



# Introduction to Grids and Grid applications

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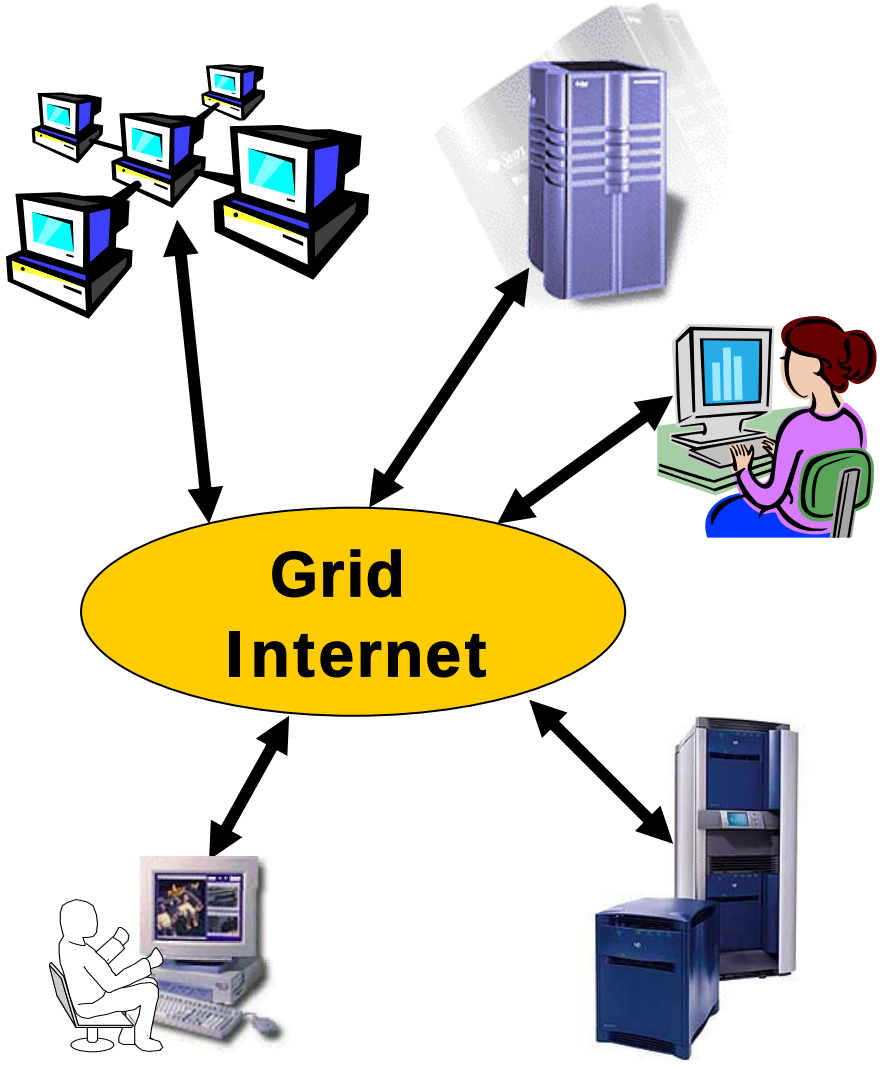
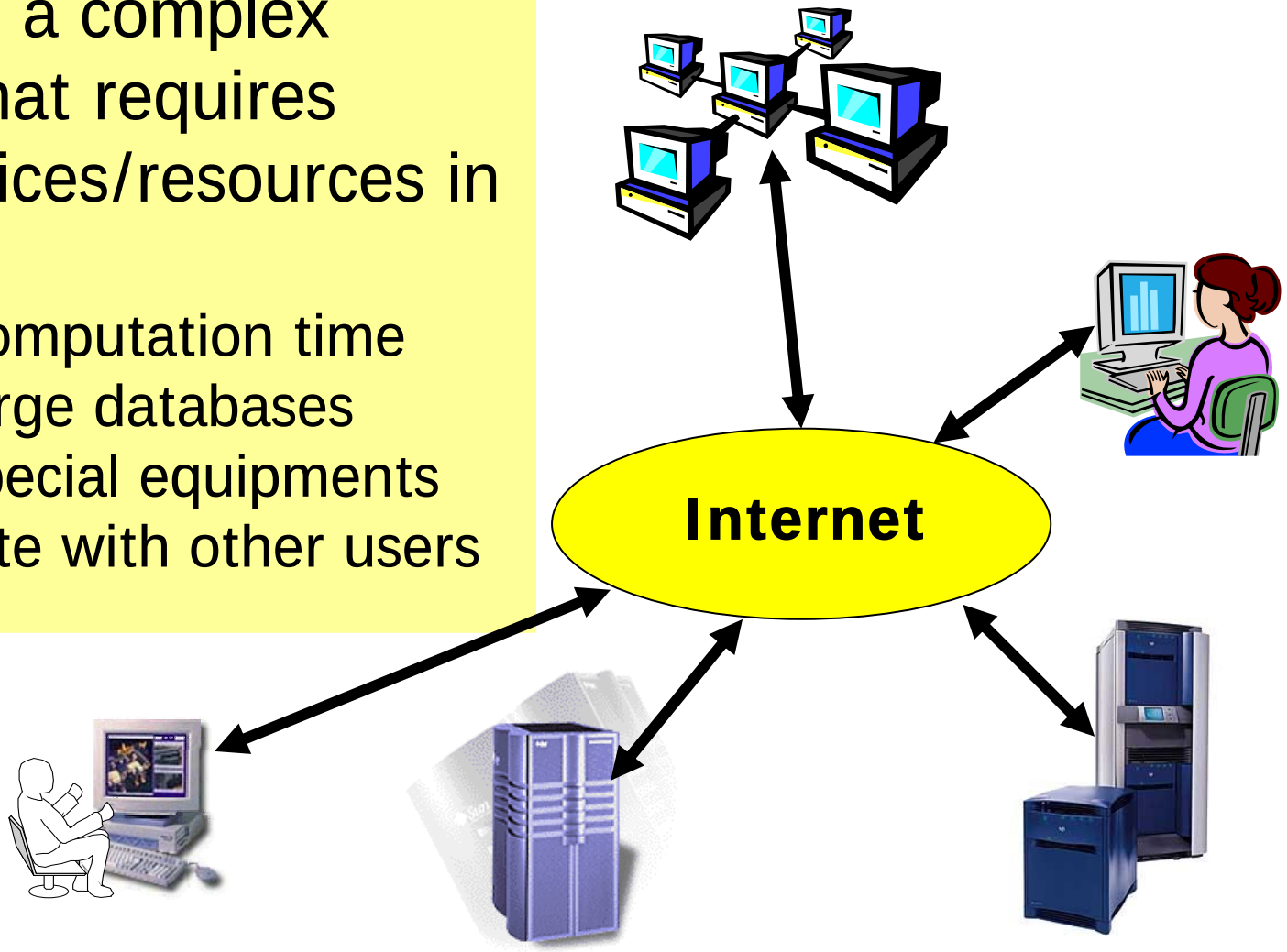
# What is Grid?

