Technical Report NEESgrid-2004-05

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NEESgrid Deliverables: Contents and Intended Use

The NEESgrid System Integration Team

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The purpose of this document is to introduce the components that the System Integrator is delivering to the NEES community for constructing and operating NEESgrid. The goal of the document is to provide a description of the NEESgrid components and their intended uses to the people who will be using NEESgrid: *especially* NEES equipment site operators and the future NEESgrid operations/support team.

This document has two major sections.

- The first section identifies each component and its role within NEESgrid.

- The second section provides a specific "use case" for grounding these descriptions in the NEES experience: using the software to establish a new NEESgrid "node" (an equipment site or other resource provider).

Future versions of this document may include other use cases that are relevant to the maintenance and operation of NEESgrid.

Table of Contents

1 An Inventory of NEESgrid Components

This section identifies each component and its role within NEESgrid.

At a high level, it is important to recognize that NEESgrid contains two classes of components.

1. Components that are primarily used to bring "nodes" (equipment sites or other resource providers) onto NEESgrid. These items will be of interest mainly to those who will be involved in equipment site operations and support and those who will be using equipment site resources in their work.

2. Components that are primarily used to operate the NEESgrid infrastructure itself in support of the entire NEES community. These items will be of interest mainly to those who will be responsible for operating the NEESgrid infrastructure and those who will be using centralized NEESgrid services (such as simulation capabilities) in their work.

Items Intended Primarily for NEESgrid Nodes	Items Intended Primarily for NEESgrid Operation
1. NTCP service and related software	1. OpenSEES
2. NSDS service and related software	2. FedeasLab
3. Data Repository services and related software	3. The NEESgrid Simulation Portal
4. Data Acquisition (DAQ) reference implementation	4. Website Materials
5. Information services	5. User Mailing Lists
6. E-notebook services	6. NEESgrid CVS Repository
7. Telepresence Mode (TPM) service	7. Recommendations for Operational Issues
8. The CHEF collaboration interface	
9. Administrative tools	

Table 1. NEESgrid components organized by primary audience.

1.1 Items Primarily Used to Bring Nodes/Sites onto NEESgrid

This section covers NEESgrid components that are primarily used by equipment site operators and other resource providers to provide standard NEESgrid interfaces to their resources. These components are the primary contents of the NEESgrid software distributions, and they are used heavily in deployment activities and equipment site operations. The following sections detail each of these components and identify their role in NEESgrid.

1.1.1 NTCP Service

The NTCP service provides a common protocol (the NEESgrid Teleoperations Control Protocol) that can be used by remote applications to control aspects of a physical experiment or simulation. The core NTCP service provides a NEESgrid-wide standard interface to local equipment and simulation capabilities. A programmer interface is provided in the Java and C programming languages for NTCP *clients* (programs that control experiments or simulations through the NTCP interface).

The NTCP service uses a plug-in architecture to integrate with local control systems and simulation code. Plug-ins written by equipment sites or simulation code developers manage the interface between the NTCP service and specific local equipment or software. The plug-in programmer interface is provided in both C and Java, and a number of example plug-ins (all of which have been used in experiments by equipment sites and/or software developers) are included.

Detailed documentation about NTCP and its interfaces is currently available on the NEESgrid.org website: see Ref. 1-7.

1.1.2 NSDS Service and Related Software

The NEESgrid Streaming Data Service (NSDS) provides a uniform interface for subscribing to and accessing streaming data originating from experiments and simulations during their execution. Streaming data allows NEESgrid users to observe data remotely as a NEESgrid activity takes place. The core NSDS service provides a subscription interface to the data streams available at a given NEESgrid node. Data streaming itself is provided by DataTurbine (see below). A programmer interface is provided in Java for interfacing a data source (e.g., DAQ system or simulation) to the NSDS/DataTurbine system. A sample Java implementation of a data provider is also provided, which allows any device that can support a simple network protocol to provide data to the system. Client interfaces to the NSDS and DataTurbine services are available in Java, and DataTurbine supports a wide variety of client interfaces for accessing streaming data.

