

Multitier Portal Architecture for Thin- and Thick-client Neutron Scattering Experiment Support

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ABSTRACT

Integration of emerging technologies and design patterns into the three-tier client-server architecture is required in order to provide a scalable and flexible architecture for novice to sophisticated portal user groups. The ability to provide user customizable portal interfaces is rapidly becoming commonplace and is driving the expectations of researchers and scientists in the scientific community. This paper describes an architectural design that maximizes information technology service reuse while providing a customizable user interface that scales with user sophistication and requirements. The Spallation Neutron Source (SNS) located at Oak Ridge National Laboratory provides a state-of-the-art facility ideal for implementation of this infrastructure. The SNS Java-based Science Portal (Tier I) and Open Grid Computing Environment (Tier II) provide thin-client support whereas the GumTree Eclipse Rich Client Platform (Tier III) and Eclipse Integrated Development Environment (Tier IV) provide thick-client support within a multitier portal architecture. Each tier incorporates all of the features of the previous tiers while adding new capabilities based on the user requirements.

Categories and Subject Descriptors

H.5.2 [Information Interfaces and Presentation]: User Interfaces – *Graphical user interfaces (GUI)*. H.5.3 [Information Interfaces and Presentation]: Group and Organization Interfaces – *Collaborative computing*. D.2.11 [Software Engineering]: Software Architectures – *Patterns*.

General Terms

Design, Management, Reliability

Keywords

Client-server architecture, Graphical user interfaces, Grid computing, Applet, Portlet, Integrated development environment.

Mark L. Green, Stephen D. Miller, *Multitier Portal Architecture for Thin- and Thick-client Neutron Scattering Experiment Support*, *International Workshop on Grid Computing Environments 2007*, Nov., Day, 2007, Reno, NV, USA. An electronic version of this document will be available at <http://casci.rit.edu/proceedings/gce2007>

1. INTRODUCTION

The Spallation Neutron Source (SNS) [4] located at Oak Ridge National Laboratory (ORNL) supports diverse science domains such as materials, chemistry, engineering, polymers, structural biology, and superconductivity. SNS is an accelerator-based neutron source, when at full power, this one-of-a-kind facility will provide the most intense pulsed neutron beams in the world for scientific research and industrial development.

While SNS is operating at full power, it will offer unprecedented performance for neutron-scattering research, with more than an order of magnitude higher flux than any existing facility. To realize the potential this offers for research in many fields, a world-class suite of instruments is being developed that makes optimal use of the SNS beams and that is suited to the needs of users across a broad range of disciplines. Instruments will be available to researchers with varying degrees of experience, from new graduate students and first-time neutron users to experienced users with an interest in instrument design. This broad range of users, novice to sophisticated, provides an ideal user community for integration and development of the Multitier Portal Architecture (MPA) in addition the user community requirements are also quite disparate based on their science domains.

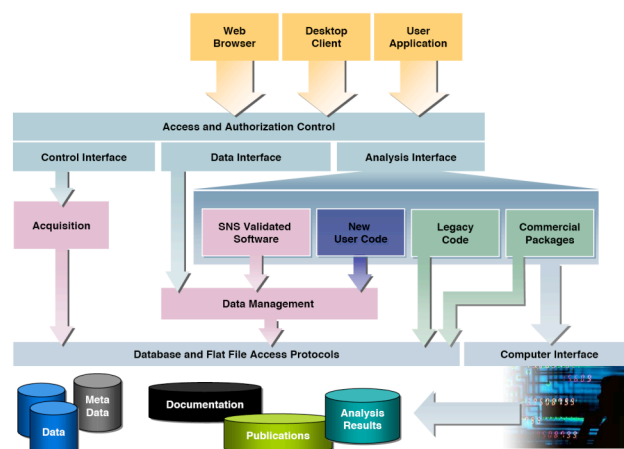


Figure 1. Overall SNS Software Architecture [5].

The SNS software architecture, Figure 1, provides an overview of the functional blocks and systems that are organized in a modular layered fashion. It is extremely important that this system be as flexible as possible to support the wide range of use cases presented by the user community. At the top of this diagram SNS software services are available from remote web clients (thin-clients) and desktop clients and user applications (thick-clients).

