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THE TECHNOLOGY INFORMATION ENVIRONMENT WITH INDUSTRY (TIE-IN): A MECHANISM FOR ACCESSING LABORATORY SOLUTIONS

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Abstract

The Technology Information Environment with Industry (TIE-In) is a system that helps users obtain laboratory-developed technical solutions without requiring that they duplicate the technical resources (in people, hardware and software) at the national laboratories. TIE-In is based on providing users with controlled access to distributed laboratory resources that are packaged in intelligent user interfaces. These interfaces help users obtain technical solutions without requiring that the user have specialized technical and computer expertise. As a designated DOE Technology Deployment Center / User Facility, industry users can access a broad range of laboratory-developed technologies on a cost-recovery basis. TIE-In will also be used to share laboratory resources with partners in U.S. industry that help the DOE meet future manufacturing needs for the stewardship of our nation's nuclear weapons stockpile.

Introduction

TIE-In provides a new mechanism for working with industry: remote electronic access to packaged technical solutions. This mechanism focuses on providing the non-expert with guided solutions embedded in intelligent user interfaces, while minimizing the investment required to utilize these technologies. Technical solutions at the labs include such capabilities as computational simulation, modeling and design, development and testing facilities, and results from ongoing research programs that can benefit the manufacturing, energy, aerospace, electronics, and automotive industries. By utilizing modern information and computer technologies, TIE-In employs existing capabilities and expertise to provide practical and timely outreach to literally thousands of enterprises of all sizes, across the entire nation. This outreach effort provides users with an on-line, on-demand, service -- offering proven solutions to a wide variety of problems, in a setting that is practical for Small to Medium Sized Enterprises (SMEs). The emphasis is on providing users with technical solutions using "off-the-shelf" technologies at the national laboratories without requiring that users have a lot of technical experts, high performance computers, or computer specialists. These technologies are packaged with intelligent user interfaces and include education and training materials, on-line help documents, expert systems and databases, guided software tools, and distributed computing resources.

By taking advantage of the expanding capabilities offered by the National Information Infrastructure (NII),[2] TIE-In begins to remove the geographic barriers that historically have stood between users' needs and solution sources, and provides realistic technology insertion into all sectors of the market and all areas of the country. Additional benefits for industry include access to a broad range of technical solutions, along with access to resources which are beyond the budgets

of most SMEs. TIE-In leverages laboratory staff and resources, freeing technology transfer from the staffing limitations that restrict the availability of current one-on-one mechanisms. The use of information technology to put applications on-line also provides rapid access to existing technical solutions. In contrast to traditional technology transfer mechanisms which can take months to establish and often involve the development of new capabilities over a period of years, TIE-In can quickly and in a cost effective manner link users to an existing set of solutions. In an economy where product life cycles are beginning to be measured in terms of months rather than years, TIE-In delivers a viable option for disseminating technology in a short time-frame. While the primary goal of TIE-In is to deploy proven technologies, as new, advanced technologies are developed within the labs, TIE-In will provide a convenient mechanism for their rapid insertion into the commercial sector.

This paper is organized into five sections. The background focuses on the needs that led to the development of TIE-In. This includes the needs of industry and SMEs in particular, and needs of the DOE to partner with commercial manufacturers. This is followed by a description of the TIE-In approach to meeting these needs. The third section of this paper is a brief technical overview of how TIE-In works and the processes that it uses. The fourth section provides a description of some of the resources that are available on TIE-In and shows examples of how technical applications are packaged in intelligent user interfaces. The final section of this paper addresses future developments and directions for TIE-In.

Background

The national laboratories have a responsibility to respond to requests from U.S. industry for lab-developed technologies. A number of mechanisms have been developed for transferring technology from the national laboratories to industry. These include license agreements, cooperative research and development agreements, "work for others" agreements, consortia, staff exchanges, user facilities, and startups[2]. Of these mechanisms, the most accessible to SMEs is the user facility. The concept behind the user facility is to take sophisticated laboratory resources and make them available for industry users on a cost-recovery basis, but as noted by Schriesheim,[2] "We need new ways of making user facilities accessible to smaller firms."

The small to medium sized enterprises constitute an important category of user because so many of the established technology transfer mechanisms have traditionally (though unintentionally) placed barriers to effective utilization by smaller firms. In addition, as outlined in a GAO report on the effectiveness of federal technology transfer efforts, many SMEs need proven, lower cost, lower risk technologies.[3] In general, since most laboratory scientists and engineers are focused on developing state of the art technologies, there has been a gap in between the technology maturity levels that are being developed at the labs and the needs of SMEs. However, many of the developed technologies at the laboratories, i.e. "off the shelf" tools and capabilities, could be very useful to a broad range of users if only they could obtain easy access to these tools and resources.

Some industry needs are equally relevant for the national laboratories. The labs also need to become more efficient in day to day operations, to focus on core competencies, and conversely to outsource those activities that are not core. One example of DOE outsourcing is the transfer of some production responsibilities to qualified, commercial vendors. This transition from a captive production complex for the nuclear weapons stockpile will be made because maintaining this complex is very expensive. However, to retain assured reliability for DOE weapons components, its industry partners should have access to the design, simulation, and testing resources that are validated and pedigreed by the national laboratories. These DOE production needs can be viewed as a microcosm of the DOD production needs described by Gansler.[4] In both cases there is a need to improve the integration of commercial and defense production to maintain secure, reliable capability at an affordable price.

The TIE-In Approach

In 1994, TIE-In received DOE designation as a Defense Programs Technology Deployment Center / User Facility. This designation makes it possible to use a streamlined approval process for allowing industry users to access and use laboratory resources on a cost recovery basis. These user fees cover the cost of software licenses, computer and other resources, and laboratory staff time for application support. Users can access TIE-In via either high speed modem or Internet and a MSWindows-compatible PC, Macintosh, or Unix Workstation. TIE-In uses the OSF/Motif X/Windows graphics standard to give some measure of multiplatform compatibility and to take advantage of X/Windows-based collaborative tools that allow laboratory staff to provide application support via shared sessions with users. Users that are interested in TIE-In can either visit an on-site facility at Sandia National Laboratories or establish an on-line connection. The ability to establish an on-line connection in concert with relatively modest user hardware and software requirements helps to make TIE-In a practical option for SME access to laboratory technologies.

