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Introduction to Grid Programming with the Globus Toolkit Version 3

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Session Introduction

- Who am I?
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  - IBM Linux Integration Center, Austin
  - Author on 2 IBM Redbooks about Globus 3
- What will we talk about ?
  - Recent history of grid computing
  - Intro to the galaxy of Globus
  - Run a Globus V3 example (fingers crossed)

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Introduction to Grid Computing

- Don't panic: it's just the new word for distributed computing
- We want to exploit resources on a wide, loose network
  - Not a cluster, but heterogeneous systems
  - CPU, storage, software, devices, all w/quality-of-service
- We started small in the early days with file copying, printing
- Later we moved to program-program communication
- We have to solve the same problems every time
  - Comms protocol, data format, security, management
- Why can't we just focus on the high-level tasks? Please?
  - Leverage existing standards
  - Follow accepted patterns

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Classes of Grids

- Computation
  - The obvious one
  - Systems dedicated to tasks, or scavenging (including desktop)
- Data Virtualization
  - Intelligent, cross-network virtual filesystem
- Business Intelligence
  - Single coherent view of enterprise data
- Analytics
  - Computation + business intelligence
- High Availability
  - Provide better uptime due to no single point of failure

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The Globus Project

- Write code to provide a grid infrastructure
  - http://www.globus.org
- Major contributors
  - Argonne National Labs
  - University of Chicago
  - University of Southern California
  - Northern Illinois University
- Sponsors
  - DARPA
  - U.S. Department of Energy
  - National Science Foundation
  - NASA
- Supporters
  - IBM, Microsoft, Cisco

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What Is Globus Toolkit 2.x?

- Known as GT2
- C-based grid toolkit – de facto grid standard
  - Used heavily in academic and research grids
  - Still supported, some features used in GT3
- Layers
  - Applications
  - High-Level Services and Tools
  - Core Service
  - Local Services

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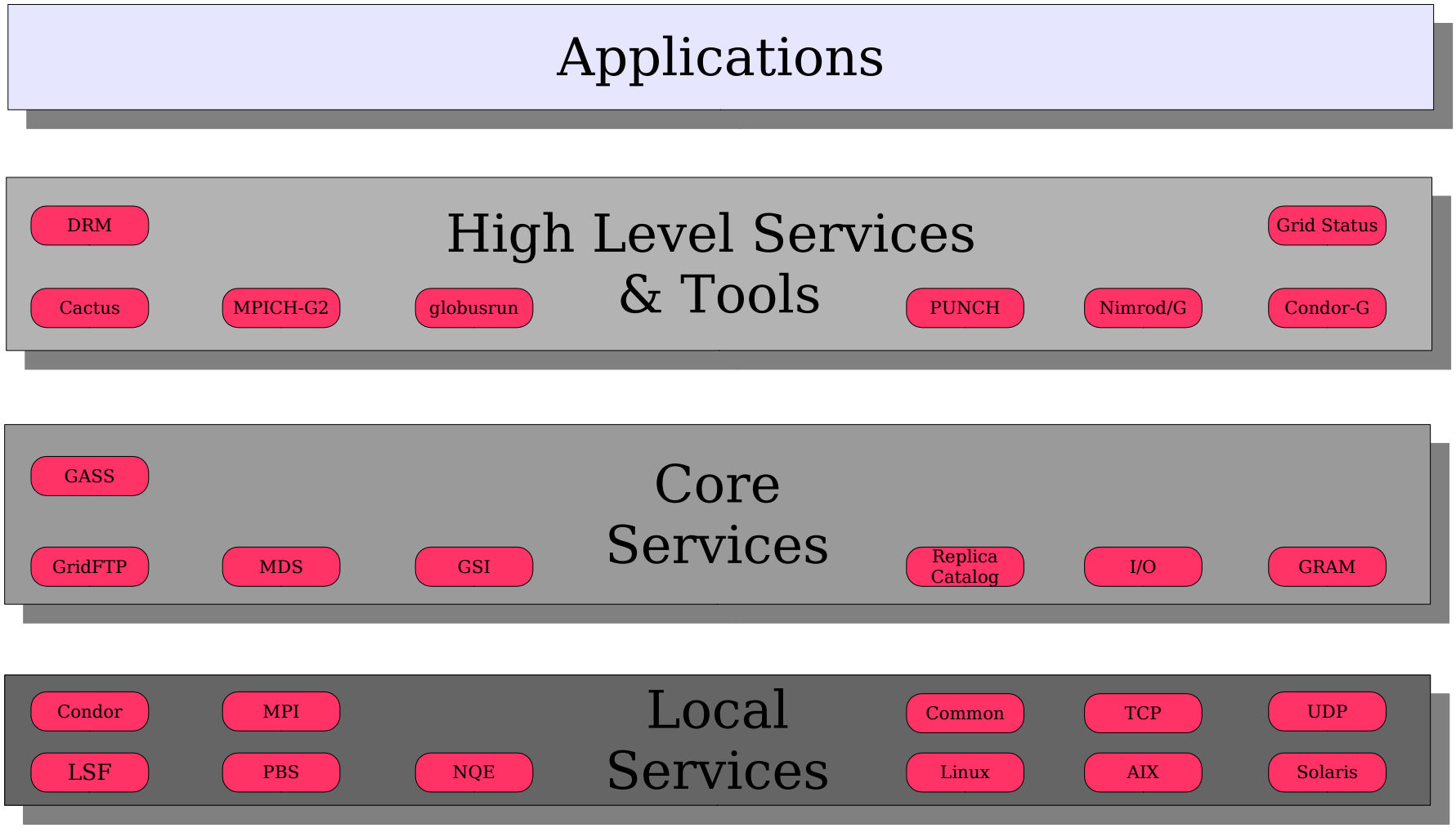
GT2 Architecture



