Grids and User Applications

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Outline

- Grid Architecture
- Globus Toolkit 4
- Computational problems
- Execution Management
- Examples

Grid

A New Infrastructure for 21st Century Science
(Ian Foster)

- An emerging infrastructure that provides seamless access to computing power and data storage capacity distributed over the world.
- It makes possible to share resources for geographically distributed groups to work together.

Virtual Organization (VO)

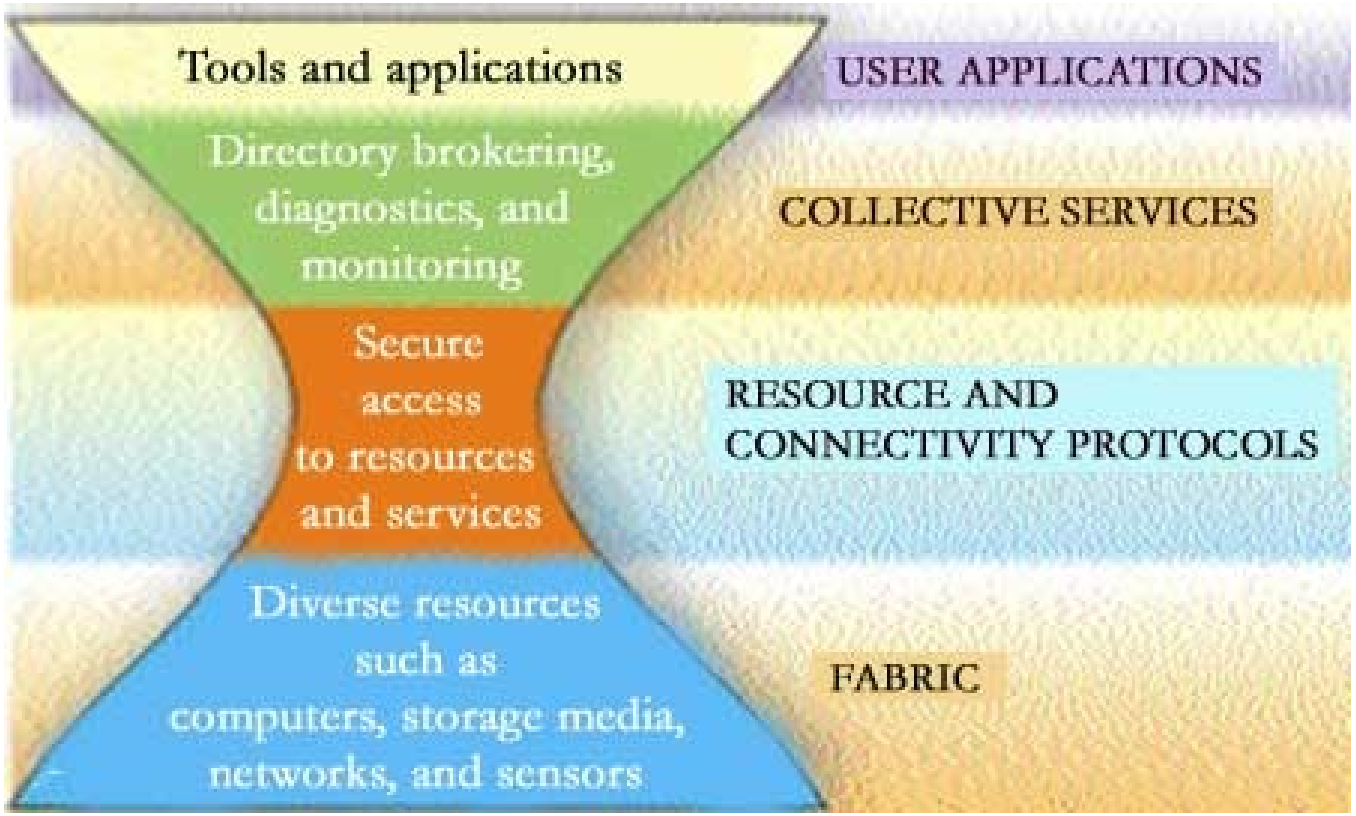
A set of disparate institutions and/or individuals which are enabled to share resources in a controlled fashion.

- Resource – any artifact, entity or knowledge required to complete an operation on the system.

Open Grid Services Architecture (OGSA)
(Global Grid Forum)

- Integrates Grid technologies and Web services.
- Defines a common, standard behaviors and interfaces for Grid Services.
- **Grid service** – a Web service that can be created dynamically and that supports security, lifetime management, manageability, and other functions required in Grid scenarios.