- A Grid is a collection of computers, storages, special devices, services that can **dynamically join and leave** the Grid
- They are **heterogeneous** in every aspect
- They are geographically **distributed** and connected by a **wide-area network**
- They can be accessed **on-demand** by a set of users



# Why use a Grid?

- A user has a complex problem that requires many services/resources in order to
  - reduce computation time
  - access large databases
  - access special equipments
  - collaborate with other users



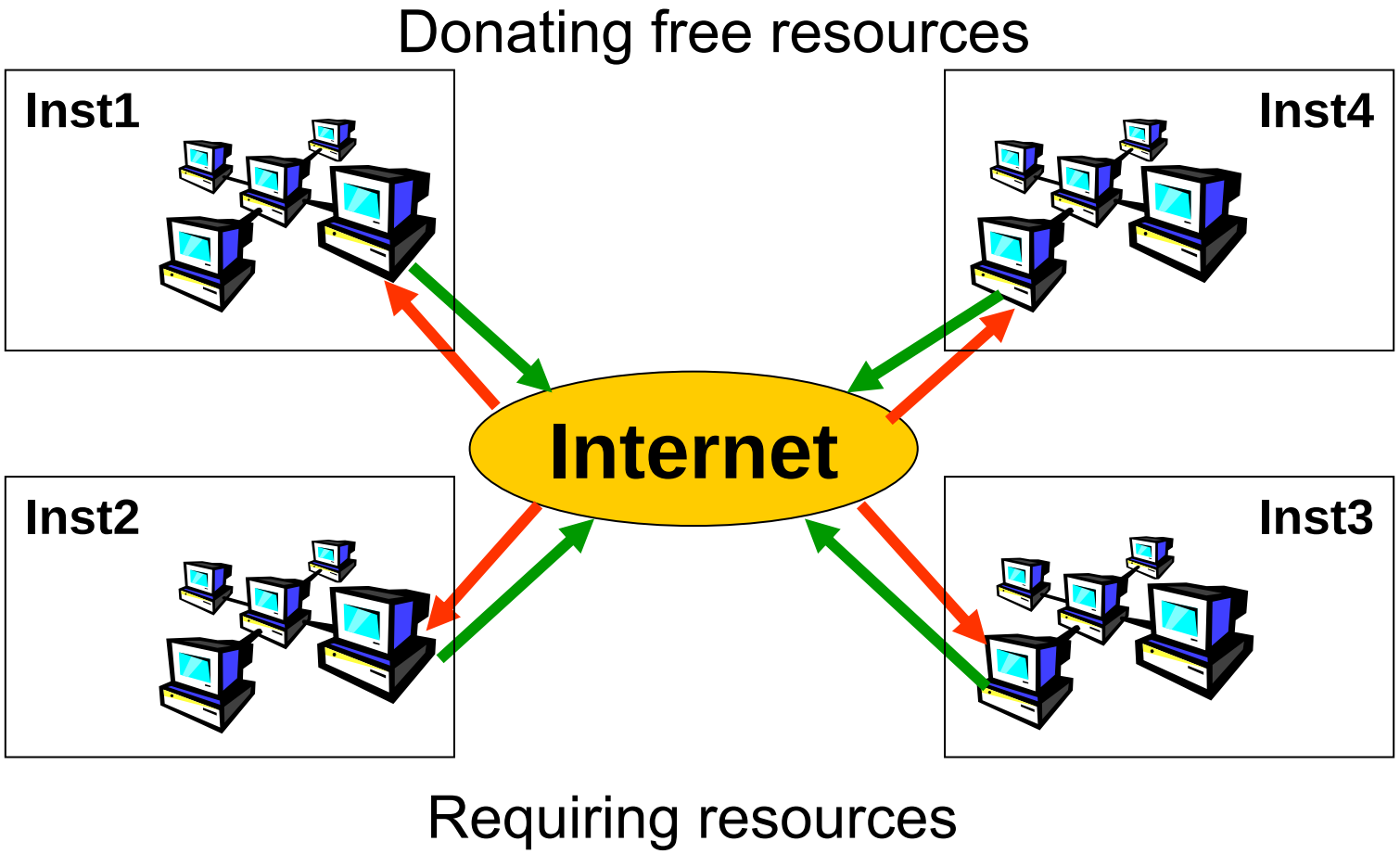

# Typical Grid application areas

- **High-performance computing (HPC)**
  - to achieve **higher performance** than individual supercomputers/clusters can provide
  - Reguirement: **parallel computing**
- **High-throughput computing (HTC)**
  - To exploit the **spare cycles** of various computers connected by wide area networks
- **Collaborative work**
  - Several users can jointly and remotely solve complex problems

# Two players of the Grid

- Resource donors = D
- Resource users = U
- Relationship between the two characterizes the Grid:
  - if U ~ D => generic Grid model
  - if U >> D => utility Grid model
  - if U << D => desktop Grid model

