The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific and
Cultural Organization

IAEA
International Atomic Energy Agency

1967-14

Advanced School in High Performance and GRID Computing

3 - 14 November 2008

Introduction to Grid computing.

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Our heads in the Grid

A brief introduction to Grid Computing

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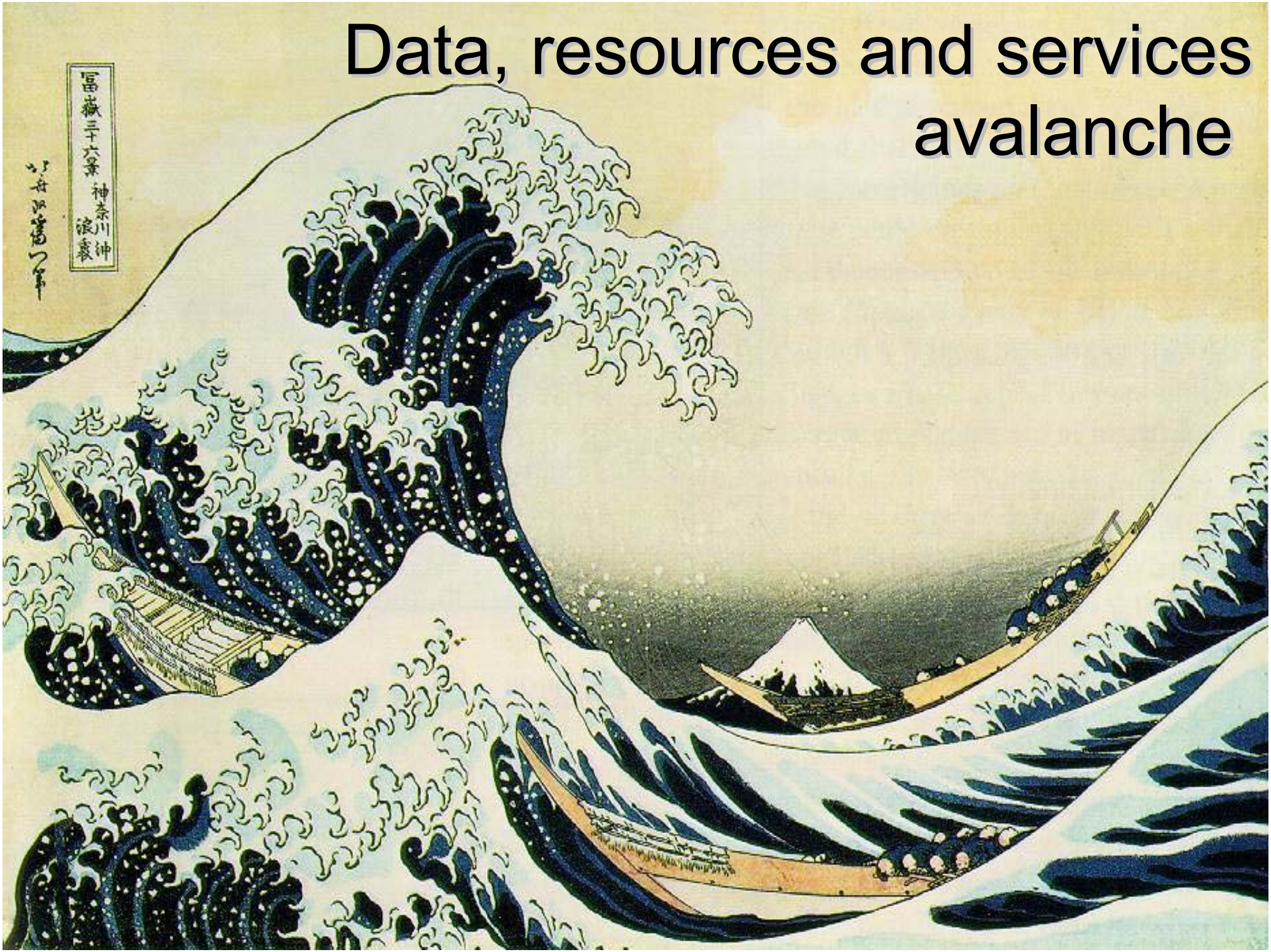
New challenges in Science

- Going further in scientific knowledge
  - New high sensitivity sensors and instruments
  - Globally distributed collaborations
- Delocalized knowledge
  - Scientific and technical knowledge is “distributed”
  - Laboratories are distributed
  - Scientific data are distributed

Data, resources and services avalanche



e-science

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“eScience is about global collaboration in key areas of science and the next generation of infrastructure that will enable it.”