DataTurbine, a high-performance multi-channel ring buffer from the Creare Corporation, will be used to store and stream data from DAQ systems, video, audio, and still cameras. This data will be viewable live or in a time-shifting Tivo-like manner. There will also be capabilities for permanently storing data automatically into the repository from DataTurbine. DataTurbine provides for precise time-synchronization of diverse channel types. DataTurbine acts in concert with the NEESgrid streaming data service (NSDS).

Detailed documentation NSDS, DataTurbine, and its interfaces is currently available on the NEESgrid.org website: see Ref.8-10.

1.1.3 Data Repository Services

The distributed data repository allows users to manage data and metadata about NEES experiments and other activities. Architecturally, this component consists of local repositories, a central repository and archiving service, and a set of service protocols to link the repositories together and connect the repositories with NEESgrid users, applications, and portal components. The NEESgrid File Management Service (NFMS) provides clients with the ability to locate files independently of how and where they are stored, as well as the ability to negotiate transactions with storage systems. The NEESgrid Metadata Service (NMDS) provides a means for creating, managing, retrieving, and modifying metadata objects in a NEESgrid repository. All of the data repository services use NEESML, an XML format for defining NEES metadata schemas and uploading metadata objects into the NEES metadata repository. NEESML allows NEESgrid users to describe real-world objects of interest to them while at the same time

making it possible to browse and retrieve data and information gathered from all of the NEESgrid sites.

Detailed documentation about the NEESgrid data repository services is available on the NEESgrid.org website: see Ref. 11-15.

1.1.4 Data Acquisition (DAQ) Reference Implementation

In order to demonstrate our vision of how NEESgrid sites would interface local data acquisition (DAQ) systems to NEESgrid, we provide a reference implementation of a DAQ system, implemented in the popular LabView framework. This reference implementation demonstrates interfaces to both streaming data services (NSDS) and the NEESgrid data repository services. This implementation also includes several test applications to simulate the NSDS, to stress test code, to measure bandwidth, to validate protocol implementation, and to simulate DAQ hardware.

Detailed documentation about the NEESgrid DAQ reference implementation are available as part of the NEESgrid software release documentation: see Ref. 16-20.

1.1.5 Information Services

The NEESgrid distribution includes a number of information services for monitoring the status of NEESgrid sites and the NEESgrid system in general. These services are included with the software for NEESgrid sites because it must be installed at a site in order for the NEESgrid operations team to be able to monitor that site. Information services included with NEESgrid include: the Globus Toolkit's Monitoring and Discover Services (MDS), basic MDS information providers for monitoring system configuration and status plus a customized information provider for NSDS status and configuration, the BigBrother service for monitoring the entire NEESgrid system, and the Network Weather Service (NWS) for monitoring network status. Each of these services includes client interfaces for those who need to use them (primarily intended for NEESgrid operations personnel), and the CHEF service for each site includes basic viewers for much of this information.

1.1.6 E-notebook Services

E-notebooks are electronic (typically online) versions of laboratory notebooks. They allow lab notes to be entered by NEESgrid users, shared with other team members, and archived in the NEESgrid data repository for later use and review. NEESgrid e-notebooks allows users to store, review, search and share text, images, and documents.

NEESgrid offers two e-notebook options, one developed at Argonne National Laboratory which emphasizes easy-to-use data entry methods, and one developed at Pacific Northwest National Laboratory which emphasizes integration with the NEESgrid system. NEESgrid users may enter data into either notebook interface, transfer data from the Argonne to the PNL notebook, and submit data from the PNL notebook to the NEESgrid data repository for archiving.

1.1.7 Tepepresence Mode (TPM) Services

The Telepresence Mode (TPM) provides an interface and display that is intuitive to users using commodity WWW browsers such as Netscape, version 7.x and Microsoft Internet Explorer, version 5.x. Remote telerobotic video cameras with PZT (pan-zoom-tilt) capabilities enable users to remotely view lab space and the physical experiment. Fixed video cameras positioned by local collaborators also allow remote, site-specific observations. High-resolution, static images, uploaded by the local users, can also be viewed. TPM also enables synchronous and asynchronous monitoring of the preparation and construction of tests and test specimens.

