Grid Computing on the NorduGrid Testbed: Tutorial

Balázs Kónya, Lund University

Linux Clusters for Super Computing

Linköping, 23-25 October 2002

Nordic Testbed for Wide Area Computing and Data Handling

outline

- 15:15-16:00 Introduction to Gridcomputing
- 16:00-16:15 Installation coffee break
- 16:15-16:30 Logging into the Grid: dealing with certificates
- 16:30-17:00 NorduGrid Testbed overview: architecture, Grid services
- 17:00-17:50 Living on the NorduGrid
  - overview of a Grid session
  - what is on the Grid?: resource discovery (MDS)
  - the “Hello Grid” job

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outline cont.

- the command line UI & Broker: ng commands
- formulating a Grid job request: the eXtended Resource Specification Language (XRSL)
  - exercises
- data access on the Grid: the notion of replicas

17:50-18:00 Summary, Future Plans

for the impatient:) www.nordugrid.org/documents/ngclient-install.html

Introduction to Grid Computing

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What is the Grid?

- Grid is a technology to share and seamlessly access resources of the world:
  - computing cycles
  - datasets,
  - software,
  - special instruments
- the Holy Grail of distributed computing
- Middleware: a bag of software which implements Grid Standards & protocols
- World Wide Web access to information

- World Wide Grid access to computing capacity and ...

What is the Grid?

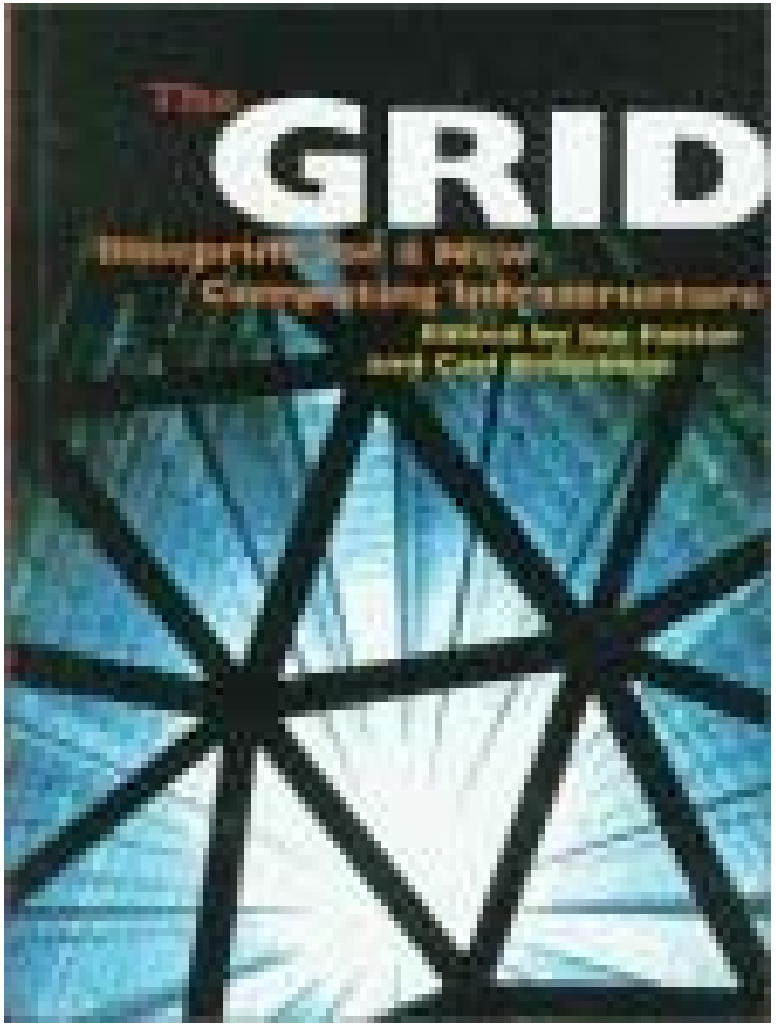
- The future infrastructure of computing and data management
- The Computational Power Grid
- a very ambitious attempt to create a new utility, next to the already existing water, heating, electricity, ...
- the present hype in IT

source: IBM

History

- Grand Scientific Challenges of the 80's
  - parallel computation
  - high performance & high throughput computing
- Early ”Testbeds” in the USA connected supercomputing centers at the late 90's
- Ian Foster, Carl Kesselman, July, 1998:

  Blueprint for a new Computing Infrastructure



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History cont.

- The Computational Grid <-> Power Grid analogy was suggested
- The birth of the ”ancient” middleware solutions
  - Globus, Legion, Condor, NWS, SRB, NetSolve, AppLes,Unicore
  - “demonstration quality Testbeds: Gusto” no real users
  - loose of interest in Grids
- 2000+: The Grid revives and gets “Global”
  - The High Energy Physics community picks up the nearly forgotten Grid idea
  - The appearance of the Global Grid Forum
  - de facto standard middleware: Globus
- the “Grid phenomena” or hype is started
  - Grid Projects are launched everywhere, governments & research agencies rush to support Grid project

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History cont.

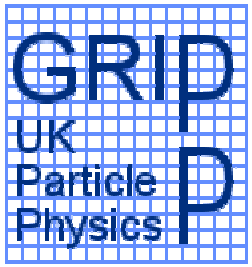
- Huge commercial interest: startup companies & the Big Names try to sell the Grid
  - IBM wants to Grid-enable the company's entire product portfolio
  - commercial Grid software (IBM, Platform Computing, SUN)
    - commercial support, consulting, training
  - seriuos research projects (mainly biology) among the customers
- last Global Grid Forum meeting in Edinburgh July, 2002:
  - over 850 participants
  - Key speakers involved: IBM, Nec, Hewlet Packard, Microsoft, SUN
- Daily Grid magazines: www.thegridreport.com, www.gridtoday.com, www.gridcomputingplanet.com