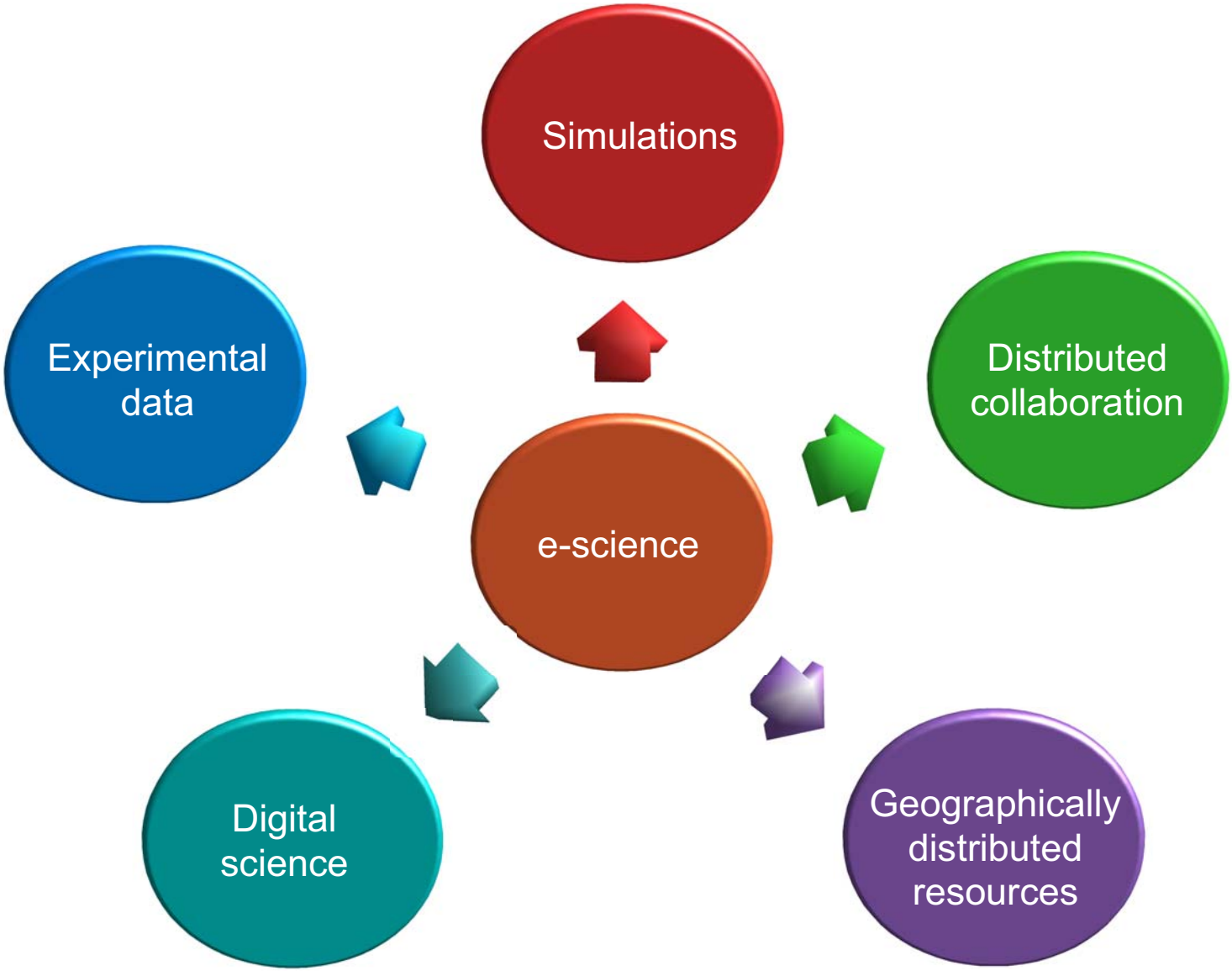
Dr.John Taylor, Director General of the Research Councils 1998-2003

“The large scale science that will increasingly be carried out through distributed global collaborations enabled by Internet”

From: http://www.nesc.ac.uk/nesc/define.html

“e-Science is a new way of using Internet and its “services” to do science”

...my definition.



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Using internet to make science

- On-line publication paper/pre-prints (eg. babbage.sissa.it)
- CPU cycle scavenging (eg. Seti@home, Condor)
- Sloan Digital Sky Survey: online database of astronomical data http://www.sdss.org/
- Google sky

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Science and WEB2.0

- Collaboration tools
- Social networking (secondlife. facebook, NING etc.)

