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NEESgrid: A Collaborative IT Experience

Sridhar Gullapalli
USC Information Sciences Institute
Lee Liming
Argonne National Laboratory and University of Chicago

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NEES and Cyberinfrastructure

- Cyberinfrastructure (CI) is an ambitious activity that brings together a:
  - CS research and development
  - Leading-edge IT (integration and deployment) expertise
  - A user community in a specific branch of science
- The goal is to develop a production-oriented IT *facility* that is of great value to the community and ideally stimulates and supports significant innovation and advancement in the target field.
- NEES is an early example of CI development that highlighted several important lessons for future CI projects.

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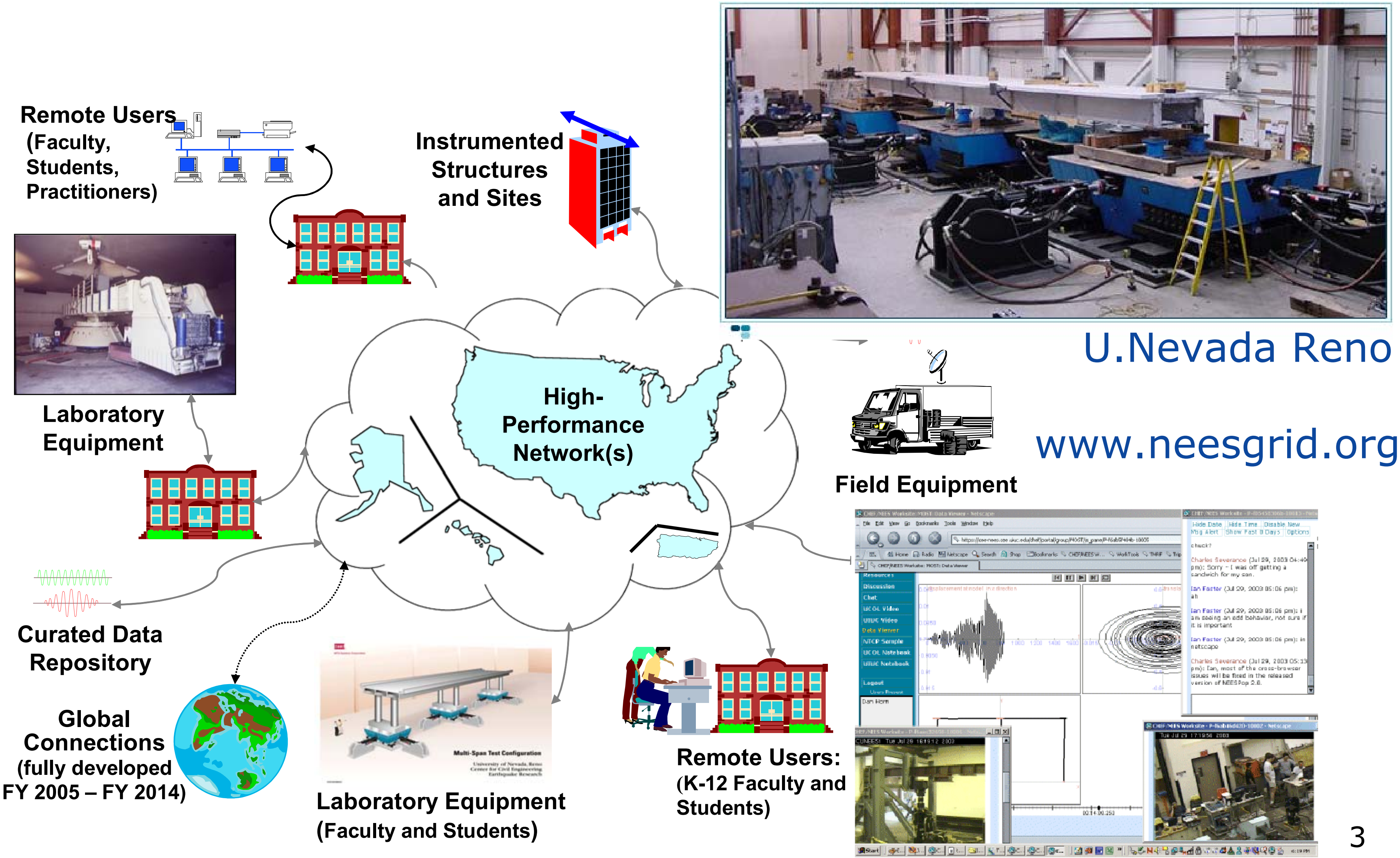
Collaborative Engineering: NEES



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NSF's Goals for NEES

- Encourage collaboration among earthquake engineering researchers and practitioners.
  - Provide remote access to large-scale NSF earthquake engineering facilities.
  - Provide distributed collaboration tools.
  - Provide easy-to-use simulation capabilities.
  - Allow integration of physical and simulation capabilities.
  - Provide a community data repository for sharing data generated by use of the system.
- Create a *cyberinfrastructure* for earthquake engineering.
  - Define and implement Grid-based integration points for system components.

