# ACCESS TO REMOTE RESOURCES – STATE OF THE ART

**WP3 New Grid Services and Tools**

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Abstract: This document gives a brief survey of projects and works related to the problems and describes the current state of the art in the scope of giving the end user easy and simple access to resources via a graphical interface. The main goal of this additional software layer positioned between the end user and middleware and applications is to decrease the knowledge required to access and use resources and data in a heterogeneous distributed environment. Portal and vortals can be a simple example of this layer.

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# 1 INTRODUCTION

## *1.1 PURPOSE*

The purpose of this document is to give a short description of the current state of projects and works aimed at giving the user easy access to remote machines, systems and/or resources from different locations and platforms via portal or simple client applications in general. The main emphasis is put on products that give access to Grid applications and resources.

## *1.2 DEFINITIONS, ACRONYMS, AND ABBREVIATIONS*

| | |
|---|---|
| CoG | Commodity Grid Kits |
| DMEFS | Distributed Marine Environment Forecast System |
| GPDK | Grid Portal Development Kit |
| GRAPPA | Grid Access Portal for Physics Applications |
| GridPort | Grid Portal Toolkit |
| GriPhyN | Grid Physics Network Project |
| HPC | High Performance Computing |
| JiPANG | Jini-based Portal Augmenting Grids |
| MD | Migrating Desktop |
| NPACI | National Partnership for Advanced Computational Infrastructure |
| PC | Personal Computer |
| PSE | Problem Solving Environment |
| SOHO | Small Office Home Office |

## *1.3 CROSSGRID – PORTALS AND ROAMING ACCESS*

The main objective of task related to portals and roaming access of the CrossGrid Project is to develop a user-friendly environment by portal access to the Grid independently from the user location. This task includes two major subtasks. The first subtask will allow one to access applications via portal, which will support the users directly by simplifying the handling of applications. The second subtask will create a mechanism allowing one to enter the Grid environment at any place and from any hardware with the same users' environment used previously [Annex].

# 2 SURVEY OF PROJECTS AND WORKS

The term “Grid” emerged in the past decade and denotes an integrated distributed computing infrastructure for advanced science and engineering applications. The Grid concept is based on co-ordinated resource sharing and problem solving in dynamic multi-institutional virtual organisations [FKT01]. Rapid growth of demands for computational power over the last few years aroused interest in the research in the area of computational Grids. More and more applications are developed specially for the Grid includes data-, compute-, and network-intensive applications. Examples range from nanomaterials, structural biology, and chemical engineering to high-energy physics and astrophysics [LGL01]. But the Grid technology, even though it gives great computational power and much improves the manner of utilisation of resources, has also its disadvantages. Grid systems, due to their distribution and heterogeneity, are very complex and thus hard to access and manage. The key issues in designing Grid systems are [Hau01]:

- security (authentication, authorization, delegation of credentials,...);
- (super) scheduling, (co)allocation;
- quality of service, fault tolerance;
- data transfer;
- network protocols;
- grid programming models;

Thus, one of the research fields is designing tools and technologies that give easy, secure and consistent access to Grid applications and resources. Among the commercial or educational products, which can be used for accessing the Grid, one can distinguish: terminal emulation software, remote control programs, portals, and special client application. The first group contains general-purpose products which are not dedicated to Grid but can be used for accessing Grid machines. Products that are designed specially to support user access to the Grid belong to the second one.

This paper contains examples of products belonging to both groups. In chapter 2.1 programs that allow the user to access a remote machine through software emulation of terminals are described. Chapter 2.2 concerns products that are dedicated mainly to PC’s and can be used for accessing and remotely operating the computer from any other machine. Web-browser based interfaces to remote computer systems – the most commonly used way of accessing grid resources - are described in chapter 2.3. This chapter is divided into paragraphs concerning portals/vortals (paragraph 2.3.1) and web-based interfaces to HPC systems (paragraph 2.3.2), which are the clue for task “Portals and roaming access” of the CrossGrid Project. The last paragraph (paragraph 2.3.3) of chapter 2.3 describes projects aimed at improving the process of developing web-based interfaces to the Grid systems.

## *2.1 TERMINAL EMULATION SOFTWARE*

### 2.1.1 Definitions

*Terminal* is a device that enables communication with a computer. Generally, a terminal is a combination of a keyboard and a display screen.

A *terminal emulation program* (often called just *terminal*) allows accessing a mainframe computer, bulletin board service, etc. with a personal computer, making the computer respond like a particular type of terminal [PCWebopedia].

### 2.1.2 Description

There is a great number of terminal emulation programs on the market (see examples in paragraph 3.2.1). One of the best known and most widely used groups of terminals is the terminal based on X Window System and X Protocol.

The X Protocol was developed in the 1980's amid the need to provide a network transparent graphical user interface primarily for the UNIX operating system. X provides for the display and management of graphical information, much in the same manner as Microsoft's Windows and IBM's Presentation Manager [XOrg]. X Window System technology and standards are maintained by X.Org - an organisation of the Open Group dedicated to maintaining the existing X Window System code base and engineering appropriate enhancements driven by current and future market requirements. X.Org periodically provides official X Window System update releases to the general public free of charge. X.Org governs the evolution of the X11R6 specifications, working with appropriate groups to revise and post updates to the standard as required [XOrg].