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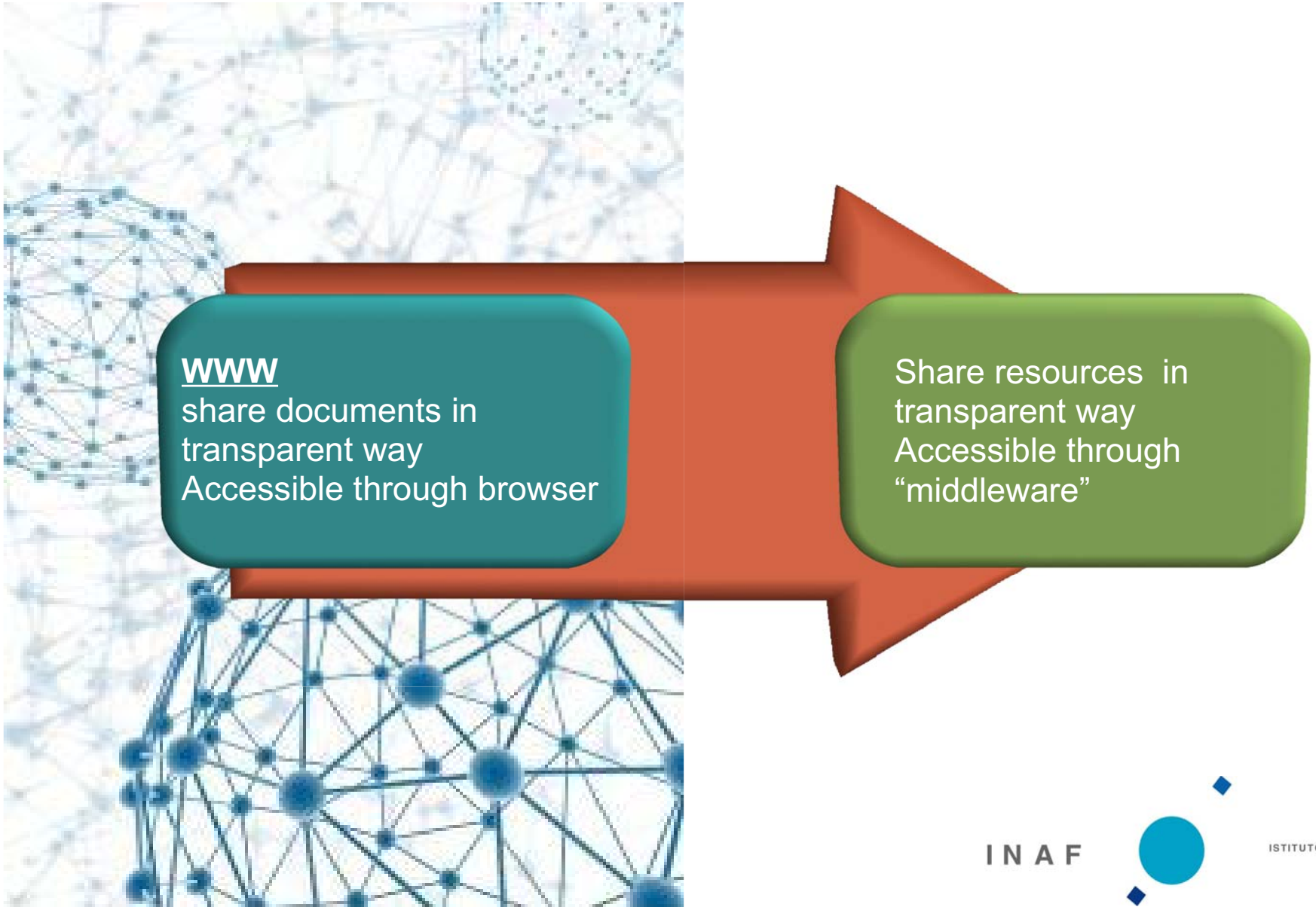
A new paradigm



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“resource” sharing

- Applications: web services technology
- CPU and Storage: Grid computing, Cloud Computing, etc.
- Data: data Grid, Virtual Observatory, Google Filesystem, etc.
- Instruments: e-Labs, collaboration tools, etc.

What is your paradigm?

Parallel Computing
single systems with many processors working on same problem

Distributed Computing
many systems loosely coupled by a scheduler to work on related problems

Grid Computing
many systems tightly coupled by software, perhaps geographically distributed, to work together on single problems or on related problems

What is Grid Computing?

