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Globus Toolkit® 4 Status and Experiences

A Workshop at GGF14

Ian Foster & Lisa Childers

Argonne National Laboratory
University of Chicago

On April 29, 2005 the Globus Alliance released the finest version of the Globus Toolkit to date!

Overview

- GT4 introduction (90 minutes)
  - Capabilities, performance, implementation of standards, future directions
  - Related tools
  - Discussion
- Early Experiences (90 minutes)
  - GridCast, QUB
  - Intel
  - Condor-G and GriPhyN
  - Ninf-G4
  - Discussion

The Application-Infrastructure Gap

Dynamic and/or Distributed Applications

Shared Distributed Infrastructure

Bridging the Gap: Grid Infrastructure

- Service-oriented **applications**
  - Wrap applications as services
  - Compose applications into workflows
- Service-oriented **Grid infrastructure**
  - Provision physical resources to support application workloads

Globus is Grid Infrastructure

- Software for Grid infrastructure
  - Service enable new & existing resources
  - E.g., GRAM on computer, GridFTP on storage system, custom application service
  - Uniform abstractions & mechanisms
- Tools to build applications that exploit Grid infrastructure
  - Registries, security, data management, …
- Open source & open standards
  - Each empowers the other
- Enabler of a rich tool & service ecosystem

A Typical eScience Use of Globus: Network for Earthquake Eng. Simulation

Links instruments, data, computers, people

An eBusiness Use of Globus: SAP Demonstration @ GlobusWorld

- 3 Globus-enabled applns:
  - CRM: Internet Pricing Configurator (IPC)
  - CRM: Workforce Management (WFM)
  - SCM: Advanced Planner & Optimizer (APO)
- Applications modified to:
  - Adjust to varying demand & resources
  - Use Globus to discover & provision resources

SAP AG R/3 Internet Pricing & Configurator (IPC)

Globus Toolkit

- Core Web services
  - Infrastructure for building new services
- Security
  - Apply uniform policy across distinct systems
- Execution management
  - Provision, deploy, & manage services
- Data management
  - Discover, transfer, & access large data
- Monitoring
  - Discover & monitor dynamic services

Globus Toolkit version 2 (**GT2**)

Globus Toolkit version 3 (**GT3**)

Globus Toolkit version 4 (**GT4**)

GT4 Components

Our Goals for GT4

- Usability, reliability, scalability, …
  - Web service components have quality equal or superior to pre-WS components
  - Documentation at acceptable quality level
- Consistency with latest standards (WS-*, WSRF, WS-N, etc.) and Apache platform
  - WS-I Basic Profile compliant
  - WS-I Basic Security Profile compliant
- New components, platforms, languages
  - And links to larger Globus ecosystem

GT4 Common Runtime

GT4 Web Services Core

GT4 Web Services Core

- Supports both GT (GRAM, RFT, Delegation, etc.) & user-developed services
- Redesign to enhance scalability, modularity, performance, usability
- Leverages existing WS standards
  - WS-I Basic Profile: WSDL, SOAP, etc.
  - WS-Security, WS-Addressing
- Adds support for emerging WS standards
  - WS-Resource Framework, WS-Notification
- Java, Python, & C hosting environments
  - Java is standard Apache

WSRF & WS-Notification

- **Naming and bindings** (basis for virtualization)
  - Every resource can be uniquely referenced, and has one or more associated services for interacting with it
- **Lifecycle** (basis for fault resilient state mgmt)
  - Resources created by services following factory pattern
  - Resources destroyed immediately or scheduled
- **Information model** (basis for monitoring, discovery)
  - Resource properties associated with resources
  - Operations for querying and setting this info
  - Asynchronous notification of changes to properties
- Service groups (basis for registries, collective svcs)
  - Group membership rules & membership management
- Base Fault type

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WSRF/WSNs Compared (HPDC 2005)

