Data Grid Management System

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Why do we need Data Grids?

• Seamless access to widely distributed data
• Sharing of data across security/administrative realms
• Large Data Scales – Millions of Files and PetaBytes
• Large-scale data movement & Access to multiple data sets
• Mediate access control across administrations
• Data Placement Strategies - Replication, Segmentation, Staging, Distributed Cache Management
• Distributed Computation & data stored beyond computation

Virtual Organization of Data, Resources, Users and Methods
Data Grids – An Analogy

- **Power Grid Analogy**
  - Multiple power generators
  - Complex transmission networks with switching
  - Simple Usage Interface – plug and play
  - Guaranteed Supply - Meeting of demands (peak and lull)
  - Complex cost function

- **Data Grid Architectures**
  - More than one data provider
  - Movement of data across computer networks
  - Seamless Access to Data with good ‘Finding Aids’
  - Guarantee of Data Access
  - Access Control, Authentication, Quotas & Complex Usage Costing
Case Study: Hayden Planetarium

- NCSA
  - SGI
  - 2.5 TB
  - UniTree
- CalTech
- UVa
- BIRN
- AMNH
  - NYC
- IBM SP2
  - GPFS
  - 7.5 TB
  - HPSS 7.5 TB
- rendering
- data simulation

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Data involved in Hayden

- **ISM = Interstellar Medium Simulation**
  - run by Mordecai Mac Low of AMNH at NCSA
  - 2.5 Terabytes sent from NCSA to SDSC.
  - Data stored in SRB (HPSS, GPFS).

- **Ionization**:
  - Simulation run at AMNH
  - 117 Gigabytes sent from AMNH to SDSC.
  - Data stored in SRB.

- **Star motion**:
  - Simulation run at AMNH by Ryan Wyatt
  - 38 Megabytes sent from AMNH to SDSC.

- **Rendering Movies**:
  - Intermediate Steps produced 7.5 Terabytes.
  - Data stored in SRB (SDSC, CalTech)
Data Grid Requirements

- Functional
- Logical
- Service-oriented
- Administrative
- Physical
Data Grid Requirements – 1

(Functional)

- Seamless Access
- Scale in Size & Number
- Guaranteed Delivery
  - Fault tolerance, load sharing
  - Replication, Consistency Maintenance
- Handle Heterogeniety & Multiplicity - Resource Abstraction
  - Platforms & systems, vendors, types of storage, types of services, types of processes & users
- Controlled Data Movement - Grid Management
  - Demand-driven Data placement
  - Caching, archiving, version and locks
  - Third-party data movement
  - Parallel data transfer
- Server-driven or client-controlled
Data Grid Requirements –2
(Logical)

- Handle Autonomous Authentication - User Abstraction
  - Multiple Authentication Realms – single sign-on
  - Uniform user name space
- Single Point Authorization & Access Control - User Abstraction
  - Seamless authorization for distributed data
  - Roles, Tickets, Rules – inheritance & longevity
- Virtual Data Organization - Collection Abstraction
  - Data Location Independence
  - Uniform data name space, persistent identifiers
  - Collections Hierarchy
- Integrate with Metadata - Access Abstraction
  - ‘finding aids’ – complex querying & browsing
  - System, user-defined, domain-specific, application
  - Access Control for Metadata
Data Grid Requirements –3

(Service-oriented)

- **Data Services**
  - Third party services
  - Web-accessibility (HTTP GET, WSDL, SOAP)
  - Language API
  - Computational Grid Interaction - Globus
  - Examples
    - Ingestion, Certification and Authenticity
    - Value-added integration

- **Server-side Operations**
  - Close-to-data
  - Proxy-operation (security/access considerations)
  - Bulk Operations - batch
  - JIT operations – interactive or on-demand
  - Seamless Chaining and Composition
  - Examples
    - Data Filtering – Eg. Data Cutter
    - Format Conversion – Eg. Thumbnail creation
    - Metadata Extraction
Data Grid Requirements -4
(Administrative)

- Virtual Administration - Administration Abstraction
  - Single-point administration
  - Autonomous local control
  - Multiple-levels of administrations –
    - Roles and Responsibilities
  - Policy Management
    - Distributed Caching, Archiving, Replication & Data Placement
    - Locking, Pinning, Back Up
    - Data Movement
    - Preferences, Priorities Administration
    - Auditing, Quotas, Pricing
Data Grid Requirements – 5
(Physical)

- **Storage**
  - Hierarchical Storage Systems, Tapes, Disks, SAN, NAS, NFS, Databases, FTP servers, HTTP servers, WSDL services, …
  - Integration on Device Characteristics
  - Storage Bricks
    - Distributed Cluster Storage

- **Network**
  - Characteristics
  - NWS
  - Guaranteed Service
SRB – A Data Grid Solution

- The Storage Resource Broker is a Middleware
- It provides uniform access to data in heterogeneous resources
- It uses a MetaCatalog to facilitate the brokering

SRB Server

Application

MCAT

Distributed Storage Resources
(database systems, archival storage systems, file systems, ftp, http, …)

HRM, DB2, Oracle, Illustra, ObjectStore, HPSS, ADSM, UniTree UNIX, NTFS, HTTP, FTP
SRB Concepts

• Abstraction of Data and Collections – Virtual Data Organization
  – Virtual Collections: Persistent Identifier and Global Name Space
  – Organization independent of physical location

• Virtual Data Management
  – Replication & Segmentation
  – Data Aggregation: Containers
  – Seamless Cache Management and Data Placement

• Metadata & Data Discovery – semantic linking
  – System Metadata - metadata needed to run a data grid
  – User-defined Metadata – Structural & Descriptive
  – Application, Schema-based, Domain-centric
  – extensible and dynamic
  – Attribute-based Access (path names become irrelevant)
SRB Concepts

• Abstraction of User Space – Global User Space
  – Single sign-on & Seamless Authorization
  – Certificates, (secure) passwords, tickets, group permissions, roles

• Abstraction of Methods
  – APIs, Command Line, GUI Browsers, Web-Access (Portal, WSDL, CGI)
  – Parallel Access with both Client and Server-driven strategies
  – Fault-tolerant and Reliable data management and
  – Proxy and Remote Operations

• Abstraction of Resources - Resource Virtualization
  – Resource Location, Type & Access transparency
  – Logical Resource Definitions – bundling
SRB Collections

- **Digital Libraries**
  - UCB, Umich, UCSB, Stanford, CDL
  - NSF NSDL - UCAR / DLESE

- **Medicine**
  - Digital Embryo (NLM)

- **Earth System Sciences**
  - ESIPS

- **Persistent Archives**
  - NARA
  - LOC

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Overview of the NSDL Architecture

NSDL Metadatat Repository

Users

Portals

HTTP

SDLIP

OAI Harvest

Gathering

Direct Entry

OAI Harvest

Services

Search and Discovery

Rights Management

Services

Collections

Metadata

Resources

HTTP

HTTP
SRB Collections

- NASA Information Power Grid
- DOE ASCI Data Visualization Corridor
- Astronomy
  - National Virtual Observatory
  - 2MASS Project (2 Micron All Sky Survey)
- Particle Physics
  - Particle Physics Data Grid (DOE)
  - GriPhyN
  - SLAC Synchrotron Data Repository
- Earth Systems Sciences
  - LTER
- Neuro Science & Molecular Science
  - TeleScience/NCMIR, Brain Images
  - SLAC, AfCS, …