Study: Online tools accelerating earthquake-engineering progress

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Santiago Pujol, at far left, a Purdue associate professor of civil engineering, surveys a private residence damaged in a Haiti earthquake. The building was among 170 surveyed by civil engineers studying the effects of the January 2010 earthquake. Such photos and research-related information regarding earthquakes are part of a database maintained and serviced by the National Science Foundation's George E. Brown Jr. Network for Earthquake Engineering Simulation (NEES), based at Purdue. Credit: Purdue University photo/Kari T. Nasi

A new study has found that online tools, access to experimental data and other services provided through "cyberinfrastructure" are helping to accelerate progress in earthquake engineering and science.

The research is affiliated with the National Science Foundation's George E. Brown Jr. Network for Earthquake Engineering Simulation (NEES), based at Purdue University. NEES includes 14 laboratories for earthquake engineering and tsunami research, tied together with cyberinfrastructure to provide information technology for the network.

The cyberinfrastructure includes a centrally maintained, Web-based science gateway called NEEShub, which houses experimental results and makes them available for reuse by researchers, practitioners and educational communities.

"It's a one-stop shopping site for the earthquake-engineering community to access really valuable intellectual contributions as well as experimental data generated from projects at the NEES sites," said Thomas Hacker, an associate professor in the Department of Computer and Information Technology at Purdue and co-leader of information technology for NEES. "The NEES cyberinfrastructure provides critical information technology services in support of earthquake engineering research and helps to accelerate science and engineering progress in a substantial way."

Findings from a recent study about cyberinfrastructure's impact on the field were detailed in a paper published in a special issue of the *Journal of Structural Engineering*, which coincides with a NEES Quake Summit 2013 on Aug. 7-8 in Reno. The paper was authored by Hacker; Rudolf Eigenmann, a professor in Purdue's School of Electrical and Computer Engineering; and Ellen Rathje, a professor in the Department of Civil, Architectural, and Environmental Engineering at the University of Texas, Austin.

A major element of the NEES cyberinfrastructure is a "project warehouse" that provides a place for researchers to upload project data, documents, papers and dissertations containing important experimental knowledge for the NEES community to access.

"A key factor in our efforts is the very strong involvement of experts in earthquake engineering and civil engineering in every aspect of our IT," Hacker said. "The software we develop and services we provide are driven by user requirements prioritized by the community. This is an example of a large-scale cyberinfrastructure project that is really working to address big-data needs and developing technologies and solutions that work today. It's a good example of how cyberinfrastructure can help knit together distributed communities or researchers into something greater than the sum of its parts."

The effort requires two key aspects: technological elements and sociological elements.

"The technological elements include high-speed networks, laptops, servers and software," he said. "The sociology includes the software-development process, the way we gather and prioritize user requirements and needs and our work with user communities. To be successful, a cyberinfrastructure effort needs to address both the technology and social elements, which has been our approach."

The project warehouse and NEEShub collects "metadata," or descriptive information about research needed to ensure that the information can be accessed in the future.

"Say you have an experiment with sensors over a structure to collect data like voltages over time or force displacements over time," Eigenmann said. "What's important for context is not only the data collected, but from which sensor, when the experiment was conducted, where the

sensor was placed on the structure. When someone comes along later to reuse the information they need the metadata."

The resources are curated, meaning the data are organized in a fashion that ensures they haven't been modified and are valid for reference in the future. "We take extra steps to ensure the long-term integrity of the data," Hacker said.

NEEShub contains more than 1.6 million project files stored in more than 398,000 project directories and has been shown to have at least 65,000 users over the past year. Other metrics information is available at http://nees.org/usage.

"We are seeing continued growth in the number of users," Rathje said. "We are helping to facilitate and enable the discovery process. We have earthquake engineering experts and civil engineering experts closely involved with every aspect of our IT and cyberinfrastructure, and we are constantly getting feedback and prototyping."

To help quantify the impact on research, projects are ranked by how many times they are downloaded. One project alone has had 3.3 million files downloaded.

"We have a curation dashboard for each project, which gives the curation status of the information so that users know whether it's ready to be cited and used," Hacker said.

The site also has a DOI, or digital object identifier, for each project.

"It's like a permanent identifier that goes with the data set," he said. "It gives you a permanent link to the data." NEES researchers will continue to study the impact of cyberinfrastructure on engineering and scientific progress.

"The use and adoption of cybeinfrastructure by a community is a process," Hacker said. "At the beginning of the process we can measure the number of visitors and people accessing information. The ultimate impact of the cyberinfrastructure will be reflected in outcomes such as the number of publications that have benefited from using the cyberinfrastructure. It takes several years to follow that process and we are in the middle of that right now, but evidence points to a significant impact."

More information: Advancing Earthquake Engineering Research through Cyberinfrastructure , DOI: 10.1061/(ASCE)ST.1943-541X.0000712

ABSTRACT
This paper describes the cyberinfrastructure (CI) of the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) and examines the evidence that this infrastructure is facilitating earthquake engineering research. Among the key features of the CI are the NEES Project Warehouse (PW), which is a data repository for earthquake engineering, an environment that supports the use of tools for web-based data analysis and simulation, and tools that support research collaboration. The value that such CI offers to the user community is discussed. The CI also gathers a myriad of usage statistics, some of which are presented in this paper. Among them are the number of users, pageviews, recorded NEES projects, and other stored resources. This information demonstrates that the CI is used significantly and increasingly so.

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