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GT2 Local Services

- Condor
  - Job and resource manager for compute-intensive jobs
- MPI – Message Passing Interface
  - Portability across plaforms
- LSF – Load Sharing Facility
  - Management of batch workload from Platform, Inc.
- PBS – Portable Batch System
  - Scheduling / resource management from Veridian Group *via* NASA
- NQE – Network Queueing Environment
  - Resource manager on Cray systems
- Common
  - Thread library, libc wrappers, callbacks, object management

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GT2 Core Servces

- GASS – Globus Access to Secondary Storage
  - File and executable staging and I/O redirection
- GridFTP - Grid File Transfer Protocol
  - Reliable, high performance FTP with 3rd party transfer capability
- MDS - Metacomputing Directory Service
  - Maintains information about available resources
- GSI - Grid Security Interface
  - Authentication, authorization *via* proxies, delegation, PKI, SSL (not Kerberos!)
- Replica Catalog
  - Manages partial copies of full data set across grid
- GRAM - Grid Resource Allocation Management
  - Allocation, reservation, monitoring and control of programs on remote systems
- I/O
  - Wrapper TCP, UDP, IP multicast and file I/O

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GT2 High Level Services

- DRM – Distributed Resource Management
  - Resource manager on ASCI supercomputer
- Cactus
  - Grid-aware numerical solver framework
- MPICH-G2
  - Grid-enabled MPI
- Globusrun
  - More complicated version of globus-job-run
  - Complex Resource Specification Language expressions

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GT2 High Level Services Cont.

- PUNCH
  - Web browser resource manager from Purdue
- Nimrod/G
  - Model computational jobs from Monash
- Grid Status
  - Repository of state of jobs in grid
- Condor-G
  - Condor job management layer to Globus

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Running GT2

- Run grid-proxy-init
  - User enters passphrase to decrypt private key
  - Private key signs proxy certificate
  - Proxy certificate placed in /tmp
  - Traffic managed by gatekeeper
    - Process acts like inetd for available services
    - Handles authentication issues
- Run desired command
  - eg. globus-job-run <host> <program> [args]

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What Is a Web Service?

