Introduction to Grid Technology

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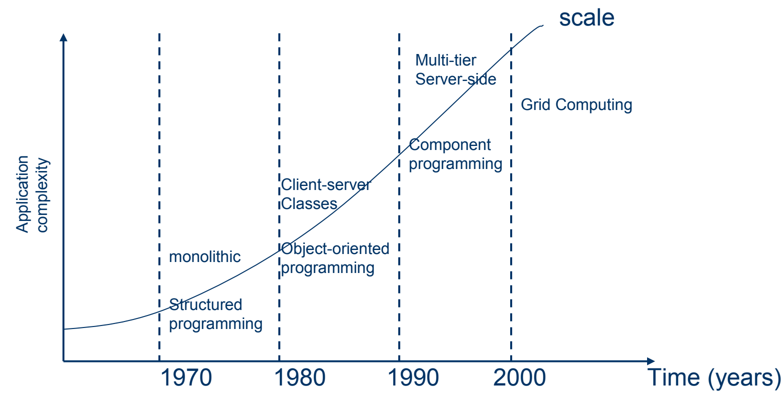
Arthur C Clarke's Laws (two of many)

"Any sufficiently advanced technology is indistinguishable from magic."

"The only way of discovering the limits of the possible is to venture a little way past them into the impossible."

Software Trends



Grid Technology

- Emerging enabling technology.
- Natural evolution of distributed systems and the Internet.
- Middleware supporting network of systems to facilitate sharing, standardization and openness.
- Infrastructure and application model dealing with sharing of compute cycles, data, storage and other resources.
- Promoted by NSF through its Network Middleware Initiative (NMI version 4).
- Publicized by prominent industries as on-demand computing, utility computing, etc.
- Move towards delivering “computing” to masses similar to other utilities (electricity and voice communication).
- Currently used for high performance computing however the trend is towards Service Oriented Applications (SOA).

Why Grid?

- What can the grid do that existing technology cannot do?
- Grid infrastructure and application architecture form a global computing framework facilitating sharing of resources and schedulability of jobs by matching their needs with available pool of compute and storage resources.
- Compute cycles can be tapped on demand from sources other then yours.
- Wasted cycles from idle sources can be utilized for use in needed application.
- Grid is molding computing into an utility similar to utilities we are used to: electricity and telephone.

Study of Grid Computing

- Components: Core, system defined and user defined
- Infrastructure
- Application model
- Standards
- Application Programming Interfaces
- Technology Support (enabling technologies)
- Job submission and associated functions
- Service creation and deployment and related functions

Introduction

- Two papers that give an overview of the components (anatomy) and the functionality (physiology) of the grid. These are:
  1. The Anatomy of a grid: Enabling Virtual Organizations by I. Foster et al.
  2. The Physiology of the Grid By I. Foster et al.
- We will discuss the "problem Space" that grid addresses.

Grid Technology Problem Space

- Grid technologies and infrastructures support the sharing and coordinated use of diverse resources in dynamic, distributed "virtual organizations".
- Grid technologies are distinct from technology trends such as **Internet, enterprise, distributed and peer-to-peer computing**. But these technologies can benefit from growing into the "problem space" addressed by grid technologies.

Virtual Organization: Problem Space

- **An industrial consortium formed to develop a feasibility study for a next generation supersonic aircraft undertakes a highly accurate multidisciplinary simulation of the entire aircraft.**
- **A crisis management teams responds to a chemical spill by using local weather and soil models to estimate the spread of the spill, planning and coordinating evacuation, notifying hospitals and so forth.**
- **Thousands of physicists come together to design, create, operate and analyze products by pooling together computing, storage, networking resources to create a Data Grid.**
- **A data grid + a compute grid to support cure/vaccine for SARS.**