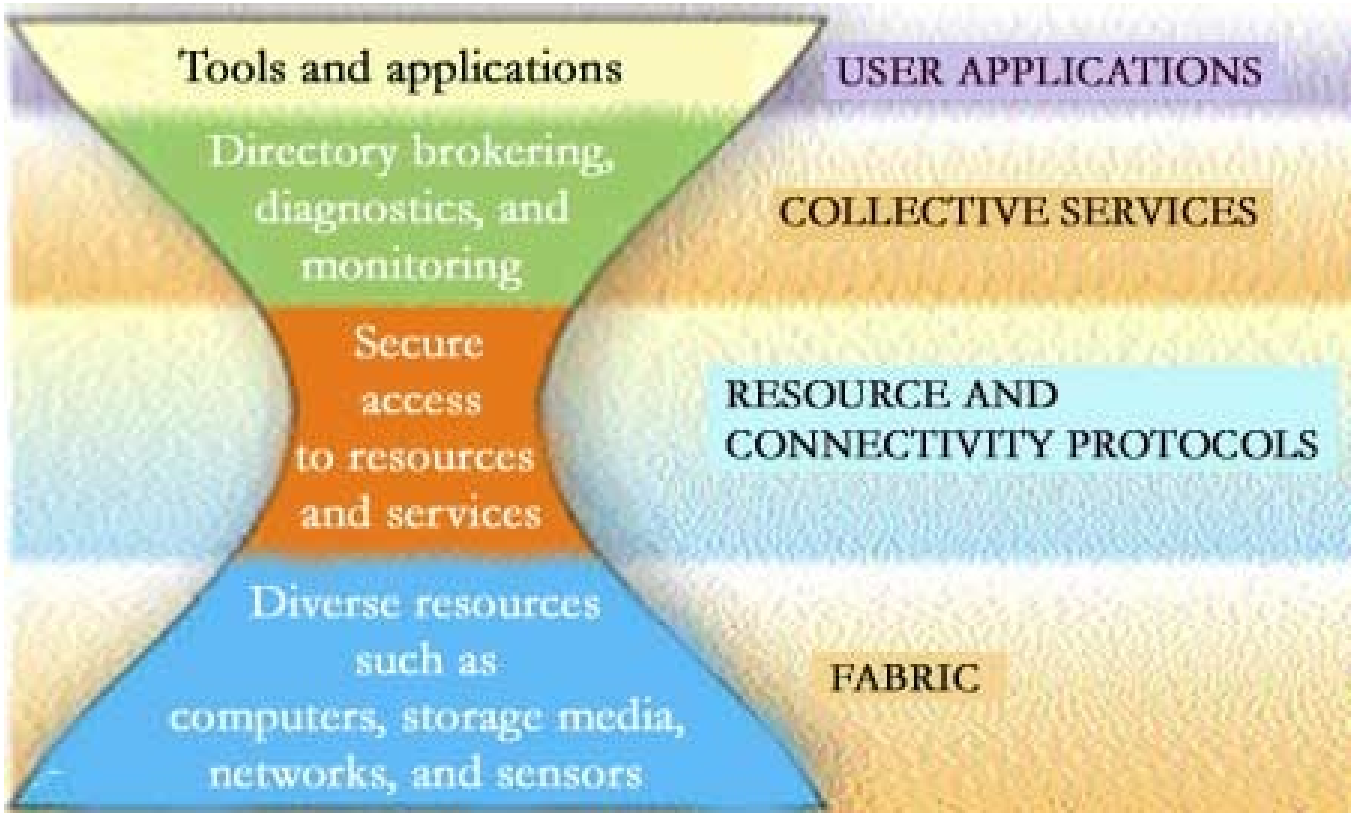
Grid Architecture



- **Fabric**
  physical infrastructure – computers, storage systems, networks, various sensors, ...

- **Middleware**
  - **Connectivity** – communication and authentication protocols, enable the exchange data between resources.
  - **Resource** – protocols enabling the secure initiation, monitoring and control of resource-sharing operations.

Grid Architecture



- **Collective services** – implement interactions across collections of resources - resource discovery and allocation, monitoring, diagnostics,...

- **Applications** and **Tools** – top layer, constructed on any other layer, and operating within a Virtual organization.