Three Teams, Three Years

August 2001-September 2004

- Equipment Sites
  - 15 teams, $2M-6.5M per team
  - Each team builds a large-scale facility
  - E.g., structural lab, shaking table, field site, centrifuge, wave tank
- System Integration Team (NEESgrid)
  - One team, 9 institutions, $10M
  - Develop the collaborative infrastructure
  - Provide a system interface for all equipment sites
- Consortium Development Team
  - Very broad team, $2M
  - Form a working consortium of academic, research, and commercial organizations that will operate NEES for 10 years.

NEESgrid System Integrators

- National Center for Supercomputing Applications (NCSA) at UIUC
- Argonne National Laboratory
- USC Information Sciences Institute
- University of Southern California
- University of Michigan
- Stanford University
- University of California-Berkeley
- Pacific Northwest National Laboratory
- Mississippi State University

NEES Requirements

- Simple, yet a comprehensive security solution
  - sign-on with Grid credentials
  - Transparent security
  - Fine grained access control
- Web interfaces for end users
  - Collaboration services (chat, video, documents, calendars, notebooks, etc.)
  - Telepresence services (video feeds)
  - Telecontrol (in limited instances)
  - Data viewing, data browsing and searching
  - Simulation capabilities
- Uniform interfaces for major system capabilities
  - Control
  - Data acquisition
  - Data streams
  - Data repository services

More NEES Requirements

- System security
  - Protect facilities from misuse
  - Physical safety!
- Distributed collaboration during real-time experiments
- Automated (pre-programmed) control of distributed experiments (physical *and* simulation)
- Adapt to heterogeneity at multiple facilities
  - For remote interaction
  - For multi-site experiments

