacific Rim.

As of 2013, 186 students had participated in the program, to include 89 female undergraduates. PRAGMA collaborators in Australia, China, India, Japan, Malaysia, New Zealand, and Taiwan have embraced this program, welcoming our students to their institutions and laboratories for nine weeks during our summer months, actively engaging them in research. Our goals have been to continue PRAGMA involvement and leadership in this related program.

**PRAGMA Students Society** The major goals are to continue evolution of the PRAGMA students society for a more active role in the organization itself. Initially defined to take place on the day preceding each semi-annual meeting with virtual meetings in-between, the students (primarily graduate students) are becoming more fully integrated into major sessions of the meeting, including demonstrations, organizing a plenary session using lightning talks, and participating in steering committee meetings.

I.D PRAGMA Organization and Steering Committee

PRAGMA Steering Committee. The bylaws of PRAGMA stipulate that “The Steering Committee will be the means by which representatives of the Institutional Members will make collective decisions on matters relating to PRAGMA” Currently there are eighteen members on the Steering Committee [see list below] from thirteen institutions. The Steering Committee meets at each of the PRAGMA Workshops, and as needed between workshops.

During this reporting period the Steering Committee met at:

* PRAGMA 25, hosted by the Computer Network Information Center, Chinese Academy of Sciences, in Beijing, PRC, on 16-18 October 2013
* PRAGMA 26, hosted by the National Center for High-performance Computing (NCHC), National Applied Research Laboratory (NARL), in Tainan, Taiwan, on 9 – 11 April 2014.

Key discussion topics at these two meetings include:

* PRAGMA Students: How to promote that activity within PRAGMA’s structure. PRAGMA Students was established after discussions at PRAGMA 22 (April 2012) to provide opportunities for students within PRAGMA. Several concrete activities were discussed and some have been implemented in this reporting period. (Details follow in this report)
* Evolving PRAGMA organizational structure to a more sustainable model and in parallel to look at ways to restructure the Working Groups and the Steering Committee and its activities. This is work in progress, but PRAGMA is looking at the GLEON Model for selection of members for the Steering Committee and for rotation of members on the committee. In addition, members of the Chairs of PRAGMA Student group to be members of the PRAGMA Steering Committee.

What was accomplished under these goals (you must provide information for at least one of the 4 categories below)?

**Major Activities:**

* PRAGMA-ENT involves participation of researchers in the US, Japan, China, Taiwan, Thailand, and South Korea.
* Teams in the US and Japan are collaborating with Internet2, National Institute of Information and Communications Technology (Japan), and Pacific Wave Peering Exchange to establish an international L2 circuit.
* Monthly conference calls synchronize PRAGMA-ENT activities in all involved countries.
* The Pragma Lake expedition involves participation of researchers at U. Florida, U. Wisconsin, and Virginia Tech. The major activities in the reporting period have been to design, deploy, test and document an HTCondor distributed virtual cluster where nodes are connected by the IPOP virtual network overlay for this expedition. The team has met via tele-conference on a bi-weekly basis, and has reached out to additional collaborators from the GLEON (Global Lake Ecological Observatory Network) community who we expect to be early adopters of the technology.
* Lifemapper [Nadya and Aimee]
* The Biodiversity Expedition organized a PRAGMA mini-symposium as part of the 8th International Conference on Serpentine Ecology, hosted by Sabah Parks, Malaysia, in June 2014. A set of information management needs emerged relating to the global community for aggregating data at a global scale, and PRAGMA was seen as a potential facilitator.
* Biodiversity Expedition participants collaborated with Univ. of Queensland and Sabah Parks researchers for five days of UAV data capture on Mount Kinabalu (prior to the conference above). The activity resulted in a preliminary data set of over 10,000 still images of multispectral data (4 bands) and several hours of video. The multispectral data is still being pre-processed (an emerging CI challenge) as the imagery will have a nominal ground resolution of ca. 15 cm. The processing, storage, and sharing of these data is a topic we hope to address together with PRAGMA-ENT.