Instrument scientists responsible for the operation of the instruments during experiments require the use of thin- and thick-clients for performing their duties and subsequent calibration and data analysis [5]. Users and instrument scientists desire an integrated platform for virtual instruments driven by sophisticated applications such as McStas [17] and VITESS [16] where virtual experiments help to understand what is actually observed in real experiments [15]. The development of this component based plugin architecture for neutron science will also incorporate DANSE [18], DAVE [19], and ISAW [20] within the tier based development (several of these components are now functional at the tier I layer SNS Portal [21], tier II layer SNS OGCE Portal [22] and tier III layer GumTree [13]).

This paper describes the design and implementation of the Multitier Portal Architecture (MPA) for thin- and thick-client neutron scattering experiment support. In Section 2 a brief overview of the three-tier layered client-server architecture is discussed, followed by a detailed explanation of the SNS design and implementation of MPA. Section 2.3.3 describes the enhanced capabilities under development for the SNS thick-client application, and finally followed by Section 3 concluding observations.

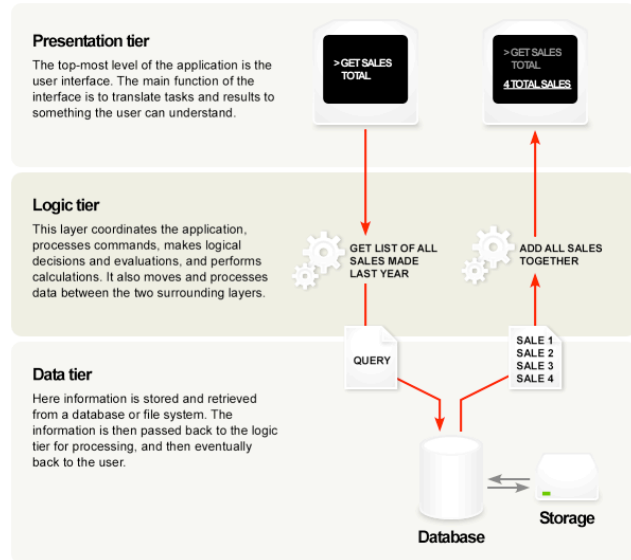


Figure 2. Typical “three-tier” or “three-layer” client-server architecture.

2. SPALLATION NEUTRON SOURCE MULTITIER PORTAL ARCHITECTURE DESIGN AND IMPLEMENTATION

The basic portal architecture is modular with well-defined interfaces facilitating a distributed development environment with the ability to incorporate new technologies seamlessly. Figure 2 introduces the three-tier layered client-server architecture used as a basis for the portal infrastructure development, also referred to as a three-layer client-server architecture. This software architecture emerged in the 1990s and effectively provided many key features including performance, scalability, flexibility, and reusability [1, 2].

The following sections provide a general overview of data tier, a more detailed presentation of a hybrid logic layer incorporating Service-Oriented Architecture (SOA) design patterns and then focus on describing the integration of the multitier presentation layer for delivering reuse of the portal infrastructure.

2.1 Data Tier

We adopt the traditional data tier consisting of databases and/or file systems storing user, shared, and public data and meta data files; portal specific user and account information, statistics, access control lists, etc. The data tier is capable of capitalizing on a distributed infrastructure of database servers, networked file systems, and high performance storage systems.

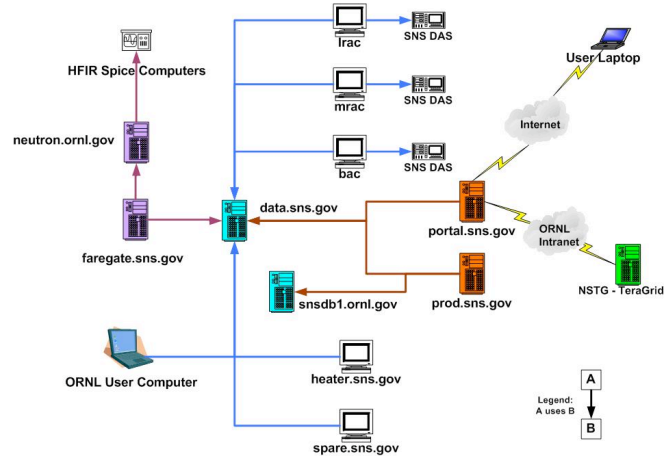


Figure 3. Spallation Neutron Source (SNS) network file system layout.