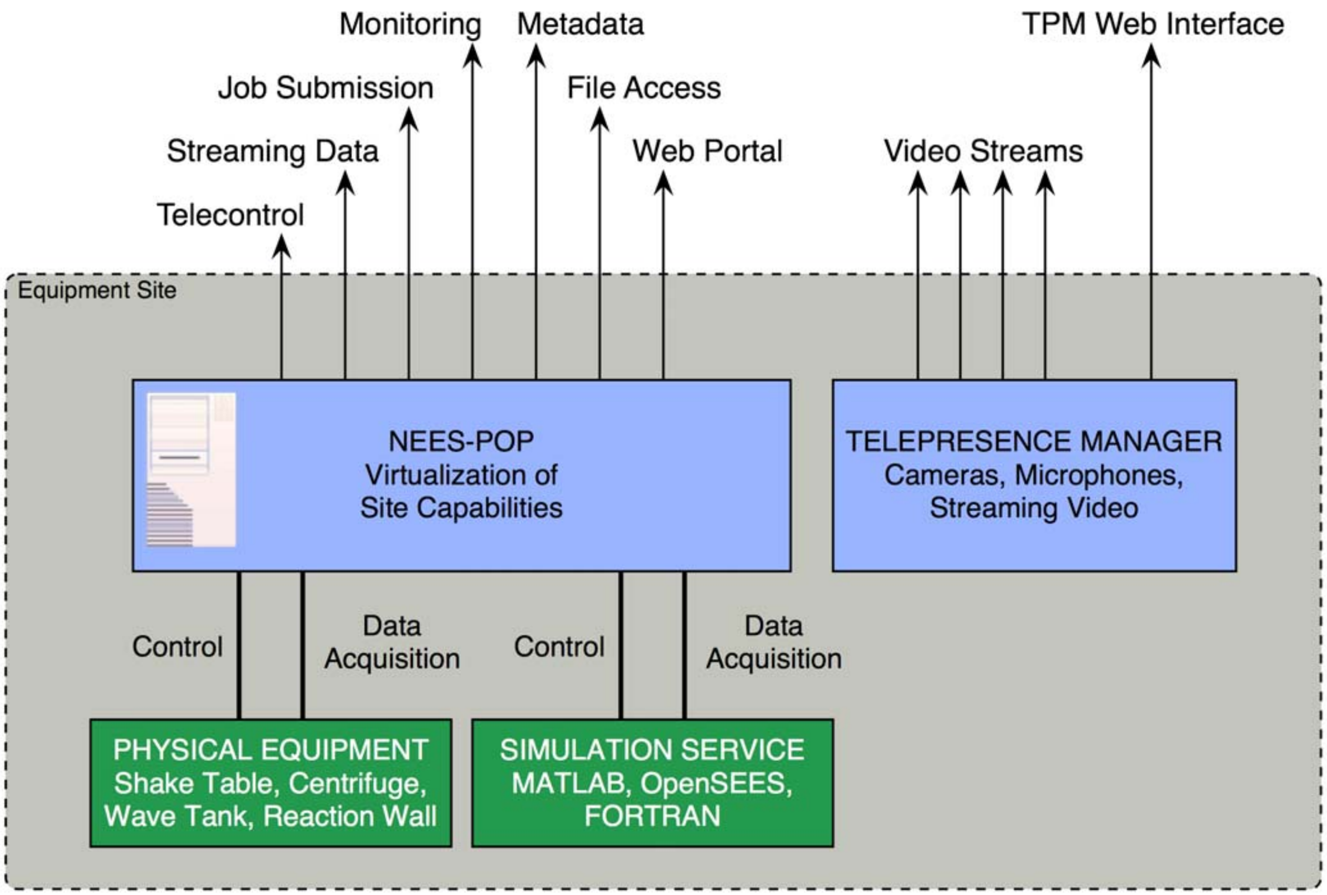
NEESgrid Core Capabilities

- Tele-control and tele-observation of experiments
- Data cataloging and sharing
- Remote collaboration and visualization tools and services
- Simulation execution and integration

Major NEESgrid Components

- OGSA Services
  - NTCP - Uniform Tele-control Interface
  - NMDS - Metadata Repository Management
  - NFMS - File Repository Management
- Creare Data Turbine - Data & Video
- CHEF - Web Portal, Collaboration Tools
- NEESgrid Simulation Portal - Simulation Tools
- OpenSEES, FedeasLab - Simulation Frameworks
- Other Grid Services
  - MyProxy - Authentication, Certificate Management
  - GridFTP - File Movement
  - GRAM - Simulation Job Submission/Management
  - MDS, Big Brother - System Monitoring
  - GSI-OpenSSH - Administrative Logins
  - GPT - Software Packaging

Architecture of a NEES Equipment Site



Lesson 1 - Vision & Expectations

- Balancing vision and expectations is hard, but *critical*.
  - *Vision* stimulates participation and involvement. You need these to get people to try your work.
  - *Expectations* give people a sense of what they can and can't rely on. You need this to keep plans in sync and avoid PR disasters.
- NSF's cyberinfrastructure vision is very ambitious (by necessity) and that makes setting expectations quite challenging.
  - One must get comfortable with the discomfort this causes. It seems unavoidable.

Lesson 2 - Requirements

- Requirements are hard to define when a community is unused to collaboration.
  - If no one has done it before, it genuinely is the case that *no one knows* how it should work.
  - There will be many issues that no one anticipates until they start using (*really* using) a prototype.
- Develop and use a strategy that helps identify and communicate requirements early.
  - Conduct site visits to learn how potential users work.
  - Identify short term deliverables that can be tried early.
  - Early deployment and genuine use is critical for focusing work.
  - Iterative design is useful in this situation. (Traditional "waterfall" method is less useful.)
  - Remember, expectations need to be managed carefully!

Lesson 3 – Engaging the Community

- Two pronged approach for interaction
  - Experiment-based Development
    - Working closely with a small set of sites to develop and demonstrate early capabilities
    - Have a clear map, feature set and deadline
    - Use results and broaden the scope and deployment
  - Experiment-based Deployment
    - Engage the majority of the community (all?) in deploying a stable base of code and conducting useful experiments.
  - Start both these activities early and stay focused on their goals throughout the development phase
- Some problems can't be solved by technology!

Lesson 3-contd.