The TIE-In system is based on a number of key elements: packaging of applications with intelligent user interfaces, controlled and secured on-line access to distributed laboratory application servers, and use of established graphics protocols for multi-platform compatibility. Intelligent user interfaces make it easier for lab-developed applications to be used by more than just the application developers. In general, a scientist or engineer should be able to use these technical applications without having to be a Unix expert or spend months learning the idiosyncrasies of a piece of technical software. This packaging is especially important since TIE-In allows users to remotely access a wide variety of different resources.

TIE-In uses an integrated system to perform user authentication and to control access to lab applications and user files. By allowing users to run applications on computers that are configured and maintained at the labs, a broader range of applications can be made available to users. In contrast to traditional methods for distributing software, TIE-In avoids many of the configuration and software support issues that arise when users try to run software on other platforms. This makes it practical to share packaged applications with users without having to make a large commitment to port the application to a broad range of potential user platforms. In addition, users gain the benefits of using applications that are upgraded and maintained by the scientists and engineers that developed and maintain the technology.

The technical applications that users can access through TIE-In are laboratory-developed tools and resources that the DOE will need to share with partners in U.S. industry in order to meet its future production requirements. In general, these are "off the shelf" laboratory applications since these applications are used to help design, analyze and test components that are used in the nation's nuclear stockpile.

TIE-In Technical Overview

This section provides a general overview of the TIE-In System Infrastructure and Front End System (FES). Included is a discussion of the components which comprise the infrastructure, brief descriptions of the processes which make up the various components, and instructions on how to access TIE-In.

TIE-In is designed to work across a TCP/IP network, with a router subsystem interconnecting the various subnetworks. This router subsystem may act as a firewall between the outside network and the internal subnetwork. The infrastructure of TIE-In works with these firewall routers by acting as a trusted agent through which access between users and applications can be accomplished by secure, authenticated and controlled methods. The TIE-In System Infrastructure is composed of four key components; the Kerberos Authentication Service, the Front End System, the Common Services System, and the Application Server. Figure 1 shows the relationship between the components of the infrastructure and the underlying network.

Kerberos Authentication Service

Key to the security of TIE-In is authentication. TIE-In not only authenticates the user at the front end system but authenticates all interprocess communication as well, through the use of Kerberos tickets. Kerberos is an authentication scheme developed by MIT for project Athena.[5] It uses a trusted third party authentication methodology utilizing private keys. It uses a trusted third party authentication methodology utilizing private keys, and has been used in Sandia's Internal Secure Network as a network authentication service for a number of years. Each user and application registered with TIE-In has a corresponding principal entry in the Kerberos Authentication Service (KAS). The KAS issues tickets, which when presented to the server, authenticates the user and the system which issued the request. Added authentication of users is available through the KAS with the use of one time password devices such as the Security Dynamics SecurID card. When users are further authenticated with such a device, the KAS notes this in the Ticket Granting Ticket (TGT) it issues. This information cannot be modified by any process except the KAS since the TGT is encrypted in a key known only to the KAS. This same information is contained within the tickets presented to the servers, so that servers may make decisions based upon the level of authentication performed by the user.

Front End System

The Front End System provides the initial user interface to TIE-In applications. This interface is provided through the Session Manager, an OSF/Motif graphical user interface (Figure 2). The Session Manager performs user authentication and initiates user application requests to the Request Manager, located on the Common Services System. The Session Manager is also the user's interface to the Accounting Manager and the Profile Manager, also located on the Common Services System. The Session Manager provides a wide range of administration tools for the TIE-In system and application administrators.

The other key process provided by the Front End System is the Gateway Service. The Gateway Service is used to provide seamless access between applications and the users workstation or desktop system. Presently only an X11 gateway service is available. X servers typically require users to specify the systems which will be allowed access, or open up access to all systems. This requirement forces users to know or be notified of the systems that applications reside on. To overcome this the Session Manager establishes an X proxy gateway each time a user selects an application to run. The application then sends X11 data to the proxy gateway, which forwards it on to the user's X server. With the proxy gateway users only need to allow X access to the Front End System. Once the application terminates the Gateway Service is notified and the proxy gateway is closed down. A special type of X11 gateway service is planned for 1995. This gateway, known as the Interactive Collaborative Environments (ICE) gateway, will allow for interactive X sessions between a number of X Servers. This capability allows for collaborative design and interactive assistance with TIE-In application experts. Other planned gateways include FTP, a general TCP/UDP gateway, and a variety of distributed file systems such as NFS and AFS.

Common Services System

The Common Services System maintains all user and application information, and collects accounting and usage information. All requests to Application Servers go through the Common Services System. Three processes comprise the Common Services System, the Request Manager, the Profile Manager, and the Accounting Manager.

The Request Manager is the intermediate between the Session Manager and the Application Server. It's primary function is to relay requests, status, and accounting information between the Session Manager, Application Server, and Accounting Manager, while monitoring the states of active requests. The Request Manager takes Session Manager requests, places an identifier on them, and passes them to the Application Server. This process also receives state and accounting information from the Application Server and passes it onto the Accounting Manager. When active requests are complete, the Request Manager notifies the appropriate Gateway Service to close down any gateways established for that request. Occasionally, if status and accounting information have not been received for an active request, the Request Manager will query the Application Server for update information.

The Accounting Manager maintains the state of application requests, as well as accounting information which may have been received by the Request Manager from the Application Servers.

The Accounting Manager is available to the users for inquires concerning active and completed requests, as well as accumulated charges.

The Profile Manager maintains information relating to users and applications. With regard to users, this information consists of items such as username, userid, required authentication level, and applications available to the user. Users may also provide phone numbers, email addresses, fax numbers, as part of their profile information. With regard to applications, items such as application name, application administrator, required authentication level, consultants and server locations are maintained. Only TIE-In Front End Systems may query or write information to the Profile Manager. For additional information about these processes see Reference 6.

Application Server

The Application Server is the process which authenticates and validates incoming requests, performs the authorization when users wish to register for or run an application, executes and monitors the application, and returns status and accounting information back to the Request Manager. Local system administrators have final control over who has access to an application. Through a local configuration file, the Application Server will execute authorization and account setup scripts, provided by the local administrators, when users register for, or request to run an application. Local administrators may also elect to have the application run under a captive account, or with a totally different root filesystem than other users of the system. A single Application Server can handle many applications.