The Networked File System (NFS) mounts are depicted in Figure 3, where data.sns.gov serves the SNS data repository to all computational and data access resources. The Neutron Spallation Source (NSS) network topology, Figure 4, provides additional detail of the high performance storage system located at the National Center for Computational Sciences (NCCS) providing programmatic access to long-term storage data. Additional storage may occasionally be accessed through the 10 Gigabit network link to TeraGrid storage resources across the United States.

2.2 Logic Tier

Capitalizing on the tremendous amount of development activity of the grid communities worldwide in providing robust and reusable middleware is our primary objective. Integration of applications, processes, and services into the logic tier layer has proven to be cost-effective even with legacy applications in the past. Currently, an architectural style where services, which may be grouped by functionality, pass data from one service to another is gaining tremendous popularity with the Information Technology (IT) community. This Service-Oriented Architecture (SOA) supports the modular construction of large applications by reusing smaller atomic IT services replacing the legacy monolithic applications of the past.

Using SOA design patterns reusable IT services can be used to separate the logic tier into a service layer, a controller layer, and an entity/object management layer [3]. In essence the logic tier provides an application server container. The service layer is responsible for specifying the operation and serializing and de-serializing messages in and out of the container. The controller

layer is responsible for implementing the logic of the service. The entity management layer is responsible for entity management and ensuring the transaction integrity.

With this view of the logic tier the Web Service Resource Framework (WSRF) [7] OASIS published specifications for web services have been implemented by the Globus Toolkit [6] with the associated Java Commodity Grid (CoG) [14]. Further discussion of additional infrastructure, services, and applications will be presented in the following section.

servlets, applets, and portlets in addition to thick-client Rich Client Platform (RCP) and Integrated Development Environment (IDE) support. This multitier layered presentation tier design is described in the subsequent sections.

2.3.1 Tier I: Thin-Client Applets

The major tier I thin-client applet, as denoted in Figure 5, is the SNS Java-based Applet Portal [5] this applet is fully functional and provides data browsing, search, file transfer, visualization, etc. capabilities for the SNS scientists and researchers. It utilizes portal server servlets for transferring files, visualization caching, repository file meta-data transfer, etc. There will eventually be 18