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Some definitions

“a single seamless computational environment in which cycles, communication, and data are shared, and in which the workstation across the continent is no less than one down the hall"

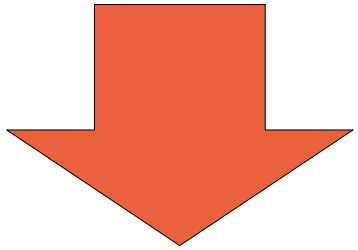
“wide-area environment that transparently consists of workstations, personal computers, graphic rendering engines, supercomputers and non-traditional devices: e.g., TVs, toasters, etc."

“[**framework** for] flexible, secure, coordinated resource sharing among dynamic collections of individuals, institutions, and resources"

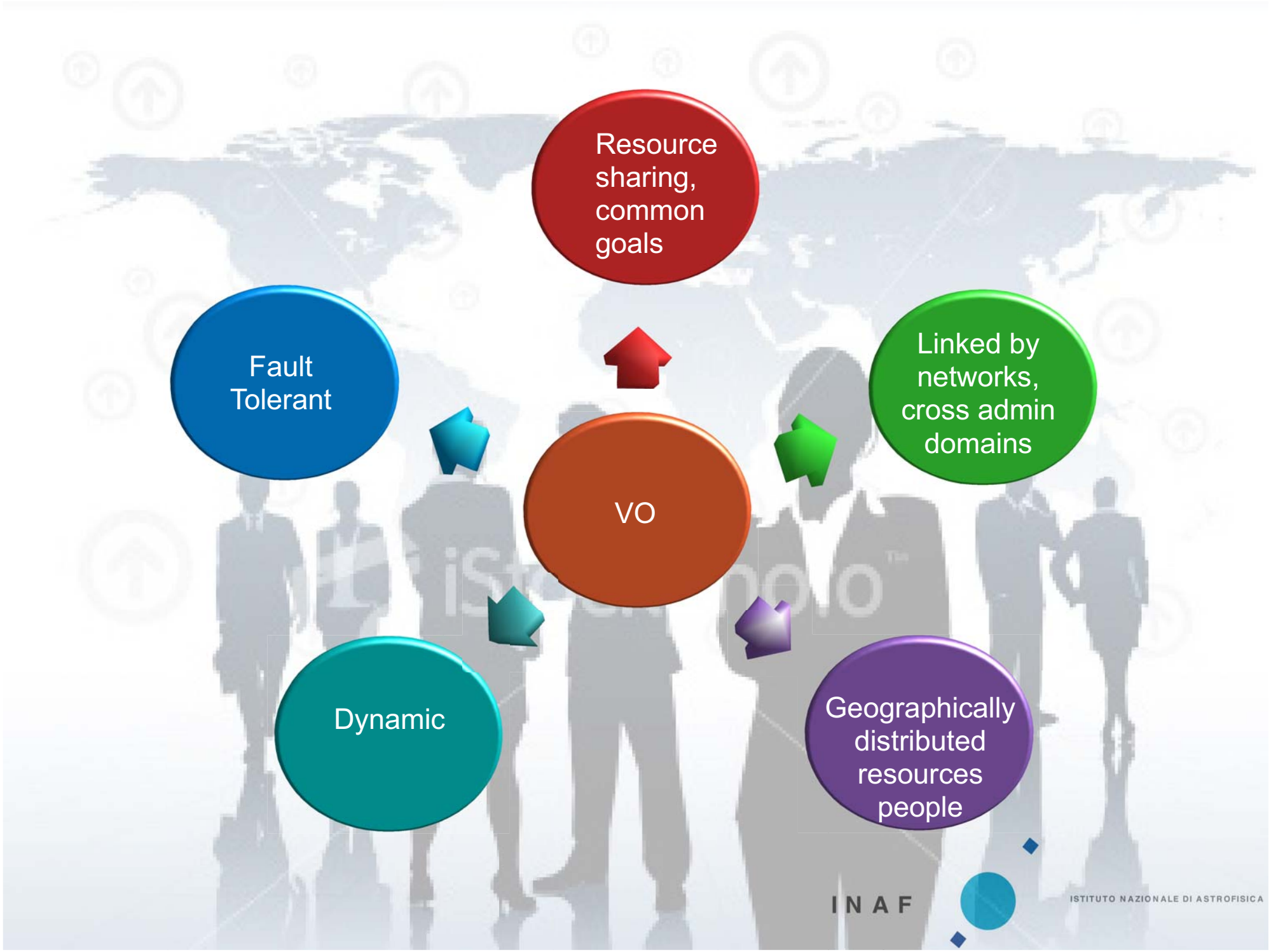
“collection of geographically separated resources (people, computers, instruments, databases) connected by a high speed network [...distinguished by...] a software layer, often called middleware, which transforms a collection of independent resources into a single, coherent, virtual machine”