- Program-program interoperability standard
  - Allows for construction of loosely coupled applications
- Platform and language independent
- You don't need previous knowledge of a service to use it
- Uses standards-based protocols
  - WSDL – Description of the Web service interface
  - UDDI – Directory of available services
  - SOAP – Network procedure call
  - HTTP – Transport protocol (gets through ~ anything)
  - XML – Payload data format for messages
- See Hatzidakis, Nash, Lawrence

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Web Services Invocation

- Find a service by querying the UDDI registry
- Registry replies with a list of servers
- Ask web service to describe its invocation format
- Service replies with WSDL definition
- Send SOAP request message to service
- Service replies with SOAP response message
  - Contains requested data or error info

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What Is the GGF?

- Global Grid Forum http://www.ggf.org
  - " to promote and support the development, deployment, and implementation of Grid technologies and applications via the creation and documentation of "best practices" – technical specifications, user experiences, and implementation guidelines."
- Developed two key specifications for us
  - OGSA
  - OGSI

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Goals of OGSI and OGSA

- Provide a grid framework
- Leverage existing standards
- Services are heterogeneous
- Services are dynamic
- Services are searchable
- Services are callable by any system on the grid
- Services are independent of implementation

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What Is OGSA?

- Open Grid Services Architecture
- Defines what Grid Services are
  - Enhanced Web Services
- Defines a set of core and higher-level features
  - Factory, Registry, Discovery, Lifecycle, Authentication
  - Policy, Monitoring, Management, SLA, Hierarchy, QOS
  - Query Service Data, Notification, Reliable Invocation
- Architecture layers can be implemented by different products, ISVs, open source communities, *etc*.
- Pick and choose the “best” implementation

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OGSA Programming Model

- All OGSA services adhere to specific service interfaces and behaviours
- Service interface defined by GWSDL
  - Grid WSDL
  - OGSA has identified several WSDL extensions

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What Is OGSI?

- Open Grid Services Infrastructure
- Formal specification for OGSA concepts
- What do we need to build grid services?
  - Stateful Web services
  - Life cycle functions
  - Naming functions
  - Service Data
  - Notification of state change

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OGSI Stateful Web Services

- Normal Web services are not stateful
  - This is not helpful in a grid environment
- We need smarter instances
  - Can be long-running
  - Can be used in a chain of related operations
  - Need to be able to query, pause, stop jobs, *etc*.
- Introduce Factory approach
  - Creates and manages pool of running instances
  - Can be unique or shared amongst clients

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OGSI Lifecycle

- Create and destroy service instances
  - Actual mechanism not defined by OGSI
- Can create *via:*
  - Direct invocation of method on service
  - Factory
- Can destroy *via* direct invocation of method
- Can allow to die
  - Don't respond to the keep-alive notification

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OGSI Naming

- Web Services addressed *via* a URI
  - http://my.server.com/applications/serviceA
  - Permanent, unique
  - But OGSA calls it a Grid Service Handle (GSH)
- A GSH is insufficient to talk to an instance
  - Resolve GSH to a Grid Service Reference (GSR)
  - This is temporary as an instance could die at any time
  - GSR is defined by a WSDL grammar (methods, *etc*.)
  - Use WSDL because GT3 implemented SOAP / HTTP

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OGSI Service Data

- One of the most important concepts
  - Storage area associated with a grid service
  - Collection of Service Data Elements (SDE)
  - Zero of more SDEs per instance
  - List of types defined by OGSI
  - Externally expose state data to service requesters
- Query
- Update
- Fire notification to subscribers on change

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OGSI Notification

- Register and deliver async events
- Notification Source
  - Delivers notification messages
- Notification Sink
  - Receives notification messages