**Specific Objectives:**

**Significant Results:**

**Key outcomes or other achievements:**

* An end-to-end wide-area software-defined network has been established between UF and UCSD. An Internet2 AL2S VLAN connects hardware OpenFlow switches at UF and UCSD.
* Software tunnels have been used to connect US and Japanese sites, establishing an international network of OpenFlow switches.
* Lake expedition users typically work on Windows environments; to better support Windows computers, an enhancement to the IPOP software has been implemented in the form of a service that monitors the status of the IPOP software and automatic starts/restarts IPOP.
* A prototype HTCondor pool with Windows virtual machines and running the IPOP overlay has been deployed at University of Florida resources, and documentation has been created in a GitHub repository for the expedition ([www.github.com/graple](http://www.github.com/graple)). The prototype at UF is slated to have 50 cores deployed at UF by the end of August 2014.

What opportunities for training and professional development has the project provided?

On-line seminars exposed students at PRAGMA institutions (in the US and abroad) to the technologies being integrated into PRAGMA-ENT. The seminar “Towards Software-Defined Systems”, delivered by José Fortes in February 2014, introduced to the PRAGMA community the concepts and technologies that will be integrated and exposed in PRAGMA-ENT.

The lake expedition has provided opportunities for development of students at the participating institutions in High-Throughput Computing (HTC) and overlay virtual network software.

How have the results been disseminated to communities of interest?

PRAGMA-ENT activities and results are shared with PRAGMA community during semi-annual PRAGMA meetings.

PRAGMA-ENT webpage, on the main PRAGMA website, disseminates PRAGMA-ENT to a broader community.

Lake expedition activities have been disseminated through the PRAGMA and GLEON web sites. Enhancements and documentation on the IPOP software have been disseminated through the IPOP project’s Web site.

Biodiversity Expedition activities were disseminated on the ICSE web site and through direct interaction with serpentine ecologists in the mini-PRAGMA symposium. The proceedings of the conference/symposium will be published.

What do you plan to do during the next reporting period to accomplish the goals?

PRAGMA-ENT participants will continue to interact monthly through on-line meetings. PRAGMA-ENT infrastructure will be expanded to include more sites and countries, and a second team, focused on applications, will work on the integration of PRAGMA multi-cloud and user-defined trust envelopes.

The Lake expedition participants will continue to interact bi-weekly through conference calls. The team plans to have a presentation and demonstration of the HTCondor/IPOP system at the GLEON-16 meeting in Quebec, Canada, and at the PRAGMA meetings, both in October 2014; a planned outcome of these events is to bring additional users and computing resources from the GLEON and PRAGMA communities to the distributed HTCondor/IPOP virtual cluster. The team also plans to pursue supplementary travel funds to bring computer science and limnology students to these events to catalyze interactions between the two domains.

NOTE: You may upload PDF files with images, tables, charts, or other graphics in support of the Accomplishments section. You may upload up to 4 PDF files with a maximum file size of 5 MB each.

**Products**   
You have the option of selecting “nothing to report” in this section. There are no limitations to the number of entries you submit and you can also pull information directly from Thomson Search when using the online tool on Research.gov.

Within the Products section, you can list any products resulting from your project during the specified reporting period, such as:

**Journals:**

Pierre St Juste, Kyuho Jeong, Heungsik Eom, Corey Baker, Renato Figueiredo, ‘TinCan: User-Defined P2P Virtual Network Overlays for Ad-hoc Collaboration‘, ICST Transactions on Collaborative Computing, Volume 14 Issue 2, 08/2014

**Books:**

**Book Chapters:**

Maurício Tsugawa, Andréa Matsunaga, José A. B. Fortes. Cloud Networking to Support Data Intensive Applications. Cloud Computing for Data-Intensive Applications. (to appear)

**Thesis/Dissertations:**

**Conference Papers and Presentations:**

**Other Publications:**

**Technologies or Techniques:**

**Patents:**

**Inventions:**

**Licenses:**

**Websites:**

<http://www.pragma-grid.net/expeditions.php>

<http://www.github.org/graple>

http://www.ipop-project.org

**Other Products:**

NOTE: You may upload PDF files with images, tables, charts, or other graphics in support of the Products section. You may upload up to 4 PDF files with a maximum file size of 5 MB each.

Participants

There are no limits on the number of participants you list for this section; however, you must list participants who have worked one person month or more for the project reporting period. You have the option of selecting “nothing to report” in this section. For Research Experience for Undergraduates (REU) sites and supplements, specific questions will be listed in this section. The online service will also ask for additional information on participants such as:

* What individuals have worked on the project?
* What organizations have been involved as partners?
* Have other collaborators or contacts been involved?