For detailed documents about the NEESgrid TelePresence Mode (TPM) see Ref. 21-23.

1.1.8 CHEF Service

CHEF is a set of web-based collaborative tools that allow users to access computing facilities, communicate via discussion forums and text chat, and collaborate using scheduling and data sharing and exchange teamlets. The NEESgrid CHEF service also includes the NEESgrid DataBrowser and DataViewer, both of which allow users to browse and view repository data. Detailed information about CHEF is available at the CHEF website (Ref. 24).

1.1.9 Administrative Services

The NEESpop software distribution includes the GSI-OpenSSH tool, which provides a remote login service that uses Grid security credentials for authentication and authorization. This allows system administrators and other authorized users to login to the NEESpop using their NEESgrid credentials. The distribution also includes the MyProxy package, which includes the MyProxy client software used by the CHEF portal to obtain Grid credentials for users who login to the CHEF portal via standard web browsers. These Grid credentials are then used by CHEF to perform NEESgrid operations (like accessing the NEESgrid data repository, submitting simulation jobs, or subscribing to data streams) on behalf of the user. Note that the MyProxy software included here can also be used by the central NEESgrid operations team to establish a NEESgrid MyProxy server.

1.1.10 Other Software

The NEESgrid software distribution includes a number of other open source software packages that are either required by the NEESpop software or that are likely to be needed in the future by NEESgrid operators. These include the Apache web server, various Web services and Web portal support packages, Grid programming libraries and commonly-used Grid services, and security tools.

1.2 Items Primarily Used for NEESgrid-wide Operations

The services and items described in this section will be operated by the NEESgrid operations/support team and made available for use by the entire NEES community. These items are to be installed in a central location rather than at each equipment site.

The following sections will detail each of these components and identify their role in NEESgrid.

1.2.1 OpenSEES

The Open System for Earthquake Engineering Simulation, or OpenSees, is a software framework for computational simulation of structural and geotechnical systems. Simulation is an important part of NEES research, and OpenSees provides NEESgrid users a wide range of material and element models for nonlinear analysis (material and geometric), solution methods, and data processing procedures for research and problem-solving. OpenSees is open-source software, and it has an application program interface (API) for researchers to extend OpenSees for simulation applications. OpenSees is designed to support parallel processing, and researchers have been developing OpenSees applications for hybrid experimental methods.

1.2.2 FedeasLab

FedeasLab is a Matlab toolbox developed at the University of California, Berkeley, for nonlinear structural analysis. FedeasLab is useful for research in simulation methods because it allows rapid prototyping of models and computational methods within the Matlab environment. FedeasLab is also ideal in education and development of courses on structural analysis, nonlinear analysis, and dynamic analysis. The toolbox contains a variety of beam-column elements and material models that can be used for nonlinear materials and P-Δ analysis. FedeasLab is designed hierarchically in a modular manner so that prototype developments can be re-implemented using a similar software architecture in OpenSees.

1.2.3 The NEESgrid Simulation Portal

The NEESgrid Simulation Portal supports remote access to the simulation capabilities of OpenSees. This Portal provides the following benefits to NEESgrid users:

- It eliminates the need for users to install and update the OpenSees software.

- It adds tools to help construct and validate OpenSees scripts and to visualize the results of scripts.

- It seamlessly integrates OpenSees simulation capabilities with NEESgrid's data repositories and computational resources.

1.2.4 Website Materials

During the System Integration award period, the SI team has operated a website at http://www.neesgrid.org/. This website contains news, events, and a document repository for NEESgrid. A software section provides access to downloads, documentation, and help for all NEESgrid software releases. Additional information is available explaining the basic NEESgrid system and framework.

Once the System Integration team completes its work in September 2004, content and documentation from the www.neesgrid.org website will be transferred to the NEES Consortium.

