Introduction to GT3

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A Story of Evolution

- Definition of Grid problem has been stable since original Globus Project proposal in 1995
  - Though we've gotten better at articulating it
- But our approach to its solution has evolved:
  - From APIs and custom protocols...
  - to standard protocols...
  - to Grid services (OGSA).
- Driven by experience implementing and deploying the Globus Toolkit, and building real applications with it

What is a Grid?

- We believe there are three key criteria:
  - Coordinates distributed resources ...
  - using standard, open, general-purpose protocols and interfaces ...
  - to deliver non-trivial qualities of service.
- What is not a Grid?
  - A cluster, a network attached storage device, a scientific instrument, a network, etc.
  - Each is an important component of a Grid, but by itself does not constitute a Grid
Challenging Technical Requirements

- Dynamic formation and management of virtual organizations
- Discovery & online negotiation of access to services: who, what, why, when, how
- Configuration of applications and systems able to deliver multiple qualities of service
- Autonomic management of distributed infrastructures, services, and applications
- Management of distributed state
- Open, extensible, evolvable infrastructure

The Globus Project™
Making Grid computing a reality (since 1996)

- Close collaboration with real Grid projects in science and industry
- The Globus Toolkit®: Open source software base for building Grid infrastructure and applications
- Development and promotion of standard Grid protocols to enable interoperability and shared infrastructure
- Development and promotion of standard Grid software APIs to enable portability and code sharing
- Global Grid Forum: We co-founded GGF to foster Grid standardization and community

From APIs & Custom Protocols, To Standard Protocols

API
Application Programming Interface

- A specification for a set of routines to facilitate application development
  - Refers to definition, not implementation
- Often language-specific (or IDL)
  - Routine name, number, order and type of arguments; mapping to language constructs
  - Behavior or function of routine
- Examples of APIs
  - GSS-API (security), MPI (message passing)
Network Protocol

- A formal description of message formats and a set of rules for message exchange
  - Rules may define sequence of message exchanges
  - Protocol may define state-change in endpoint, e.g., file system state change
- Good protocols designed to do one thing
  - Protocols can be layered
- Examples of protocols
  - IP, TCP, TLS (was SSL), HTTP, Kerberos

A Protocol can have Multiple APIs

- TCP/IP APIs include BSD sockets, Winsock, System V streams, ...
- The protocol provides interoperability: programs using different APIs can exchange information
- I don’t need to know remote user’s API

An API can have Multiple Protocols

- An API provides portability: any correct program compiles & runs on a platform
- Does not provide interoperability: all processes must link against same SDK
  - E.g., MPICH and LAM versions of MPI

Initial Focus On APIs and Custom Protocols

- Primary concern was allowing Grid applications to be built quickly, in order to demonstrate feasibility
- Good development APIs and SDKs mattered most
- Protocols were a means to an end
  - We borrowed and extended standard protocols to make life easier (e.g. LDAP)
  - We defined custom protocols (e.g. GRAM)
But Focus Shifted To Protocols

- As demand grew, customers worried about:
  - compatibility between versions (i.e. Stop changing the protocols!)
  - independent implementations of some components (i.e. What are the protocols?)
- Ubiquitous adoption demands open, standard protocols
  - Internet and Web as guides
  - Enables innovation/competition on end points
  - Avoid product/vendor lock-in

Layered Grid Architecture

- "Coordinating multiple resources": ubiquitous infrastructure services, app-specific distributed services
- "Sharing single resources": negotiating access, controlling use
- "Talking to things": communication (Internet protocols) & security
- "Controlling things locally": Access to, & control of, resources


GT2 Key Protocols

- The Globus Toolkit v2 (GT2) centers around four key protocols
  - Connectivity layer:
    - Security: Grid Security Infrastructure (GSI)
  - Resource layer:
    - Resource Management: Grid Resource Allocation Management (GRAM)
    - Information Services: Grid Resource Information Protocol (GRIP)
    - Data Transfer: Grid File Transfer Protocol (GridFTP)
- Also key collective layer protocols
  - Info Services, Replica Management, etc.
Protocol Standards Efforts

- X.509 Proxy Certificate Profile
  - GGF & IETF
- GridFTP Protocol
  - GGF

But Along The Way...