	GT4-Java	GT4-C	pyGridWare	WSRF::Lite	WSRF.NET
Languages supported	Java	C	Python	Perl	C#/C++/VBasic, etc.
WS-Security password profile	Yes	No	In progress	In progress	Yes
WS-Security X.509 profile	Yes	In progress	Yes	In progress	Yes
WS-SecureConversation	Yes	No	Yes	No	Yes
TLS/SSL	Yes	Yes	Yes	Yes	Yes
Authorization	Multiple	Multiple	Callout	None	
Persistence of WS-Resources	Yes	Not default	Yes	Yes	Yes
Memory Footprint	JVM + 10M	22 KB	12 MB	12 MB	Depends
Memory size per WS-Resource	Depends on resource state	70B	Depends on resource state	0 (file/DB) or 10B (process)	Depends on resource state
Unmodified hosting environment	Yes	No	Yes	Yes (Apache)	Yes
Compliance with WS-I Basic Profile	Yes	Yes	Yes	In progress	Yes
Compliance with WS-I Basic Security Profile	Yes	Yes	Yes	No	Yes
Logging	Log4J	Yes	Yes	Yes	WSE diagnostics
WS-ResourceLifetime	Yes	Yes	Yes	Yes	Yes
WS-ResourceProperties	Yes	Yes	Yes	Yes	Yes
WS-ServiceGroup	Yes	Yes	Yes	Yes	Yes
WS-BaseFaults	Yes	Yes	Yes	Yes	Yes
WS-BaseNotification	Yes	Consumer	Yes	No	Yes
WS-BrokeredNotification	Partial	No	No	No	Yes
WS-Topics	Partial	Partial	Partial	No	Partial

GT4 WS Core Performance

(1) Message-level security (times in milliseconds)

	GT4 Java	GT4 C	GT4 Python	WSRF.NET
GetRP	181.96	14.77	140.50	81.39
SetRP	182.04	14.99	142.21	82.48
CreateR	188.46	14.98	132.26	96.22
DestroyR	182.03	15.76	136.12	86.89
Notify	219.51	N/A	244.93	101.57

(2) Transport-level security (times in milliseconds)

	GT4 Java	GT4 C	GT4 Python	WSRF.NET
getRP	11.46	2.85	149.67	12.91
setRP	11.47	2.86	150.79	12.3
createR	18.00	2.82	132.60	20.84
destroyR	14.92	2.71	149.21	16.05
Notify	29.26	9.67	169.07	45.0

"WSRF/WSNs Compared," HPDC 2005.

GT4 Security

Globus Security

- Control access to shared services
  - Address autonomous management, e.g., different policy in different work-groups
- Support multi-user collaborations
  - Federate through mutually trusted services
  - Local policy authorities rule
- Allow users and application communities to set up dynamic trust domains
  - Personal/VO collection of resources working together based on trust of user/VO

Virtual Organization (VO) Concept

- VO for each application or workload
- Carve out and configure resources for a particular use and set of users

GT4 Security

GT4 Security

- Public-key-based authentication
- Extensible authorization framework based on Web services standards
  - SAML-based authorization callout
    - As specified in GGF OGSA-Authz WG
  - Integrated policy decision engine
    - XACML policy language, per-operation policies, pluggable
- Credential management service
  - MyProxy (One time password support)
- Community Authorization Service
- Standalone delegation service

GT4's Use of Security Standards

	Message-level Security w/X.509 Credentials	Message-level Security w/Usernames and Passwords	Transport-level Security w/X.509 Credentials
Authorization	SAML and grid-mapfile	grid-mapfile	SAML and grid-mapfile
Delegation	X.509 Proxy Certificates/ WS-Trust		X.509 Proxy Certificates/ WS-Trust
Authentication	X.509 End Entity Certificates	Username/ Password	X.509 End Entity Certificates
Message Protection	WS-Security WS-SecureConversation	WS-Security	TLS
Message format	SOAP	SOAP	SOAP
	Supported, but slow	Supported, but insecure	**Fastest, so default**

GT-XACML Integration

- eXtensible Access Control Markup Language
  - OASIS standard, open source implementations
- XACML: sophisticated policy language
- Globus Toolkit ships with XACML runtime
  - Included in every client and server built on GT
  - Turned-on through configuration
- … that can be called transparently from runtime and/or explicitly from application …
- … and we use the XACML-”model” for our Authz Processing Framework

GT Authorization Framework

Other Security Services Include …

- MyProxy
  - Simplified credential management
  - Web portal integration
  - Single-sign-on support
- KCA & kx.509
  - Bridging into/out-of Kerberos domains
- SimpleCA
  - Online credential generation
- PERMIS
  - Authorization service callout

GT4 Data Management

GT4 Data Management

- **Stage/move** large data to/from nodes
  - GridFTP, Reliable File Transfer (RFT)
  - Alone, and integrated with GRAM
- **Locate** data of interest
  - Replica Location Service (RLS)
- **Replicate** data for performance/reliability
  - Distributed Replication Service (DRS)
- Provide **access** to diverse data sources
  - File systems, parallel file systems, hierarchical storage: GridFTP
  - Databases: OGSA DAI