GRID today

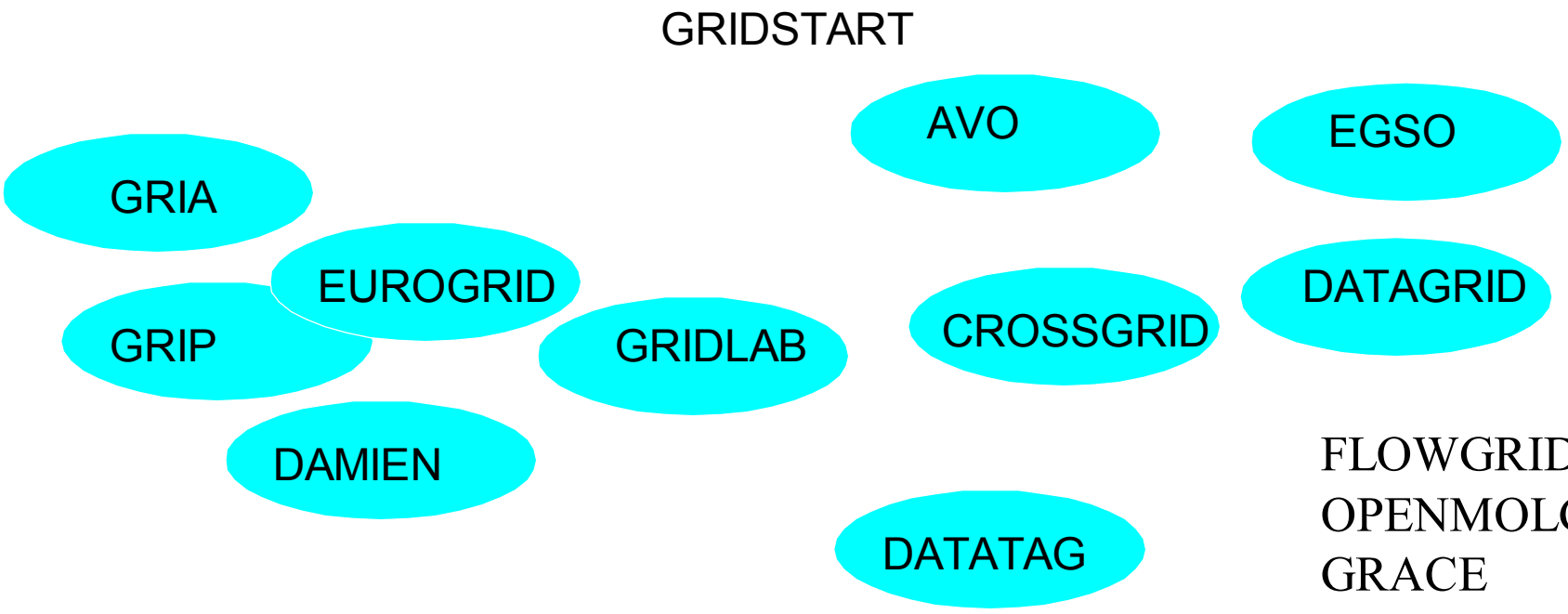
The Grid Report
the state of grid computing

- Everything is called Grid, the word "Grid" is inflated to a marketing term
- the divergence of Grid Toolkits and solutions

European projects

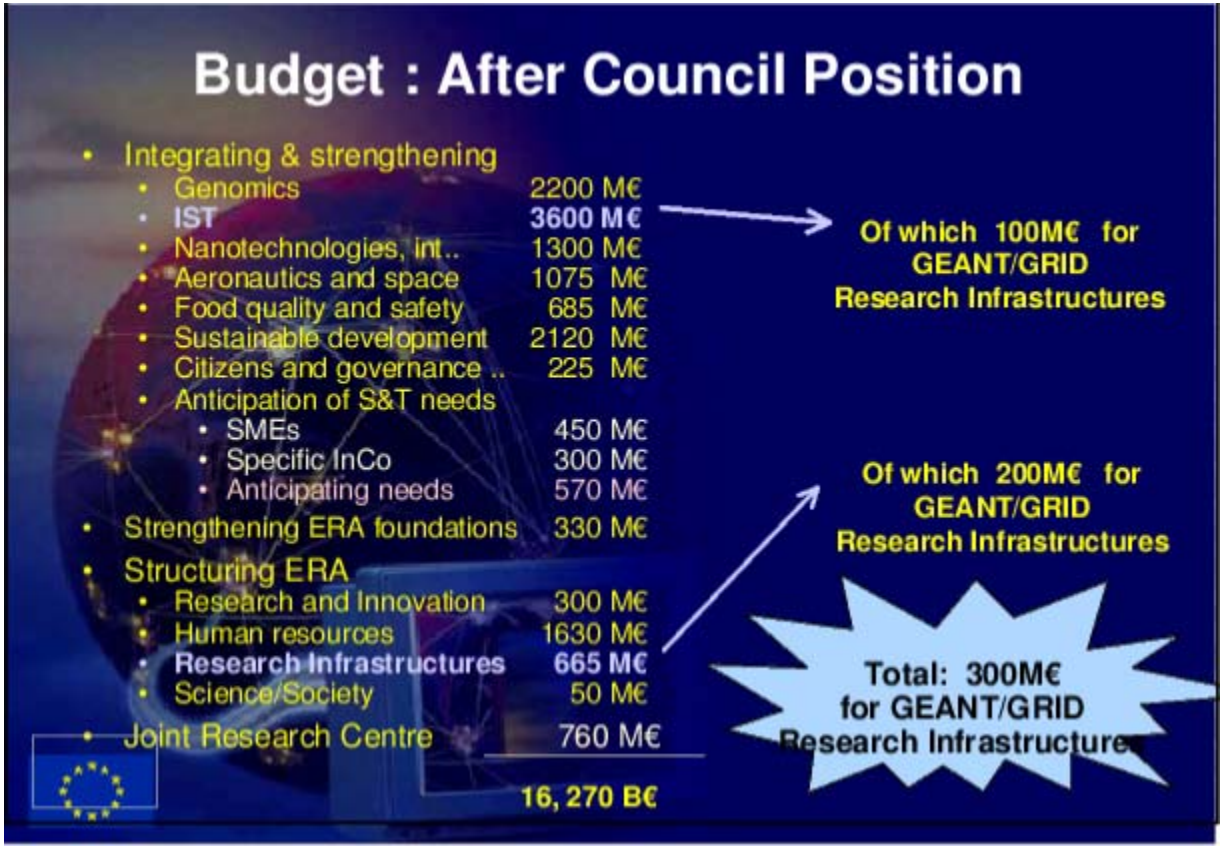


Current EU founded projects



FLOWGRID
OPENMOLGRID
GRACE
COG
MOSES
GEMSS
BIOGRID
SELENE
MAMMOGRID

EU FP6


Budget : After Council Position
Integrating & strengthening
Genomics 2200 M€
IST 3600 M€
Nanotechnologies, int.. 1300 M€
Aeronautics and space 1075 M€
Food quality and safety 685 M€
Sustainable development 2120 M€
Citizens and governance .. 225 M€
Anticipation of S&T needs
SMEs 450 M€
Specific InCo 300 M€
Anticipating needs 570 M€
Strengthening ERA foundations 330 M€
Structuring ERA
Research and Innovation 300 M€
Human resources 1630 M€
Research Infrastructures 665 M€
Science/Society 50 M€
Joint Research Centre 760 M€
16, 270 B€
Of which 100M€ for GEANT/GRID Research Infrastructures
Of which 200M€ for GEANT/GRID Research Infrastructures
Total: 300M€ for GEANT/GRID Research Infrastructure