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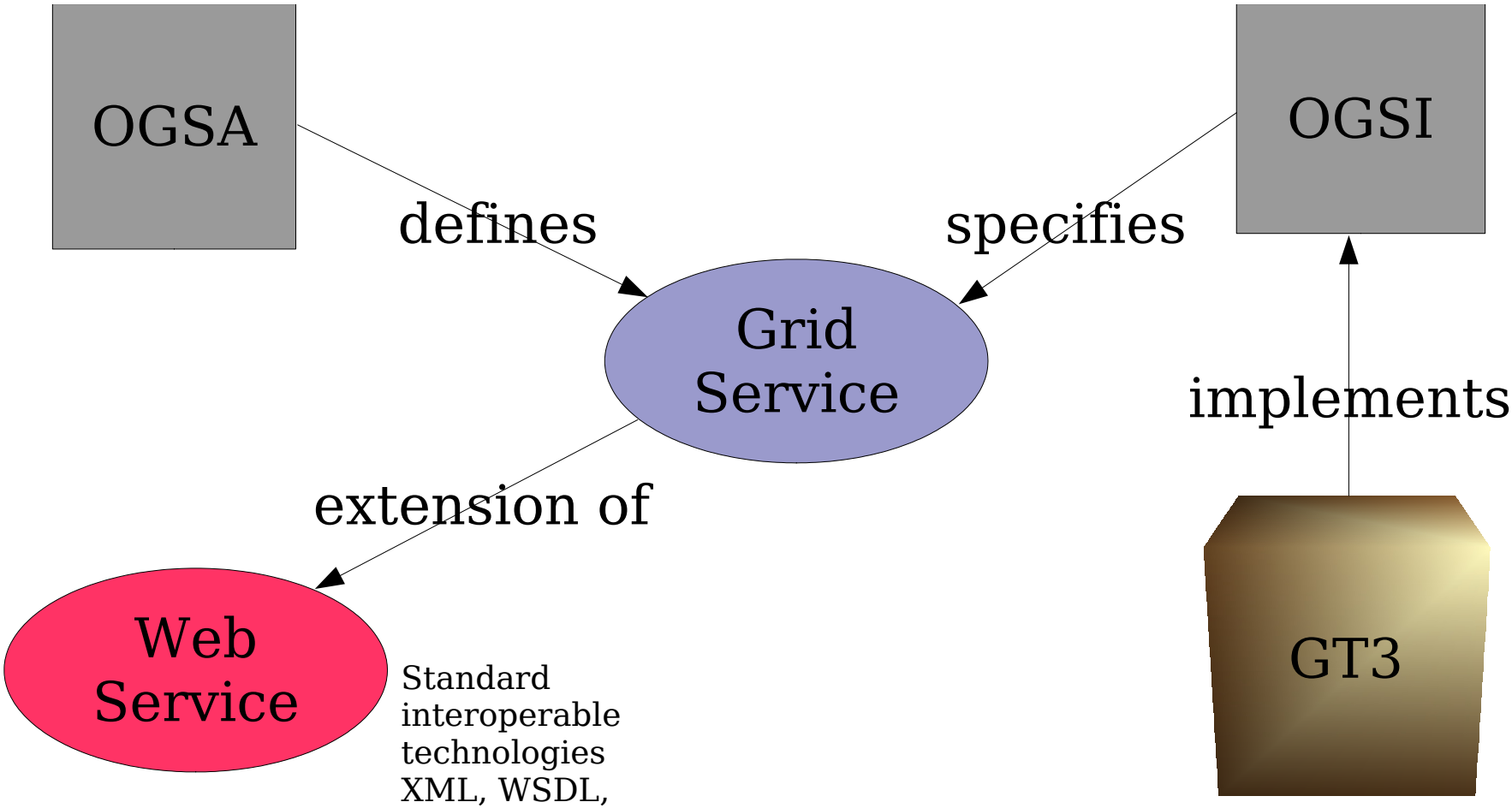
OGSA/OGSI/GT3 Relationship



Standard interoperable technologies XML, WSDL, SOAP, ...

From GT3 Tutorial, Sotomayor

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What Is the Globus 3 Toolkit?