- Involve "real users" as early as possible
  - You'll learn a lot and be able to "course correct"
  - You will establish a set of happy users to help down the road
- Pick early adopters carefully.
  - Aggressive users, technologically skilled, representative of the target user base.
  - Set expectations carefully.
  - Be wary of over-investment.
- Deployment is a significant chunk of your effort.
  - Separate team?
  - Make sure it's linked to the development activity.
- Demonstrate results early and often, and work with new users to get an "ownership" of the code and features

Lesson 4 - Data Modeling

- Most communities do not have well-established data models (schema, etc.) that cover all of their data. Creating these is hard.
  - To be successful, the model must be created by people who genuinely represent the community's constituencies.
  - IT expertise is needed to provide a framework in which to develop models that can be implemented.
- Strategies:
  - Start early!
  - Develop small, focused working groups of domain and data experts to develop initial data and metadata models.
  - Use/refine these models iteratively in real-life work.

Lesson 5 - Architecture

- System architecture should be coherent, modular, flexible, simple, and mandatory.
  - The earlier you produce and share a project-wide architecture document, the more it will be used.
  - The design will be iterated on, so get it out early!
  - The cost of deviation can be quite painful.
    - Duplication of effort
    - Incompatible components
    - Complicated/unworkable deployment challenges
    - A bad user experience
- Working by Consensus does not work in a distributed development activity.
  - A strong software manager should lead the charge and ensure that all teams are working in cohesion.

Lesson 6 - System Interfaces

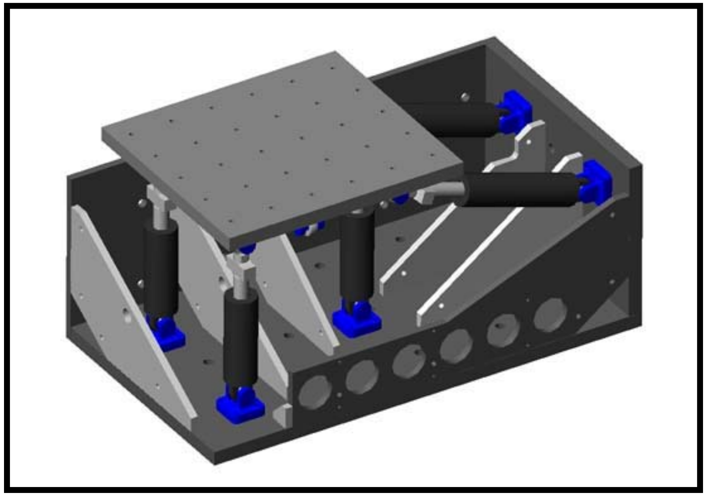
- Every interface that app developers need to use should include an API specification, a higher-level "how to use this" document, and a very simple example that demonstrates typical use.
  - App developers want interfaces that make sense to them, not sophisticated, super-flexible, CS-oriented interfaces.
  - Web services-based components must include client APIs (Java, C, C++, Perl, Python, etc.) to be useful. (Auto-generated WSDL bindings usually don't cut it.)
  - (It may be possible to reuse unit test code as the example code, but unit tests could also be too complicated for this purpose.)

Lesson 7 - Plug-in Interfaces

- Plug-in interfaces (“drivers”) can be surprisingly useful.
  - Eases integration (primary purpose)
  - Eases testing (via “diagnostic” drivers)
  - Might also play a role in actual use cases
    - Simulation vs. physical drivers
    - Miniature-scale vs. full-scale drivers
    - Local vs. remote drivers
    - Private vs. public drivers
    - Secured vs. unsecured drivers
    - “New interface” vs. “old interface” drivers

Experiment Variations

Full-scale LBCB



LBCB simulator (Computer Model)

1/5th-scale LBCB

Lesson 8 - Integration Tests

- Unit testing is not enough! Integration tests are critical to success. They…
  - …document the critical use cases;
  - …track coverage of the critical use cases; (You know how much is—and isn't—done.)
  - …provide the initial versions of user documentation;
  - …provide a nice set of release requirements;
  - …identify integration issues between components;
  - …identify usability issues;
  - …can be reused as deployment validation criteria.
- Early uses of the system should cover many/most integration tests. If they don't, something's wrong.
  - Plans for early uses are not broad enough?
  - Requirements are out of sync with reality?

Lesson 9 - Evolution & Adaptation

- Cost/benefit of "improving" system components has to be considered carefully.
  - What is the benefit offered by the changes?
  - What else changes from the *user's* perspective?
  - How many people (users, administrators, trainers, tech support, …) would be affected?
  - How much "deployment and use" investment would be lost? (Documentation, training, redeployment, integration, app development, data conversion, etc.)
- Most costs increase as time passes, assuming you've been engaging the community successfully.

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NEES Lives!