USA projects

DISCOM

SinRG

APGrid

IPG …

the globus project
www.globus.org

NEESgrid

iVDgL

GriPhyN
Data Intensive Science

United States virtual observatory

SDSC TERAGRID
NSF PACI

SDSC
SRB
Storage Resource Broker

GrADS
Grid Application Development Software Project

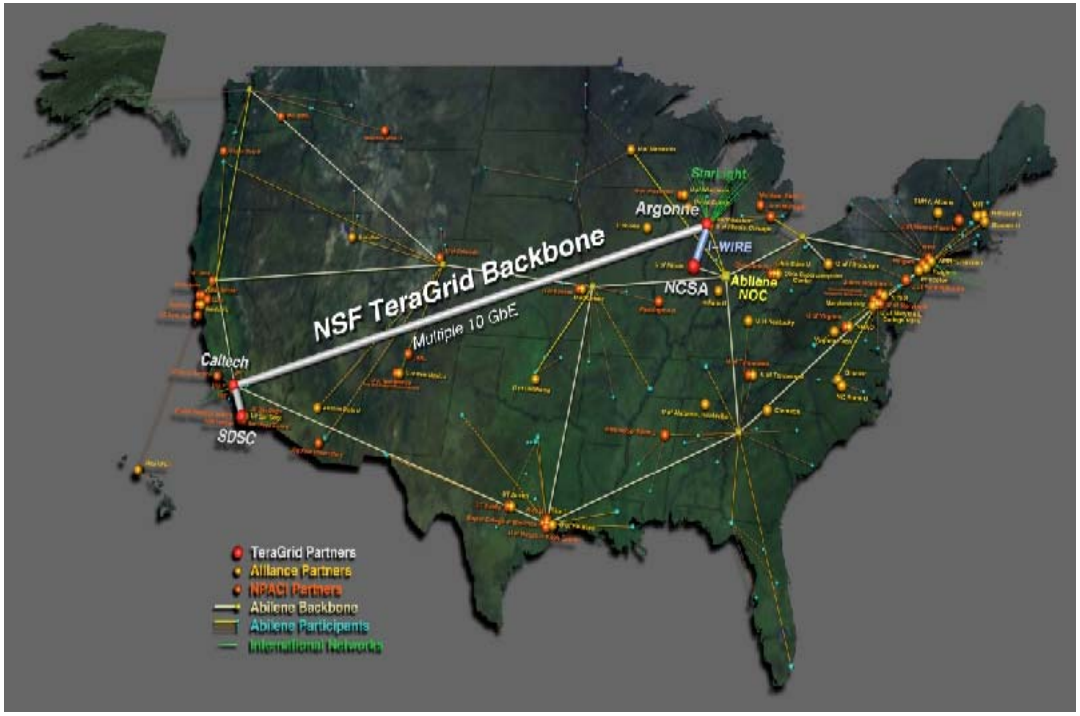
Network Weather Service

LEGION
Worldwide Virtual Computer
e pluribus unum: one out of many

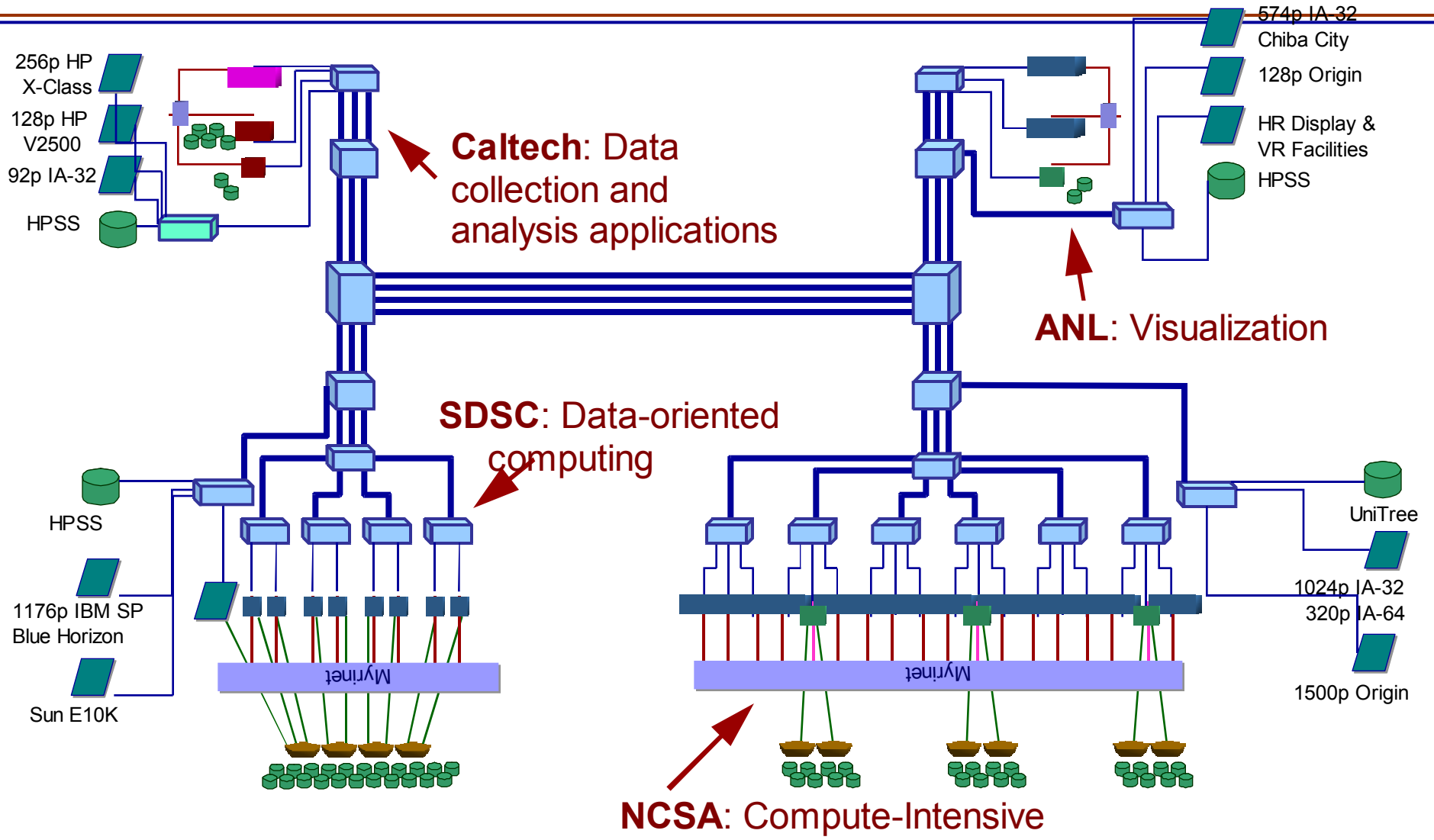
Condor
High Throughput Computing

TeraGrid

- 53 million from the NSF
- 13.6 teraflops of Linux clusters
- 450 terabytes of data storage
- 4 sites
- 40 Gbits/sec (later 50-80) network connections
- Globus based Grid toolkits
- Visualisation environment