CPU vs collaboration: VO concept

The size and/or complexity of the problem requires that people in several organizations collaborate and share computing resources, data, instruments



VIRTUAL ORGANIZATIONS


Resource sharing, common goals
Fault Tolerant
Linked by networks, cross admin domains
VO
Dynamic
Geographically distributed resources people
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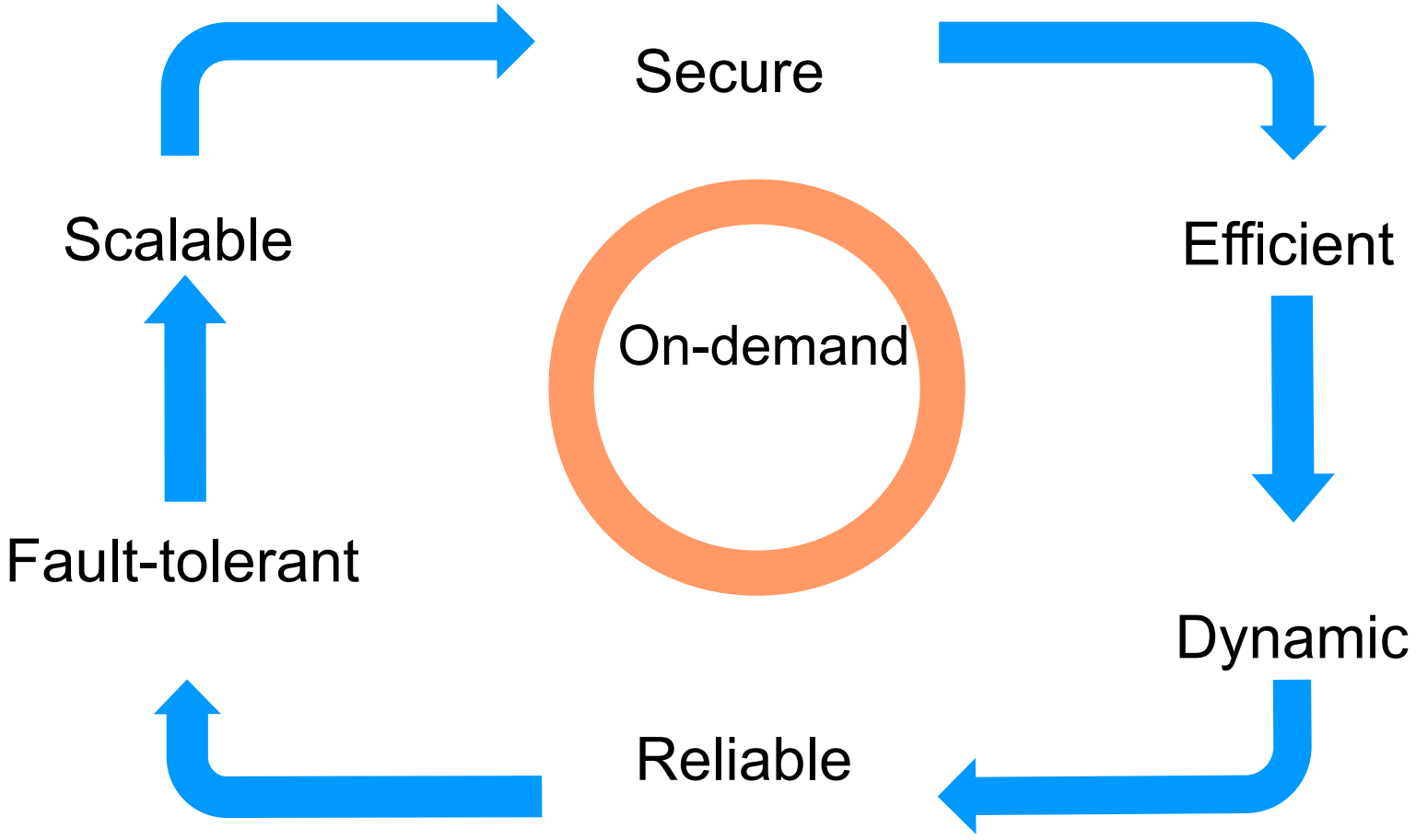
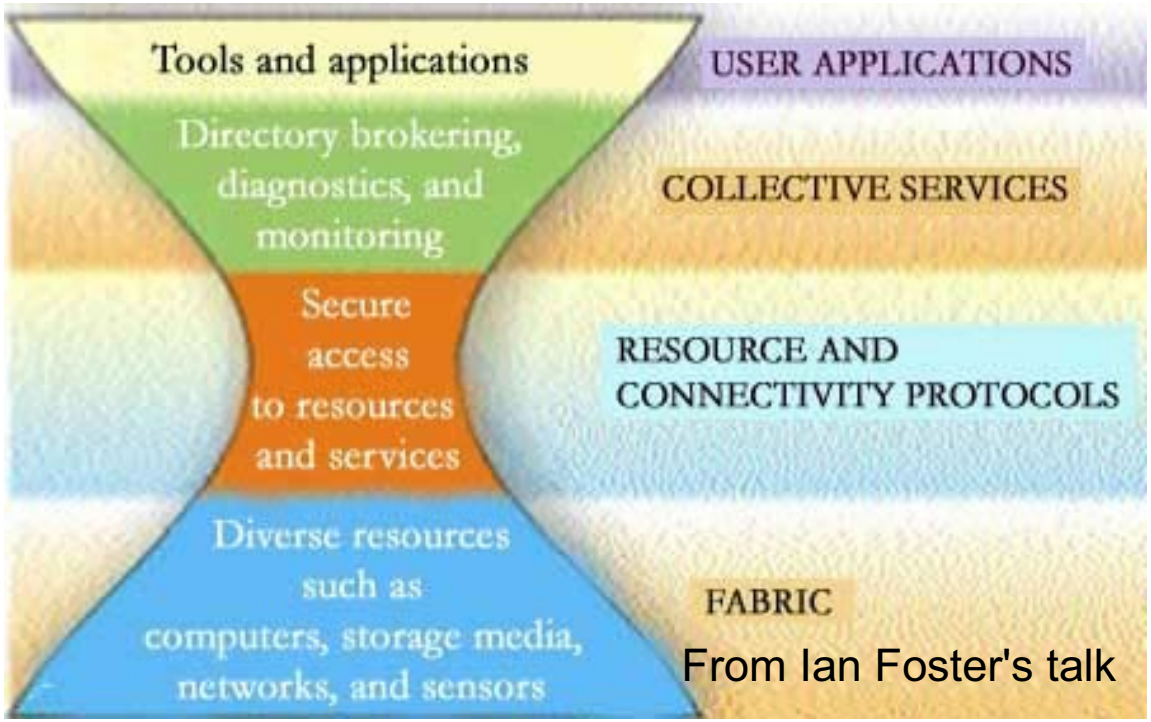
Grid Concepts