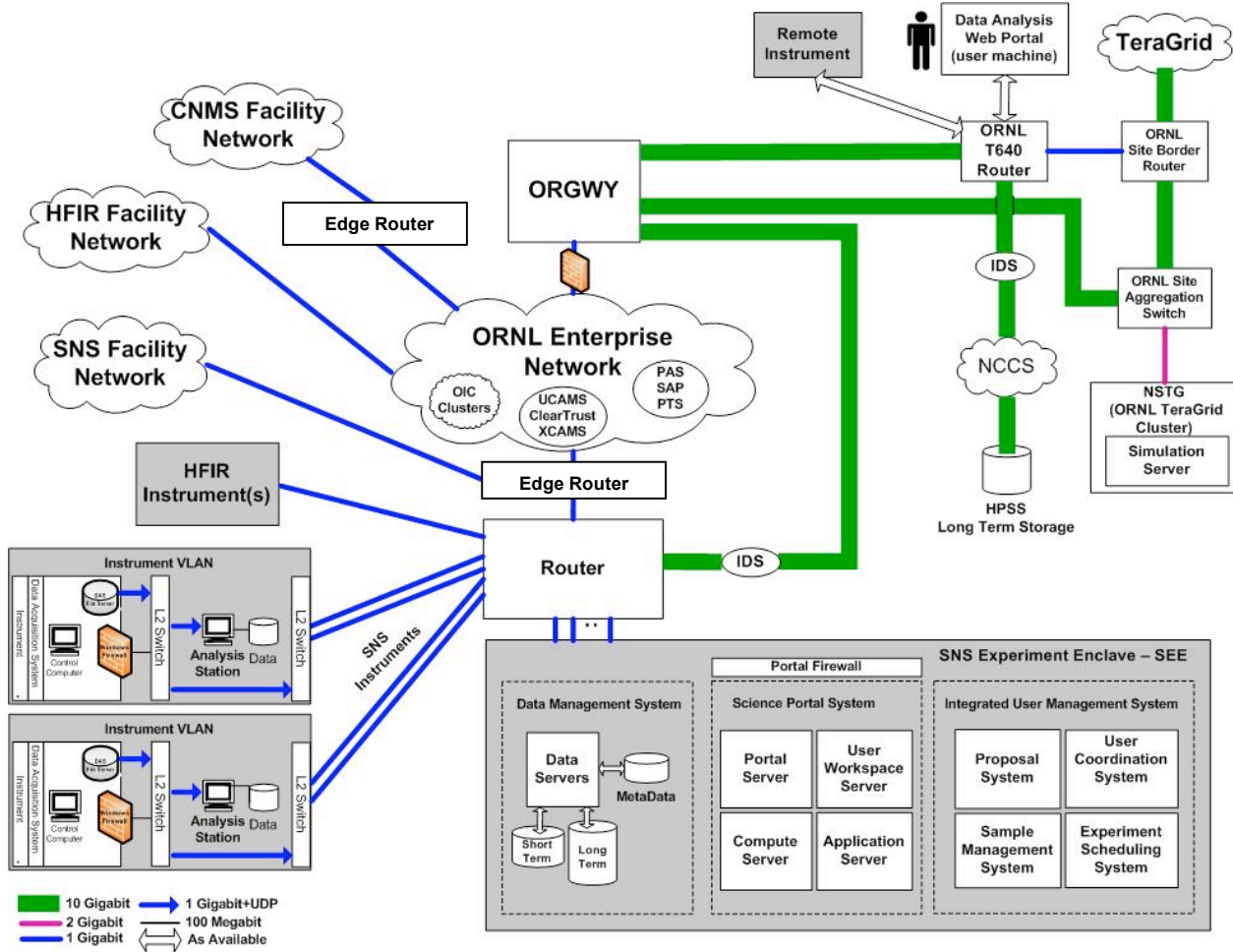


Figure 4. Spallation Neutron Source network topology.

2.3 Presentation Tier

Today many portals are required to perform in an extremely dynamic environment where the quantity, sophistication, and requirements of portal users change rapidly. It is highly desirable to scale the portal capabilities with the requirements and sophistication of the user. In order to effectively and efficiently provide a scalable, robust, and flexible presentation tier we present the following multitiered approach providing thin-client

SNS instruments coming online over the next several years and we anticipate that there will be instrument specific applet development efforts continuing for quite some time. It is very important that we utilize the time and resource investment in this applet and servlet development effort in the successive presentation layer tiers.

This browser based thin-client is the lightest weight user access to the SNS data repository and services available to the user except for direct SSH shell access. All of the features available through the SNS Java-based Applet Portal are made available through the