Multiple Organizational Realms

TIE-In can be scaled into multiple organizational realms (Figure 3). Each realm has responsibility for administration of its own Front End, and Kerberos Authentication Systems. Users and applications are designated as belonging to a particular realm, and administrators may only modify information on users or applications belonging in the same realm. Users receive authentication from their local realm, however they may still have access to applications in different realms. This type of configuration allows organizations to share resources, in a limited and controlled fashion. The Common Services System is shared by all realms, which provides information about users and applications in all realms. The Profile Manager will ensure uniqueness of usernames and userids, which can be an area of concern when resources are shared between organizations.

Examples of TIE-In Applications

There are a broad range of applications that are available through TIE-In and additional applications will be added as they are packaged with intelligent user interfaces. At the present time, the list of technical applications includes:

• *Hydrocode Simulations for Very-High Strain Rate Processes* This application is used to analyze the mechanical and thermal effects of high strain processes either caused by high velocity impact or explosive detonation processes. The intelligent user interface guides the user through problem definition, access to technical databases of material properties and failure models, submission of runs to workstations or laboratory high performance computing resources, and visualization of results.

• *Experimental Impact Physics Tools* This application provides the user with tools to design impact tests to be carried out at Sandia, to access and retrieve test results on-line and to analyze and interpret test results. This is a powerful example of how unique facilities can be made available to a broad range of users. This application has completed a test series for an out-of state user that never had to physically travel to Sandia National Laboratories to obtain test results or access lab-developed tools for data analysis.

• *Glass-to-Metal Seals Design Guide* This application provides the glass-to-metal seal designer with tools to determine the proper dimensions that will ensure residual stresses do not exceed the strength limit for the glass. This application includes Sandia references on fabrication processes, inspection procedures and expertise on materials compatibility.

• *3D CAD Translation* This application is used to convert a user's AutoCAD file into an ACIS solid model file. This help to make Sandia's analysis tools applicable to a broader range of user-provided models and component descriptions.

• *Automatic Mesh Generation Tool* This tool is used to take an ACIS model of a component and automatically generate a mesh for subsequent finite element analysis. This ACIS model can be uploaded directly from the user or provided as an output of the 3D-CAD file translation application.

• *Virtual Prototyping of Robotics Systems for Manufacturing Processes* This application provides the user with an interface to a set of tools that can be use to perform robot path planning, and automatically determine assembly/disassembly sequences. Users can also access the robotics laboratory to perform instrumented tests of different manufacturing processes.

• *Parachute Design Tools* This computational application provides a user with an application that captures the expertise of Sandia's parachute designers. A number of specialized simulation tools are available to analyze the performance and design of various parachute-payload systems.

• *Structural Dynamics Analysis, Test, Correlation Environment* This application provides the user with tools to analyze the structural response of a system to external forces. Finite element simulations can also be compared to experimental results of modal testing to improve the analytical models.

• *Integrated Development Environment and Assistant (Electronic Design)* This tool provides the electronics designer with access to an easily searchable database of prior design records and expertise. Electronics designers can also access of set of references that are commonly used by Sandia designers in the course of their work.

• *FAST Advice: Integrated Circuit Failure Analysis Expert System* This tool is an expert system designed to guide the user through the failure analysis of integrated circuits and wafers. This application guides the user through the identification of failure modes to a user-specified level of confidence.

<u>Images from actual TIE-In applications</u>

Figures 4-9 are examples from various TIE-In applications that illustrate the ability of intelligent user interfaces to package various technical resources at the labs.

• Figure 4 illustrates the ability to capture design knowledge of compatible materials in a user interface.

• Figure 5 illustrates the ability to guide the user through the process of building complex input decks.

• Figure 6 illustrates the ability to use NQS to queue jobs to laboratory high performance computing resources.

• Figure 7 illustrates the ability to preview simulation results online, prior to downloading results files to the user's computer .

• Figure 8 illustrates the ability to design a test for performance at a laboratory test facility.

• Figure 9 illustrates the ability to obtain results from testing and diagnostics resources.

Future Developments

Later this year, the first linkages should be established to Application Servers in realms at Sandia's sister laboratories, Los Alamos National Laboratory and Lawrence Livermore National Laboratory. A key result from the extension of TIE-In to other organizations will be the definition of roles and responsibilities for a large scale, distributed system that crosses many organizational boundaries. If this linkage is successful, TIE-In could be used to establish connections to resources at other federal laboratories, universities and industrial sources of technologies.

New licensing agreements will be established for commercial software that are used in conjunction with the laboratory-developed applications that users can access. A portion of the user fees will cover the license costs for commercial software. One measure of success for TIE-In will be the entry of commercial developers of technical applications into TIE-In. This mechanism would give these commercial interests a way to expand their user base into the market of SMEs. Another opportunity for teaming with the commercial sector will be to establish links to commercial providers of computer services.

Finally, an important role for TIE-In is to serve as a technology source for the growing social network of extension service providers, such as the NIST Manufacturing Technology Centers, and other State and University technology extension services. These front-line agents can introduce users to TIE-In, help provide needs/solutions matching, consultation and guidance, and be a source of valuable feedback for the TIE-In system. Since many of these organizations have higher speed connections to Internet than are currently practical for most SMEs, they also provide an important conduit to such bandwidth-intensive functions as collaborative tools and video conferencing.

Acknowledgments

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Definitions

ACIS	ACIS is a trademark of Spatial Technologies, Inc.
AFS	Andrew File System
AutoCAD	AutoCAD is a trademark of Autodesk, Inc.
DOD	Department of Defense
DOE	Department of Energy
FES	Front End System
GAO	General Accounting Office
ICE	Interactive Collaborative Environment
KAS	Kerberos Authentication Service
Kerberos	Kerberos is a trademark of MIT
Macintosh	Macintosh is a trademark of Apple Computer, Inc.
MS-Windows	MS-Windows is a trademark of Microsoft Corp.
Motif	Motif is a registered trademark of OSF
NFS	Network File System
NII	National Information Infrastructure
NIST	National Institute of Science and Technology
NQS	Network Queuing System
OSF	Open Software Foundation
SecurID	SecurID is a trademark of Security Dynamics
SME	Small and Medium sized Enterprises
TCP/IP	Transmission Control Protocol/Internet Protocol
TCP/UDP	Transmission Control Protocol/User Datagram Protocol
TIE-In	Technology Information Environment with Industry, TIE-In is a trademark of Sandia National Laboratories
X/Window	X/Window is a trademark of MIT