Another example of free (redistributed under the terms of the GNU Public License) and platform-independent (based on Java programming language) terminal emulation software is the Virtual Network Computing System from AT&T Laboratories Cambridge [VNC]. VNC is, in essence, a remote display system, which allows the user to view a computing 'desktop' environment not only on the machine where it is running, but from anywhere on the Internet and from a wide variety of machine architectures. Its functionality and architecture is quite similar to X Window System.

### 2.1.3 The use of terminals for accessing the Grid

Terminals, due to their “not so sophisticated” functionality, can be used in the Grid environment only for accessing remote computing machines that “create the Grid”.

## *2.2 REMOTE CONTROL PROGRAMS*

### 2.2.1 Definitions

*Remote control applications* allow accessing, and remote operating computer from any other machine in the world that is connected to the Internet. Their functionality is similar to the one of terminals but is extended by additional features like file transferring, security options etc.

### 2.2.2 Description

Most remote control programs are commercial products designed for personal computers and systems used for SOHO purposes like MS Windows family systems or MacOS (e.g. *Timbuktu Pro* from Netopia [Timbuktu], *LapLink Gold* from LapLink.com, Inc [LapLink], or Symantec *pcAnywhere* [pcAnywhere], etc.) These applications let the users that work away from the office connect to the office PCs or servers in order to transfer files or run applications. Some part of the remote control programs require client program which must be installed on a remote computer (like *LapLink* or *pcAnywhere*) but there are also applications which only need a browser to remotely control another computer (e.g. *GoToMyPC* from Expertcity, Inc [GoToMyPC]).

### 2.2.3 The use of remote control programs for accessing the Grid

Remote control applications are designed for different use and platforms than the Grid systems, so they (in general) cannot be used for accessing the Grid resources but are worth-mentioning examples of techniques used for accessing remote resources.

## 2.3 WEB-BROWSER BASED INTERFACES

Web-browser based interfaces are the most common way used for accessing the Grid application and resources. Almost every commercial and educational computation centre that uses the Grid technology offers a kind of a graphical interface as a the window to Grid environment. This group of products is the clue for task “Portals and roaming access” of the CrossGrid project.

The well-known organisation which monitors and co-ordinates world-wide activities related to designing Grid environments is one of *The Global Grid Forum* [GGF] research group - The *GGF Grid Computing Environment* research group [GCE]. The Global Grid Forum (GGF) is a community-initiated forum of individual researchers and practitioners working on distributed computing, or "grid" technologies. GGF is the result of a merger of the Grid Forum, the eGrid European Grid Forum, and the Grid community in Asia-Pacific. These initial forum efforts included five major workshops in the US in 1999 and 2000 and two in Europe during 2000. The GGF Grid Computing Environment research group is aimed at contributing to the coherence and interoperability of frameworks, portals, PSE's, and other Grid-based computing environments by establishing standards that are required to integrate technology implementations and solutions [GGF].

Web-browser based interfaces [Hau01]:

- extend the user desktop by providing a seamless access to remote resources;
- the user can state complex problems, allocate all resources needed to solve them, and analyse results;
- hide from the user complexity of heterogeneous, distributed, high performance back end;
- definitions of problems, methods of solving them, and their solutions are persistently stored; consequently they can be viewed and reused later, can be shared between researchers and engineers and transitioned for operational or educational use;

There are two groups of environments that can be distinguished among web browser interfaces: portals (vortals) and Web based interfaces to HPC systems. The features that systems belonging to both groups offer to the user are quite similar but the Web based interfaces are usual more complex, flexible and extensible systems.

### 2.3.1 Portals and vortals

#### 2.3.1.1 Definitions

*Portal* is a Web site or service that offers a broad array of resources and services, such as e-mail, forums, search engines, and on-line shopping malls. The first Web portals were online services, such as AOL, that provided access to the Web, but by now most of the traditional search engines have transformed themselves into Web portals to attract and keep a larger audience [PCWebopedia].

*Vortal* (Vertical Industry Portal) is the industry-specific equivalent of the general-purpose portal on the Web [TechEncyclopedia]. It is a portal Web site that provides information and resources for a particular industry. Vortals are the Internet's way of catering to consumers' focused-environment preferences. Vortals typically provide news, research and statistics, discussions, newsletters, online tools, and many other services that educate users about a specific industry [PCWebopedia].

*Grid Portal* is a portal that addresses the large user Grid community with its various requirements [Las01]. Its main task is to provide transparent, easy and secure Web access to computational Grids [ACE01].

#### 2.3.1.2 Description

Geoffrey Fox [Fox00] distinguishes several groups of portals, e.g. :

- Commodity Portal – Web-based Information Source (e.g. Yahoo) or Shop (e.g. Amazon);
- Enterprise Information Portal ;
- Education Portal - Web-based University
- Computing Portal – „Problem Solving Environment";

Typical services that Grid portals provide include [AlCa], [Hau01]:

- users' profile management;
- information services;
- remote job submission;
- job tracking;
- file transfer;
- authentication and authorisation;
- composition of multistep tasks;
- dissemination of results;
- persistency of task and their configurations;

There is a great number of Grids, which give access to their resources through the Web portal e.g.