# Generic Grid modell

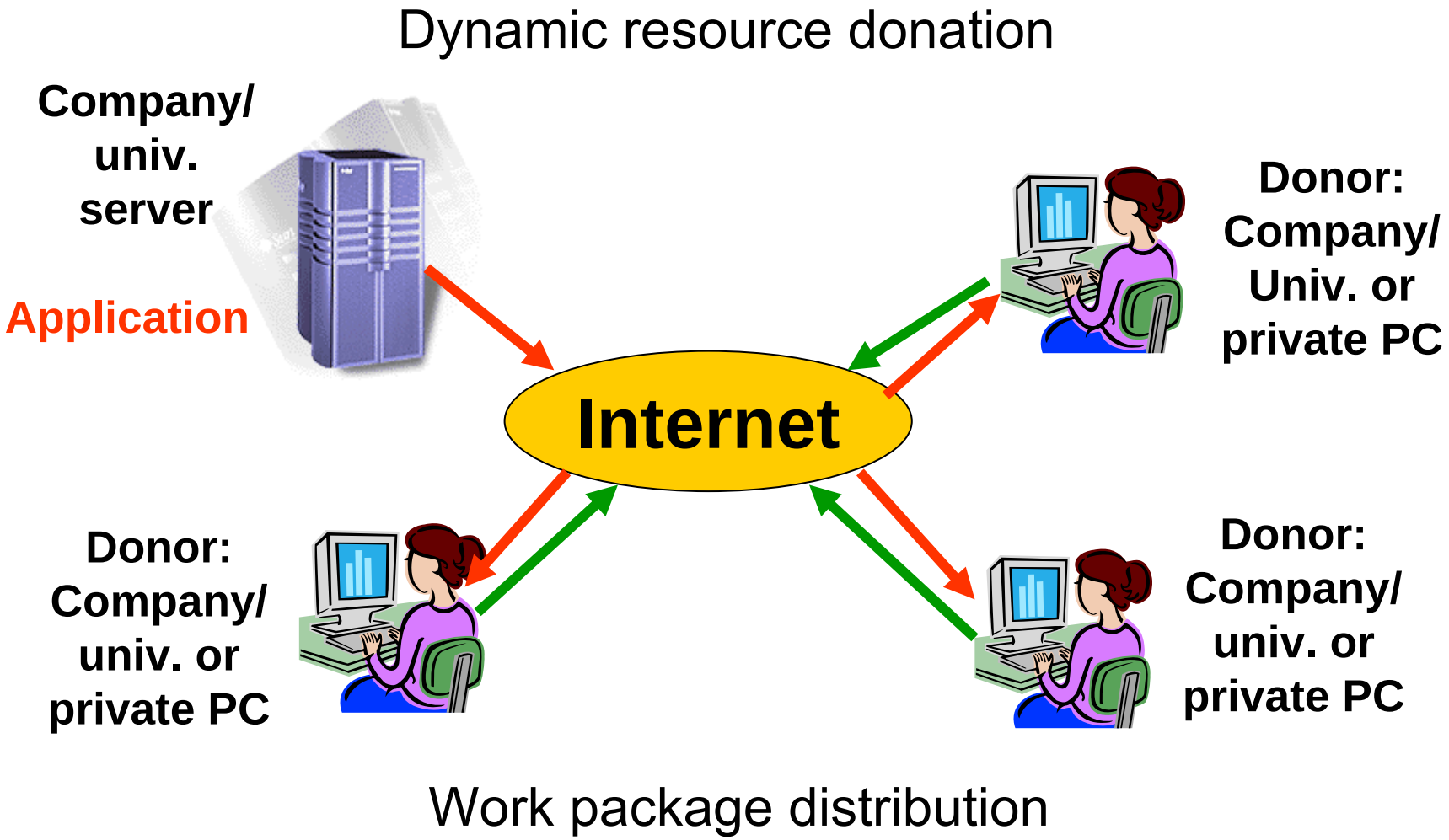


# Characteristics of the generic Grid model

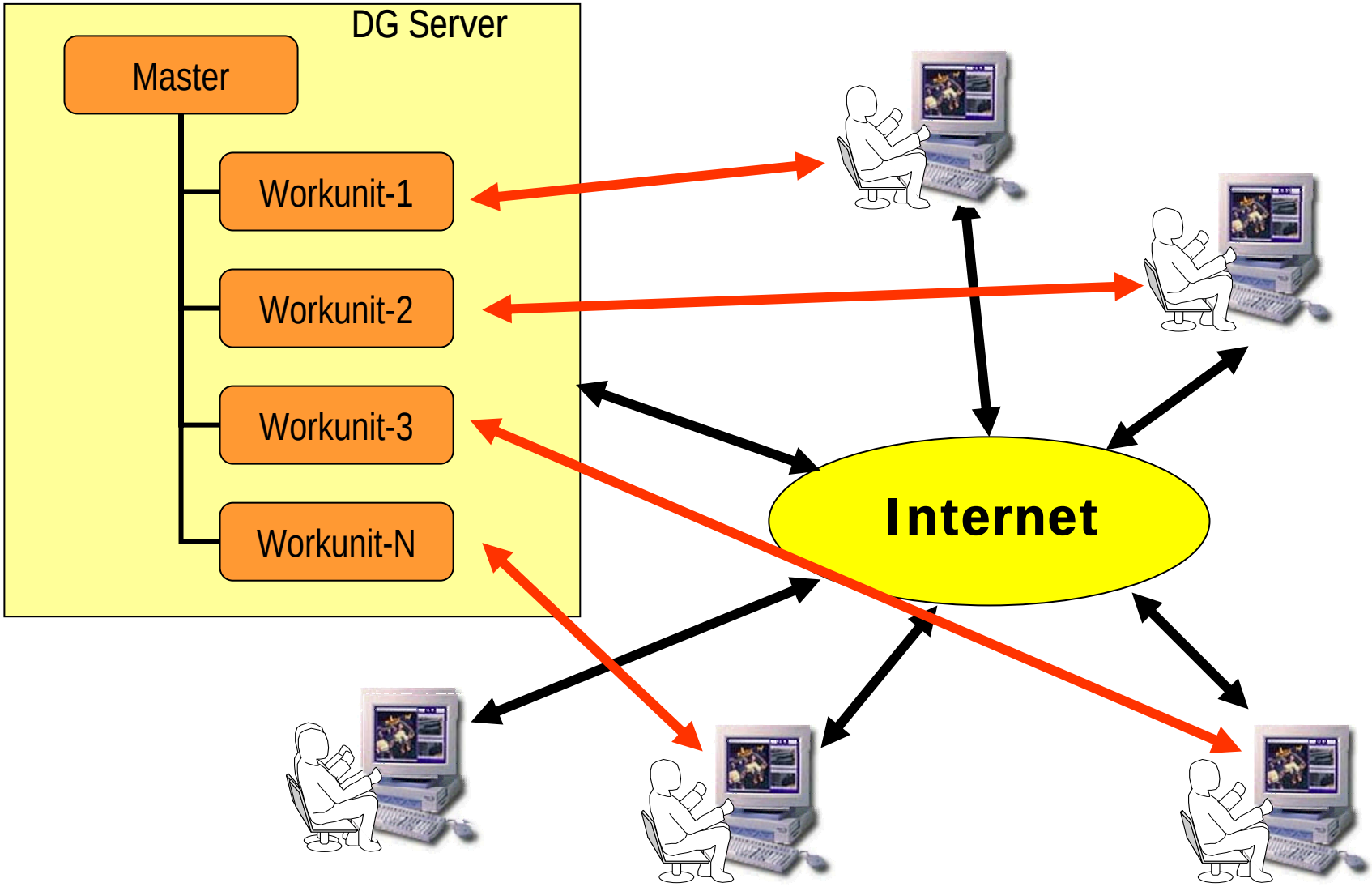
- **A volunteer Grid**: Anybody can donate resources
- Heterogeneous resources, that dynamically join and leave
- Anybody (belonging to the donating institutes) can use the donated resources for solving her/his **own** applications
- Symmetric relationship between donors and users:

  U ~ D
- Examples:
  - GT-2 grids
  - 1st version of UK NGS
- **Problems:**
  - Installing and maintaining client and server grid software are too complicated
  - Volunteer Grids are not robust and reliable

# Desktop Grid model



# Desktop Grid model – Master/slave parallelism



# Characteristics of the desktop Grid model

- **A volunteer Grid**: Anybody can donate resources
- Heterogeneous resources, that dynamically join and leave
- **One or a small number of projects** can use the resources
- Asymmetric relationship between donors and users:

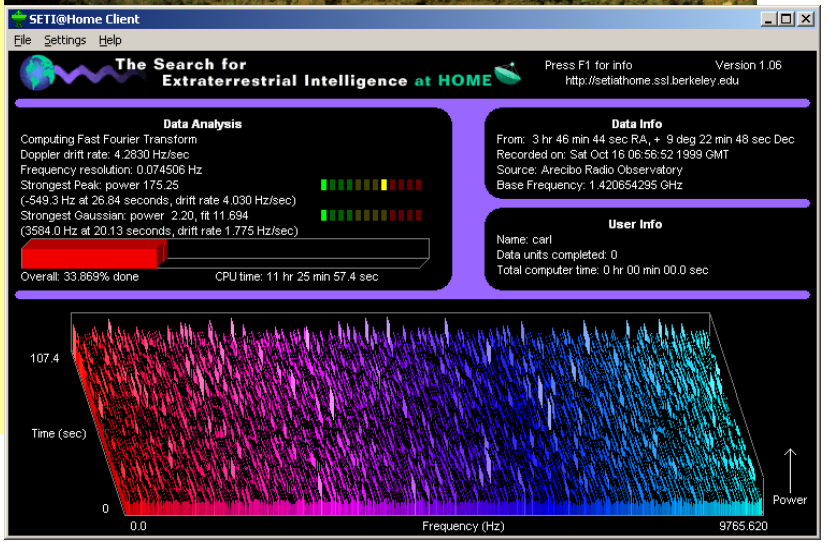
  U << D
- Advantage:
  - Donating a PC is extremely easy
  - Setting up and maintaining a DG server is much easier than installing the server sw of utility grids

# Types of Desktop Grids

- Global Desktop Grid
  - Aim is to collect resources for grand-challenge scientific problems
- Example:
  - BOINC (SETI@home)
  - SZTAKI Desktop Grid (SZDG)
- Local Desktop Grid
  - Aim is to enable the quick and easy creation of grid for any community (company, univ. city, etc.) to solve their own applications
- Example:
  - Local SZDG