References

1. *The National Information Infrastructure: Agenda for Action*, NTIS/PB93-231272, Sept. 1993.
2. Alan Schriesheim, "Toward a Golden Age for Technology Transfer", *Issues in Science and Technology*, Winter 1990-91.
3. *TECHNOLOGY TRANSFER: Federal Efforts to Enhance the Competitiveness of Small Manufacturers*, GAO/RCED-92-30, Nov. 1991.
4. Jacques S. Gansler, "Restructuring the Defense Industrial Base", *Issues in Science and Technology*, Spring 1992.
5. S.P. Miller, B.C. Neuman, J.I. Schiller, and J.H. Saltzer. Section E.2.1: Kerberos authentication and authorization system. *Project Athena Technical Plan*, MIT Project Athena, Cambridge, Mass., Dec. 1987.
6. Glenn D. Machin, Rich Detry, *TIE-In System Description*, Sandia Report (In Progress), Feb., 1995.

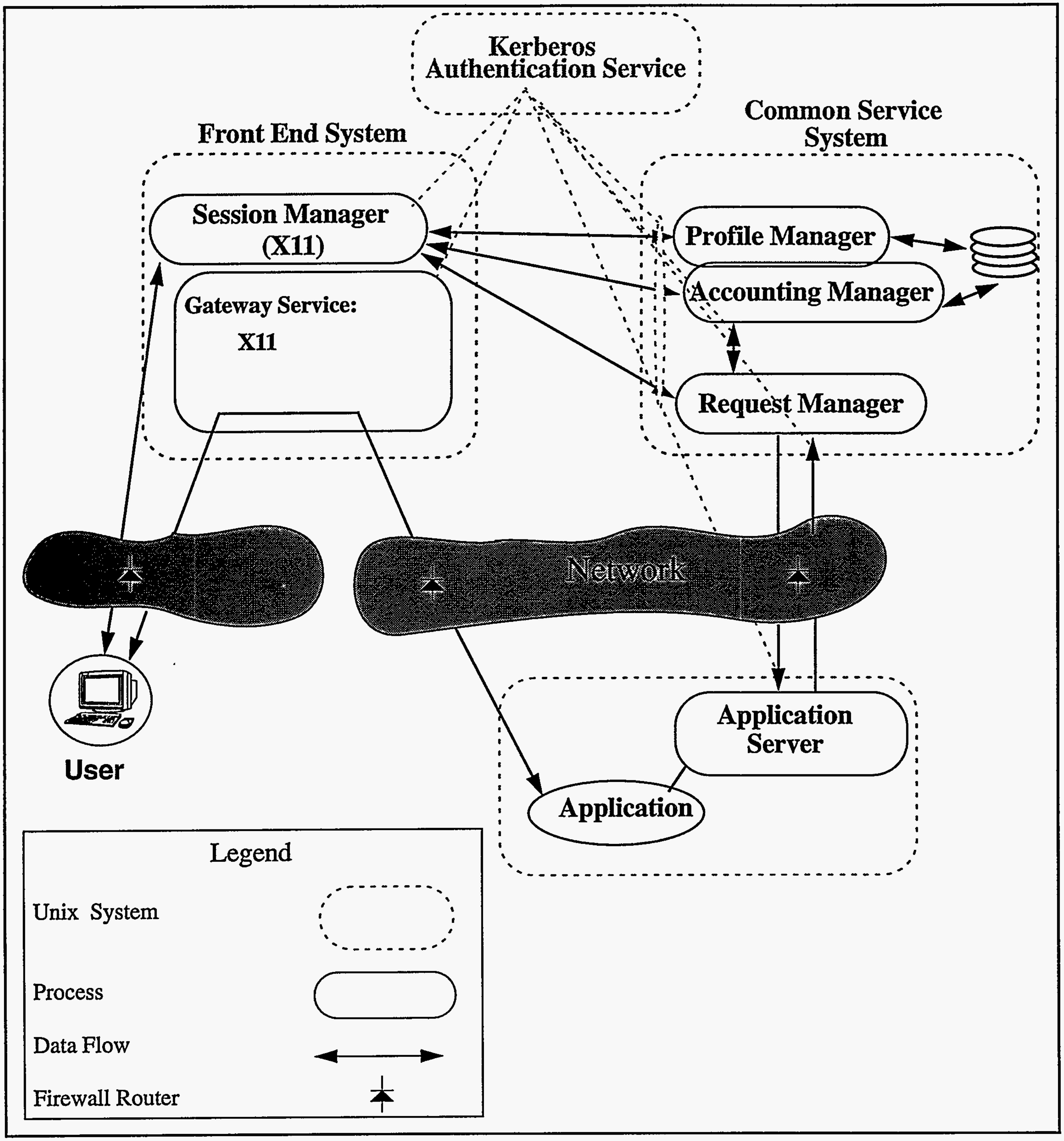

Figure 1. Schematic diagram of the TIE-In System Infrastructure

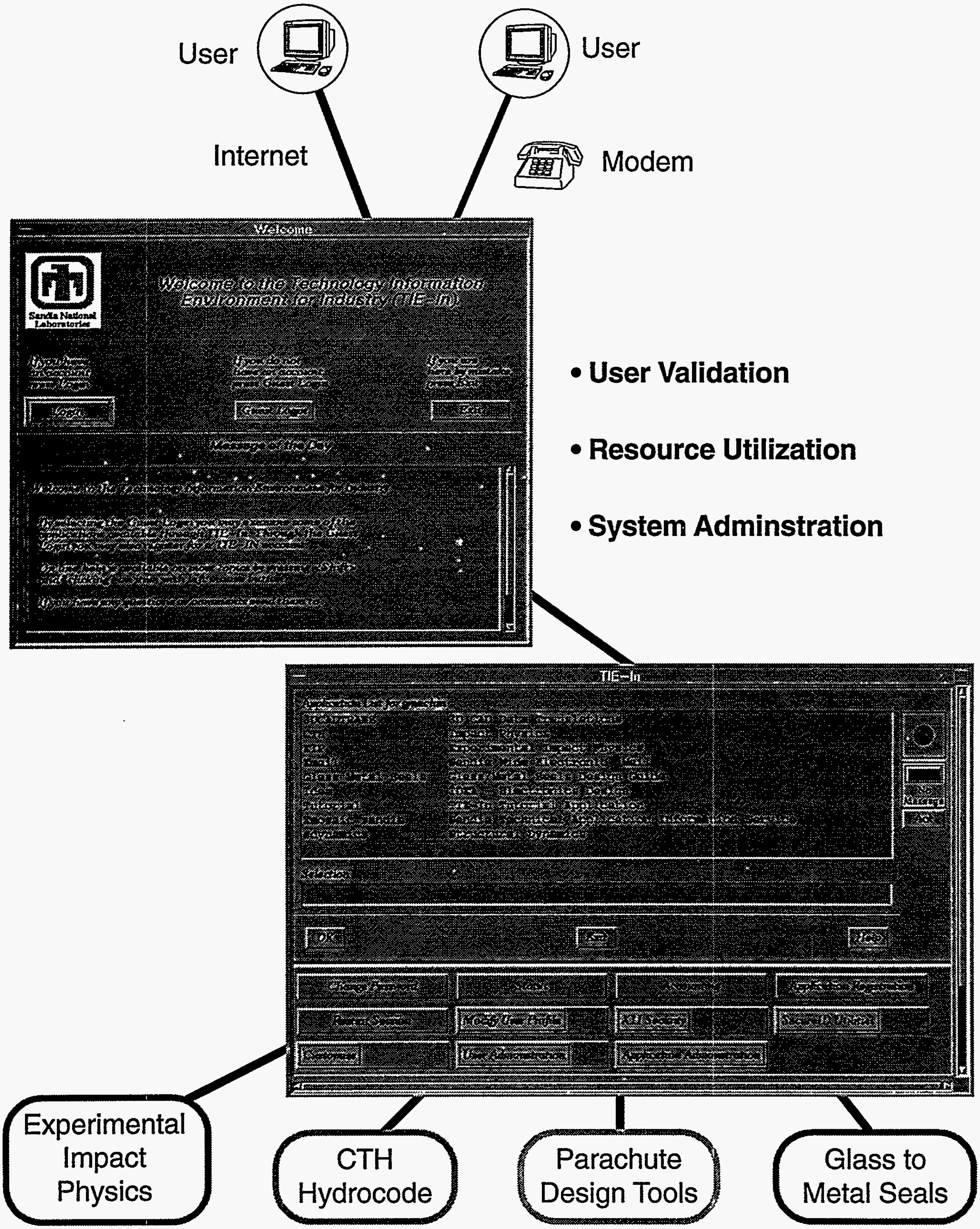

Figure 2. Image of the TIE-In Front End System graphical user interface.

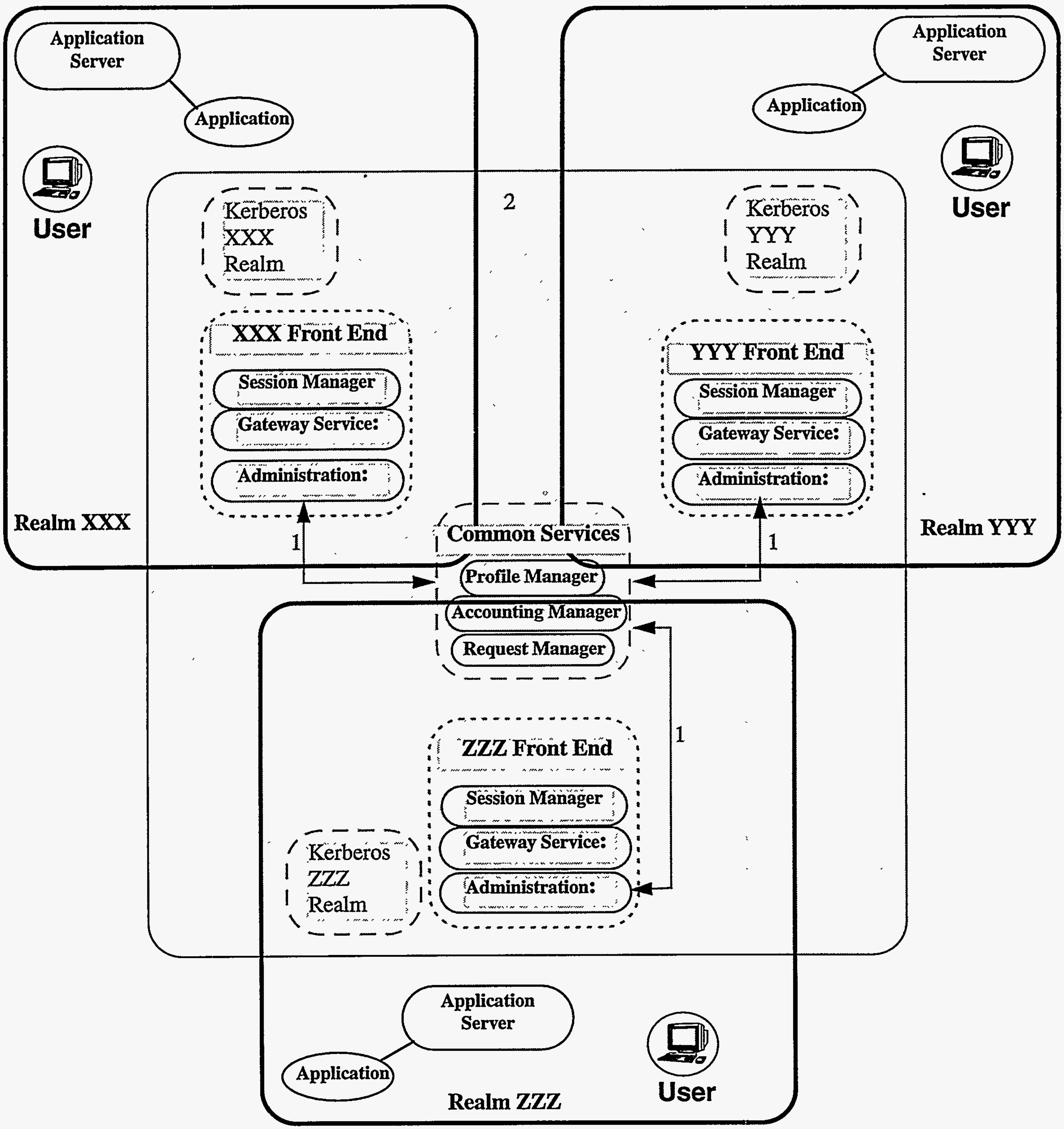

Figure 3. Schematic diagram of TIE-In Multiple Organizational Realms.