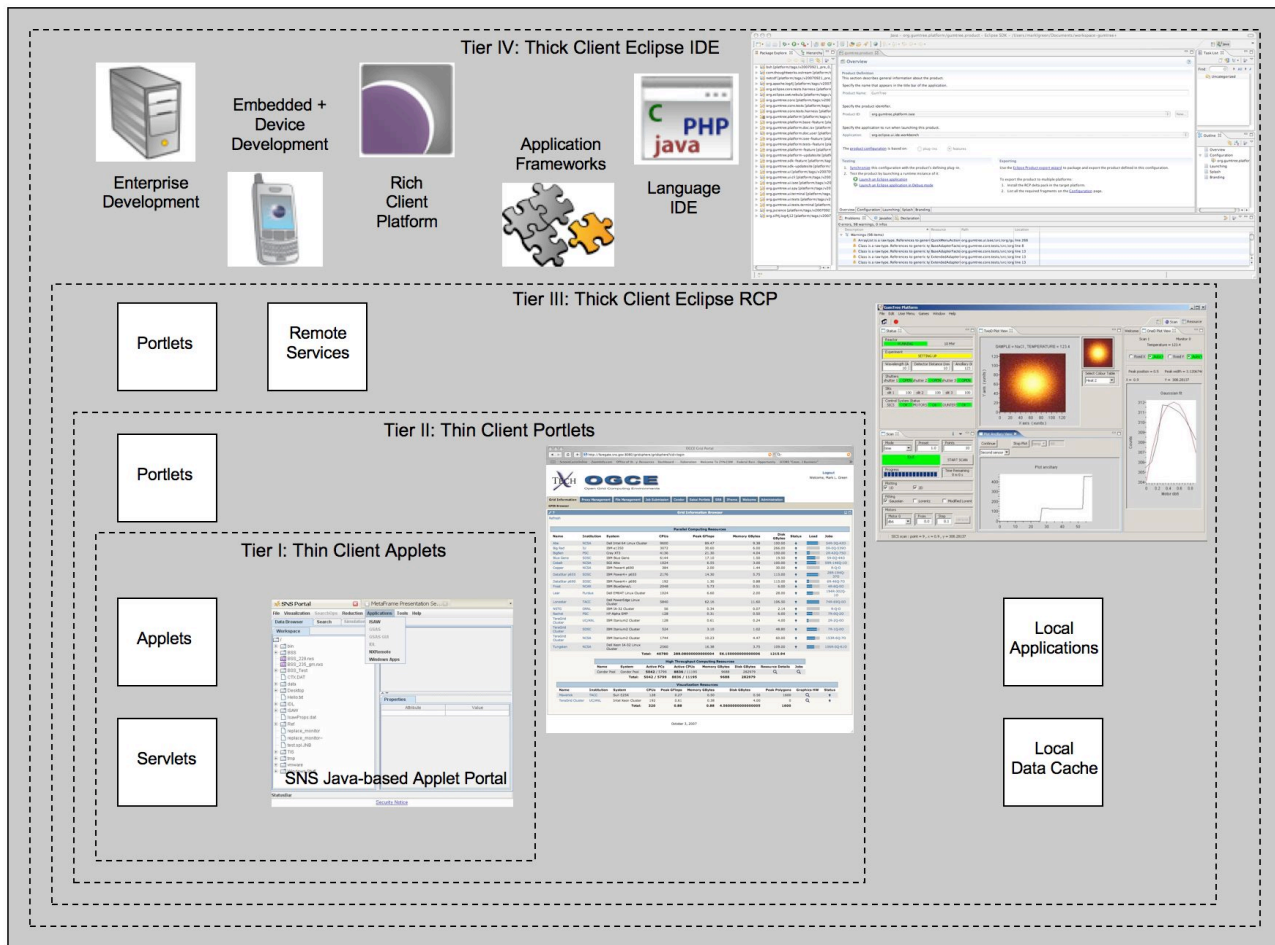


Figure 5. Multitier Portal Architecture layered presentation tier.

tier II without modification or need to integrate with the Applet Portal development team.

2.3.2 Tier II: Thin-Client Portlets

The Open Grid Computing Environment (OGCE) [8], as denoted in Figure 5, is used as the tier II thin-client portlets framework for this project. The full feature set of the tier I thin-client applets are incorporated into the OGCE framework using the iFrame portlet displayed as a tab within the portal. The user now has access through the SNS Java-based Applet Portal and the additional features offered within the OGCE framework.

The OGCE framework provides several features that are currently not available through the SNS Java-based Applet Portal including:

- Grid credential proxy management portlets;
- Portlets for managing remote files through GridFTP and other file management systems;
- Portlets for running jobs through Globus Toolkit versions 2.4 and 4.0 (both Web Service and pre-Web Service versions);
- Storage Resource Broker (SRB) portlets; and

- Grid Portals Information Repository (GPIR) portlets and services
- Condor job submission portlets.

Many other JSR 168 compliant portlets are available through collaboration with OGCE portals such as the CIMA [10] and LEAD [11] projects and other web repository sites such as java.net [9] and SyncE [12]. The integration of OGCE and associated portlet repository infrastructure is providing substantial portal capability with a low expenditure of time and resources.

The development of component based neutron science pre-experiment specific portlets that integrate an experiment protocol planner and experiment sample scheduler, Monte Carlo simulations, sample activation calculator, and group collaborative calendars for on-site trip planning are in the planning stages.

2.3.3 Tier III: Thick-Client Eclipse RCP

The aim of the GumTree Project [13] is to create a highly Integrated Scientific Experiment Environment (ISEE), allowing interconnectivity and data sharing between different distributed components such as motors, detectors, user proposal database and data analysis server. GumTree is an open source and multi-

platform graphical user interface for performing neutron scattering and X-ray experiments. It handles the complete experiment life cycle from instrument calibration, data acquisition, and real time data analysis to results publication.