The Grid Middleware

- Its the software layer that glue all the resources
- Everything that lies between the OS and the application



From Ian Foster's talk

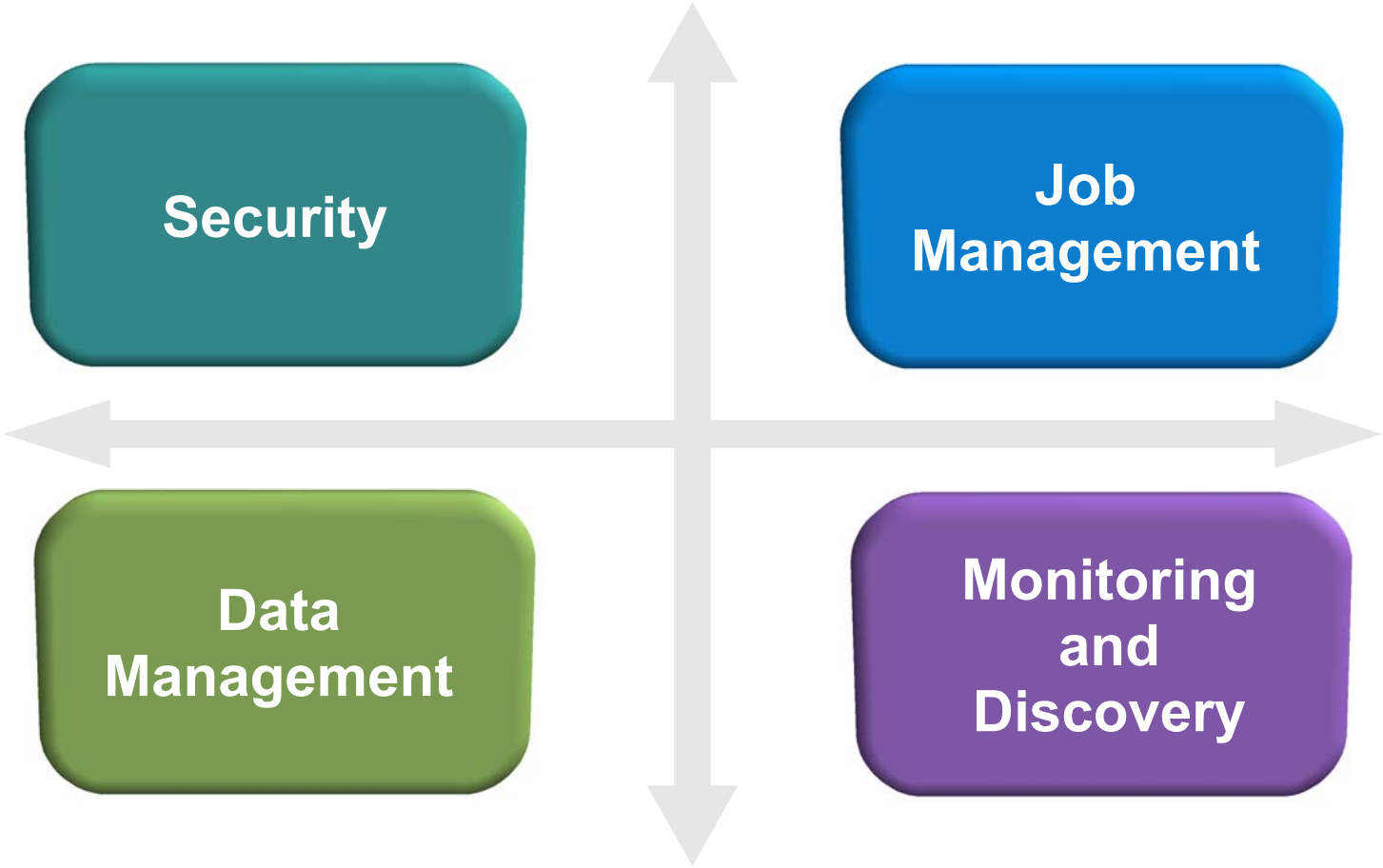
Grid Resource

- Storage systems
- Computer clusters
- HPC clusters
- Supercomputers (IBM SP, blue jean, etc)
- Databases
- Keyword: heterogeneous as regards hardware and software

Local vs remote

- Resources are locally managed
  - Policies
  - Accountability
  - OS
  - Storage systems
  - Batch systems
- Global policies
- Global accessibility
- Dynamic resource identification
- Remote resource utilization

MW generic services



Grid Middleware

- Grid is as Operating System:
  - different middleware = different Grid
- Globus alliance (Globus Toolkit)
- gLite (EGEE middleware)
- Unicore (DE)
- GridBus
- GRIA

Explore the middleware

- Bottom-up
  - From low level services to global services
  - From fabric to GRID
  - From Unix user to GRID user

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The Resources

- Group of “sites” glued by the Middleware
- Sites are homogeneous as regards OS and SW:
  - Scientific Linux cern 4
- Sites are heterogeneous as regards HW:
  - x86/x86_64 arch
- Some collective services: WMS, DMS etc.

A Grid Site

- Computing Element
- Storage Element
- Worker nodes

- Master node
- Storage system
- Computing nodes

- Scheduler+queue system (torque+maui, LSF, etc.

The Low level services

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Security

- **Grid is a highly complex system**
- Authentication: establishing identity
- Authorization: establishing rights
- Message protection

Passwords are not scalable and secure!!!

What do we require to security?

- Users point of view
  - Easy to use, transparent, single-sign on, no password sharing
- Administrators point of view
  - Define local access control
  - Define local polices
- The Grid Security Infrastructure
  - X509 digital certificates

Job Management

- The challenge: enabling access to heterogeneous resources and managing remote computation
- Create job environment
- Stage files in/out the environment
- Submit a job to the local scheduler
- Monitor job state
- Job description language

Monitor and discovery service

- What is the status of a resource?
- What are the available resources?