- *Grappa* – Grid Access Portal for Physics Applications - part of the Grid Physics Network Project (GriPhyN), the U.S. ATLAS Software and Computing Project, and the International ATLAS Experiment;
- *HotPage* – National Partnership for Advanced Computational Infrastructure (NPACI) User Portal – An implementation of the GridPort infrastructure, HotPage is the latest version of the NPACI User Portal. Developed by the Grid Portal Architectures group at the San Diego Supercomputer Center, HotPage was originally designed to be purely informational. It offered users features such as the ability to view technical documentation, news, training and consulting information, data on computational platforms, and information about allocations and accounts. The functionality was later expanded to include active features such as the current operational status of computational resources, current MOTDs on all operational platforms, and automated batch script generation for our HPC resources. After further development, HotPage offers users the ability to access and interact with their HPC accounts with features such as file editing, submission, and monitoring.
- *Mississippi Computational Web Portal* – web portal for Distributed Marine Environment Forecast System (DMEFS) funded by the Office of Naval Research and Mississippi State University as the primary contractor [Hau01];
- *Information Power Grid (NASA)* - NASA's high performance computational grid. IPG is an example of a Grid computing environment, and the vision for IPG is to revolutionize the use of computing in NASA's science and engineering activities. The overall mission of the Information Power Grid (IPG) is to provide NASA's scientific and engineering communities with a substantial increase in their ability to solve problems that depend on the use of large-scale and/or distributed resources. The project team is focused on creating an infrastructure and services to locate, combine, integrate, and manage

resources from across NASA centers. An important goal of the IPG is to produce a common view of these resources, and at the same time provide for the distributed management and local control [JVHT].

Lots of other examples can be found on web pages of *The Globus Project* [Globus] or *The Global Grid Forum* [GGF].

### 2.3.2 Web based interfaces to HPC systems.

#### 2.3.2.1 Definitions

*Web based interface to HPC systems* – seamless, uniform and intuitive graphical interface to multiple HPC resources provided using Web browsers, usually with similar functionality as Grid Portal but having more complex, flexible and extensible characteristics to support the underlying changes.

#### 2.3.2.2 Description

*Web based interfaces to HPC systems* can be numbered among the Grid portals because of a very similar functionality and outlook they have. Like portals, they make HPC resources easier to use by replacing a constantly changing range of unfamiliar command-driven queuing systems and applications environments with a single seamless user interface [MKD98]. The most important feature that distinguishes both groups is that the web based interfaces to the HPC systems are usual more complex, flexible and extensible then the Grid portals.

- *WebFlow* – one of the pioneering projects that aimed at Web-based graphical interface to HPC systems; platform independent, three-tier system (high level, visual user interface for GLOBUS) developed in Northeast Parallel Architectures Center, Syracuse University. System GUI allows the user to compose new applications dynamically from reusable components just by clicking on visual module icons, dragging them into the active editor area, and linking by drawing the required connection lines (see picture -from [AFFH98]) [BBC96].