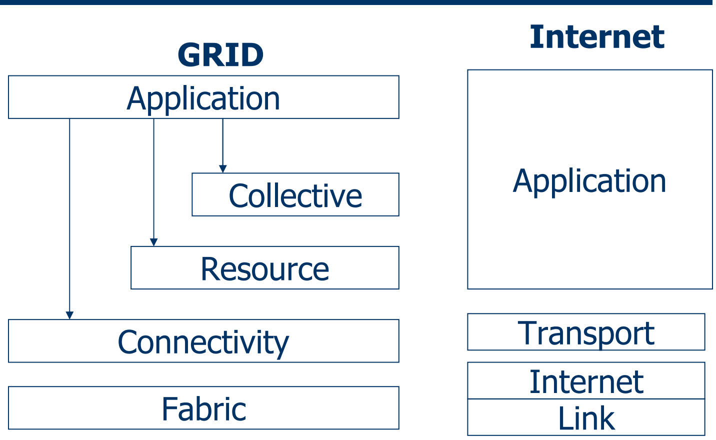
Resource Sharing Requirements

- Members should be trustful and trustworthy.
- Sharing is conditional.
- Should be secure.
- Sharing should be able to change dynamically over time.
- Need for discovery and registering of resources.
- Can be peer to peer or client/server.
- Same resource may be used in different ways.
- All these point to well defined architecture and protocols.

Grid Definition

- Architecture identifies the fundamental system components, specifies purpose and function of these components, and indicates how these components interact with each other.
- Grid architecture is a protocol architecture, with protocols defining the basic mechanisms by which VO users and resources negotiate , establish, manage and exploit sharing relationships.
- Grid architecture is also a services standards-based open architecture that facilitates extensibility, interoperability, portability and code sharing.
- API and Toolkits are also being developed.

Architecture



Fabric Layer

- Fabric layer: Provides the resources to which shared access is mediated by Grid protocols.
- Example: computational resources, storage systems, catalogs, network resources, and sensors.
- Fabric components implement local, resource specific operations.
- Richer fabric functionality enables more sophisticated sharing operations.
- Sample resources: computational resources, storage resources, network resources, code repositories, catalogs.

Connectivity Layer

- Communicating easily and securely.
- Connectivity layer defines the core communication and authentication protocols required for grid-specific network functions.
- This enables the exchange of data between fabric layer resources.
- Support for this layer is drawn from TCP/IP's IP, TCL and DNS layers.
- Authentication solutions: single sign on, etc.

Resources Layer

- Resource layer defines protocols, APIs, and SDKs for secure negotiations, initiation, monitoring control, accounting and payment of sharing operations on individual resources.
- Two protocols information protocol and management protocol define this layer.
- Information protocols are used to obtain the information about the structure and state of the resource, ex: configuration, current load and usage policy.
- Management protocols are used to negotiate access to the shared resource, specifying for example QoS, advanced reservation, etc.

Collective Layer

- Coordinating multiple resources.
- Contains protocols and services that capture interactions among a collection of resources.
- It supports a variety of sharing behaviors without placing new requirements on the resources being shared.
- Sample services: directory services, coallocation, brokering and scheduling services, data replication service, workload management services, collaboratory services.

Applications Layer

- These are user applications that operate within VO environment.
- Applications are constructed by calling upon services defined at any layer.
- Each of the layers are well defined using protocols, provide access to useful services.
- Well defined APIs also exist to work with these services.
- A toolkit Globus implements all these layers and supports grid application development.

Open Grid Services Architecture

- **Builds on concepts and technologies from the Grid and Web services communities.**
- **Defines a uniform exposed service semantics.**
  - **Defines standard mechanisms for creating, naming, and discovering transient grid service instance;**
  - **Provides location transparency and multiple protocol bindings**
  - **Supports integration with underlying native platform facilities.**
  - **Defines WSDL definition for creating sophisticated distributed system including lifetime management, change management, and notification. It also supports authentication, authorization, and delegation.**

An Open Grid-services Architecture

- Service orientation and virtualization:
  - A service is a network-enabled entity provides some capability.
  - Virtualization allows the composition of services to form lower-level resources.
  - WSDL allows for multiple bindings of a single interface, including distributed communication protocols.

Service Semantics

- **OGSA defines the semantics of a Grid Service instance: how it is created, how its lifetime is determined, how to communicate and so on.**
- **WSDL** is used to define **standard interfaces** that address discovery, dynamic service creation, lifetime management, notification, and manageability.
- **Transient services** along with the conventional persistence services. Example: video conferencing, where is QoS is important.
- **Upgradeability**: services within a complex distributed system must be independently upgradeable. Needs reliable service invocation and authentication.