- Heterogeneous protocol base was hurting us
- Increasing number of virtual services that needed to be managed
- Web services (WSDL, SOAP) appeared

Web Services

- At the heart of Web services is:
  - WSDL: Language for defining abstract service interfaces
  - SOAP (and friends): Binding from WSDL to bytes on the wire
- Web services appears to offer a fighting chance at ubiquity (unlike CORBA)
- But Web services does not go far enough to serve a common base for the Grid...
**Transient Service Instances**

- "Web services" address discovery & invocation of **persistent services**
  - Interface to persistent state of entire enterprise
- In Grids, must also support **transient service instances**, created/destroyed dynamically
  - Interfaces to the states of distributed activities
  - E.g. workflow, video conf., dist. data analysis, subscription
- Significant implications for how services are managed, named, discovered, and used
  - In fact, much of Grid is concerned with the management of service instances

**Standard Interfaces & Behaviors: Four Interrelated Concepts**

- **Naming and bindings**
  - Every service instance has a **unique name**, from which can discover **supported bindings**
- **Lifecycle**
  - Service instances created by **factories**
  - Destroyed **explicitly** or via **soft state**
- **Information model**
  - **Service data** associated with Grid service instances, operations for accessing this info
  - Basis for service introspection, monitoring, discovery
- **Notification**
  - Interfaces for registering existence, and delivering **notifications** of changes to service data

**Grid Evolution:**

**Open Grid Services Architecture**

- Refactor Globus protocol suite to enable common base and expose key capabilities
- Service orientation to virtualize resources and unify resources/services/information
- Embrace key Web services technologies for standard IDL, leverage commercial efforts
- Result: standard interfaces & behaviors for distributed system management: the **Grid service**

**OGSA Structure**

- A standard substrate: the **Grid service**
  - OGSI = Open Grid Service Infrastructure
  - Standard interfaces and behaviors that address key distributed system issues
  - Much borrowed from GT abstractions
- ... supports **standard service specifications**
  - Resource mgt, dbms, workflow, security, ...
  - Target of current & planned GGF efforts
- ... and arbitrary application-specific services based on these & other definitions
OGSI Grid Service Specification

- Defines WSDL conventions and GSDL extensions
  - For describing and structuring services
  - Working with W3C WSDL working group to drive GSDL extensions into WSDL
- Defines fundamental interfaces (using WSDL) and behaviors that define a Grid Service
  - A unifying framework for interoperability & establishment of total system properties

Globus Toolkit (GT)

- A software system addressing key technical problems in the development of Grid-enabled tools, services, and applications
  - Offer a modular set of orthogonal services
  - Middleware for building solutions, not turn-key
  - Enable *incremental* development of Grid-enabled tools and applications
  - Implement and inform Grid standards
  - Available under liberal open source license
  - Large community of developers & users
  - Multiple commercial support providers

Why Open Source is Important

- Leverages large body of code and experience
  - Efforts of a large e-Science community
- Encourages adoption of open standards
  - Reference implementation, community pressure
- Facilitates integration of new platforms
  - Port the implementation
- Allows vendors to focus on value add
  - Platforms, integration, higher-level services, turnkey applications, training, support

OGSA and the Globus Toolkit

- Technically, OGSA enables
  - Refactoring of protocols (GRAM, MDS, GridFTP), *while preserving all GT concepts/features!*
  - Integration with hosting environments: simplifying components, distribution, etc.
  - Greatly expanded standard service set
- Pragmatically, we are proceeding as follows
  - Develop open source OGSA implementation
    - Globus Toolkit 3.0; supports Globus Toolkit 2.0 APIs
  - Partnerships for service development
  - Also expect commercial value-adds
GT2 Evolution To GT3

- What happened to the GT2 key protocols?
  - Security: Adapting X.509 proxy certs to integrate with emerging WS standards
  - GRIP/LDAP: Abstractions integrated into OGSI as serviceData
  - GRAM: ManagedJobFactory and related service definitions
  - GridFTP: Unchanged in 3.0, but will evolve into OGSI-compliant service in 2004
- Also rendering collective services in terms of OGSI: RFT, RLS, etc.

GT Timeline

- GT 1.0: 1998
  - GRAM, MDS
- GT 2.0: 2001
  - GridFTP, packaging, reliability
- GT3 Technology Preview: Apr-Dec 2002
  - Tracking OGSI definition
- GT3.0 Alpha: Jan 2003
  - OGSI Base, GT2 functionality
- GT3.0 Production: June 2003
  - Tested, documented, etc.
- GT3.2.1 Production: July 2004
- GT3.9.2 Development: Aug 2004
- GT4 Scheduled beta development Dec 2004

Summary

- The Grid: Coordinates resources that are not subject to centralized control; using standard, open, general-purpose protocols and interfaces; to deliver non-trivial qualities of service.
- Considerable impact within eScience, growing interest & adoption within eBusiness
- Globus Toolkit an open source, defacto standard source of protocol and API definitions—and reference implementations
- GT3 is evolution of the Globus Toolkit path