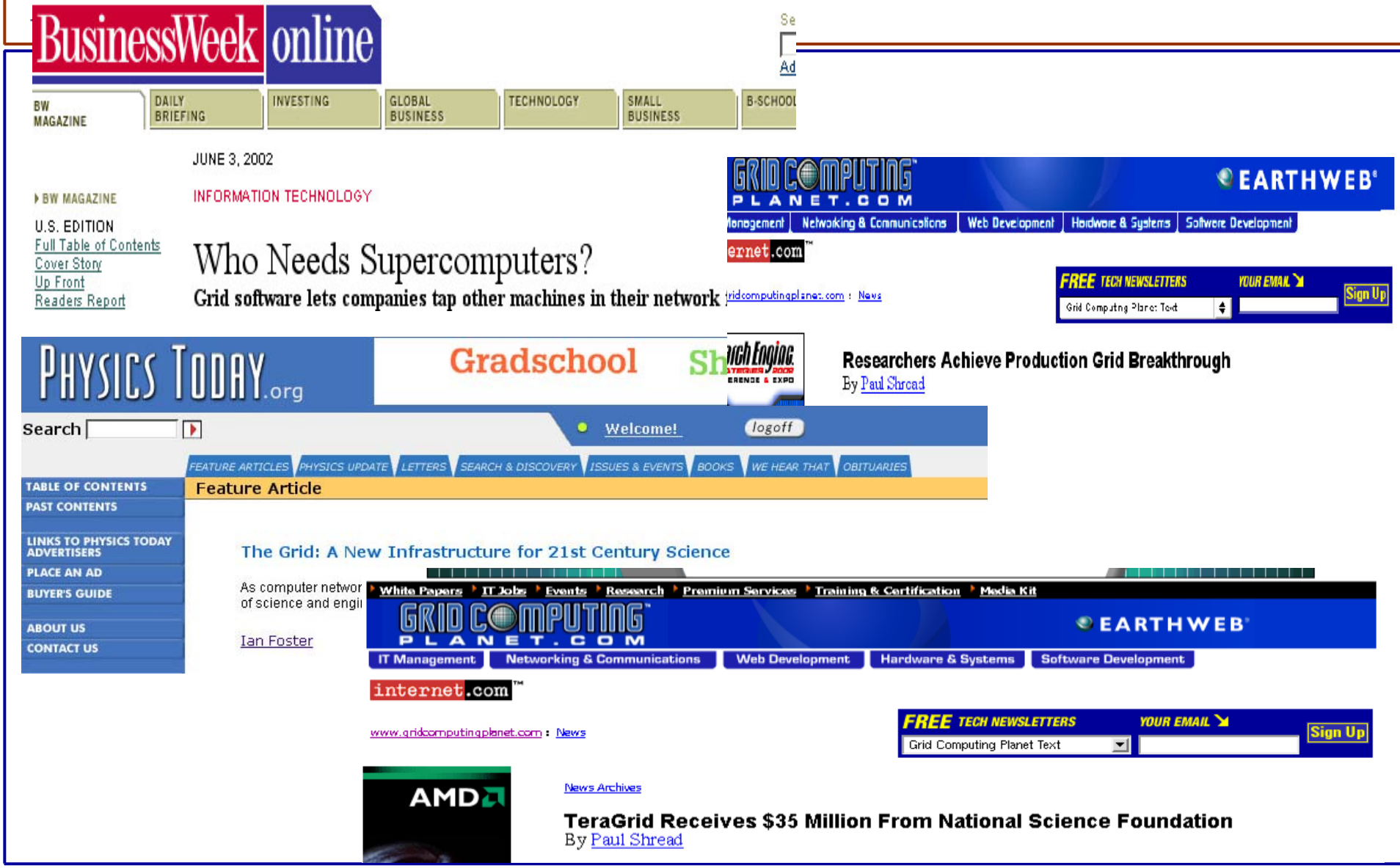
TeraGrid


574p IA-32
Chiba City
128p Origin
HR Display &
VR Facilities
HPSS
256p HP
X-Class
128p HP
V2500
92p IA-32
HPSS
Caltech: Data collection and analysis applications
ANL: Visualization
SDSC: Data-oriented computing
HPSS
1176p IBM SP
Blue Horizon
Sun E10K
Myrinet
Myrinet
UniTree
1024p IA-32
320p IA-64
1500p Origin
NCSA: Compute-Intensive

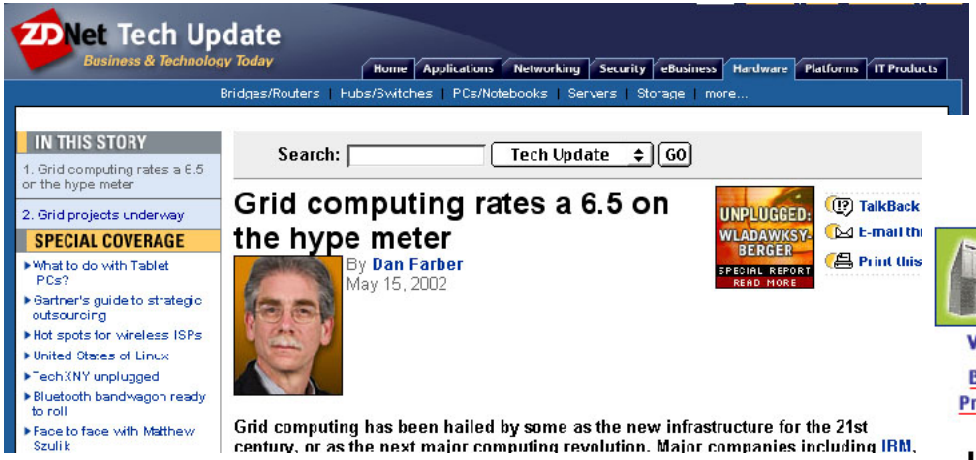
Asia Pacific Projects

Japan: AIST GTRC
China: SDG
Korean Grid
Thailand:ThaiGrid
Australia: GRIDSLab

Grid in the NEWS



Grid in the NEWS



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IN THIS STORY

1. Grid computing rates a 6.5 on the hype meter
2. Grid projects underway

SPECIAL COVERAGE

- What to do with Tablet PCs?
- Gartner's guide to strategic outsourcing
- Hot spots for wireless ISPs
- United States of Linux
- TechXNY unplugged
- Bluetooth bandwagon ready to roll
- Face to face with Matthew Szulik

Search: Tech Update GO

Grid computing rates a 6.5 on the hype meter

By Dan Farber
May 15, 2002

UNPLUGGED: WLADAWKSY-BERGER SPECIAL REPORT READ MORE

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Grid computing has been hailed by some as the new infrastructure for the 21st century, or as the next major computing revolution. Major companies including IBM,

NetworkMagazine.com

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Insanely Overhyped Technology of the Month-Grid Computing

Distributing executable processing capacity across thousands or millions of CPUs isn't the right approach for most of the problems that computers solve.

by Steve Steinke, Editor-in-Chief

Network Magazine
05/06/02. 12:52 p.m. ET

Utilities

BUILDING GRIDS: HYPE MEETS REALITY

The senior executives from Compaq (now part of the new HP), Platform Computing and renowned analysts from IDC invite you to attend an Exclusive Executive event on Grid Computing.

Vision...

- Cohen Communication Group:
  - Grid computing will be the driving force behind the 150% annual internet traffic expansion in 2005
  - in contrast to the 60% predicted growth rate accounted mainly for video streaming and video file transfer forecasted by McKinsey - JP Morgan
- IBM:
  - Grid is the next utility in the line of the water, drainage, gas and electricity systems
  - people will pay their “computing bills”

Nordic Testbed for Wide Area Computing and Data Handling

Oversold?