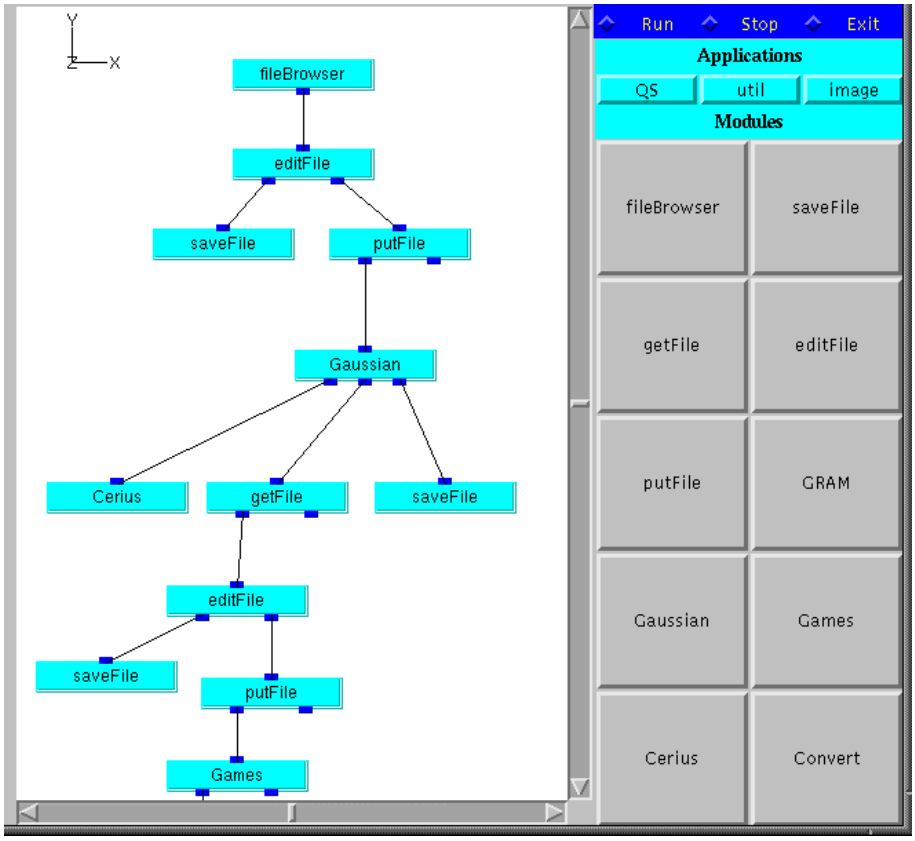


**Fig. 1 WebFlow**

- *WebSubmit* – a system developed at the National Institute for Standard and Technology to simplify access to software and HPC systems at a single site. WebSubmit allows both batch and interactive use of the machine that it interfaces. The main component of the system is an interactive module that enables the user to submit commands to any of the included computer as if they were logged on. WebSubmit is not intended to be a distributed computing system, although it is extensible to its direction. See picture (from WebSubmit home pages) [MKD98].

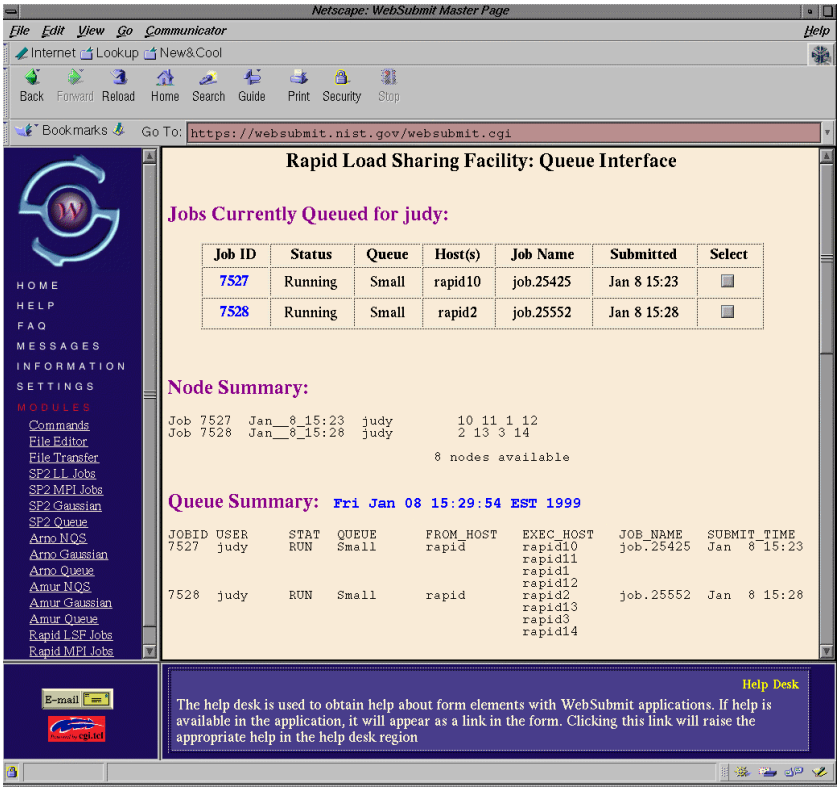


**Fig. 2 WebSubmit**

- *Unicore* (UNiform Interface to COmputing REsources) – a system developed as a co-operation of several German universities and computation centers lets the user prepare or modify structured jobs through a graphical user interface on a local Unix workstation or a Windows PC. The system architecture is based on client-server model. The client enables the user to create, submit it to any of the platforms of a UNICORE GRID and control from any workstation or PC on the Internet. Next, the server manages the submitted UNICORE jobs. The EuroGrid IST started in November 2000 was based on the UNICORE system. The development and distribution of the UNICORE GRID system is promoted by the UNICORE Forum – an open, non-profit association – funded by the developers, leading European HPC Centers and supporting hardware vendors. See pictures (from Unicore home pages).

