



White Paper

Intel's Grid Programming Environment

An Overview



Introduction

Intel's Grid Programming Environment is an Open Source technology demonstrator that provides a full Grid software stack ready to be used out-of-the-box. It enables the development of Grid-enabled applications that are independent of the underlying Grid middleware, and includes powerful graphical user interfaces for Grid experts, administrators and "ordinary" end users.

What is GPE?

GPE enables its users to transparently access distributed compute and data resources through Web Service interfaces. On top of this, GPE provides SDKs for the development of portable Grid applications and a graphical user interface framework that hides the complexity of the underlying technology from the end user.

As illustrated in Figure 1 below, GPE adds components to all three levels: at the **Applications** level, the GridBean SDK and GUI framework provide support for accessing lower-level Grid services, and for defining application-specific user interfaces. At the **Services** level, GPE adds higher-level services including a dynamic

resource and service registry, an enactor for Business Process Execution Language (BPEL) workflows that can orchestrate the execution of complex BPEL workflows, a simple resource broker that matches requests for service execution with available providers, and an OS image repository that contains binary images for service execution environments that can be dynamically provisioned on available compute resources. At the **Utility** level, GPE defines a set of basic Grid services (called Atomic Services) that drive GPE's own TSI execution service, or interface with Grid systems that comply to the WS-RF and OGSA Basic Profile standards.

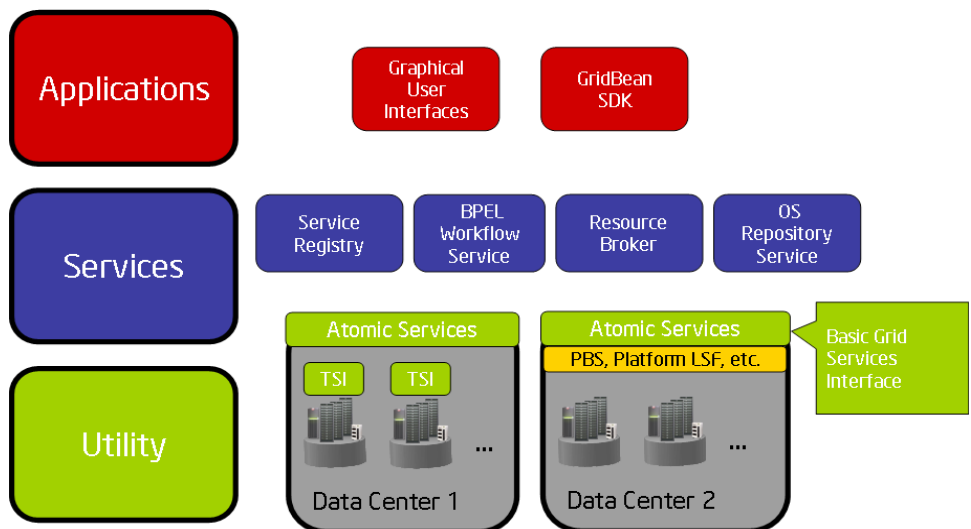


Figure 1 GPE provides components at the application, service and utility levels.

GPE Features

GPE provides installation packages for the server and client sides that orchestrate the installation process and guide users through the steps of setting up a Grid. The server package includes a bundled and pre-configured Globus Toolkit* version 4 container – building a Grid from scratch has never been easier.

Intuitive Graphical User Interfaces

GPE contains an extensible GUI framework for accessing applications and Grid services. It provides five Grid clients, each of them tailored to a particular usage model. With the exception of the Portal Client, these are implemented as Java applications running on a multitude of desktop and mobile platforms. The **Application Client** can be customized for specific applications and is suited for portable devices. The **Expert Client** gives access to all Grid services and includes a workflow editor for user-defined BPEL workflows. The **Portal Client** can be integrated into JSR 168-based Web Portal solutions. The **Remote File Manager** supports remote file management on the Grid, and last but not least the **Admin Client** implements a rich management console that enables Grid administrators to monitor and configure Grid resources.

GridBeans for Application Development

The GridBean concept enables flexible and highly portable application development for WS-RF compliant Grids (including the Globus Toolkit* version 4 and UNICORE* version 6). GPE provides APIs, libraries and source code templates for accessing Grid services, for defining how to deploy and wrap applications as services, and for creating application specific user interfaces that can be dynamically loaded into the different GPE clients or used from a Web browser through the portal solution.

Piotr Bala (ICM, Warsaw): "Our developers implemented GridBeans for a variety of bio-molecular applications that run on UNICORE* 6 Grids. Our users are particularly interested in using the advanced capabilities of GridBean applets in a web browser."