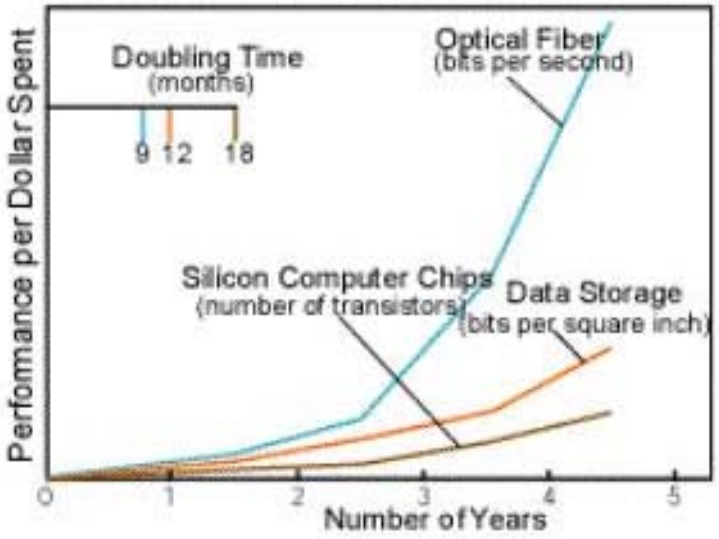
- The promise of the Grid has been not oversold but the difficulty of developing the necessary Grid infrastructure has been underestimated

Ian Foster:

- People used to overestimate the short term impact of change but underestimate the long-term effect

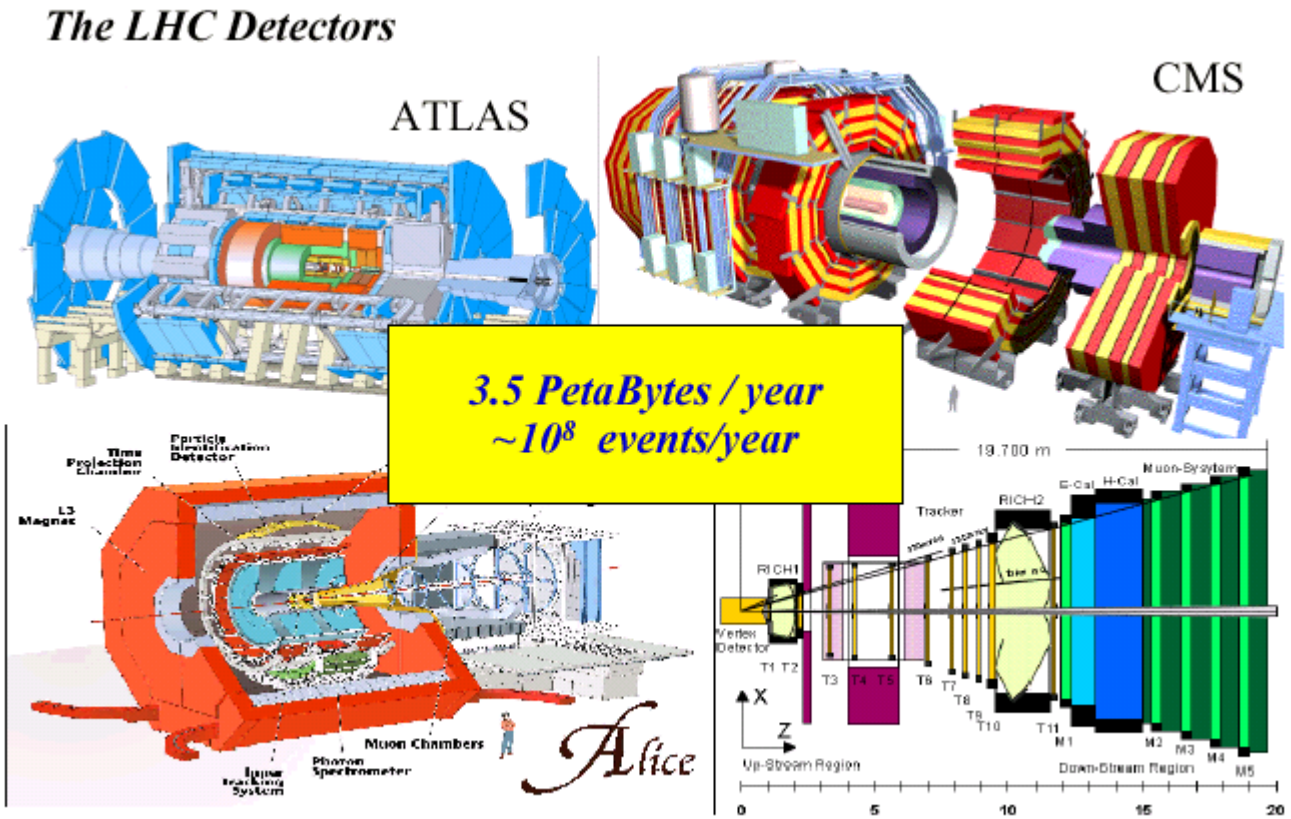
what is behind?

- Powerful PCs are everywhere
- Clusters are commodity
- Network & Storage & Computing exponentials:
  - Networking speed grows faster than computing power
  - Even data storage outperforms the CPUs



source: Scientific American, Jan 2001

The physicist's real challenge:



Nordic Testbed for Wide Area Computing and Data Handling

there are already ...

Walmart Inventory Control

- Satellite technology used to track every item
- Bar code information sent to remote data
- Inventory adjusted in real time to avoid shortages and predict demand
- Data management, prediction, real-time, wide-area synchronization

SETI@HOME

- 3.8M users in 226 countries
- 1200 CPU years/day
- 1.7 ZETAflop over last 3 years (10^21)
- 38 TF sustained performance

  (Japanese Earth Simulator is 40 TF peak)
- Highly heterogeneous: >77 *different* processor types

... distributed applications

Everquest

- 45 communal “world servers” (26 high-end PCs per server) supporting 430,000 players
- Real-time interaction, individualized database management, back channel communication between players

Napster, Gnutella, Kazaa, etc...

- file sharing
- ask the music industry :)

KaZaA

Google

- database, search engine
- more than 150 million searches per day, 2 billion indexed pages, more than 10.000 linux servers

Google™

Nordic Testbed for Wide Area Computing and Data Handling

there should be a Grid ...

- Existing real world examples demonstrate that it is technically, commercially, and economically viable to deploy robust, large-scale distributed applications
- The Grid
  - will extend those distributed applications
  - should accelerate the progress of distributed applications
  - will use common interfaces
  - will be based upon well-defined protocols & standards
  - will offer scalable Grid services for applications

Nordic Testbed for Wide Area Computing and Data Handling

where we are now?

- lots of theoretical papers
  - *The anatomy of the Grid:Enabling Scalable virtual organizations*, I.Foster et.al.
  - *The Physiology of the Grid: An Open Grid Services Architecture for Distributed System Integration*, I.Foster,C.Kesselman, et. al.
  - *The patology of the Grids*, ???
- non-existing (very few) TestBeds:
  - they are incompatible,
  - Difficult to get access to them
  - very expensive to maintain
- non existing standards (GGF has not produced anything yet)
- “de facto standard” middleware is rather limited in functionality
- diverging solutions
- huge amount of (overlapping) projects
- we are living in the Grid hype era

Nordic Testbed for Wide Area Computing and Data Handling

not even (hardly) addressed:

- political issues
- heterogeneity
- Grid-based authorization
- Grid schedulling
- Program development environments
- Debugging, compiling, performance tuning
- Fault tolerance
- Modeling of dynamic, unpredictable environments
- Grid market economy (allocation, accounting, cost models)

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Definition

- Ian Foster *(www.gridtoday.com/02/0722/100136.html):*
  - coordinates resources that are not subject to a centralized control
  - using standard, open, general-purpose protocols and interfaces
  - delivers nontrivial qualities of service

- Rajkumar Buyya:
  - A type of parallel and distributed system that enables the sharing, selection, & aggregation of resources distributed in administrative domains depending on their availability, capability, performance, cost, and users quality of service requirements.