1.2.5 User Mailing Lists

During the System Integration award period, the SI team has operated a public email discussion list for use by early NEESgrid users. The list has been archived and the archive contains valuable answers to common questions that can be retrieved for subsequent use.

Once the System Integration team completes its work in September 2004, the data from the list archive will be transferred to the NEES Consortium. Operation of the mailing list itself will also most likely be transferred.

1.2.6 NEESgrid CVS Repository

The CVS repository is a generic CVS archive containing the NEESgrid code. This is used by the developers to manage the source code among multiple sites, and is the source for creating distributions.

Once the System Integration team completes its work in September 2004, the contents of this CVS archive will be transferred to the NEES Consortium. Detailed information about the CVS archive is available at Ref.25.

1.2.7 Recommendations for Operational Issues

During the System Integration award period, the SI team has been responsible for operating a number of centralized services in support of the NEESgrid infrastructure. These services include a central data repository, computer account services, security services in support of NEESgrid's single sign-on capability, videoconferencing services, and the system monitoring and information services.

As the SI team completes its work by September 2004, these services will be transitioned to the NEES Consortium for operation. The SI team will prepare and deliver a set of recommendations to the NEES Consortium regarding the operation of these services. In all but one case (account management), the SI team's deliverables in this area will take the form of written recommendations, not implementations. In the area of account management, the SI team will offer implementations of services to support NEESgrid-specific account management needs.

2 Use Case: Bringing Up a New NEESgrid Node

In order to understand how the NEESgrid component are intended to be used, a specific "use case" is described here: using the NEESgrid components to establish a new NEESgrid "node" (e.g., an equipment site). It is our hope that by reviewing how the NEESgrid components would be used for this purpose, a deeper understanding of the components will be conveyed.

2.1 Recommended Goals

It is important that the stakeholders in any new NEESgrid node define and agree on goals before the work to add the node to NEESgrid is begun. The new node will be considered "fully operational" when each of these goals has been met, and not until then. The stakeholders referred to here include: the owners and operators of the node, the operators of the NEESgrid infrastructure, support personnel assisting in establishing the node, and intended users of the node. Failing to do establish clear goals will most likely result in effort being wasted on unnecessary tasks.

We recommend using the following set of general goals to direct and focus the work of bringing up a new NEESgrid node. These goals are based on the results of user requirements analysis throughout the period of the SI team's work.

1. The node should have a running CHEF service accessible from other sites.

2. A set of telepresence video channels (which could be an empty set) will be accessible via the node's CHEF service.

3. The node's local data repository will be accessible via the node's CHEF service.

4. The node's e-notebook service will be accessible via the node's CHEF service.

5. A set of equipment and/or simulation capabilities (which could be an empty set) can be controlled via the node's NTCP service.

6. A set of output data channels will be accessible via NSDS and can be viewed via the node's CHEF service.

7. The local data repository accepts data from local experiment and simulation activities and can be viewed via the node's CHEF service.

8. The node's NEESpop system appears in the NEESgrid "Big Brother" information service with up-to-date status information.

9. A combination of local staff and NEESgrid central operations personnel will be prepared to maintain the node's NEESgrid interfaces and to provide technical support to users of the node's resources.

2.2 Action Plan for Accomplishing Goals

We recommend the following nine high-level tasks for bringing a new node onto NEESgrid. This plan ensures that the goals above will be met and that appropriate personnel will receive the information needed to understand, deploy, and subsequently support the NEESgrid software at their site.

Note that this plan is based on the goals in the previous section. If you have established different goals for your site (especially goal 5, which focuses on telecontrol), then you may also need to make corresponding changes to this plan.

1. Ensure that prerequisite hardware/software/network requirements are satisfied.

2. Familiarize appropriate site personnel with NEESgrid documentation.

3. Establish the local NEESpop (NEES "Point of Presence") server.

4. Establish a local Telepresence Mode (TPM) server.

5. Use the Computation-Only Simulation application to validate the operation of your servers.

6. Develop design documents for the NTCP plug-in and DAQ driver for your local control system and data acquisition system. This will begin with documenting the control elements (goal 5) and data acquisition elements (goal 6) that the site will provide to external users.