Gridifying Applications

A **grid application** – might proceed by:

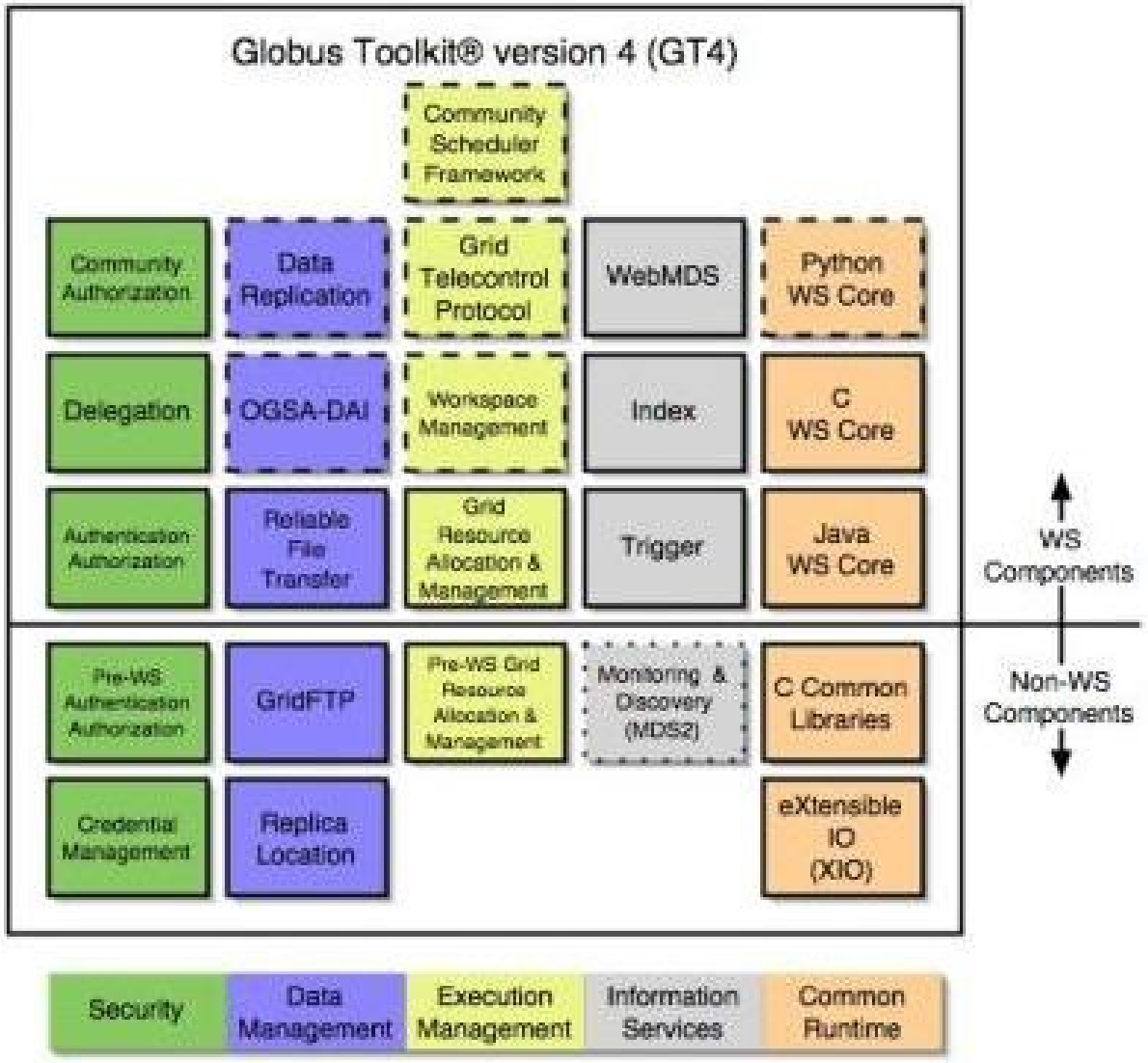
1. **Obtaining** authentication credentials.
2. **Querying** an information system to determine availability of resources.
3. **Submitting** requests to computers and networks to initiate computations, move data,...
4. **Monitoring** the progress of computations and data transfers.

Globus Toolkit 4 (GT4)

(Globus Alliance)

The software toolkit – a set of Grid infrastructure services and libraries that support programming grid-based applications and tools.

GT4 Architecture



GT4 Components

- **Security Tools** – establishing the identity of users or services, determining access rights, protecting communication.
- **Data Management** – location, transfer, and management of distributed data.
- **Execution Management** – initiation, monitoring, management, scheduling, and coordination of remote computations.

GT4 Components

- **Information Services** – Web services to monitor and discover resources and services on Grids.
- **Common Runtime** – several Web services, libraries and tools.

  Java WS Core implements specifications: WS-Addressing, WS-Notification, WS Resource Framework – generic infrastructure for modeling stateful resources using Web services.

Computational Problems

- Let's suppose we have a computational problem which is simply too complex to be executed on just one computer.
- What is to do?

Computational Categories

(from a computer scientist's point of view)

- General computational nature
  - degree of parallelism
  - granularity
- Computation-centric
- Data-centric
- Community-centric

Degree of parallelism

- If the computation problem can be split into many smaller sub-problems that can be worked on by different processor in parallel, then the computation can be speed up a lot by using many computer resources from across a business, a company or an academic institution.