- NEES is in operational mode through 2014.
- Time will reveal many more interesting lessons:
  - Does the design hold up to 10+ years of use?
  - Will it be used to its full potential?
    - If so, what contributes?
    - If not, what inhibits?
  - Will it be used with any other national or international cyberinfrastructure elements?
    - Teragrid
    - Other Civil Engineering systems
    - Geotechnical systems (e.g., SCEC)
    - Disaster planning/response systems
- Stay tuned…

Appendix - Additional Material

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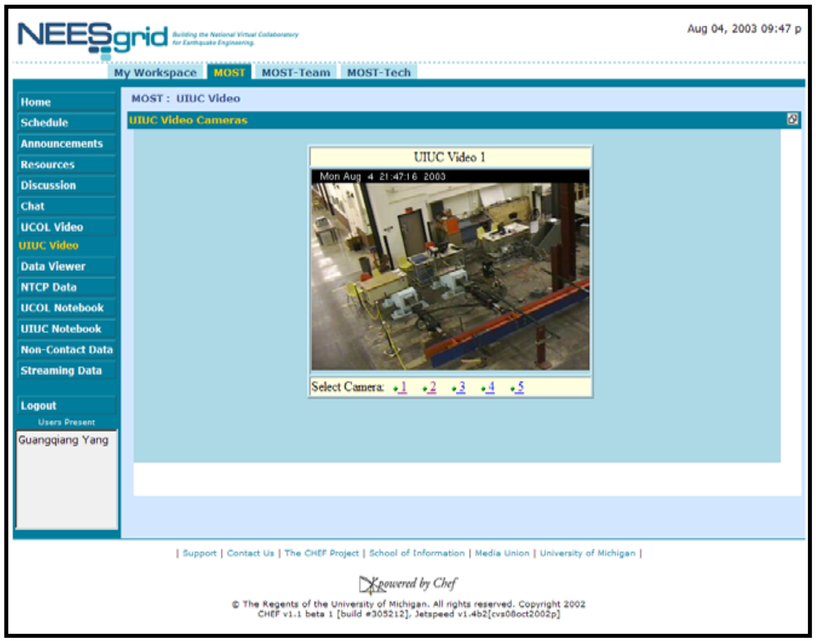
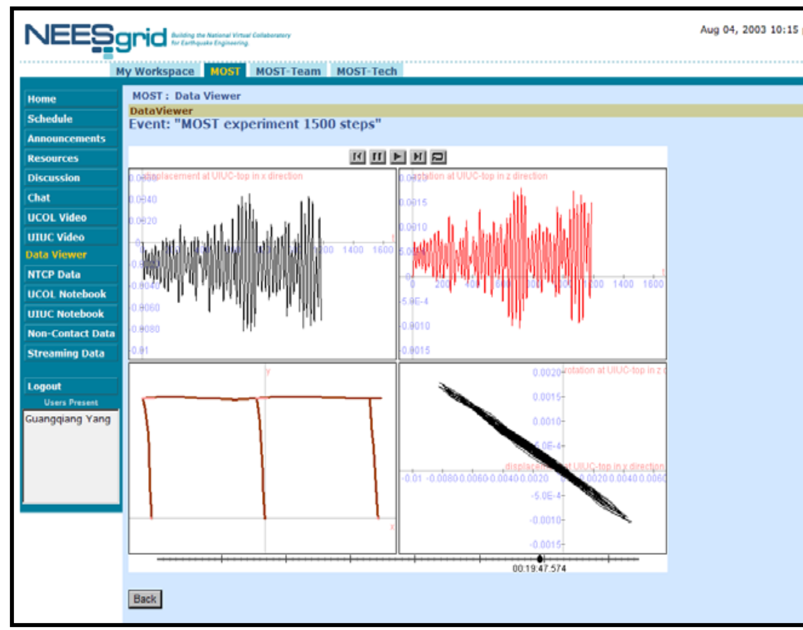
The MOST Event





Grid Services in NEESgrid

- GSI (Grid Security) used system-wide for authentication
  - MyProxy used to simplify cert management
- OGSI (Web services) used for core system interfaces
  - Telecontrol (NTCP)
  - Data/Metadata Services (NFMS/NMDS)
  - Simulation job submission (GRAM)
- Pre-WS services also used
  - Data Transfer (GridFTP)
  - Job submission (GRAM)
  - Monitoring (MDS, Big Brother front-end)
- Globus Toolkit 3.2 (NMI-R5) implementation