7. Develop, install and test the code for your NTCP plug-ins and DAQ drivers.

8. Develop a software-only simulation of your site that includes, for example: a fake DAQ representing your data acquisition system, a fake control system (e.g. control of robots, daq, cameras, etc.).

9. If needed, customize and enhance your site's CHEF interface to add site-specific features and capabilities.

2.2.1 Prerequisite Hardware/Software/Networking

A typical NEESgrid node for an equipment site may have the following computer systems, although not all are necessary in every case.

1. A Linux workstation acting as the NEESpop;

2. A Windows XP machine acting as the DAQ system;

3. Another Linux workstation acting as the Telepresence Monitor (TPM) server;

4. A Windows machine acting as a computational node or simulation coordinator.

Requirements for these systems are all available at www.neesgrid.org/software as part of the documentation of the current release.

We assume, as a starting point, that these systems have all been loaded with their operating systems, are networked, and that the IP addresses where each of these computers reside are known. You will also need the URL of the web camera(s) if you are setting up a TPM server.

Network requirements are specified in NEESgrid TR-2002-01, *Local Area Network Requirements* (Ref.26).

2.2.2 Familiarization with NEESgrid Documentation

It is strongly recommended that system administrators, users, and developers make use of the comprehensive body of documentation that the SI team has produced to meet a

variety of needs. Included are user and administrator manuals, developer guides, deliverable specifications, and FAQs and troubleshooting guides. Several useful overviews of the system, its architecture, and its implementation have also been developed. All documentation is available from a searchable archive on the NEESgrid website at http://www.neesgrid.org/news/documents.php and is updated with each release.

We particularly recommend Ref. 21, 26-30, for those preparing to establish a new NEESgrid node.

2.2.3 Establishing a Local NEESpop Server

Installing the NEESpop software on the node's NEESpop system will accomplish most of the work needed for goals 1, 3, 4, and 8 from section 2.1. It will also enable work on goals 2, 5, 6, and 7 to proceed to completion. When this installation is finished, the node will have an operational CHEF collaboration interface, a local data repository, e-notebook systems, and local monitoring and information services, which covers the NEESgrid components identified in sections 1.1.3, 1.1.5, 1.1.6, and 1.1.8. The node will also have the CHEF interfaces to streaming data, the local data repository, and telepresence mode video streams, though these features will require additional configuration to complete an end-to-end capability.

The NEESgrid software distribution includes detailed installation instructions for the NEESpop software.

2.2.4 Establishing a Local Telepresence Mode (TPM) System

The NEESgrid Telepresence Mode (TPM) system (described in section 1.1.8) allows remote users to monitor events at a site via web-enabled video cameras.

Setting up the TPM system involves purchasing the recommended equipment, installing the equipment, installing the TPM software, configuring the software, and verifying correct operation of the system using the CHEF collaboration interface. Each of these steps is described in detail in the NEESgrid software release TPM installation instructions. Hardware recommendations are available in the white paper named *NEESgrid TelePresence System Overview* (Ref. 22).

2.2.5 Using the Computation-Only Simulation and MiniMOST Applications for Validation

The SI team has identified two applications that can be used to validate the functionality of a site's core NEESgrid interfaces. The applications are: a three-site, distributed, computation-only simulation ("Computation-only MOST"), and a hybrid computation/simulation experiment ("Mini-MOST"). If these two applications can be run successfully at a new NEESgrid site, it is relatively certain that the site's base software has been installed and configured properly. This validation step should be taken immediately after installing the NEESgrid software so that any problems with the software's installation and configuration will be found and resolved before work is begun on site-specific code.

It is important to note that these applications utilize all of the major NEESgrid interfaces, including the telecontrol (NTCP) interface. Although not all NEESgrid sites view telecontrol as a priority, testing the other NEESgrid interfaces (streaming data, data repository, CHEF interface) is quite important, and these applications are thus still useful. We do not believe that the additional (minimal) effort involved in validating the NTCP interface is sufficient reason to skip this step.