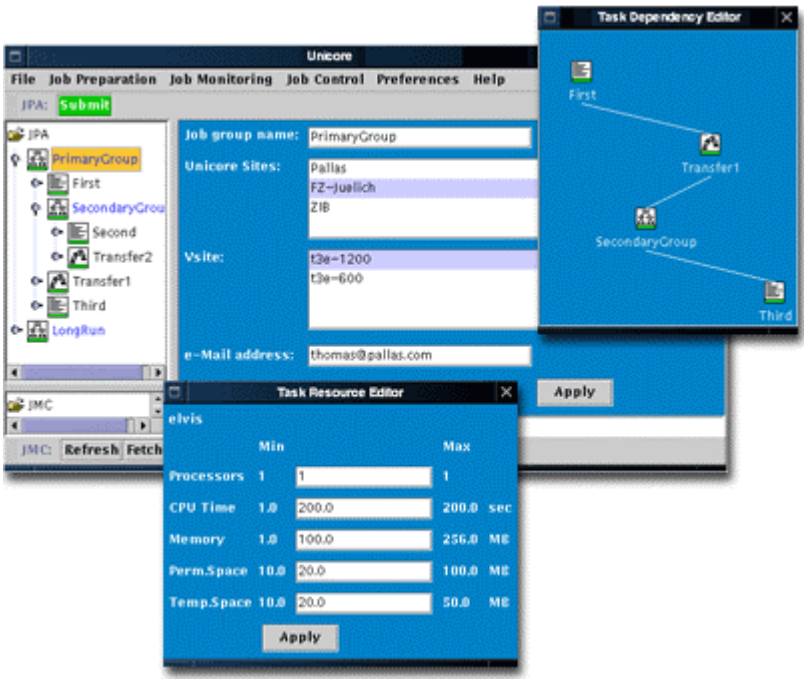


**Fig. 3 Unicore - submitting job.**

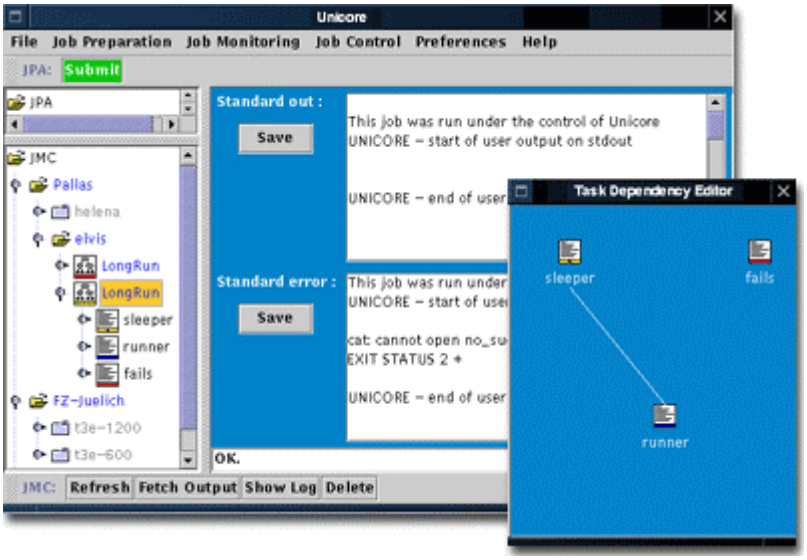


**Fig. 4 Unicore - defining dependencies**

- *The Gateway Project* – a commodity-based web portal that provides secure remote access to unclassified USA Department of Defense computational resources via a standard web browser [PYF00]. Gateway is what may be called a "system portal" in that it is designed to interact with queuing systems, file systems, mass storage system, etc., and codes as objects rather than supporting programming internally to codes. Gateway is designed as a three-tiered system, with a front-end user interface and a distributed component-based middle tier (WebFlow). Most system services are defined as modules that are plugged into the extensible middle tier. These modules can either directly implement the services or they can act as proxies to backend resources. The system

can either directly interact with specific resources (queuing system and so on) or else with an intermediate grid layer [HAFK].

- *IPG LaunchPad* - The Launch Pad is a web based application which allows credentialed users to have access to a suite of tools for submitting jobs, transferring files, and managing accounts within the systems that are a part of the Information Power Grid. Long-term plans of Launch Pad authors include modularising components of the Launch Pad to allow users to build a customised portal [MWHH].