What individuals have worked on the project?

**Name:** José Fortes

**Nearest Person Month Worked: 1**

**Contribution to the Project:** Fortes oversees all PRAGMA activities at the University of Florida, works on aspects of the PRAGMA-ENT design, and collaborates with other PRAGMA PIs on activities aimed at promoting, expanding and disseminating PRAGMA engagements and collaborations with researchers at international sites.

**Funding Support:** This award

**Country(ies) of foreign collaborator:**

**Traveled to foreign country:** yes

**Country:** China, Taiwan and Malaysia

**Duration of stay: 10 days (China), 10 days (Taiwan) and 6 days (Malaysia)**

**Name:** Renato Figueiredo

**Nearest Person Month Worked:** 1

**Contribution to the Project:** Figueiredo has led cyber-infrastructure design and integration activities in the PRAGMA Lake expedition, including IPOP overlay networks and HTCondor

**Funding Support:** This award

**Country(ies) of foreign collaborator:** none

**Traveled to foreign country:** yes

**Country: China and Taiwan**

**Duration of stay: 5 days (China), 5 days (Taiwan)**

**Name:** Reed Beaman

**Nearest Person Month Worked:** 1

**Contribution to the Project:** Beaman organized the mini-PRAGMA symposium in Malaysia and participated in the UAV remote sensing data collection on Mount Kinabalu. He also collaborates with the Lifemapper team.

**Funding Support:** This award

**Country(ies) of foreign collaborator:** Australia, Malaysia

**Traveled to foreign country:** yes

**Country: Taiwan, Malaysia**

**Duration of stay: 5 days (Taiwan), 10 days (Malaysia)**

**Name:** Youna Jung

**Nearest Person Month Worked:** 2

**Contribution to the Project:** Jung has led software engineering and documentation activities in the PRAGMA Lake expedition

**Funding Support:** This award

**Country(ies) of foreign collaborator:** none

**Traveled to foreign country:** no

**Country:**

**Duration of stay:**

**Name:** Kensworth Subratie

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Subratie has led development of Windows restart/monitoring service for IPOP and prototype development/deployment in the PRAGMA Lake expedition

**Funding Support:** This award

**Country(ies) of foreign collaborator:** none

**Traveled to foreign country:** no

**Country:**

**Duration of stay:**

**Name:** Pierre St. Juste

**Nearest Person Month Worked:** 5

**Contribution to the Project:** St. Juste has contributed to development, documentation and testing of IPOP overlay software

**Funding Support: This award**

**Country(ies) of foreign collaborator:** none

**Traveled to foreign country:** no

**Country:**

**Duration of stay:**

**Name:** Maurício Tsugawa

**Nearest Person Month Worked:** 1

**Contribution to the Project:** Research and development of virtual network technologies and co-leader of PRAGMA Experimental Network Testbed expedition.

**Funding Support:** University of Florida

**Country(ies) of foreign collaborator:** Japan, China, Taiwan, Thailand, South Korea

**Traveled to foreign country:** yes

**Country:** China and Taiwan

**Duration of stay:** 5 days (China), 5 days (Taiwan)

**What other organizations have been involved as partners?**

The online service will also ask you for additional information such as:

* Type of Partner Organization
* Name
* Location
* Partner’s contribution to the project

**Type of Partner Organization:** Collaborative research (e.g., partner's staff work with project staff on the project)

**Name:** University of Florida

**Location:** Florida, USA

**More detail on partner contribution (optional):**

**Type of Partner Organization:** Collaborative research (e.g., partner's staff work with project staff on the project)

**Name:** University of Queensland

**Location:** Brisbane, Queensland, Australia

**More detail on partner contribution (optional):** Partners at U. Queensland provided the Unmanned Aerial Vehicles (UAVs) and expertise. Three Univ. Queensland participants were involved.

**Type of Partner Organization:** Collaborative research (e.g., partner's staff work with project staff on the project)

**Name:** Sabah Parks

**Location:** Kota Kinabalu, Sabah, Malaysia

**More detail on partner contribution (optional):** Provided logistical support, coordination, permits, etc. for data collection and hosted the mini-PRAGMA symposium on Serpentine Ecology.