1. Each realm has administrative control over users and applications in their realm.
2. Services in gray area must be accessible by all users and applications.

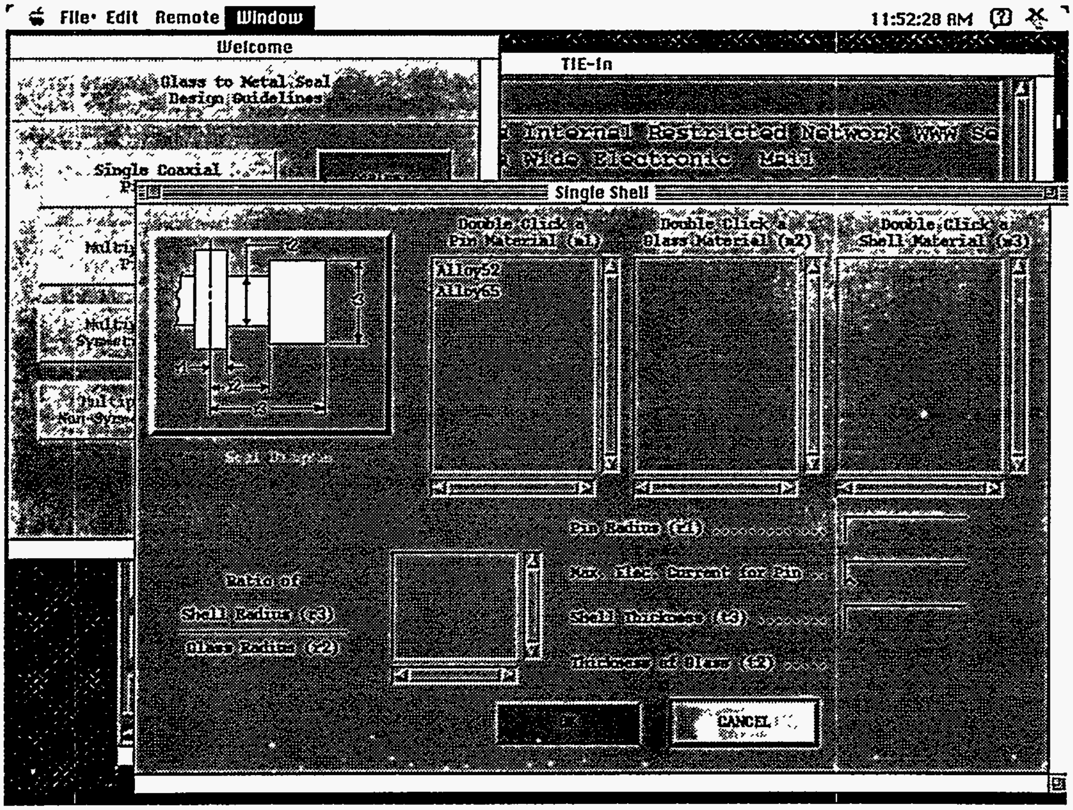

Figure 4. This example from the Glass to Metal Seals Design Guide application illustrates the ability to embed knowledge of compatible materials into the user interface. The selection of a pin material will present the user with a set of compatible glass materials and the selection of a glass will present a list of compatible shell materials.

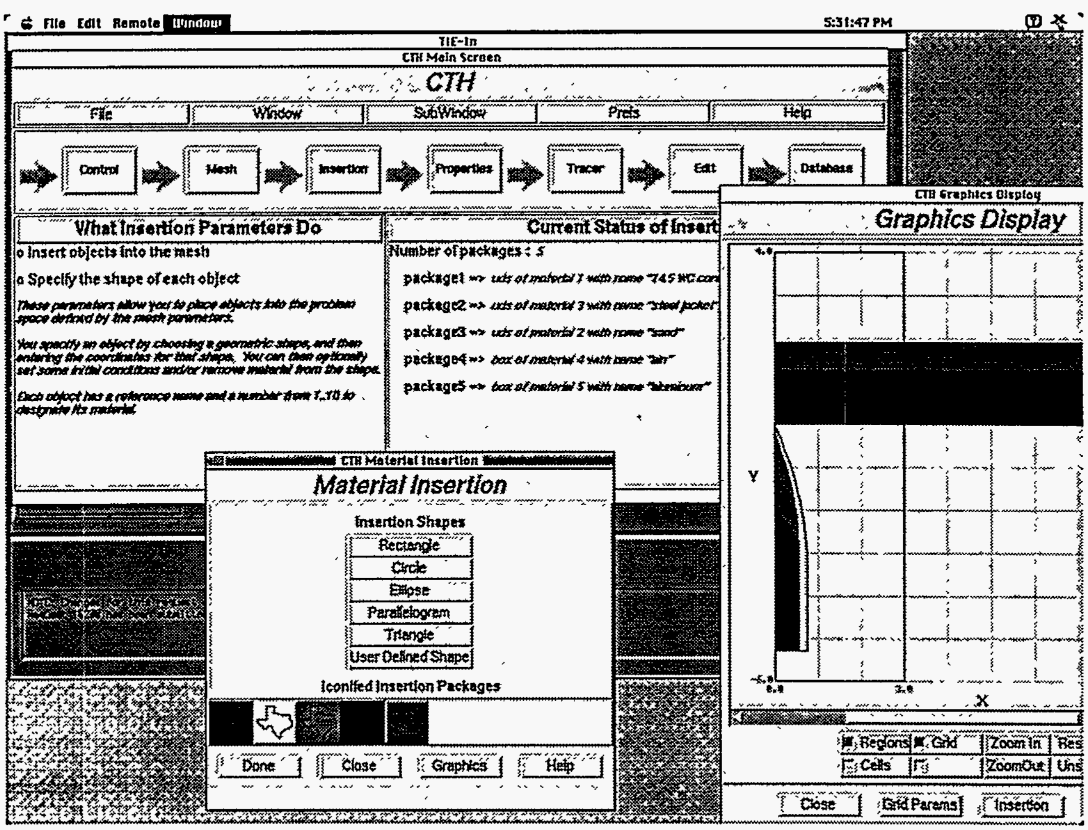

Figure 5. This example from the CTH Hydrocode application shows how the intelligent user interface can guide the user through the process of defining a ballistics penetration problem.

