



**NORDUGRID**

*Grid Solution for Wide Area  
Computing and Data Handling*

# **Grid Architecture: Nordugrid Experience**

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# The Grid Idea

- A user should be able to submit a computing job to the “grid” and get the result back without caring about where the job is being executed
- Such a computational grid would use many computer resources distributed over a large area
- The term “grid” originates from the analogy with the electrical power grid, where consumers plug their machines to the outlets and don’t need to care about where the electricity is being produced

# Why Grids?

- Uniform access to many resources — easier to use.
- No need to remember different usernames and passwords for different sites
- Automatic search for resources that satisfy the requested criteria
- More efficient use of available resources

# What is NorduGrid?

- NorduGrid – the project
  - The original NorduGrid project 2001–2002
  - Aim: enable grid in the Nordic countries
  - No production quality middleware available at the time
    - Decision to develop the NorduGrid middleware, later to be known by the name ARC (*Advanced Resource Connector*).
- NorduGrid – the middleware (*ARC*)
- NorduGrid – the research collaboration
  - The successor of the original project
  - Committed to the maintenance and continued development of ARC

- A Grid based on the ARC middleware
  - One of the world's largest production level grids
- Close cooperation with other grid projects:
  - EU DataGrid (2001-2003)
  - SweGrid, DCGC ...
  - NDGF
  - LCG
  - EGEE



# ARC Functionality

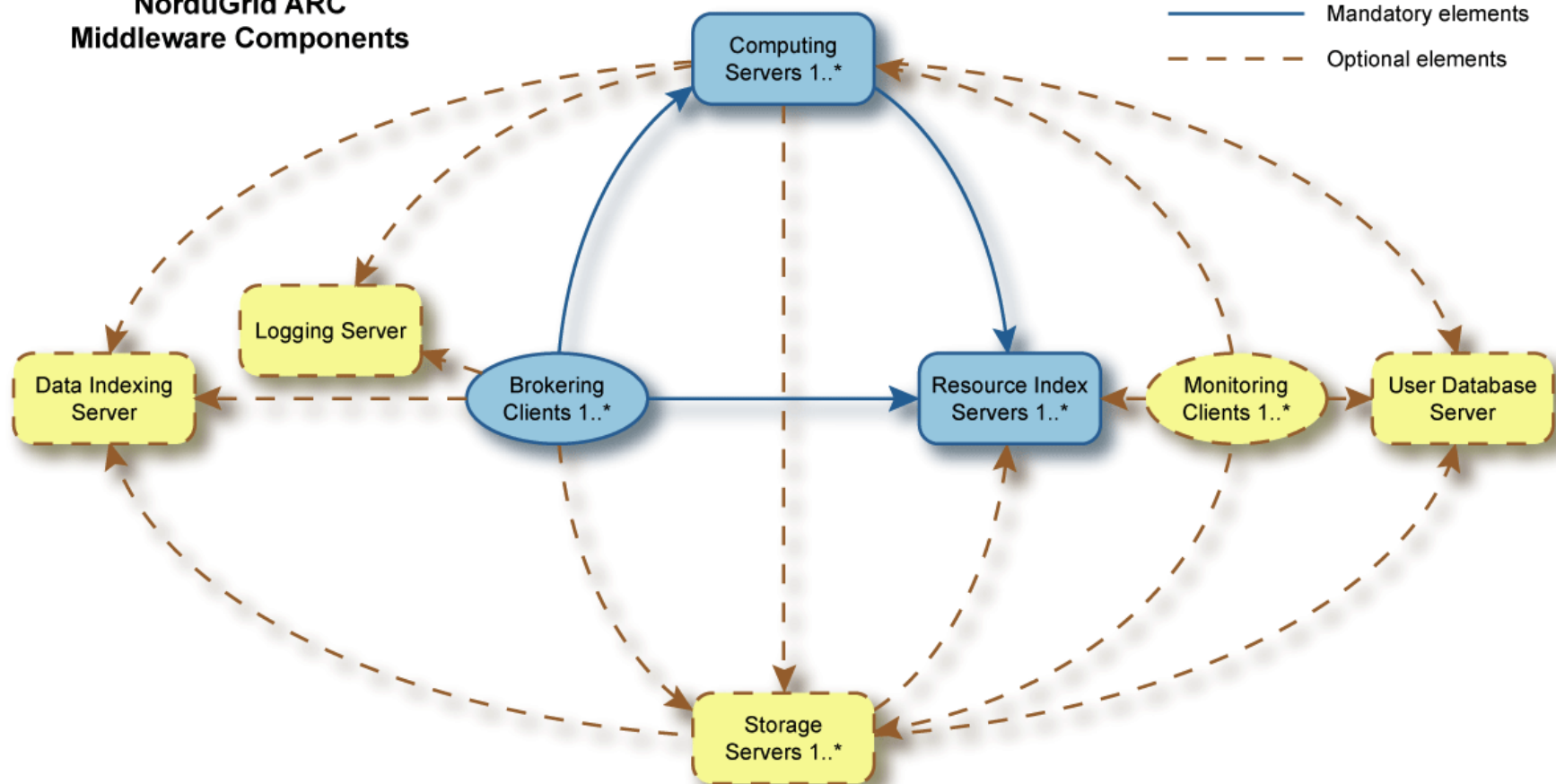
- Single sign-on to a heterogeneous distributed set of computing and storage resources
  - based on Globus Security Infrastructure (GSI)
- Up-to-date information about available resources
- Automatic match making (resource brokering)
- Job monitoring
- Input and output data movement