GridFTP in GT4

- 100% Globus code
  - No licensing issues
  - Stable, extensible
- IPv6 Support
- XIO for different transports
- Striping → multi-Gb/sec wide area transport
  - 27 Gbit/s on 30 Gbit/s link
- Pluggable
  - Front-end: e.g., future WS control channel
  - Back-end: e.g., HPSS, cluster file systems
  - Transfer: e.g., UDP, NetBLT transport

Reliable File Transfer: Third Party Transfer

- Fire-and-forget transfer
- Web services interface
- Many files & directories
- Integrated failure recovery
- Has transferred 900K files

Replica Location Service

- Identify location of files via logical to physical name map
- Distributed indexing of names, fault tolerant update protocols
- GT4 version scalable & stable
- Managing ~40 million files across ~10 sites

Local DB	Update send (secs)	Bloom filter (secs)	Bloom filter (bits)
10K	<1	2	1 M
1 M	2	24	10 M
5 M	7	175	50 M

Reliable Wide Area Data Replication

LIGO Gravitational Wave Observatory

Replicating >1 Terabyte/day to 8 sites

>30 million replicas so far

MTBF = 1 month

www.globus.org/solutions

GT4 Execution Management

Execution Management (GRAM)

- Common WS interface to schedulers
  - Unix, Condor, LSF, PBS, SGE, …
- More generally: interface for process execution management
  - Lay down execution environment
  - Stage data
  - Monitor & manage lifecycle
  - Kill it, clean up
- A basis for application-driven provisioning

GT4 WS GRAM

- 2nd-generation WS implementation optimized for performance, flexibility, stability, scalability
- Streamlined critical path
  - Use only what you need
- Flexible credential management
  - Credential cache & delegation service
- GridFTP & RFT used for data operations
  - Data staging & streaming output
  - Eliminates redundant GASS code

GT4 WS GRAM Architecture

GT4 WS GRAM Architecture

Delegated credential can be:
Made available to the application

GT4 WS GRAM Architecture

Delegated credential can be:
Used to authenticate with RFT

GT4 WS GRAM Architecture

Delegated credential can be:
Used to authenticate with GridFTP

GT4 WS GRAM Performance

Sustained Job Load Per Client Thread (N)	Number of Client Threads (M)							
	1	**2**	**4**	**8**	**16**	**32**	**64**	**128**
1	7	15	29	57	80	69	69	70
2	15	29	58	79	74	70	70	64
4	29	58	78	77	68	69	52	69
8	59	77	77	72	65	27		69
16	77	77	75	64	27			50
32	76	75	68	64	67			
64	75	73	70	66	65			
128	80	72	64	63	71			

All numbers are simple jobs/minute, no delegation or staging

GT4 Information Services

Monitoring and Discovery

- "Every service should be monitorable and discoverable using common mechanisms"
  - WSRF/WSN provides those mechanisms
- A common aggregator framework for collecting information from services, thus:
  - MDS-Index: Xpath queries, with caching
  - MDS-Trigger: perform action on condition
  - (MDS-Archiver: Xpath on historical data)
- Deep integration with Globus containers & services: every GT4 service is discoverable
  - GRAM, RFT, GridFTP, CAS, …

GT4 Monitoring & Discovery

Index Server Performance (3.9.4)

Index Size	1 client		2 Clients		25 Clients		100 Clients	
	Sing. clt q/sec	Resp. Time (msec)	Sing. clt q/sec	Resp. Time (msec)	Sing. clt q/sec	Resp. Time (msec)	Sing. clt q/sec	Resp. Time (msec)
10	24	40	22	44	4.5	245	0.85	1243
30	15	64	10	93	n/a	n/a	n/a	n/a
100	5	190	4	265	0.78	1334	0.19	5824

Index Server Performance

- As the MDS4 Index grows, query rate and response time both slow, although sublinearly
- Response time slows due to increasing data transfer size
  - Full Index is being returned
  - Response is re-built for every query
- Real question – how much over simple WS-N performance?

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GT 4.0 General
- Release Notes
- Key Concepts
- Installing GT 4.0 (System Administrator's Guide)
- Site/VO Planning
- Platform Notes
- Best Practices for Developing with GT 4.0
- Guide to APIs
- Coding Guidelines
- Migration Guide
  - From GT2 to GT4
  - From GT3 to GT4
- Samples
- Command Line Clients Guide
- GUI Guide
- Resource Properties Guide
- Overview and Status of Current GT Performance Studies
- Release Version Scheme

GT 4.0 Common Runtime Components
- Common Runtime Components: Key Concepts
- Java WS Core
- C WS Core
- XIO
- C Common Libraries

GT 4.0 Security (GSI)
- Security: Glossary
- Security: Key Concepts
- WS A&A
  - Community Authorization Service (CAS)
  - Delegation Service
  - Authorization Framework
  - Message/Transport-level Security
- Credential Management
  - MyProxy
  - SimpleCA
- Utilities
  - GSI-OpenSSH
- Pre-WS Authentication & Authorization

GT4 Documentation is Much Improved!