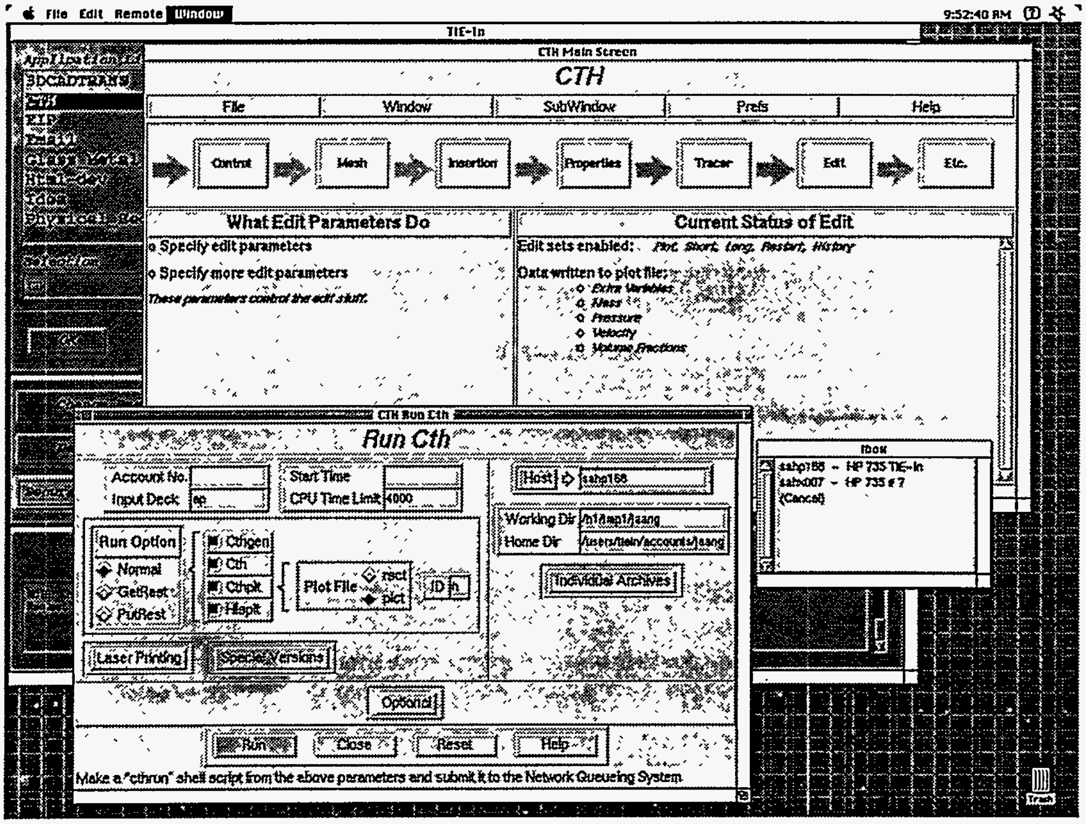

Figure 6. This example from the CTH Hydrocode application shows how the simulation can be queued to a workstation, or a more powerful high performance computer.

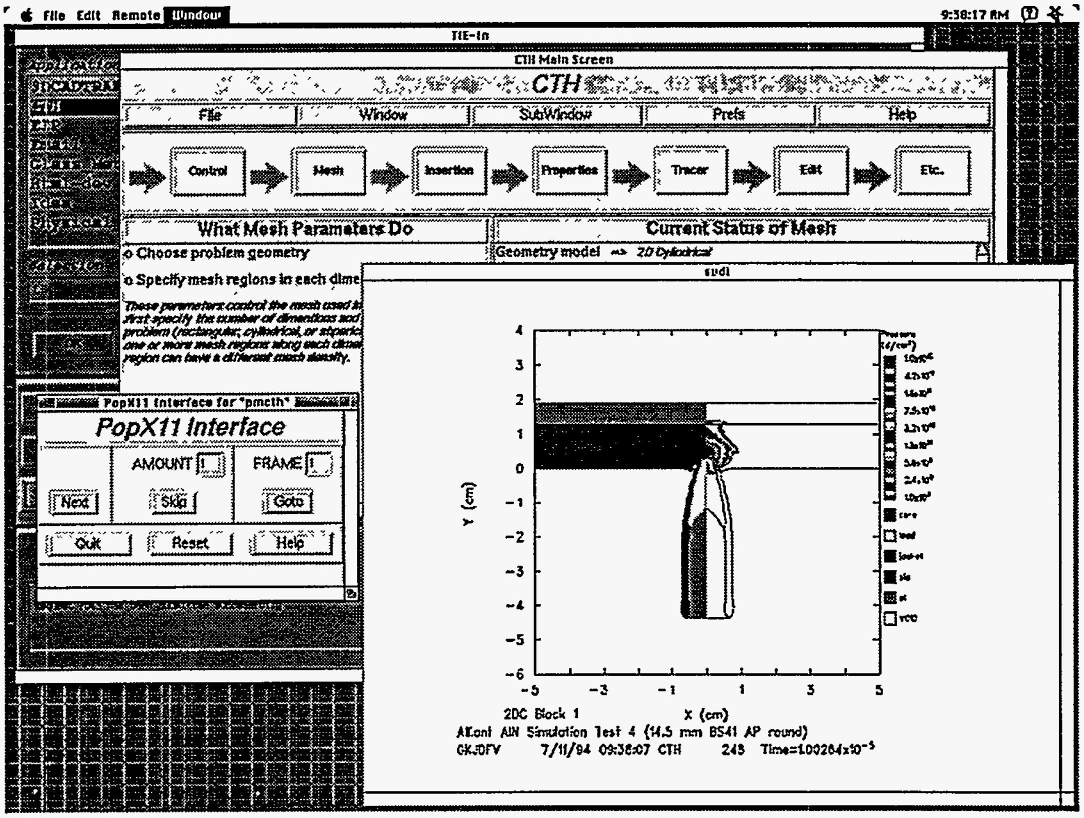

Figure 7. This image from the CTH Hydrocode application shows how a user can preview results before deciding to download them to the user's local computer.