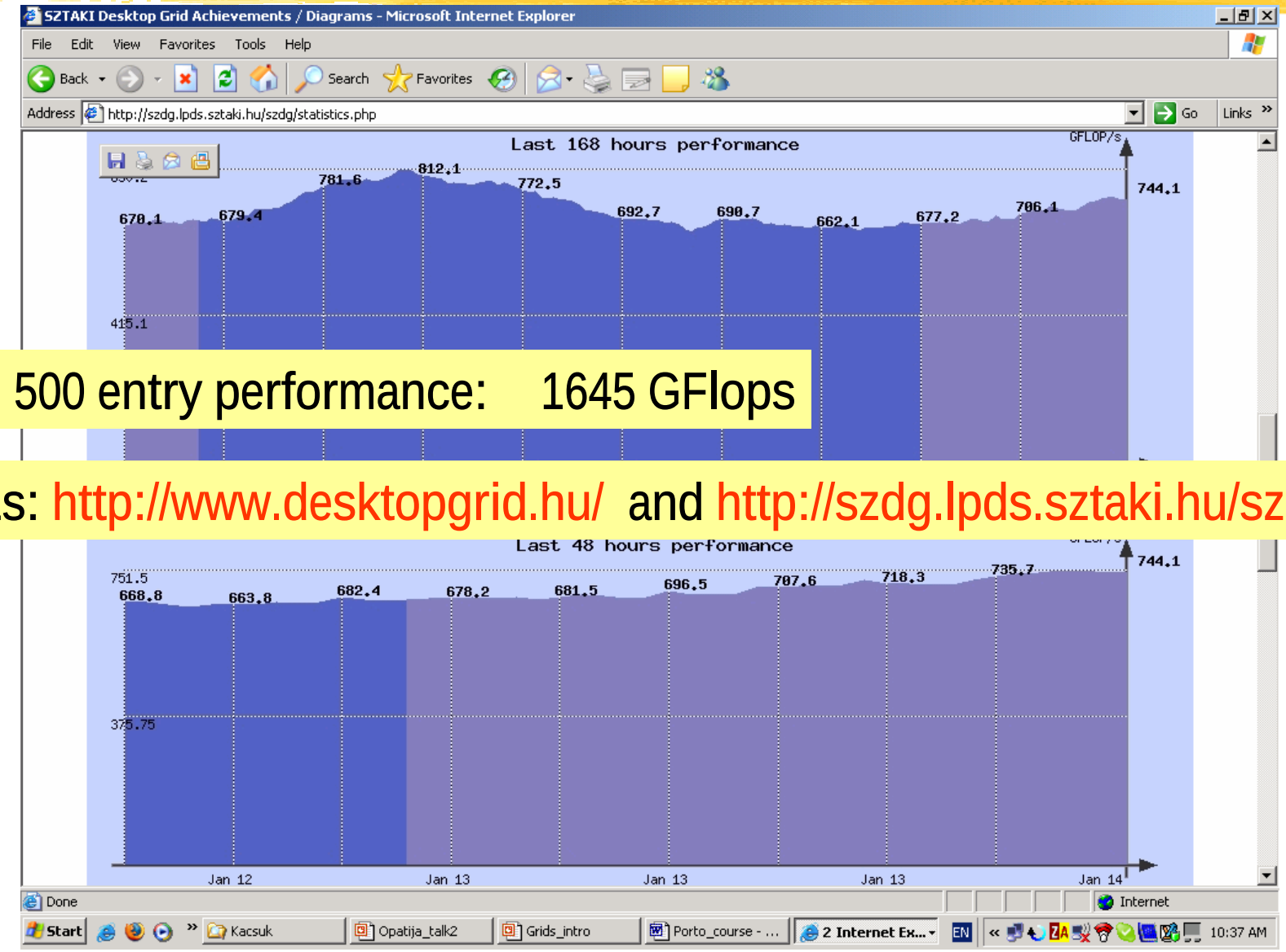
# SETI: a global desktop grid

- SETI@home
  - 3.8M users in 226 countries
  - 1200 CPU years/day
  - 38 TF sustained (Japanese Earth Simulator is 32 TF sustained)
  - Highly heterogeneous: >77 *different* processor types




SZTAKI Desktop Grid - Microsoft Internet Explorer
File
Address
SZTAKI Desktop Grid
global version
MTA SZTAKI
SZTAKI DESKTOP GRID
BOINC
Number of users: 14819 Number of hosts: 29414
Active hosts in last 48 hours: 1920
Estimated performance of last 48 hours[1,2]: 744.085 GFlop/s
Peak performance[1,2]: 1.5 TFlop/s
Workunits processed in last 48 hours[3]: 9574
Join SZTAKI Desktop Grid
Rules and policies [read this first]
Getting started
Frequently Asked Questions(FAQ)
Create account
Applications
Returning participants
Your account - view stats, modify preferences
Teams - create or join a team
Application currently run by Project
SZTAKI Desktop Gridcurrently searches for generalized binary number systems.
Description on the application is available here.
Internet
Start
Kacsuk
Opatija_talk2
Grids_intro
Porto_cour...
SZTAKI Des...
SZTAKI De...
EN
10:34 AM

# SZTAKI Desktop Grid global version




TOP 500 entry performance: 1645 GFlops

URLs: http://www.desktopgrid.hu/ and http://szdg.lpds.sztaki.hu/szdg/

# SZTAKI Desktop Grid local version

- **Main objective:**
  - **Enable the creation of local DG for any community Demonstrate how to create such a system**
- Building production Grids requires huge effort and represents a privilege for those organizations where high Grid expertise is available
- **Using the local SZDG package**
  - **Any organization** can build a local DG in a day with minimal effort and with minimal cost (a strong PC is enough as a server machine)
  - The applications of the local community will be executed by the **spare PC cycles** of the local community
  - There is no limitation for the applied PCs, all the PCs of the organization can be exploited (**heterogeneous Grid**)
  - You can download the local SZDG package from: **http://www.desktopgrid.hu/**

# DSP application on a local SZDG in the Univ. of Westminster

- **Digital Signal Processing Appl.:** Designing optimal periodic nonuniform sampling sequences
- Currently more than 100 PCs connected from Westminster and planned to extend over 1000 PCs