Distributed Computing

- **Distributed computing**
  any system where many computing resources solve a problem together – this network of computers is used as a single, unified resource.

- **Grid computing**
  one species of distributed computing.

High-performance computing

- **fine-grained** parallel calculations – each sub-problem is highly dependent on results of other sub-problems.
  - big monolithic supercomputer
  - cluster of computers
  - very tightly coupled clusters of computers

- For development of such applications – **Message Passing Interface** (MPI) model is used.

High-throughput computing

- **coarse-grained** parallel calculations – each subproblem is independent of all others.
  - loosely coupled network of computers

- For development of such applications – high-level distributed programming models are applied: Web technologies, CORBA, workflow systems, MPICH-G2, ...

Grid computing

- A combination of fine-grained and coarse-grained parallel approaches.
  - loosely coupled network of computers and clusters of computers

- For development of such applications –
  - high-performance computing technologies
  - Web technologies
  - Grid technologies

Computational Problems

- **Computation-centric** problems
  the domain of high-performance computing and grid computing.
- **Data-centric (**data-intensive**)** problems
  the primary driving force behind the Grid; huge amounts of scientific data will be stored and analyzed in geographically distributed repositories, libraries and databases.
- **Community-centric** problems
  attempt to bring people and communities together for collaborations of various types.

Job Management

- Run an executable on a remote computer.
- Run a parallel program across multiple distributed computers.
- Run a set of loosely coupled tasks.
- Make a program available as a network service.

GT4 Job

represents a computational task (executables, scripts) which may perform input/output operations (staging of data) while running.

- A job may be parallel - multijob - a job that is itself composed of several executable jobs.
- A job can be described through an XML Schema Resource Specification Language (RSL).

Grid Resource Allocation and Management (GRAM) represents a basic mechanism for initiation, monitoring, management, and/or scheduling of remote computations.

- GRAM implementation is built on Web services technologies (WS GRAM).
- WS Resource Framework is used to implement distributed communications and service state.
- WS GRAM services provide a job submission to an optional local job schedulers: PBS, LSF, Condor.

WS GRAM

is based on a component architecture at both the protocol and software implementation levels.

- The job management with GRAM makes use of multiple types of services:
  - Job management services
  - Credential management services
  - File transfer services

WS GRAM Services

- **Job management services**
  represent, monitor and control the overall job life cycle.
- **Credential management services**
  are used to control the delegation of rights among distributed elements of the GRAM architecture on users' application requirements.
- **File transfer services**
  provides for reliable transfers of files between the compute resources and external data storage elements before and after the job execution.

Job Management Services

- Each submitted job is exposed as a distinct resource qualifying the generic ManagedJob service providing an interface to monitor the status of the job or to terminate the job.
- Each compute element is exposed as a distinct resource qualifying the ManagedJobFactory service providing an interface to create ManagedJob resources.

Job Management Client

- **globusrun-ws** – the official WS GRAM command line client for submitting and managing jobs to a local or remote host.

- The client provides a secure job submission for users who have the right to access a job hosting resource in a Grid environment.

The globusrun-ws client

- A job may be submitted by a job-command directly or by using a job-description file.
- Interactive and batch modes are supported with reattachment (recovery), and monitoring of jobs.
- Additional features are offered to
  - fetch job output files during the run
  - delegate credentials automatically
  - determine lifetime

Submitting a simple job (interactively)

- **globusrun-ws** -submit \
  -job-command /test/maxcut /test/adjmatrix.dat

Submitting job...Done

Job ID: uuid:n9a19984-55d7-...

Termination Time: 11/16/2006 12:59 GMT

Current Job State: Active

Current Job State: CleanUp

Current Job State: Done

Destroying job...Done

Submitting a simple job (in batch mode)

- **globusrun-ws** -submit -batch \
  -job-epr-output-file /test/maxcut.epr \
  -job-command /test/maxcut /test/adjmatrix.dat

- **globusrun-ws** -status \
  -job-epr-file /test/maxcut.epr

Submitting a simple job to a remote host

- **globusrun-ws** -submit \
  -factory https://remotehost:8443/wsrf/services/ManagedJobFactoryService \
  -job-command /test/maxcut /test/adjmatrix.dat

Submitting a simple job with job description

- **globusrun-ws** -submit \
  -job-description-file /test/maxcut_desc.xml

Job description file

```
<!-- maxcut_desc.xml -->
<job>
  <executable>/test/maxcut/</executable>
  <directory>/test</directory>
  <argument>adjmatrix.dat</argument>
  <stdout>stdout.maxcut</stdout>
  <stderr>stderr.maxcut</stderr>
</job>
```

http://www.eu-egee.org
http://www.ggf.org
http://www.globus.org
http://www.w3.org

Thank you for your attention.