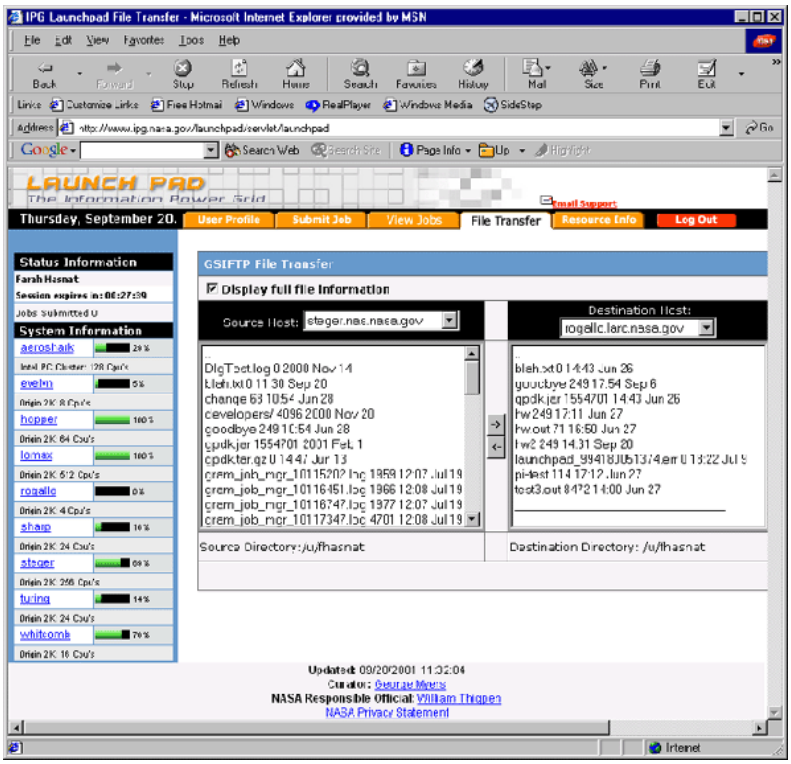


**Fig. 5 IPG LaunchPad -file transfer**

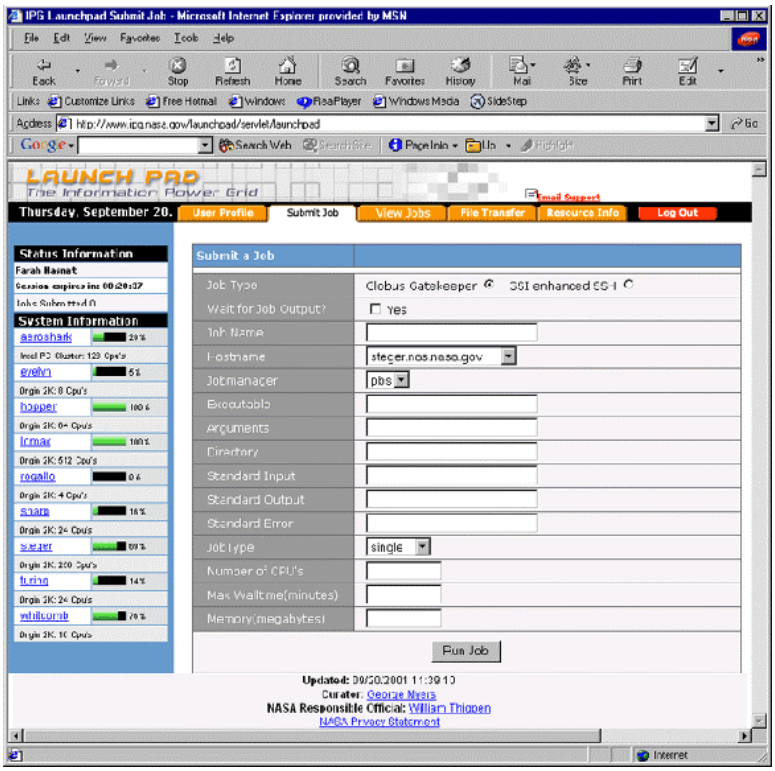


**Fig. 6 IPG LaunchPad - job submission**

- *Jini-based Portal Augmenting Grids* (JiPANG) – developed at Tokyo Institute of Technology, built on top Jini distributed object technology, portal system and a toolkit, which provides uniform access interface layer to a variety of Grid systems. JiPANG performs uniform higher-level management of the computing services and resources being managed by individual Grid systems such as Ninf, NetSolve Globus, etc. In JiPANG the user interacts with the Grid systems using JiPANG Browser application that allows managing, navigating and launching JiPANG Grid services [SMN].

### 2.3.3 Portal Development Tools

#### 2.3.3.1 Definition

*Portal Development Tool* is the collection of script, tools and modular reusable components for accessing Grid services that can be used by developers to build a Grid portal or other kind of Web based interfaces to HPC systems.

#### 2.3.3.2 Description

Because of the growing use of graphical interfaces as a very useful tool that hides from the user complexity and heterogeneity of the Grid systems, some tools which improve the process of creation of such environments have been developed. These tools provide the developer with a set of already defined components (or parts of a common code) and a framework that can be used for portal development. The most commonly used tools are:

- *CoG - The Commodity Grid Toolkits* – a project developed at Mathematics and Computer Science Division of Argonne National Laboratory provides access to Grid services through commodity technologies such as frameworks, environments, and

languages (technologies and frameworks of interest include Java, Pyton, CORBA, perl, .NET, JXTA). The most commonly used is the Java CoG Kit that provides middleware for accessing the grid functionality from the Java framework. The toolkit also includes a common set of reusable components for accessing Grid services that can be used while designing the Grid application. The client libraries of the Java CoG Kit are used in several projects to access Grids driven by the C Globus software [LGL01].

- *The Grid Portal Development Kit (GPDK)* - designed at the USA National Laboratory for Applied Network Research, high modular architecture system provides reusable components for accessing common Grid services by using Java Server Pages (JSP) and Java Beans technologies. GPDK also provides a sample template portal which can be used as a framework for the development and deployment of application specific portals. There are several projects in which GPDK is currently being adopted as a framework for accessing Grid services e.g.: NASA IPG LaunchPad [Nov01].
- *The Grid Portal Toolkit (GridPort)* – developed by San Diego Supercomputer Centre, written in perl/CGI with a similar functionality as GPDK. The main mission of the toolkit is simplifying the development of portals by providing a common code that can be easily used and fitted to satisfy different requirements. GridPort is probably the oldest and the most frequently used tool for Grid portal development. There are several portals based on the Grid Portal Toolkit technology, like e.g.: The NPACI HotPage, NASA/AMES, Stennis Space Centre and many others [TMD01], [Nov01].

## *2.4 SUMMARY*

The rapid growth of computing techniques and technologies over the past decade is strictly related to growing users' demands for the computational power. The problem of how the user can perform access to remote HPC systems (that are very complex due to their distribution and heterogeneity, and hence hard to access and manage) in an easy and transparent manner becomes a more and more important issue.

### 2.4.1 Access to remote resources

Described in this paper examples of techniques and technologies that allow the user to access remote resources are terminal emulation software, remote control programs, and web-browser based interfaces.