The following three subtasks will validate the core NEESgrid interfaces associated with your new NEESgrid node.

- Install and run the example computation-only simulation application with three local simulation components. Use this simulation to exercise all NEESgrid capabilities (data uploading to repository, data viewing via CHEF, repository browsing, etc.)

- Reconfigure the computation-only simulation to replace a local simulation component with a remote simulation component at NCSA.

- Reconfigure the computation-only simulation application to replace an NCSA simulation component with a MiniMOST physical experiment, either at NCSA or local to the site.

Instructions for conducting each task are available with the NEESgrid training materials (see NEESgrid website) and the *Guide to the NEES Reference Implementation* (Ref. 30).

2.2.6 Designing Local Interfaces for Control and Data Acquisition

By definition, each NEESgrid node provides a set of resources to the NEES community. These resources are a combination of physical equipment, computational simulation, and data. Providing local equipment, simulation, and data resources to the NEES community requires designing and developing site-specific interfaces between the local resources and the NEESgrid infrastructure in the areas of control (for equipment and simulations) and access to data.

The NTCP service (described in section 1.1.1) is the NEESgrid infrastructure's primary control interface, and the NSDS and Data Repository services are the NEESgrid infrastructure's two main data interfaces.

Each distinct NEESgrid node will emphasize different types of resources, and each type of resource involves the use of specific NEESgrid components. Defining the specific combination of resources to be provided by the node to the community is a key step in establishing a NEESgrid node. A design document would not only identify where the focus for these interfaces will be, but also define in detail the local hardware and software elements for which interfaces must be developed and how these interfaces will be constructed.

Interfacing equipment or simulations to NTCP will generally require development of an NTCP plug-in (see Section 1.1.1). The NEESgrid distribution includes a number of plug-ins that have been used in experiments by early adopter sites, and it is expected that many new NEESgrid nodes can reuse these plug-ins (most likely with some local customization, but not necessarily) rather than developing new plug-ins from scratch.

Interfacing data sources to NSDS and the Data Repository services will typically involve developing an NSDS/DataTurbine driver or plug-in and configuring the DAQ system to store data locally following conventions that allow the Data Repository to ingest the data automatically. The NEESgrid distribution's DAQ reference implementation includes both NSDS and Data Repository interfaces, and a number of NSDS/DataTurbine drivers are available for reuse or customization.

It is expected that a combination of engineering and IT expertise will be brought to bear on this design effort.

2.2.7 Developing Local Interfaces for Control and Data Acquisition

Once the local hardware and software elements that require NEESgrid interfaces have been identified and a design has been established, the design must be implemented by software developers. The staff requirements at this point will be dictated by the design. As indicated in section 2.2.6, the NEESgrid distribution includes a number of reusable interface components that can make this work easier.

It is important to note that this "high-level" step must be understood to include not only code development, but also testing, validation, and documentation of the code. For equipment sites, testing and validation will most likely be carried out first by running the system in a "simulation" mode (without the connections to physical equipment established), and then in a "live" mode using real equipment and data acquisition.

2.2.8 Developing a Software-only Simulation of Your Site

A software-only simulation of your site will allow you to test control and data software for use with your site (controlling your equipment or consuming data from your site) without using any physical equipment. This is an important step in validating an experiment code prior to its execution, because it allows the experiment code to be tested *before* it is certain that the code has no flaws that could damage equipment or be unsafe.

A software-only simulation can be produced by duplicating the control and data interfaces used at your site and replacing the physical interfaces with software code. For example, beginning with your NTCP plug-in, replace any calls to your local control system with software that "fakes" the behavior of the control system. You can then use this NTCP plug-in to provide an NTCP service dedicated to testing purposes. A similar technique can be used for the NSDS service. (It is unlikely that you will need to produce a simulator for the data repository, since the repository has no physical components and access control will prevent any manipulation of the stored data.)

