Introduction to GT3

The Globus Project™

Argonne National Laboratory
USC Information Sciences Institute

Introduction to GT3

- **Background**
  - The Grid Problem
  - The Globus Approach
  - OGSA & OGSI
  - Globus Toolkit
- GT3 Architecture and Functionality: The Latest Refinement of the Globus Toolkit
  - Core
  - Base Services
  - User-Defined Services
  - Future Directions
- Installation and Administration
  - Installation
  - Configuration
  - Debugging
  - Support
- Important Things to Remember

the globus toolkit®
www.globustoolkit.org

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

the globus toolkit®
www.globustoolkit.org

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)

the globus toolkit®
www.globustoolkit.org

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

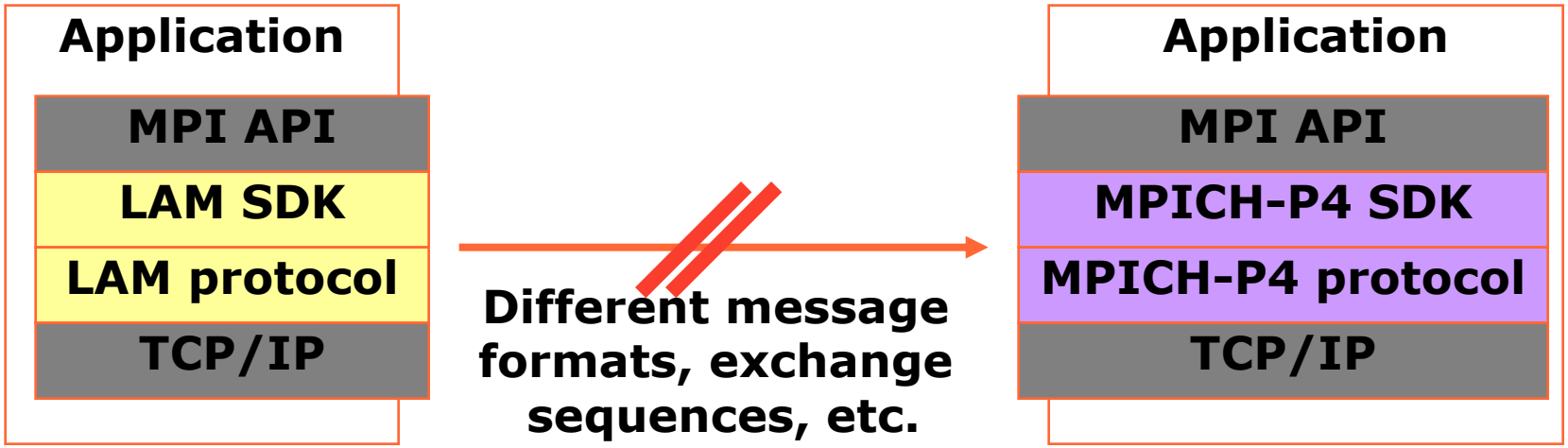
the globus toolkit®
www.globustoolkit.org

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)