GT 4.0 Data Management
- Data Management: Key Concepts
- RFT
- GridFTP
- RLS

GT 4.0 Information Services
- Information Services: Key Concepts
- WS MDS (MDS4)
  - Aggregator Framework
  - Index Service
  - Trigger Service
  - WebMDS (Tech Preview)
- Pre-WS MDS (MDS2)

GT 4.0 Execution Management
- Execution Management: Key Concepts
- WS GRAM (GRAM4)
- WS Rendezvous
- Pre-WS GRAM (GRAM2)

Working with GT4

- Download and use the software, and provide feedback
  - Join **gt4friends@globus.org** mail list
- Review, critique, add to documentation
  - Globus Doc Project: **http://gdp.globus.org**
- Tell us about your GT4-related tool, service, or application
  - Email **info@globus.org**

Future Directions

The Future: It's All About VOs

- We now have a solid and extremely powerful Web services base
- Next, we will build an expanded open source Grid infrastructure
  - Virtualization
  - New services for provisioning, data management, security, VO management
  - End-user tools for application development
  - Etc., etc.
- And of course responding to user requests for other short-term needs

Short-Term Priorities: Security

- Improve GSI error reporting & diagnostics
- Secure password, one-time password, Kerberos support for initial log on
- Trust roots, use of GridLogon
- Identity/attribute assertions in GT auth. callouts (e.g., Shib, PERMIS, VOMS, SAML)
- Extend CAS admin & policy support
- Security logging with management control for audit purposes

Short-Term Priorities: Data Management

- Space & bandwidth management in GridFTP
- Concurrency in globus-url-copy
- Priorities in RFT
- Data replication service
- Enhance policy support in data services
- Physical file name creation service
- Scalable & distributed metadata manager

Short-Term Priorities: Execution Management

- Implement GGF JSDL once finalized
- Advance reservation support
- Policy-driven restart of "persistent" jobs
- Improved information collection for jobs
- Improved management of job collections
- Credential refresh
- Virtual workspace service
- Integration of virtual machines (Xen, VMware) and associated services
- Windows port of WS GRAM

Short-Term Priorities: Information Services

- Many more information sources, including gateways to other systems
- Automated configuration of monitoring
- Specialized monitoring displays
- Performance optimization of registry
- Archiver service
- Helper tools to streamline integration of new information sources

Short-Term Priorities: WS Core

- Streamlined container configuration
- Remote management interface
- Dynamic service deployment
- Service isolation: multiple service instances
- WS-Notification, subscription performance
- Full functionality in C WS Core
- Optimized WS-ServiceGroup support
- WS-SecureConversation support

What to Expect in the Coming Months …

- Support for users of GT4
  - Working to make sure the toolkit meets user needs
  - Answering questions on the mailing lists
  - Further improving documentation
- Normal evolution of performance, scalability and feature enhancements
- Development of new tools and services in support of VOs

Future Release Plans

- Short term
  - An incremental **4.0.1** release in a few weeks
- Medium term
  - Additional incremental releases
  - Additional packages (e.g., VM support)
- Long term
  - New version (4.1/4.2): no date set yet

Sidebar: What is an Incremental Release?

4.0.1 Release Highlights (ETA early July)

- Important bug fixes, including the WS MDS exploit and C message-level security fixes
- Improved support for Tomcat container
- A version of OGSA-DAI with a complete set of public interfaces
- MPICH-G2 support
- Updates of many contributions and tech previews
- Full Apache license

GT4-Related Tools

The Globus Ecosystem

- Globus **components** address core issues relating to resource access, monitoring, discovery, security, data movement, etc.
  - GT4 being the latest version
- A larger Globus **ecosystem** of open source and proprietary components provide complementary components
  - A growing list of components
- These components can be combined to produce **solutions** to Grid problems
  - We're building a list of such solutions