- Here we are finally!
- Open source implementation of OGSI 1.0
- Usable Web services-based grid services toolkit
- Runtime environment called the container
- Written in Java
- Some GT2 components have no GT3 equiv
  - Full support for GT2.4, written in C
  - GT3 job manager launches as separate process
  - Deprecating over time

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GT3 Core Services

- Implements all OGSI interfaces
  - GridService, Factory, Notification, HandleResolver
  - Admin, Logging, Management, *etc*.
- Run time environment for services
  - Between application and plumbing
  - Embedded: library for any J2SE application
  - Standalone: lightweight server (test, development)
  - Web: runs in a J2EE servlet engine
  - EJB: expose stateful Entity and Session beans as services

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GT3 Security Services

- Transport- and message-level security
  - Transport being deprecated
  - Message based on WS-Security, XML Signature
  - At SOAP level
  - Per-session or per-message
- SSL, X.509 certificates
- Based on JAAS
  - Authentication, Authorization Service Framework

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GT3 Base Services

- Database services
  - Persisting Service Data in native XML db
- Managed Job Service
  - Notify, subscribe, pause, stop, query jobs
- Index Service
  - Query services around grid
- Reliable File Transfer
  - Guaranteed large file transfers *via* restart
- Replica Location Service

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Writing a Simple Grid Service

- Define all aspects of the service interface
  - Java Interface and/or GWSDL
- Generate grid service support code
  - Server and client stub classes
- Implement the service guts
- Fortunately this process is very automated
  - ant is your friend

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Our Simple Grid Service

- Message of the Day service
- Differentiate it from a normal Web Service
  - Stateful server keeps track of which messages sent
  - Messages delivered in order
  - Will not repeat until all MOTDs delivered
- Client calls instance's getMOTD()

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Define a Service Interface

- Two ways:
- Bottom-up
  - Write a Java Interface
  - Run a tool against it to generate WSDL
  - Be careful! Some complex Java types do not map well into WSDL.
  - Good for exposing legacy code w/o reprogramming
- Top-down
  - Write a GWSDL Port Type definition
  - Run two tools against it to generate full WSDL

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Top-Down Service Definition

- Write the abstract definition of the service
  - Types, Messages and PortType in GWSDL
  - Better for more compex service data types
  - Annoying XML syntax
- Run throught the GWSDL2WSDL tool
  - Creates WSDL 1.1 portType definition
- Run through the generateBindings tool
  - Creates the wsdl:binding and wsdl:service parts of portType definition

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Generate Service Support Code

- Generate Java stubs
  - Handles marshalling of data to/from XML
  - Server & client side JAX-RPC-compliant interfaces
- All done by ant

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Implement the Service

- Write a Java class that does the job
  - Implement the service interface
  - Private attributes make it stateful
  - Private methods in the class are OK
- Simple constructor
  - Calls super() to pass to GridServiceImpl
- Implement service methods
  - String getMOTD()

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Deploy the Service

- Write a deployment descriptor
  - Tells the Web server how the service is published
  - Extra fields define factory attributes
- Create a GAR
  - Grid ARchive, a JAR with grid-specific extras
  - Best to copy/paste an existing ant task
  - target="makeGar"
- Deplot the GAR into a hosting environment
  - ant deploy -Dgar.name=<path to GAR>

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Write a Service Client

- Command-line client application
  - Good idea to pass service info on command line
  - Or use Index Service to discover
- Make a GSH from the factory service URI
  - Build up with hostname and factory path
- Locate the factory using the GSH
- Create a service instance with the factory
- Call a remote method on the instance
- Destroy the instance

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Prepare the Server for Clients

- Start the container
  - ant startContainer
- If using factory, don't need to create an instance
- If not using a factory, create a service instance
  - java org.globus.ogsa.client.CreateService <serverURL>/<factory service name>
  - ServerURL = http://hostname:8080/
  - Factory = /<path to factory>
- Container now running, waiting for requests

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Test the Client

- Launch the client
- Pass on the command line
  - Instance reference (GSR)
  - Like handle, but with /hash-123.... on end
- Client pulls and displays one MOTD
- Try it with your wireless laptop!

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    - In process at this time