Simple Model of the Grid

Data Management

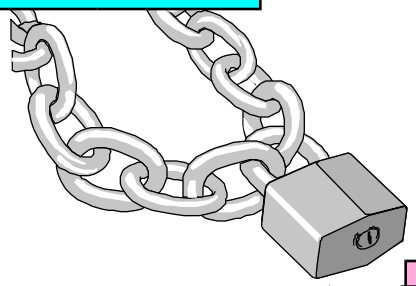
Resource & Job Management

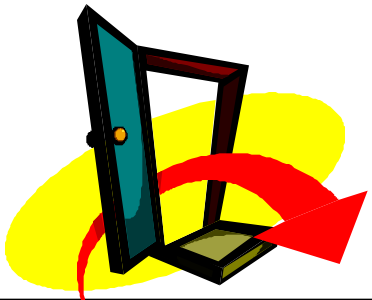
Information System

+ security

another model (basic elements)

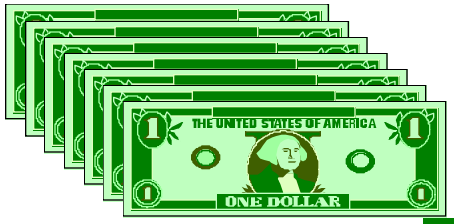
Security



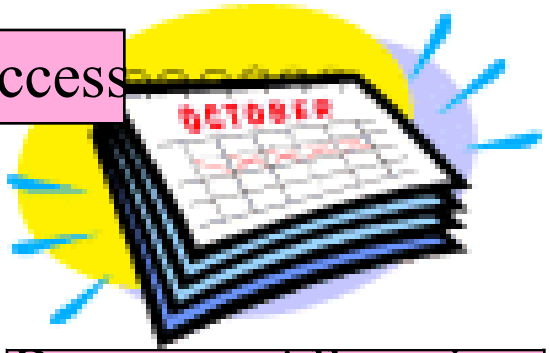


Uniform Access

Computational Economy

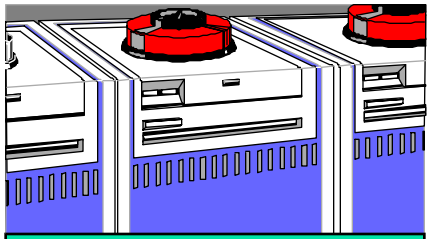


System Management



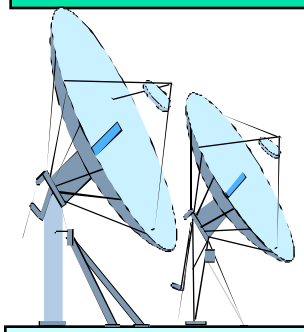
Resource Allocation & Scheduling

Resource Discovery



Data locality

Application Development Tools



Network Management

source:Rajkumar Buyya

Nordic Testbed for Wide Area Computing and Data Handling

The layers of the Grid:

Grid Applications

science,engineering,commercial apps, web portals

Grid Programming environment

languages,interfaces,libraries,compilers, griddifying tools

User level Middleware

resource management and scheduling services

Low level Middleware

job submission, storage access, info service,accounting

Security Infrastructure

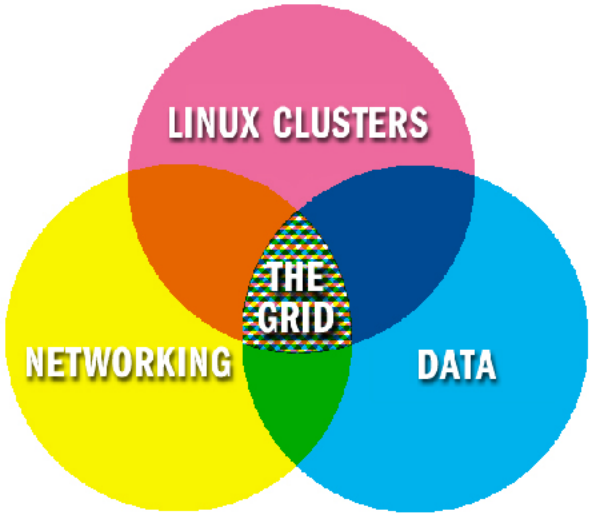
single log-on, authentication, authorization, secure communication