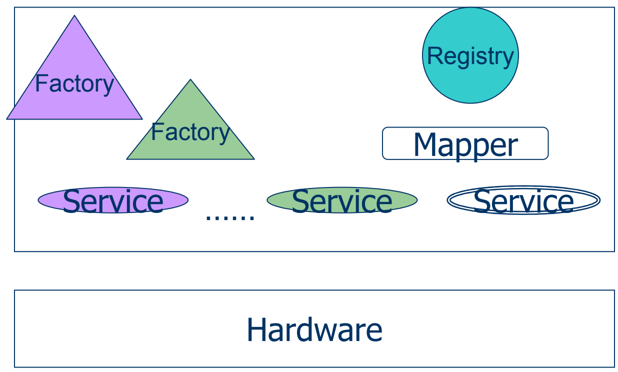
Building Virtual Organization

- Applications create transient services to discover and determine the properties of available services.
- OGSA's Factory, Registry, GridService, and HandleMap interfaces support the creation of transient service instances and the discovery of services associated with a VO.

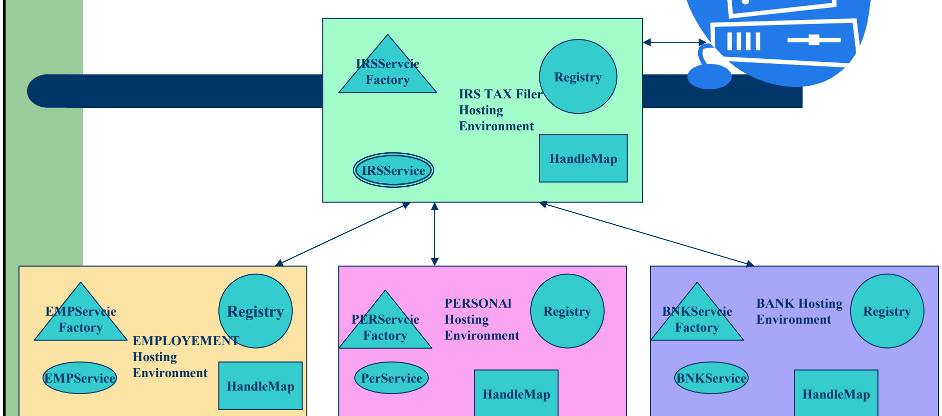
Possible Environments

- Simple hosting environment: Set of resources located within a single administrative domain.
  - Example: J2ee application server, MS's .net system, or a Linux cluster.
- Virtual Hosting environment: VO span heterogeneous, geographically distributed "hosting environments", a combinations several simple environments.
- Collective operations: A "virtual hosting environment" that provides VO participants with more sophisticated, virtual "collective" or "end-to-end" services.

VO Organization (notation introduced by Bina Ramamurthy)



Application: Tax Return Filer

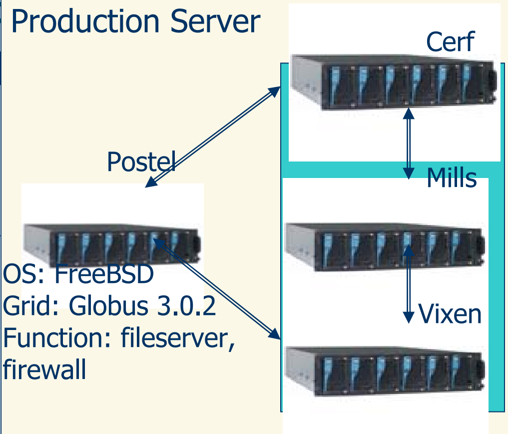


Concepts illustrated: Virtual organization (VO) called IRS/Tax Filer that brings together virtualized capabilities of physical organizations of banking, personal profiles, and employment. Grid service handle (GSH) and Grid service reference (GSR), registry and handlemap, discovery of services, index services, application of notification, logging.

CSELinux: Development Environment

OS: Solaris 8.0
Grid: Globus 3.0.2
Function:
Debug and test services

Production Server



OS: FreeBSD
Grid: Globus 3.0.2
Function: fileserver, firewall

OS: Red Hat Linux 9.2
Grid: Globus3.0.2
Function: Deploy services