Data Managment

- Requirements
  - Fast: as fast as networks and protocols allow
  - Secure: server must only share files with strongly authenticated clients and no passwords in the clear or similar
  - Robust: Fault tolerant, time-tested protocol

And the winner is…GRIDFTP

High Level Services

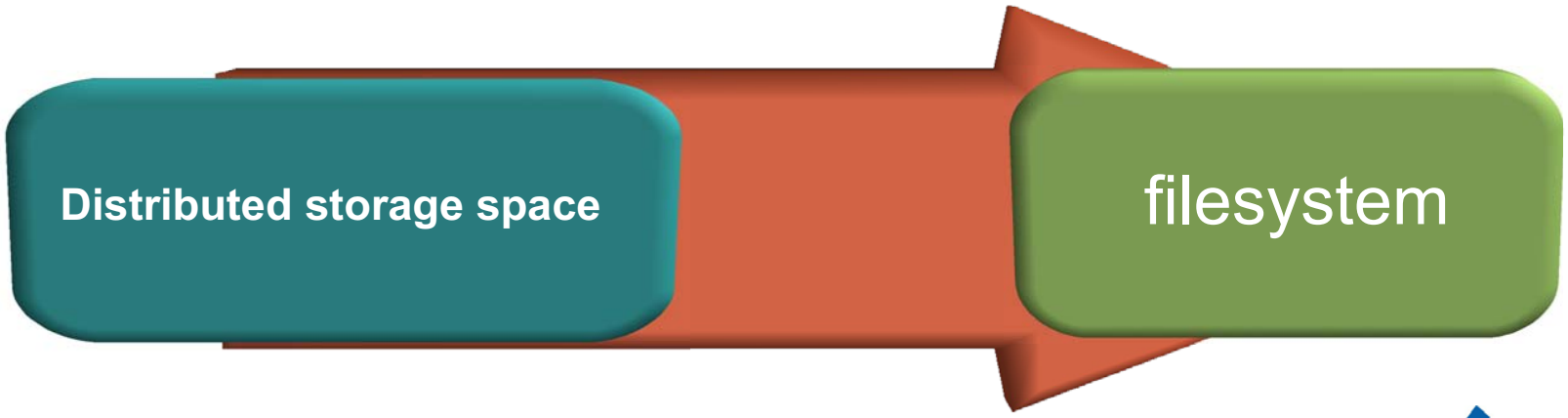
Information system

- Which resources are available?
- Where are them?
- What is their status?
- How can I optimize their use?

We need a general information infrastructure:
Information System

Data Management

- Where are data/files?
- Which data/file exist?
- How can I reach it?
- Are they accessible by others?
- ex. LFC file catalogue



Job Management

- Cooperation infrastructure for WAN distributed resources:
  - Chaotic system to direct;
  - Locate, book and use the “right” resource
  - Scheduling service
  - Job description language

Taxonomy of a scheduler

- Centralized systems
- Distributed systems
- Hierarchical systems (hybrid)

Centralized

- Single point of knowledge
- Optimum scheduling
- Single point of failure
- Example: Condor-G

Distributed

- Application delegation method
- Optimum scaling & Fault tolerance
- Sub-optimal resource allocation
- Each Application has to develop a scheduler
- Example: NetSolve

Hybrid

- Distributed systems are scheduled by a centralized one
- Examples: Darwin and Nimrond-G, GridBUS

Applications for Grid computing

- Computation intensive
  - Interactive simulation (climate modeling)
  - Large-scale simulation and analysis (atomistic simulations)
  - Engineering (parameter studies, optimization model)
- Data intensive
  - Experimental data analysis (e.g., H.E.P.)
  - Image & sensor analysis (climate)
- Distributed collaboration
  - Online instrumentation (microscopes, x-ray) Remote visualization (climate studies, biology)

Grid Projects

ACCESS GRID

Open Science Grid

grangenet

National Grid
NG
SINGAPORE

GRIP
UK
Particle
Physics

Grid3
2003

Ninf

iVDgL

CERN
openlab for DataGrid applications
Developing Solutions for the Data-Intensive Science of the Large Hadron Collider

LCG

West Grid

NORDUGRID
Grid Solution for Wide Area Computing and Data Handling

INFN
GRID

grid.it
project

Grid Consortium Japan

eGee
Enabling Grids for
E-science in Europe

GridLab

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National Research Grid Initiative
Grid Applications
Grid Middleware
Networking
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Summing up

- Modern Science requires a large amount of computing resources
- GRID computing and HPC are now fundamental tools for scientific research
- The challenge is now to build/use the infrastructure that fits at best your computational requirements.
- HPC and GRID computing are not mutually exclusive but can be both used to address computational resources in a transparent way.