NEESgrid Deployment

- NEES-POPs installed at 16 facilities
- Experiment-based Deployment (EBD)
  - Sites proposed experiments in Y2 and Y3
  - SI and sites cooperatively ran experiments in Y2 and Y3 using NEESgrid (deployment)
  - Tested architecture and components, identifying new requirements
- October 2004 transition to M&O team (SDSC and partners)
- First round of research proposals also begin in October 2004
- Grand Opening in November 2004 at NSF and sites

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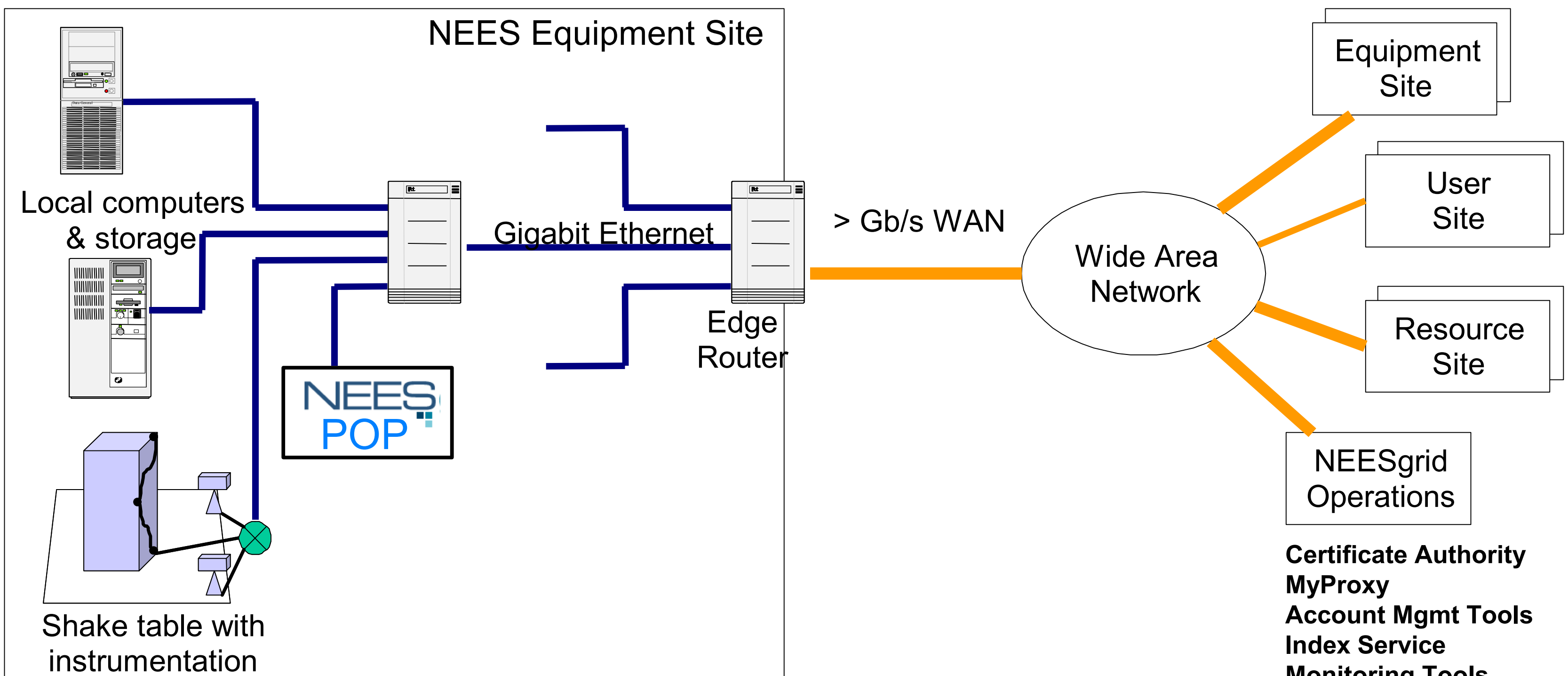
NEESgrid High-level Structure



Certificate Authority
MyProxy
Account Mgmt Tools
Index Service
Monitoring Tools
NEESgrid Website
Bugzilla
Mailing Lists

Telecontrol Services

- Transaction-based protocol and service (NTCP) to control physical experiments and computational simulations.
- OGSI-based implementation (GT3.2)
- Plug-ins to interface the NTCP service
  - A computational simulation written in Matlab
  - Reference Shore Western control hardware
  - MTS control hardware (via Matlab and xPC)
  - LabView control software
  - Still-image camera control
  - DAQ triggering
- Security architecture, including GSI authentication and a flexible, plug-in-based authorization model.

Telecontrol Service Use Case