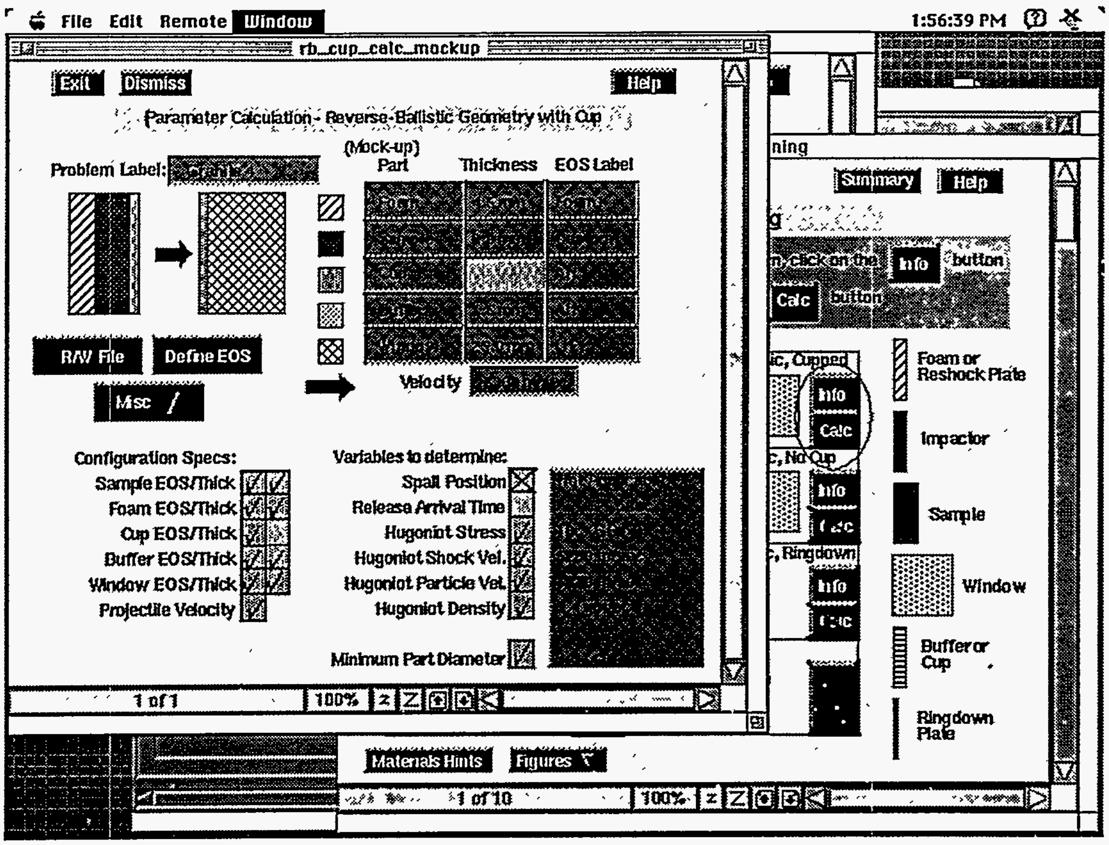

Figure 8. This example from the Experimental Impact Physics application shows the user interface to access tools for designing impact tests that can be performed at a Sandia facility

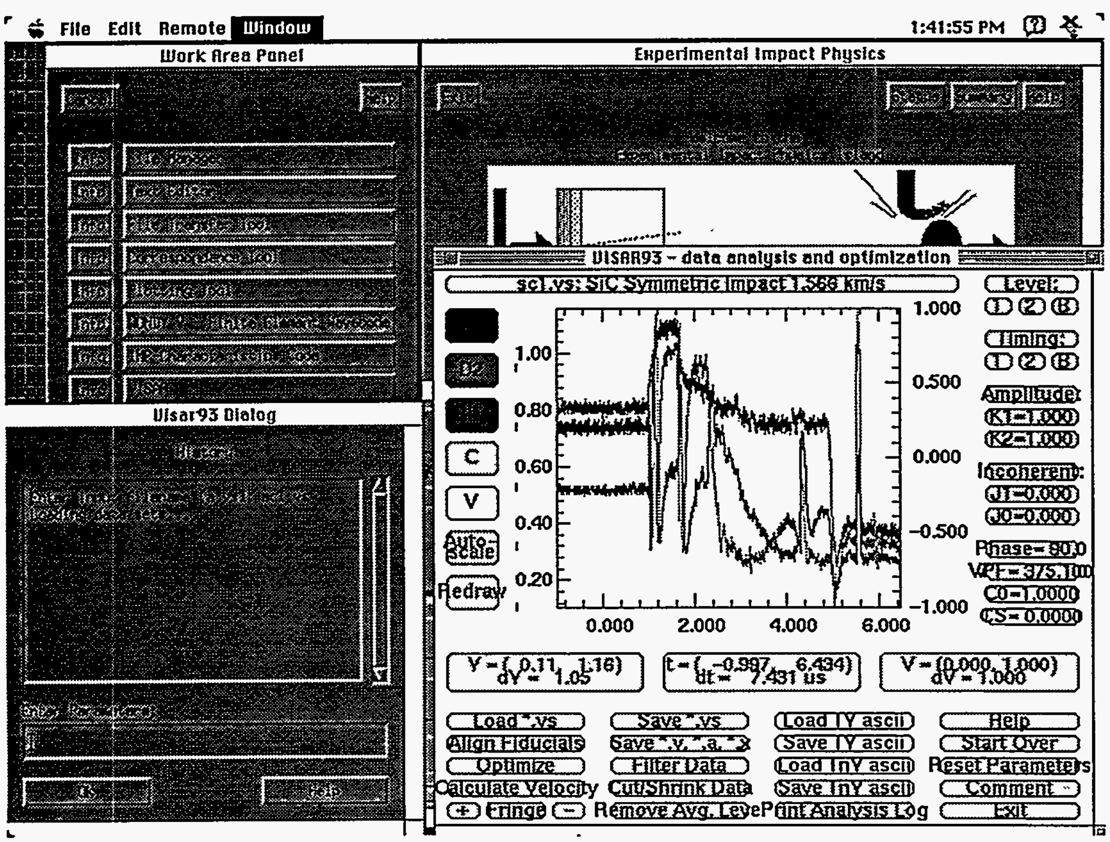

Figure 9. This example from the Experimental Impact Physics application shows results from an actual impact test that are captured with transient digitizers and displayed in an application for performing data analysis.