

## White paper on **Collaborations to Enable Transnational Smart Cyberinfrastructure Research, Applications and Workforce** by José Fortes, University of Florida.<sup>1</sup>

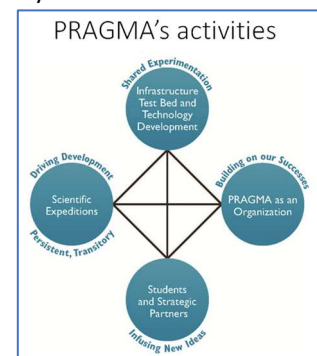
*“...envisions vibrant partnerships among academia, government laboratories and industry, including international entities, for the development and stewardship of sustainable CI services that can enhance productivity and accelerate innovation in science and engineering.” In “Transforming Science Through Cyberinfrastructure: NSF’s Blueprint for a National Cyberinfrastructure Ecosystem for Science and Engineering in the 21st Century”*

Broadly construed, Artificial Intelligence (AI) goes beyond algorithms and technology to include cultural, ethical and socio-technical issues. For AI to generalize in a global context it is essential to engage with transnational experts and users who are best positioned to understand those issues as well as to interface and integrate with technologies and user policies that differ across countries. In many scientific domains (e.g. biodiversity and environmental monitoring) data may be physically bound to specific locations and expressed in local languages. Therefore, learning may have to occur in a distributed fashion and research collaborations may require access and use of resources across different national cyberinfrastructures. These cyberinfrastructures typically use different hardware/software technologies, different management policies and external network connectivity. In this context, several cyberinfrastructure challenges are faced, including:

- No framework for establishing, maintaining and executing transnational collaborative projects.
- Inexistence of trusted networks of researchers upon which to build such a framework and a community with shared research goals that need transnational cyberinfrastructure.
- Incomplete easy-to-use technical solutions for connecting cyberinfrastructures and overlaying trustworthy transnational systems across them.
- No shared understanding of local requirements for solutions to global problems.
- Very small number of researchers who are aware of variations across countries of socio-technical issues affecting shared/connected cyberinfrastructure and the problems that require its usage.
- Insufficient training opportunities for workforce capable of contributing to transnational cyberinfrastructure and/or its applications.

Successful solutions to the above-listed challenges exist for big science in specific domains such as physics and astronomy, as illustrated by recent well-publicized successes in observation of gravitational waves, detection of the Higgs particle and imaging of a black-hole. However, when dealing with the long-tail of (medium and small scale) science, most current solutions are ad-hoc, clunky, transient and built on personal links. There is a need for systematic, effective, persistent and structured approaches to the creation, execution and sustenance of collaborations for the development, usage and application of shareable transnational cyberinfrastructure. The NSF-funded PRAGMA and CENTRA projects (<http://www.pragma-grid.net/> and <http://www.globalcentra.org/>) exemplify ongoing efforts to address this need and may provide a basis for international collaborations on smart cyberinfrastructure.

PRAGMA has been building an international, distributed community of practice, primarily around the Pacific Rim, for technology and approaches that support the long tail of science, namely enabling small- to medium-sized international groups, to make rapid progress in conducting research and education by providing and developing international, experimental cyberinfrastructure. To realize this mission, PRAGMA's current activities include four interrelated activities:



- Fostering international "scientific expeditions" by forging teams of domain scientists and cyberinfrastructure researchers who develop and test information technologies that are needed to solve specific scientific questions and create usable, international-scale, cyber environments; There are three current expeditions:
  - Biodiversity: Understanding adaption in extreme environments.
  - Limnology: Predicting lake eutrophication and training the next generation of lake scientists who are part of the Global Lakes Ecological Observatory Network (GLEON), an international organization, that

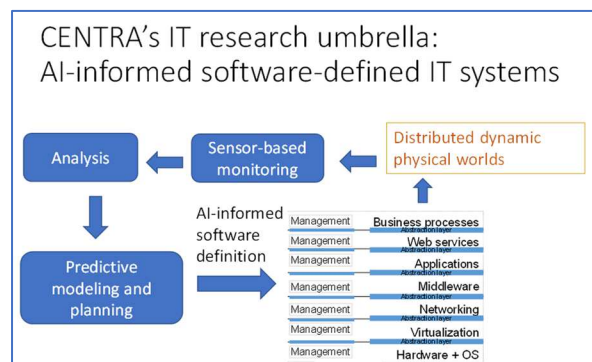
grew out of an early PRAGMA experiment, whose mission is to understand, predict and communicate the role and response of lakes in a changing global environment.

- ENT: Developing an experimental network testbed for experimenting with software-defined networks and monitoring impacts of choices.
- Developing and improving a grassroots, international cyberinfrastructure for testing, computer-science insight and, advancing scientific applications by sharing resources, expertise and software;
- Infusing new ideas by developing young researchers who gain experience in cross-border science and by extending engagements with strategic partners;
- Building and enhancing the essential people-to-people trust and organization developed through regular, face-to-face meetings - a core foundation of PRAGMA's success.

CENTRA currently integrates participants from universities and research centers in the US, Korea, Japan, Portugal and Taiwan who meet annually and host visiting researchers involved in collaborations. CENTRA's mission is:

- To enable research on cyberinfrastructure technologies needed to address transnational societal needs in domains that include but are not limited to disaster management, environmental modeling and smart and connected communities; and to advance the science needed to design and use these technologies to build effective and efficient transnational IT systems. Collaborative projects emerge organically from interactions that take place within the CENTRA research network and annual meetings.
- Train the next generation of junior researchers and innovators to work in transnational settings through
  - Convening experts in workshops and webinars to communicate or identify solutions to key problems.
  - Providing junior researchers an immersive experience in collaborative, multidisciplinary teams that address the transnational problems (including stays at international sites involved in collaborations).
  - Facilitating the use and development of prototypes and testbeds to demonstrate solutions.

Communities like PRAGMA and CENTRA advance targeted science areas through developing, applying, and lowering the barriers to use of critical information technologies. Funding is highly leveraged, with each country funding its own researchers and cyberinfrastructure. These communities form the backbone people-network to create a unique, coordinated initiative to provide opportunities for cyberinfrastructure workforce training. Therefore, we have the opportunity to create multi-site programs that (a) identify promising researchers in early to mid-career, (b) gives them multiple rotational global experiences in labs run by leading global researchers, and (c) homes them strategically in their respective national research institutions. Over time, this would create a corps of international researchers who will advance global research effort through multidisciplinary and multinational collaboration. The guiding principle is to create strategically structured problem-based learning activities that enhance student skill sets with long-term engagement for students as they move from undergraduate to graduate stages within PRAGMA/CENTRA and among multiple institutions. This coordinated, multi-lateral approach, which is expected to provide additional value to both students and institutions, is a key difference when comparing this program to other bilateral approaches and provides different types of benefits for students, institutions, and companies.



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