*Terminal emulation software* – Products belonging to that group of software allow accessing a mainframe computer, bulletin board service, etc. with a personal computer. Very general and flexible tools are widely used, although due to its limited and simple functionality in Grid environment can be used only for accessing ("logging into") machines "that create the Grid". The best known examples of terminal emulation software are applications that implement X Window System protocol.

*Remote control programs* - (e.g. *Timbuktu Pro*, *LapLink Gold*, or *pcAnywhere*) extends functionality of terminals by offering the user additional features (like file transferring, running remote applications, etc). These products are mainly designed for personal computers and systems used for SOHO purposes (MS Windows family systems, MacOS, Linux, etc) so their role for accessing Grid systems is marginal – they are mentioned in that paper only as examples of interesting techniques used for accessing remote resources.

*Web-browser based interfaces* - are the clue for the task "Portals and Roaming Access" of The CrossGrid Project. These products are preferred and the most commonly used way of accessing Grid remote resources. They offer intuitive and easy manner of interaction with user that hides from the user heterogeneity and complexity of the Grid systems. Web-browser based interfaces beside services dedicated for Grid systems (like users' profile

management, information services, remote job submission, job tracking, file transfer, authentication and authorisation, composition of workflow between tasks) usually provides also a large set of additional services, such as e-mail, forums, search engines, etc. Products belonging to web-browser interfaces can be divided into two groups: Grid portals/vortals (e.g. *Grappa*, *HotPage, Mississippi Computational Web Portal, Information Power Grid (NASA))* and Web based interface to HPC systems (e.g. *WebFlow, WebSubmit, Unicore, The Gateway Project, etc.*). Both groups have very similar architecture and functionality but Web based interfaces to HPC systems are more complex, flexible and extensible characteristics.

### 2.4.2 Supporting portal development

The development of the graphical interface to HPC systems followed the development of tools, which improved the process of creation of user interfaces. The global trend is to give a developer a flexible and general tool containing a set of already made components and frameworks that can be easily used and fitted to satisfy different requirements and speed up the development of Grid portals and other graphical interfaces.

Examples of portal development tools, described in that paper are: *The Commodity Grid Toolkits (CoG) The Grid Portal Development Kit (GPDK)* and *The Grid Portal Toolkit (GridPort).* The main mission of the toolkits is simplifying the development of portals by providing a common code, a common set of reusable components or (like GPDK) even a template portal which can be used as a framework for the development and deployment of application specific portals.

### 2.4.3 Related works

World-wide activities that are aimed at developing graphical interfaces to the HPC systems include lots of projects involving a great number of educational and commercial institutions. Among the projects, which are still in progress is the majority of the described above. There are also a lot of projects that were just started. The most interesting examples can be:

- *The CrossGrid Project* – within *The Fifth European Framework Programme* – with tasks concerning access to remote Grid resources via client application (roaming access) which offer, among other things, a possibility of storing the environment settings to the user that often changes their workplace.
- *The GridLab Project* – also within *The Fifth European Framework Programme* – with tasks concerning access to remote Grid resources via mobile devices.
- *The Grid Enable Desktop Environment (GrEnaDE)* – a project of Manchester Research Centre for Computational Science at the University of Manchester – the main goal of the project is the integration of the Linux windows managers (like KDE, Gnome, etc) with the Grid environment;

### 2.4.4 Portals and Roaming Access in the CrossGrid Project

The main objective of task “Portals and Roaming Access” is to develop an environment that allows accessing Grid resources independent from the location and used hardware in user-friendly way, hiding from the user heterogeneity and complexity of the Grid systems. This goal will be realized in two ways: by developing portals dedicated to Grid applications, and by developing additional client application (“Migrating Desktop”).

The portals will simplify the handling of applications and provide several additional services and Grid tools like, e.g. authenticating and authorising users to remote resources, presenting static and dynamic information about particular Grid system, file transferring, etc. Especially interesting software product is Migrating Desktop that will be a user work environment, providing a specialised advanced graphical user interface independent of the system version

and hardware, accessible from any user location. It will have the form of the user desktop – similar to those of Windows or Linux family systems. Migrating Desktop will allow to run applications, manage data files, store personal settings (configuration definitions that characterise e.g. links to the user data files, links to applications, access to portals and HPC infrastructure, as well as windows settings), independently of the localisation or the terminal type. Both portals and Migrating Desktop application will be made in most possible general way in order to support all kinds of Grid systems and Grid application only with small number of changes to fit particular purposes.

Implementing an environment that will improve the interaction of the roaming user with Grids based on Globus system by developing desktop that migrate following the user, so the user has always access to its own work environment independent from his location, has been not a subject of any project, yet. Thus developing task “Portals and Roaming Access” can bring many interesting experiences that will benefit in future projects.

### 2.4.5 The Future

There are also quite new ways of interaction between the user and web-based applications. One of the standards, which have recently become more and more popular, is VoiceXML that makes voice communication between the user and the portal possible.

High Performance Computing and the Grid technologies related to that problem will probably be a subject of rapid development also in the nearest future so we can expect that many new techniques and technologies that give the user easy, transparent and secure access to remote resources will occur.