Grid Fabric

clusters, networks, batch systems, devices, databases

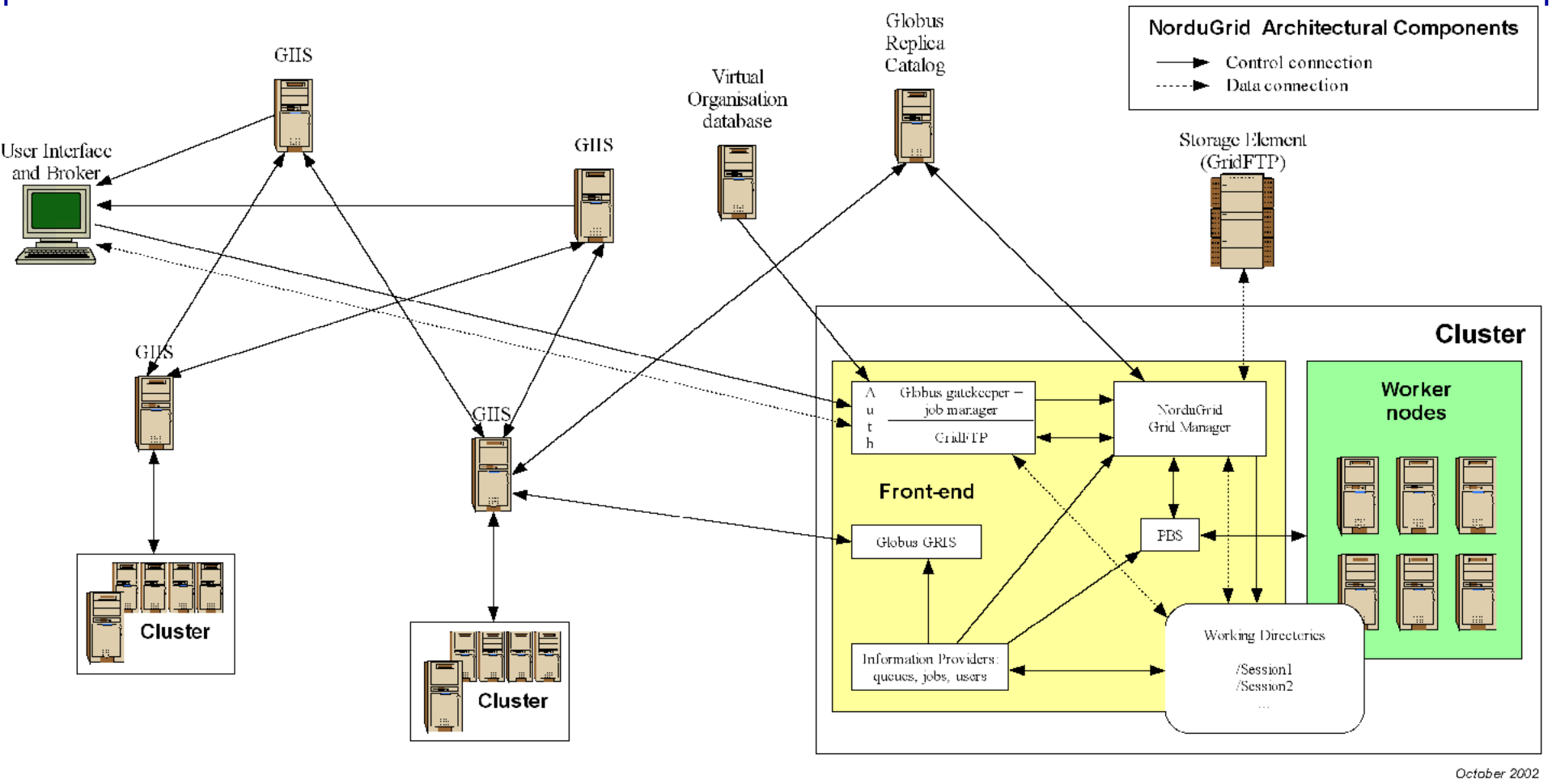
TeraGrid model of the Grid

- Linux Operating Environment
- Basic and Core Globus Services
  - GSI (Grid Security Infrastructure)
  - GSI-enabled SSH and GSIFTP
  - GRAM (Grid Resource Allocation & Management)
  - GridFTP
  - Information Service
  - Distributed accounting
  - MPICH-G2
  - Science Portals



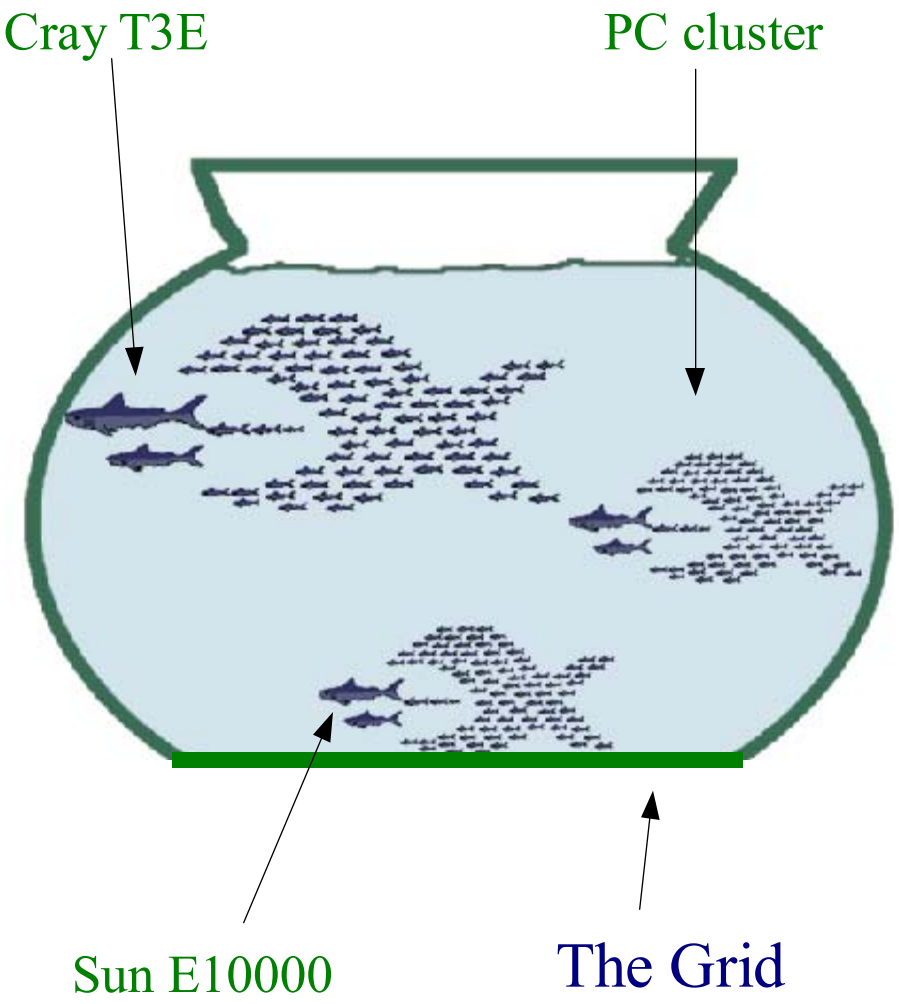
- Advanced and Data Services
  - Replica Management Tools
  - GRAM-2 (GRAM extensions)
  - CAS (Community Authorization Service)
  - Condor-G (as brokering “super scheduler”)
  - SDSC SRB (Storage Resource Broker)
  - APST user middleware, etc.

The NorduGrid Architecture



Grid & Supercomputers

- The present day Supercomputers are the PC clusters
- Grid will provide a uniform access to all the resources
- The Supercomputing centers will be the power plants of the Grid



Nordic Testbed for Wide Area Computing and Data Handling

clusters,P2P,Grid

- Cluster:
  - single administrative domain
  - centralised resource management, full controll over resources
  - suitable for strongly-coupled applications
  - limited capacity
- Grid:
  - a layers on top of clusters, bunch of services on top of clusters
  - “borrows” resources from clusters, capacity will be able to be reserved
  - multiple administrative domains
- Peer-to-Peer
  - millions of uncoordinated, unorganized desktops (screensavers)
  - parallel application pools
  - capacity varies and mostly unpredictable

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Applications

- Applications are key to the success of Grid
- Application developers will only pick up the Grid IF:
  - Grid services will have a well-defined interface
  - Grid infrastructure some day be as natural part of the picture as the OS
- We are still very far from “throwing any application onto the Grid”
- Considerable porting effort in “Griddifications” of problems

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targeted application areas

Genetics

Computer Graphics

VLSI Design

Bioinformatics

Data Mining

Network Simulation

Molecular Dynamics

BioInformatics

Fluid Dynamics

Astrophysics

Drug Design

Protein Structure

Meteorology

Earth Observation

Civil Engineering

Financial Risk Analysis

Nordic Testbed for Wide Area Computing and Data Handling

“best” applications for the Grid

Decoupled applications (minimal communication)

- embarrassingly parallel apps, parameter sweeps

Staged/linked applications

- (complete part A then do part B)
- Includes remote instrument applications (get input from instrument at site A, compute/analyze data at site B)