the globus toolkit®
www.globustoolkit.org

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

the globus toolkit®
www.globustoolkit.org

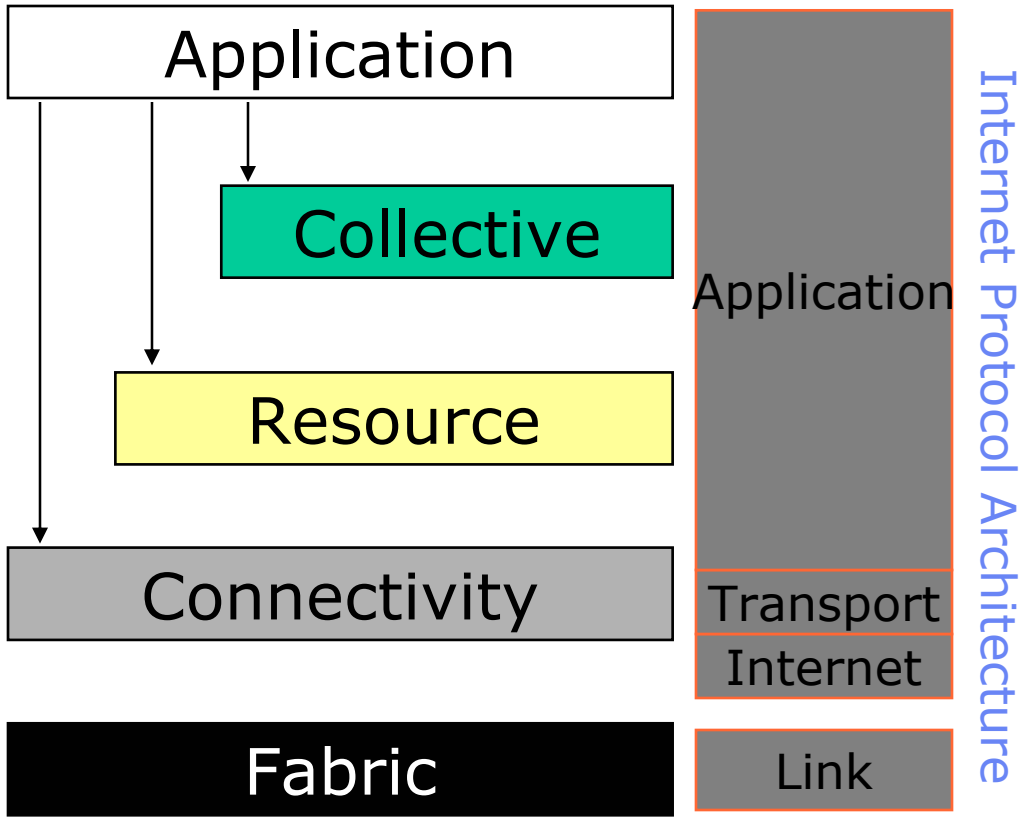
Layered Grid Architecture

"Coordinating multiple resources": ubiquitous infrastructure services, app-specific distributed services

"Sharing single resources": negotiating access, controlling use

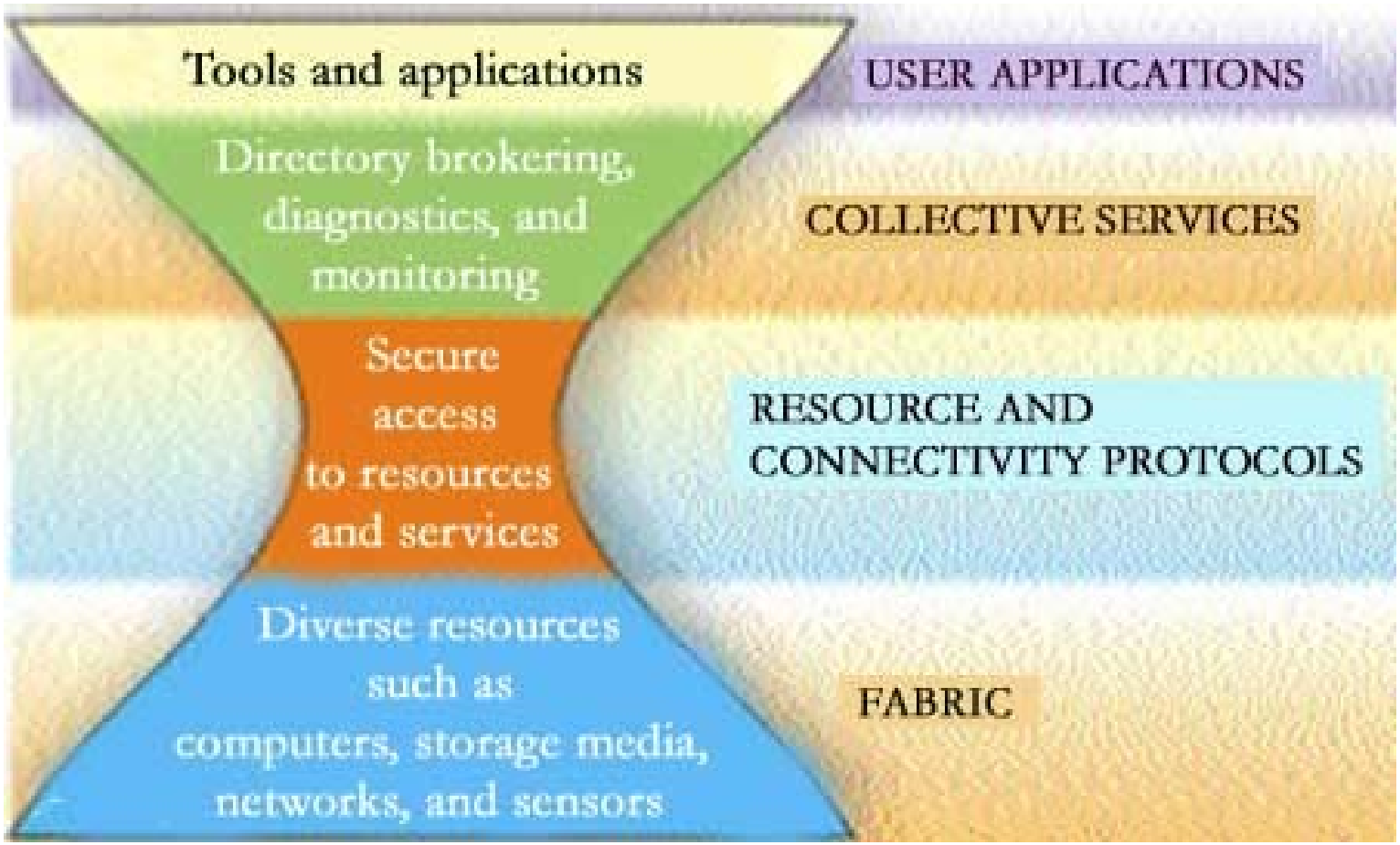
"Talking to things": communication (Internet protocols) & security