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## *3.2 RELATED LINKS*

### 3.2.1 Terminals:

3.2.1.1 X11 R6.6
http://www.x.org/

3.2.1.2 WinVNC (AT&T Laboratories Cambridge)
http://www.uk.research.att.com/vnc/

3.2.1.3 EXTRA!® Personal Client version 6.7 (Attachmate Corporation)
http://www.attachmate.com

3.2.1.4 Chameleon HostLink (NetManage, Inc.)
http://www.netmanage.com/

3.2.1.5 Data Rumba (NetManage, Inc.)
http://www.netmanage.com/

3.2.1.6 ViewNow (NetManage, Inc.)
http://www.netmanage.com/

3.2.1.7 Eicon Aviva (Aviva Solutions)
http://www.avivasolutions.com/

3.2.1.8 Personal Communications v. 5.0 (IBM)
http://www-4.ibm.com/software/network/pcomm/

3.2.1.9 QWS3270 Plus (Jolly Giant Software Inc.)
http://www.jollygiant.com/

3.2.1.10 PuTTY
http://www.chiark.greenend.org.uk/~sgtatham/putty.html

3.2.1.11 CRT
http://www.vandyke.com/products/crt/

3.2.1.12 VT320 Telnet Terminal Emulator
http://www.ipswitch.com/Products/VT320/index.html

### 3.2.2 Remote control programs:

3.2.2.1 GoToMyPC (Expertcity, Inc.)
http://www.gotomypc.com/

3.2.2.2 Timbuktu Pro 2000 (Netopia)
http://www.netopia.com/

3.2.2.3 LapLink 2000 (LapLink.com, Inc)
http://www.laplink.com/

3.2.2.4 PcAnywhere 10 (Symantec Corporation)
http://www.symantec.com

### 3.2.3 Grid Computing Portals

3.2.3.1 HotPage
https://hotpage.npaci.edu/

3.2.3.2 UNICORE
http://www.unicore.de/

3.2.3.3 WebSubmit
http://math.nist.gov/mcsd/savg/websubmit/websubmit.html

3.2.3.4 Information Power Grid (NASA)
http://www.ipg.nasa.gov/

3.2.3.5 Grid Access Portal for Physics Applications
http://lexus.physics.indiana.edu/~griphyn/grappa/

3.2.3.6 The Grid Resource Broker
http://www-itg.lbl.gov/Grid/public/events/GPDW/slides/grb.pdf
http://aspen.ucs.indiana.edu/gce/C539aloisio/c539grb.pdf

3.2.3.7 The Gateway Project
http://www.gatewayportal.org/
http://www.npac.syr.edu/users/haupt/WebFlow/papers/JG99/JavaGrande99.html

3.2.3.8 DISCoVEr)
http://tassl-pc-5.rutgers.edu/discover/main.php

3.2.3.9 Mississippi Computational Web Portal
http://www.ggf1.nl/abstracts/GCE/mcwp.pdf
http://www.erc.msstate.edu/geotech/DMEFS/welcome.html

3.2.3.10 .Lattice Portal
http://aspen.ucs.indiana.edu/gce/C548watson/LatticePortal_paper_v1.pdf

3.2.3.11 WebFlow
http://www.npac.syr.edu/users/haupt/WebFlow/papers/FGCS/index.html
http://www.npac.syr.edu/users/haupt/WebFlow/demo.html

3.2.3.12 Science Portals Project
http://www.extreme.indiana.edu/an/index.html

3.2.3.13 Jini-based Portal Augmenting Grids (JiPANG)
http://matsu-www.is.titech.ac.jp/~suzumura/jipang/contents/related.html

http://www-unix.mcs.anl.gov/gridforum/jini/ggf1/toyotaro.ppt
http://matsu-www.is.titech.ac.jp/~suzumura/jipang/contents/overview/jini.html

3.2.3.14 IPG LaunchPad
http://www.ipg.nasa.gov/launchpad/launchpad
http://www.nas.nasa.gov/Main/Features/2001/Winter/launchpad.html

### 3.2.4 Portal Development Tools

3.2.4.1 Commodity Grid (CoG) Kits
http://www.globus.org/cog
http://www.cogkits.org/

3.2.4.2 The Grid Portal Toolkit (GridPort)
https://gridport.npaci.edu/

3.2.4.3 The Grid Portal Development Kit (GPDK)
http://www-itg.lbl.gov/Grid/projects/GPDK/index.html
http://dast.nlanr.net/Projects/GridPortal/

### 3.2.5 Other

3.2.5.1 GridLab
http://www.gridlab.org/Welcome/Description.html

3.2.5.2 EuroGrid
http://www.eurogrid.org/wp1.html

3.2.5.3 Nimrod-G
http://www.globus.org/research/applications/nimrod.html

3.2.5.4 Grenade
http://mrccs.man.ac.uk/research/grenade/

3.2.5.5 PCWebopedia.
http://www.pcwebopedia.com/

3.2.5.6 TechEncyclopedia
http://www.techweb.com/encyclopedia

3.2.5.7 The Global Grid Forum
http://www.gridforum.org/

3.2.5.8 The GGF Grid Computing Environment research group.
http://www.gridcomputing.com/

3.2.5.9 Globus
http://www.globus.org/