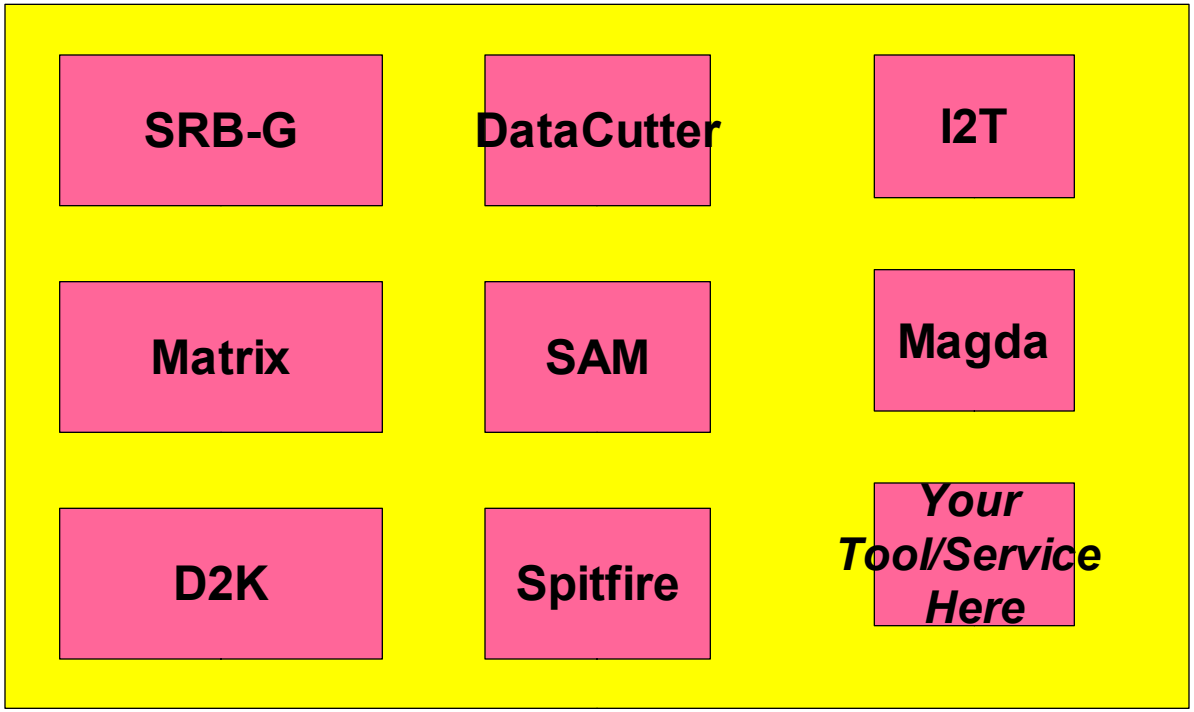
Access to resources (mainly data)

- get “something” from/do “something” at site A
- dataGrids
- data & controlled/shared acces to date is the critical issue of the future

Nordic Testbed for Wide Area Computing and Data Handling

“Data is the killer app”

there are many simillar but incompatible solutions :

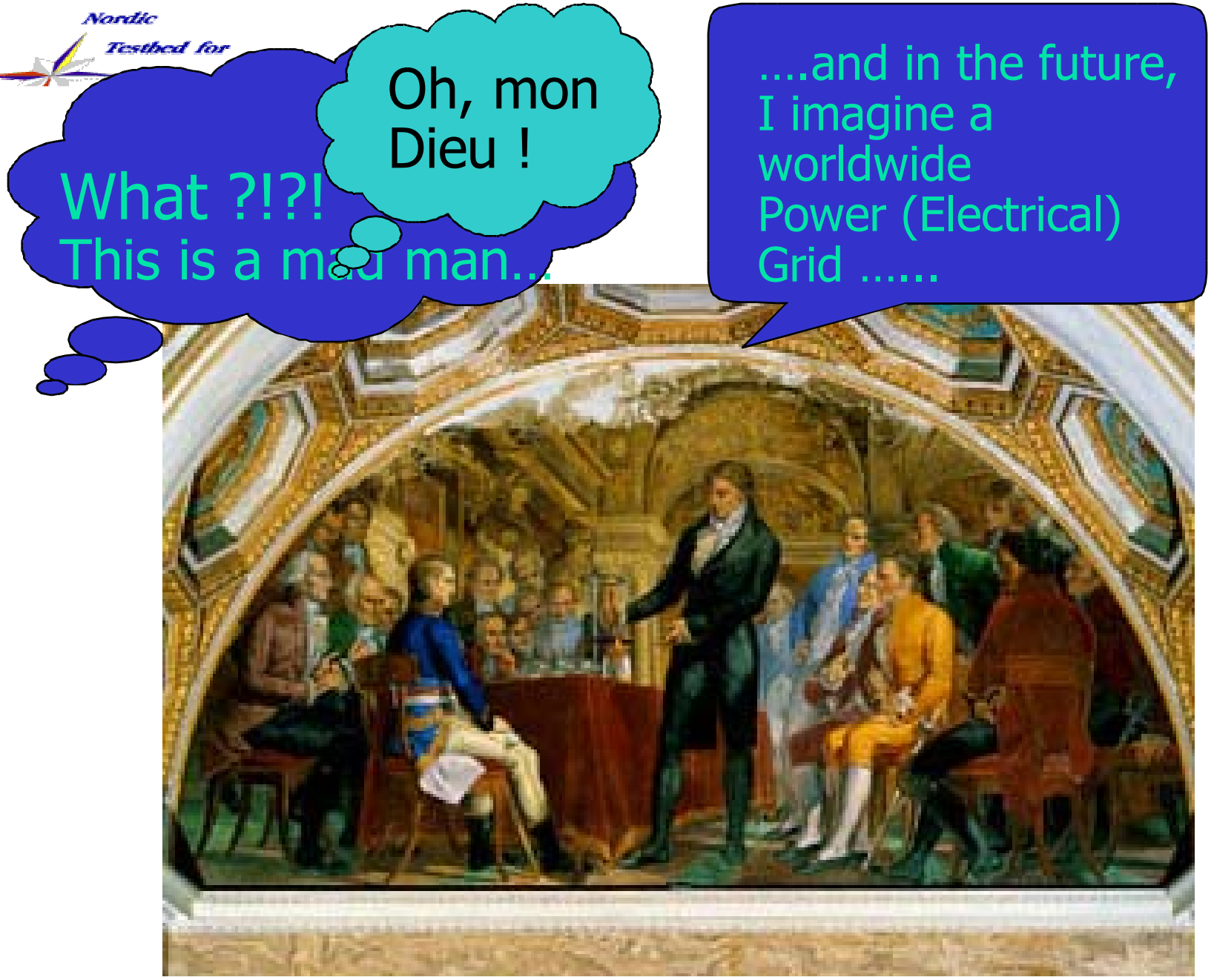


Alessandro Volta in Paris in 1801 inside French National Institute shows the battery while in the presence of Napoleon I

Fresco by N. Cianfanelli (1841)

(Zoological Section "La Specula" of National History Museum of Florence University)

source: Rajkumar Buyya



source: Rajkumar Buyya

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acknowledgement

- while I was preparing for this introductory Grid talk I “borrowed” slides, ideas, pictures from general Grid-talks. I would like to thank all the authors of those talks. Especially to Rajkumar Buyya & Fran Berman*

*GGF5 Plenary Keynote: TeraGrid "State of the Grid 2002"