The GumTree project site hosts projects associated with the GumTree ISEE and Eclipse RCP technology including:

- GumTree Integrated Scientific Experiment Environment (ISEE) Workbench
- GumTree NeXus Instrument eXtension (GumNIX)
- GumTree Plug-in Library

The GumTree+ Project has been proceeding for several months with the following thick-client RCP goals and capabilities; this project will be complete in January 2008. The GumTree+ project development focuses on several areas of interest and synergistic activities within the Neutron Science scope:

- SNS/ANSTO synergistic efforts
 - McStas software development project
 - Integrate into GumTree with help of SNS/TeraGrid
 - Code Development Repository
 - GumTree development in subversion repo at Codehaus
 - Tech-X and SNS development in subversion repository at ORNL
 - Combined project using subversion externals property
 - We anticipate development under the Eclipse Public License - v 1.0
- NeXus (HDF5) File Management
 - Search capabilities within current workspace tailored to NeXus file metadata
 - Google Desktop Search Eclipse Plugin
 - Plugin Directory / Network / Google Desktop Search
 - NeXus file transfer capabilities
 - SshTool's java api for SSH - SFTP Eclipse Plugin
 - Plugin Directory / Network / Sshftp
 - Integrate SCP with SSL authentication
 - Investigate SSL/HTTPS and GridFTP PKI transport mechanisms
 - Facilitate remote thick-client direct access
 - *SSH Terminal Access Eclipse Plugin*
 - *Plugin Directory / Network / SshView*
- Eclipse Virtual File System (VFS) Integration

- SNS Virtual File System (VFS)
 - Scientific catalog based on ICAT
 - Includes XML describing the structure of a NeXus file and its properties
 - Access options:
 - Direct database query
 - Java Content Repository (JCR) API
 - Stateful API
 - WebDAV
 - Web Service
- Function:
 - Repository file discovery for SNS file browser
 - Basic file search capability (query based)
 - Repository absolute file path definition
- GumTree/Eclipse IDL Integration
 - Java IDL: IDL to Java Language Mapping
 - Aggregate existing IDL scripts/modules/programs into repository for testing and development
 - IDL Eclipse DE in 7.0 beta release
 - Tech-X has NDA access to this release for evaluation
 - Investigate Tech-X FastDL integration
 - Cluster Computing with IDL
 - Timely Visualization and Analysis of Large Data Sets Using IDL and Parallel Computing (FastDL)
- GumTree ISAW Integration
 - APS already has proof of concept
 - ISAW - Eclipse integration
 - ANSTO GumTree has already integrated ISAW at some level
 - Requirements/Actions:
 - Identification of current ISAW capabilities in GumTree
 - Identify user community requirements
 - Develop capability requirements and service integration list
 - Develop work plan
 - Obtain validation and test suite NeXus files for both IDL and ISAW development efforts
- Computational and Data Grid Integration
 - SNS/ORNL

- TeraGrid pre- and web service interfaces
- Open Science Grid pre- and web service interfaces
- ANSTO
 - APAC web service interfaces
 - APAC Gridsphere available
 - APAC Gridportlets available
- Open Grid Computing Environment (OGCE)
 - Develop portlet and web service repository
 - Integrate Storage Resource Broker (SRB) Portlet available (SRB)
 - Access scalability of Computational/Data grid portlets
 - GPIR, GridFTP, Condor, etc.

The thick-client GumTree Eclipse RCP application allows the SNS team to package and deploy enhanced features with the thick-client installation and a data cache can be used for local data file processing and visualization. This significantly increases the flexibility of the user portal and removes the need to maintain high bandwidth network connections. The ability to process cached data offline is highly desirable for the SNS instrument scientists.

2.3.4 Tier IV: Thick-Client Eclipse IDE

The Tier IV thick-client Eclipse Integrated Development Environment (IDE) incorporates all of the features provided by the previous tiers in Eclipse based projects stored in a central Subversion code repository. This tier is meant to provide access for very sophisticated users that have the desire to develop infrastructure and capabilities specific to their SNS instrument using the available plugins, servlets, portlets, and applications.

User legacy code bases can be integrated into the MPA environment by utilizing the extensive Eclipse debugging, development environment, tutorials, manuals, and available plugins. We anticipate that the number of qualified users that will take advantage of this tier will be limited but the potential for scientific discovery could be unlimited with the capability of tightly integrated scientific research codes.

3. CONCLUSION

The Multitier Portal Architecture has the potential to scale to the expertise and requirements level of the user while maximizing the reuse of the developed infrastructure and services in successive tiers. The portlets available from repositories have substantially increased in the past year and continue to grow in this active area of research and development. We anticipate over the next several months the GumTree+ Project will provide significantly more thick-client capabilities for use by SNS scientists and researchers..

4. ACKNOWLEDGMENTS

This work was supported by the Spallation Neutron Source at Oak Ridge National Laboratory.

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