Expert Client User Interface

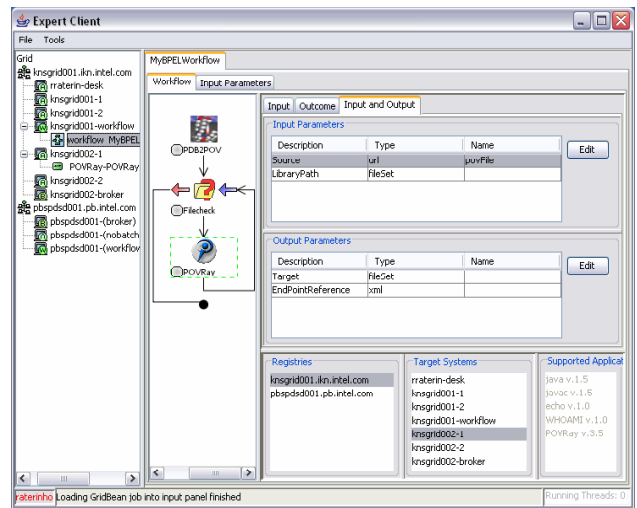


Figure 2 The GPE Expert Client supports the creation, execution and monitoring of workflows based on BPEL. The left window pane indicates the available compute resources in a small test Grid, and the middle pane illustrates a life-sciences workflow involving queries of a protein structure database and visualization of the results. The right most pane contains a definition of input and output data streams of the POVray* ray tracer. At the bottom, selection lists allow to pick a resource that can execute the POVray* application.

GPE Leverages Virtualization Technology

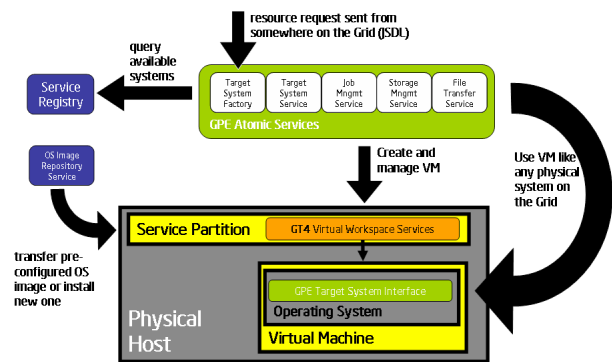


Figure 3 GPE interfaces to the Globus Toolkit* Virtual Workspace service to create, provision and deprovision execution environments. To create a new Virtual Machine, the Atomic Services interact with a Service Partition that runs the Virtual Workspace Service. Once a Virtual Workspace is created and provisioned from the OS Repository, it appears like any other resource on the GPE Grid.

Support for BPEL Workflows

The GPE workflow service supports the orchestration of Grid services and their integration into existing Service Oriented Architectures by way of the Business Process Execution Language (BPEL). These workflows can be implemented by the application developer as part of the application business logic, in which case the workflow execution will occur behind the scenes invisible to the end user. As an alternative, expert Grid users can create their own Grid workflows without writing any code by using the graphical workflow editor that is part of the GPE Expert Client.

Support for Virtualization Technology

In Grids based on GPE the actual computing resources are virtualized, so users no longer have to deal with specific OS versions or applications statically installed on physical systems. Instead they specify the hardware and software requirements for their jobs and GPE finds or provisions a suitable resource. Depending on the Grid configuration, this resource can actually be a virtual machine that has been explicitly created for the user request, although the user wouldn't notice.

Virtualization technology not only allows using available resources more efficiently, but also reduces the management overhead of maintaining large numbers of statically provisioned systems. Physical systems can now easily be shared on the Grid using different virtual machines at the same time. It is even possible to re-configure systems during run-time according to the current user request and workload on the Grid. With Intel Virtualization Technology available on current Intel platforms, GPE can improve the reliability and supportability of virtualization solutions, enabling improved consolidation and fail-over for servers.

The advantages of virtualization technology have been realized by many of the major Grid software vendors and projects. Sverre Jarp (CERN OpenLab): "Using virtual machine

technology is the next big step towards flexible, dynamic IT infrastructures."

In the current GPE snapshot, the virtual workspace services from Globus Toolkit* are integrated to create and manage virtual machines based on the Xen Virtual Machine Monitor*.

Integration with Existing Solutions

GPE is an Open Source technology development and as such does not attempt to compete with existing commercial solutions. Open interfaces based on standards facilitate the integration of 3rd party components, like local resource management or scheduling systems, into GPE-based infrastructures.

The atomic services interfaces in particular allow using the GPE clients and GridBeans with server implementations other than the native GPE server based on Globus Toolkit* version 4. For instance, the UNICORE* version 6 system as developed by Fujitsu Laboratories Europe provides an atomic service implementation that is interoperable with GPE, and the China Grid Support Platform* (CGSP) is currently working on integration with GPE.

Case Study: Collaborative Visualization and Steering

While the UNICORE* Grid system was primarily designed for the control of batch jobs and their submission to distributed computational resources, it is also feasible to establish a real time connection between a simulation and the GPE Client. The VISualization Interface Toolkit* (VISIT) developed at Research Center Jülich is a light-weight library that supports bi-directional data exchange between visualizations and parallel applications. The innovative character of VISIT is that the visualization application acts as a server that dispatches the simulation requests - unlike many other toolkits that work the opposite way. The main idea is to minimize the load on the steered simulation and to prevent slow operations of the visualization from disturbing the simulation process. The VISIT GridBean and

its services provide an infrastructure for latency-critical simulations and collaborative visualization among geographically dispersed scientists.