**Type of Partner Organization:** Collaborative research (e.g., partner's staff work with project staff on the project)

**Name:** University of Wisconsin

**Location:** Madison, Wisconsin, USA

**More detail on partner contribution (optional):** Partners at U. Wisconsin collaborated in formulation of usage scenarios, documentation, and testing of the lake expedition prototype.

**Type of Partner Organization:** Collaborative research (e.g., partner's staff work with project staff on the project)

**Name:** Virginia Tech University

**Location:** Blacksburg, Virginia, USA

**More detail on partner contribution (optional):** Partners at Virginia Tech collaborated in formulation of usage scenarios, documentation, and testing of the lake expedition prototype.

**Have other collaborators or contacts been involved?** No

Impacts   
You have the option of selecting “nothing to report” in this section.

**What is the impact on the development of the principal discipline(s) of the project?**

PRAGMA-ENT conducts research and development on the establishment of an international end-to-end software-defined networking testbed. Challenges, experience, and solutions found by PRAGMA-ENT activities will be valuable to the networking community.

The Lake expedition is deploying distributed virtual clusters that are interconnected by a new design of the IPOP overlay that uses standard protocols for peer discovery, notification, and traversal of network address translators (NATs), and where virtual network endpoints run on user devices (servers, laptops). Results and user feedback collected from this deployment will provide valuable information for the P2P and overlay network community.

**What is the impact on other disciplines?**

PRAGMA-ENT will give the necessary networking support to PRAGMA multi-cloud activities and user-defined trust envelopes . These systems, in turn, offer the necessary information technology support to multidisciplinary teams of PRAGMA researchers.

The PRAGMA Biodiversity Expedition involves sharing data across international borders. The Nagoya Protocol covering genetic resources under the Convention on Biological Diversity was recently ratified by the threshold 50th country and becomes international law on Oct 12, 2014 (90 days after the 50th signatory). It becomes ever more important that computational applications and data resources are responsive to both permitting data access and restrictions for use and distribution. The concept of trust envelopes was discussed as a method for addressing international data sharing concerns, and the idea has gained some initial traction for international partners such as Sabah Parks.

The PRAGMA Lake expedition is deploying a high-throughput computing cyber-infrastructure tailored to address computational needs of lake ecology modelers. By lowering the barrier to users to access and effectively use HTC resources, the expedition has the potential impact of enabling limnologists to refine their models, and to improve their analysis by considering larger number of simulation parameters, finer-resolution models, and/or additional dimensions.

**What is the impact on the development of human resources?**

PRAGMA-ENT enables privileged access to advanced network equipment and tools (e.g., hardware OpenFlow switches), in an international multi-site setup – a great opportunity to gain experience in advanced and software-defined networking.

The lake expedition collaboration has a potential impact on the development of human resources in both lake ecology and computer science domains: lake ecology students are able to develop skills on the use of High-Throughput Computing (HTC) and overlay virtual network in their research workflows, and computer systems students are able to develop skills in modeling of physical phenomena, in particular in lake ecology processes.

**What is the impact on physical resources that form infrastructure?**

**What is the impact on institutional resources that form infrastructure?**

**What is the impact on information resources that form infrastructure?**

**What is the impact on technology transfer?**

**What is the impact on society beyond science and technology?**

Cultural eutrophication, which is defined as excessive plant, algal, and bacterial growth due to nutrient enrichment, is particularly salient example of how human decisions impact lake ecosystem services. Eutrophication, perhaps the greatest water quality challenge facing freshwater ecosystems throughout the world, can lead to formation of harmful, or even deadly, algal blooms, fish kills, species losses, and shifts in lake food webs and biogeochemical cycling. By connecting the scientific community with data and model resources, the PRAGMA Lake expedition has the potential impact of enabling advanced simulation of lake hydrodynamics and water quality to address eutrophication research questions.

Changes / Problems  
  
If not previously reported in writing to the agency through other mechanisms, provide the following additional information or state, "Nothing to Report", if applicable.

Changes in approach and reason for change:

Actual or Anticipated problems or delays and actions or plans to resolve them:

Changes that have a significant impact on expenditures:

Significant changes in use or care of human subjects:

Significant changes in use or care of vertebrate animals:

Significant changes in use or care of biohazards:

Special Requirements

This report section is only available when Special Requirements are specifically noted in the solicitation and approved by the Office of Management and Budget.

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