"Controlling things locally": Access to, & control of, resources



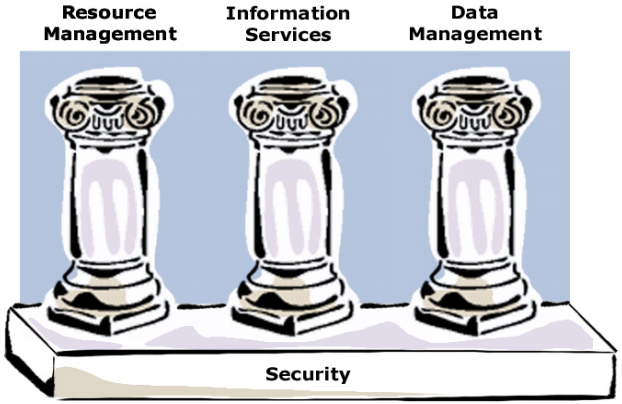
"The Anatomy of the Grid: Enabling Scalable Virtual Organizations", Foster, Kesselman, Tuecke, Intl Journal of High Performance Computing Applications, 15(3), 2001.

Layers of Grid Architecture



the globus toolkit®
www.globustoolkit.org

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.

the globus toolkit®
www.globustoolkit.org

Protocol Standards Efforts

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

From Standard Protocols, To Grid Services

the globus toolkit®
www.globustoolkit.org

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

the globus toolkit®
www.globustoolkit.org

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…

the globus toolkit®
www.globustoolkit.org

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

the globus toolkit®
www.globustoolkit.org

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

the globus toolkit®
www.globustoolkit.org

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

the globus toolkit®
www.globustoolkit.org

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

the globus toolkit®
www.globustoolkit.org

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

the globus toolkit®
www.globustoolkit.org

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

the globus toolkit®
www.globustoolkit.org

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.

the globus toolkit®
www.globustoolkit.org

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.

the globus toolkit®
www.globustoolkit.org

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

the globus toolkit®
www.globustoolkit.org

Tutorial Prep

- cp –Rp /opt/ogsa-3.0.0 ~
- cd ~/ogsa-3.0.0
- ant setup
- export GLOBUS_LOCATION=`pwd`
- mkdir tutorial ; cd tutorial
- export TUTORIAL_DIR=`pwd`
- mkdir gt3tutorial
- http://www.casa-sotomayor.net/gt3-tutorial/