# Features

- Light-weight and non-intrusive
  - resource owners retain full control
  - services can be installed on an existing cluster installation
  - cluster don't have to be dedicated
- Portable
  - pre-compiled binaries for many Linux distributions
- Client easy to install for new users
  - available from <http://ftp.nordugrid.org/>

# The ARC Middleware Architecture

**NorduGrid ARC  
Middleware Components**



# Architecture key points

- Each resource has a frontend
  - Authenticates users, interprets tasks, interacts with LRMS, publishes information, moves data
  - Resources are grid enabled by the ARC layer deployed on the frontend, no middleware components behind the frontend
- Each user can have an independent lightweight brokering client (or many)
  - Resource discovery, matchmaking, job submission and manipulation, monitoring
- Grid topology is achieved by an hierarchical, multi-rooted set of indexing services
- Monitoring relies entirely on the information system

# Computing Nodes



The computing resources are computer clusters or pools of workstations managed by a local resource management system (LRMS)

The front-end node runs a gridftp server for the communication with the clients and a grid manager that keeps track of the jobs running on behalf of the grid users

- Accepts job requests and forwards them to the LRMS
- Performs most data movement (stage in and out), cache management
- Interacts with file index servers
- Manages user work area
- Performs all kinds of job management upon client request

# Information Servers



All resources have a local information server that gathers system and job information  
The local information servers register themselves in information index servers information servers

The information index servers register to other information index servers thereby forming a hierarchical structure

- Since each information server can register to more than one index server there is redundancy in the system
- The top level in this structure is duplicated many times in order to avoid a single point of failure in the system

# User Interface



The original client is a command line interface

There are also other clients like web based portals and graphical user interfaces

The clients do

- resource discovery by querying the information servers
- matches the requirements specified by the user to the capabilities published by the resources
- and finally submits the job to a resource that fulfills the user's requirements

# Storage Elements



The grid-manager can interact with many types of storage servers: ftp, gridftp, http, https, ...

The most common kind of storage is a gridftp server

- The ARC gridftp server can be configured either as a plain gridftp server or as a gridftp server with GACL (grid access control list) support

There is also the so called smart storage element (SSE)

- web serviced based with support for automatic registrations in file index servers

# Data Management



ARC supports two different file index servers: the replica catalog (RC) and the replica location service (RLS)

- The file index servers are used to register the location of data files
- keeps track of replicas (copies of files)
  - can be used to register cached files on the computing nodes to facilitate resource brokering
  - in a user's job description an input or output file location can be specified as a file index service registration rather than a storage server location

# The Grid Monitor



Grid Monitor - Mozilla Firefox

http://www.nordugrid.org/monitor/

2005-03-15 CET 15:25:09

Processes:  Grid  Local

Country	Site	CPU's	Load (processes: Grid+local)	Queueing
Australia	Alfred (UniMelb)	54	0+42 (queue down)	14+0
	Charm (UniMelb)	16	0+0 (queue down)	0+0
Denmark	Aalborg Grid Gateway	45	45+0	172+0
	ARC@ HOME (NBI)	0		0+0
	DistLab (DIKU)	6	4+1	0+0
	HEPAX1	1	0+0	0+0
	Horseshoe (DCSC/SDU)	1121	0+861	1545+641
	LSCF (NBI)	20	10+0	215+0
Estonia	Morpheus	19	15+0	55+0
	Niflheim (DCSC/DTU)	913	0+980	15+43
	CMS Athlon64 cluster	14	0+1	0+0
	CMS Production server	5	0+0	0+0
	EENet Kriit	6	4+0	8+0
	UT Chemistry	29	0+16	0+0
	UT CS Antarctica Clus>	20	6+0	13+0
	UT DP/ITech/IPhys Ear>	12	2+2	2+0
Finland	UT IMCB Anakonda clus>	16	16+0	3+0
	UT Physics Cluster	13	0+12	18+0
	UT TI DOUG Cluster	2	0+0	0+0
	Alpha (HIP)	1	0+0	0+0
Germany	Mill (Physicum)	58	0+1	0+0
	Testbed0 (HIP)	1	0+0 (queue down)	0+0
	FZK Cluster	1068	0+816	4+536
Lithuania	PZR Uni Rostock	3	0+0	0+0
	BGM@KTU IA-64 Cluster	6	0+0	0+0
Norway	BGM@VGTU IA-64 Cluster	10	0+0	0+0
	Bergen Grid Cluster	7	0+0	1+0
	Oslo Grid Cluster	38	14+8	72+1
Russia	Parallab IBM Cluster	50	0+22	0+0
	Uio Grid	68	28+37	48+73
	Test SPbSU cluster	1	0+0	0+0
Slovakia	The SPbSU First Clust>	1	0+0	0+0
	UPJS ALICE Grid	1	1+0	0+0
Slovenia	UPJS Grid	1	0+0	0+0
	SIGNET	42	1+24	11+0
Sri Lanka	SweLanka LK	2	0+0	0+0
	Beppe (SweGrid PDC KT>	97	93+0	449+1
	Hagrid (SweGrid, Uppm>	100	90+0	1202+0
	Hive (Swegrid, UNICC)	101	101+0	353+0
	Ingrid (SweGrid,HPCZN)	96	67+29	51+33

The ARC grid monitor can be found at <http://www.nordugrid.org/monitor/>

# Future Developments

- New client libraries (arclib) will facilitate the creation of customized clients
- More data management tools – automatic scheduled replication
- Interoperability with other grid solutions

# Summary

- This has been the “grand tour” of the ARC middleware
- More details about ARC and its components can be found on the NorduGrid web site  
<http://www.nordugrid.org/>