Compatibility

All GPE components are implemented in Java and will run on platforms that support the Java* version 5 runtime environment.

Is GPE the Right Solution for My Grid Scenario?

If you are already using Open Source Grid technology like Globus Toolkit* or UNICORE*, the answer is yes. With GPE your developers will get the right tools to implement portable Grid applications, while your users will get the corresponding convenient user interfaces. While the GPE clients and GridBeans are highly portable, the GPE server side uses either Globus Toolkit* version 4 or UNICORE* version 6.

If you are new to Grid technology and plan to connect your distributed data centers to a global infrastructure, using GPE is a good starting point. There are many commercial solutions available for certain sub tasks in GPE. If you later think that one of them may be better suited, you can still decide to simply replace the corresponding GPE components.

Download GPE and Build a Grid today.

You will find the complete source code, documentation and installation packages at <http://gpe4gtk.sourceforge.net>.

Using the VISIT GridBean for an Astrophysics Simulation

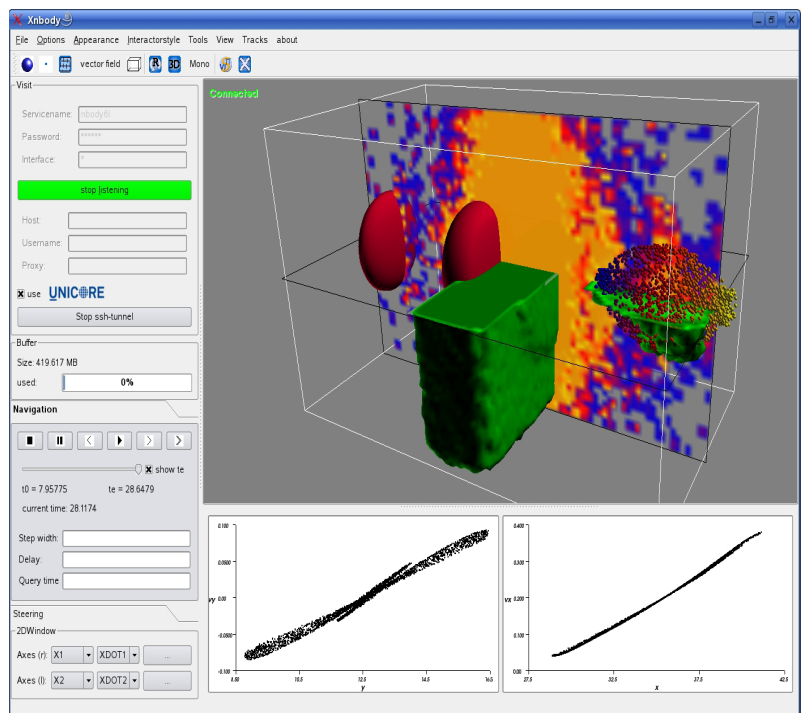
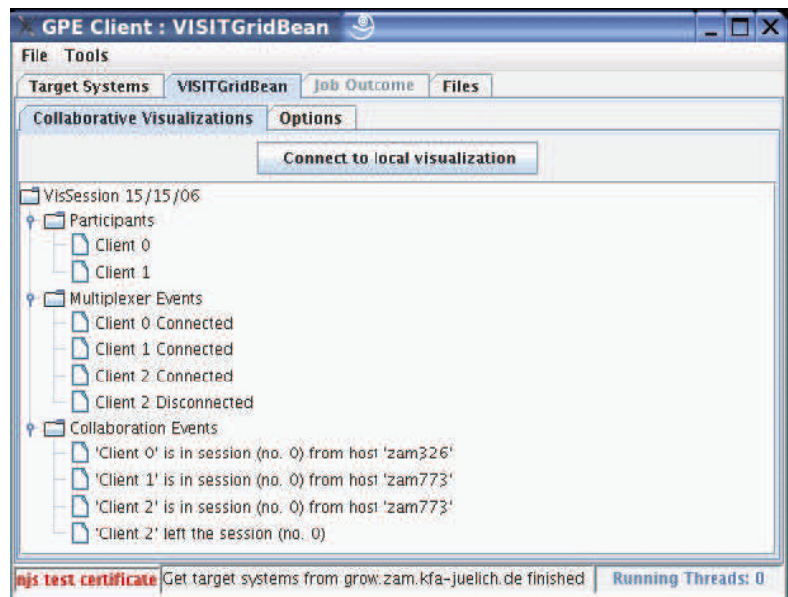
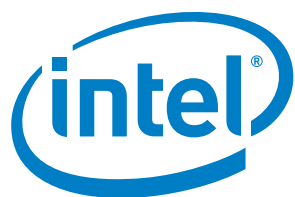


Figure 4 At the top, the VISIT GridBean interface lists the workflow components that can be controlled, plus the relevant events. At the bottom, the real-time visualization shows the results of a VISIT-enabled Xnbody visualization that illustrates n-body simulations outputs in the context of laser plasma physics or astrophysics.



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