2.2.9 Adding Site-specific Features to Your CHEF interface

Once all of the steps above have been done, you may find it useful to customize your CHEF interface to add new capabilities specific to your site. Because this step does not directly support any of the goals identified in section 2.1, it should be a final (lower priority) step in establishing a node.

Appendix A: Referenced NEESgrid Documentation

1. **NEESgrid Technical Report TR-2003-07:** *NEES Teleoperation Control Protocol*, Laura Pearlman, Erik Johnson, Carl Kesselman, http://www.neesgrid.org/documents/TR_2003_07.pdf

2. **NEESgrid Technical Report TR-2003-16:** *NTCP Control Plugin,* Laura Pearlman1, Mike D'Arcy, et al., http://www.neesgrid.org/documents/TR_2003_162.pdf

3. **NEESgrid Technical Report TR-2004-03:** *NTCP Control Plugin C API,* Joseph Bester, http://www.neesgrid.org/documents/TR_2004_03.pdf

4. **NEESgrid Technical Report TR-2004-02:** *NTCP Sample Plugin,* Joseph Bester, http://www.neesgrid.org/documents/TR_2004_02.pdf

5. **NEESgrid Technical Report TR-2003-20:** *NTCP Helper Reference,* Laura Pearlman and Mike D'Arcy, http://www.neesgrid.org/documents/TR_2003_20.pdf

6. *NEES NTCP C Client API*, Sam Lang, http://www-unix.mcs.anl.gov/~slang/NTCP/html/

7. *LabVIEW Plugin Documentation*, Paul Hubbard, http://www-unix.mcs.anl.gov/~hubbard/neesgrid/lv-protocol.html

8. **Technical Report 2003-14:** *NSDS Java Client API*, Gaurang Mehta, http://www.neesgrid.org/NEESgrid_TR_2003_14.pdf

9. **Technical Report 2003-05:** *Installing the NEESgrid NSDS Driver,* Paul Hubbard, http://www.neesgrid.org/documents/TR_2003_05.pdf

10. **Technical Report 2003-04:** *Protocol Specification for the NSDS, Driver and DAQ,* Paul Hubbard, http://www.neesgrid.org/documents/TR_2003_04.pdf

11. **NEESgrid Technical Report 2002-06:** *Storage Technologies for the NEESgrid Curated Data Repository*, Joe Futrelle, http://www.neesgrid.org/documents/StorageTechnologies_v1_0.pdf

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15. **NEESgrid Technical Report 2003-12:** *Overview of NEESML,* Joe Futrelle, http://www.neesgrid.org/documents/NEESgrid_TR_2003-12.pdf

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17. *Design of the DAQ code*, Paul Hubbard, http://www.mcs.anl.gov/neesgrid/DAQ-design.pdf

18. ***Customizing the DAQ code for your site***, Paul Hubbard,
    http://www.mcs.anl.gov/neesgrid/DAQ-customization.pdf

19. ***Example source code exported to HTML***, Paul Hubbard,
    http://www.mcs.anl.gov/neesgrid/example/

20. ***How to install the DAQ code***, Paul Hubbard,
    http://www.mcs.anl.gov/neesgrid/daq-install-instructions.pdf

21. ***NEESgrid Software Release Installation Guide,*** Chase Phillips,
    http://www.neesgrid.org/software/current/doc.php

22. ***TelePresence System Overview: White Paper,*** Nestor Zaluzec,
    http://www.neesgrid.org/documents/TPMOverview20020306.pdf

23. ***NEES TMP Site, ,*** Nestor Zaluzec, http://140.221.20.164/

24. ***CHEF website***, http://www.chefproject.org/

25. ***NEESgrid CVS website***, http://www.mcs.anl.gov/neesgrid/cvs.html

26. **NEESgrid Technical Report TR-2002-01:** *Local Area Network Requirements***,**
    Laura Pearlman, http://www.neesgrid.org/documents/NEESgrid_TR.2002-01.doc

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28. ***NEESgrid System Architecture v1.1***, Carl Kesselman, Randy Butler, et al.,
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