Many Tools Build on, or Can Contribute to, GT4-Based Grids

- Condor-G, DAGman
- MPICH-G2
- GRMS
- Nimrod-G
- Ninf-G
- Open Grid Computing Env.
- Commodity Grid Toolkit
- GriPhyN Virtual Data System
- Virtual Data Toolkit
- GridXpert Synergy
- Platform Globus Toolkit
- VOMS
- PERMIS
- GT4IDE
- Sun Grid Engine
- PBS scheduler
- LSF scheduler
- GridBus
- TeraGrid CTSS
- NEES
- IBM Grid Toolbox
- …

Documenting The Grid Ecosystem

Grid Research Integration Deployment and Support Center

GRIDS

The Grid Ecosystem: Software Components for Grid Systems And Applications

Software is a vital part of Grid projects. The open source community has produced a wide variety of Grid software components. Understanding the capabilities of each component, the strengths and weaknesses of each, and the types of problems that are currently covered (or not covered) by these components can be a bewildering challenge for new Grid projects. Moreover, each new Grid project has

The Grid Ecosystem: Software Components for Grid Systems And Applications

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software plays in Grid projects and descriptions of many of the software tools that GRIDS Center members and our partners have used successfully in ambitious Grid applications. You may choose from the following areas, which are reflected in the navigational submenu to the left.

An Ecosystem of Grid Components describes the GRIDS Center's general approach to using software components in Grid projects and applications.

Security describes a number of useful software tools for meeting the security requirements in Grid systems.

Monitoring and Discovery describes software components that can provide monitoring and discovery features in Grid systems.

Computation describes software tools that can be used to manage computational tasks in Grid applications.

Data describes software tools that can be used to manage data and datasets in data-intensive applications.

Collaboration describes software for facilitating and encouraging collaboration in distributed projects.

Packaging and Distribution describes tools for helping to create integrated software distributions for use in Grid projects.

www.grids-center.org

Example Solutions

- Portal-based User Reg. System (PURSE)
- VO Management Registration Service
- Service Monitoring Service
- TeraGrid TGCP Tool
- Lightweight Data Replicator
- GriPhyN Virtual Data System

Condor-G

- The Condor Project @ U Wisconsin Madison develops software for high-throughput computing on collections of distributed compute resources
- Condor-G is an interface to GRAM created by the Condor team that allows users to submit jobs to GRAM servers

(Jamie Frey of Condor will speak in the "Early Experiences" section)

GridShib

- Allows the use of Shibboleth-transported attributes for authorization in GT4 deployments
  - And, more generally, SAML support
- 2 year project started December 1, 2004
- Participants
  - Von Welch, UIUC/NCSA (PI)
  - Kate Keahey, UChicago/Argonne (PI)
  - Frank Siebenlist, Argonne
  - Tom Barton, UChicago

Handle System

- The Handle System from CNRI (http://www.handle.net) is a general-purpose global name service enabling secure name resolution over the internet
- The Handle System-GT Integration Project leverages the Handle System for identifier and resolution services through tight integration with GT4's Web services protocols

MPICH-G2

- MPICH-G2, developed at Northern Illinois University and Argonne National Lab, is a grid-enabled implementation of the MPI v1.1 standard
- MPICH-G2 is implemented using the pre-WS GRAM component in GT4; integration with GT4 WS GRAM is expected in the near future

Nimrod/G

- Nimrod is a specialized parametric modeling system from Monash University
- Nimrod/G uses a simple declarative parametric modeling language to express parameter sweep experiments. Based on GT4 WS services, Nimrod/G enables the formulation, execution and monitoring of multiple individual parametric experiments

Ninf-G4

- Ninf-G4, from AIST, is a reference implementation of the GGF standard GridRPC API
- Ninf-G4 is provides higher-level programming APIs for the development and execution of parallel applications on the Grid

(Hidemoto Nakada of AIST will speak in the “Early Experiences” section)

PERMIS

- PERMIS is an EU-funded Privilege Management service that implements Role-Based Access Control
- Thanks to the work of the UK Grid Engineering Task Force, services running in a Java WS Core container can use PERMIS via GT4's SAML authorization callouts

SRB

- SRB is a package from SDSC providing a uniform interface for connecting to network-based heterogeneous data resources
- GT4's GridFTP includes an interface to SRB data sources, and vice versa

Sun Grid Engine

- TheSun Grid Engine is an open source distributed resource management system from Sun Microsystems
- In a collaboration between the London e-Science Centre, Gridwise and MCNC, the Sun Grid Engine has been integrated with GT4

For More Information

- Links to these projects are listed on the "Related Software" of the Globus Toolkit web http://www.globus.org/toolkit/tools/

- If we've got details wrong or you have a GT4-related tool to list on our website, please send mail to info@globus.org

Questions?