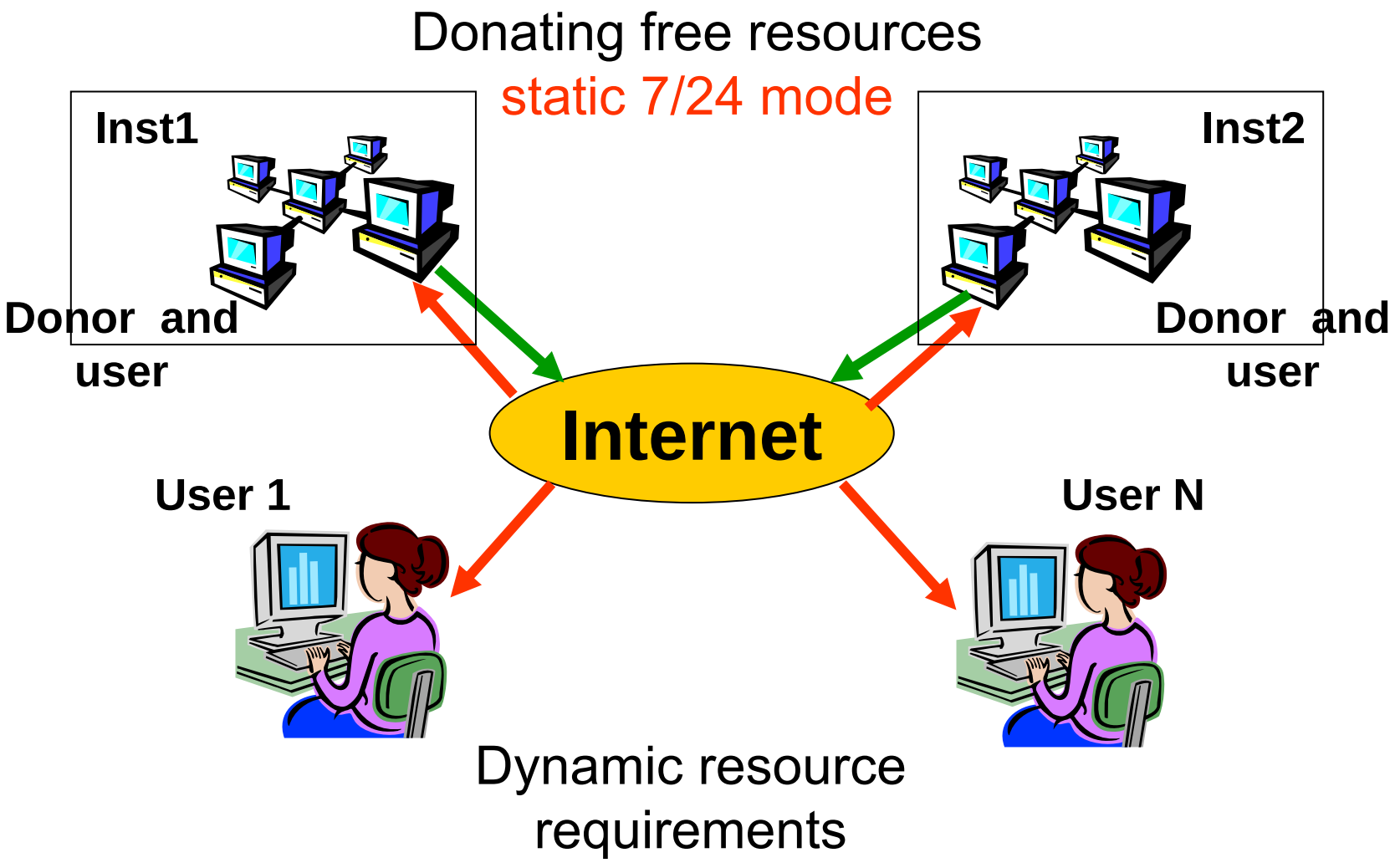

## The speedup

| DSP size | Sequential | Production | SZDG |
|---|---|---|---|
| 20 | ~3h 33min | ~35min | ~1h 44min |
| 22 | ~41h 53min | ~7h 23min | ~5h 4min |
| 24 | ~724h | ~141h | ~46h 46min |

# Usage of local SZDG in industry

- **AMRI Hungary Ltd.**
  - Drug discovery application
  - Creating enterprise Grid for prediction of ADME/Tox parameters
  - Millions of molecules to test according to potential drug criteria
  - New FP6 EU Grid project: CancerGrid
- **Hungarian Telecom**
  - Creating enterprise Grid for supporting large data mining applications where single computer performance is not enough
- **OMSZ (Hungarian Meteorology Service)**
  - Creating enterprise Grid for climate modeling

# Utility Grid model

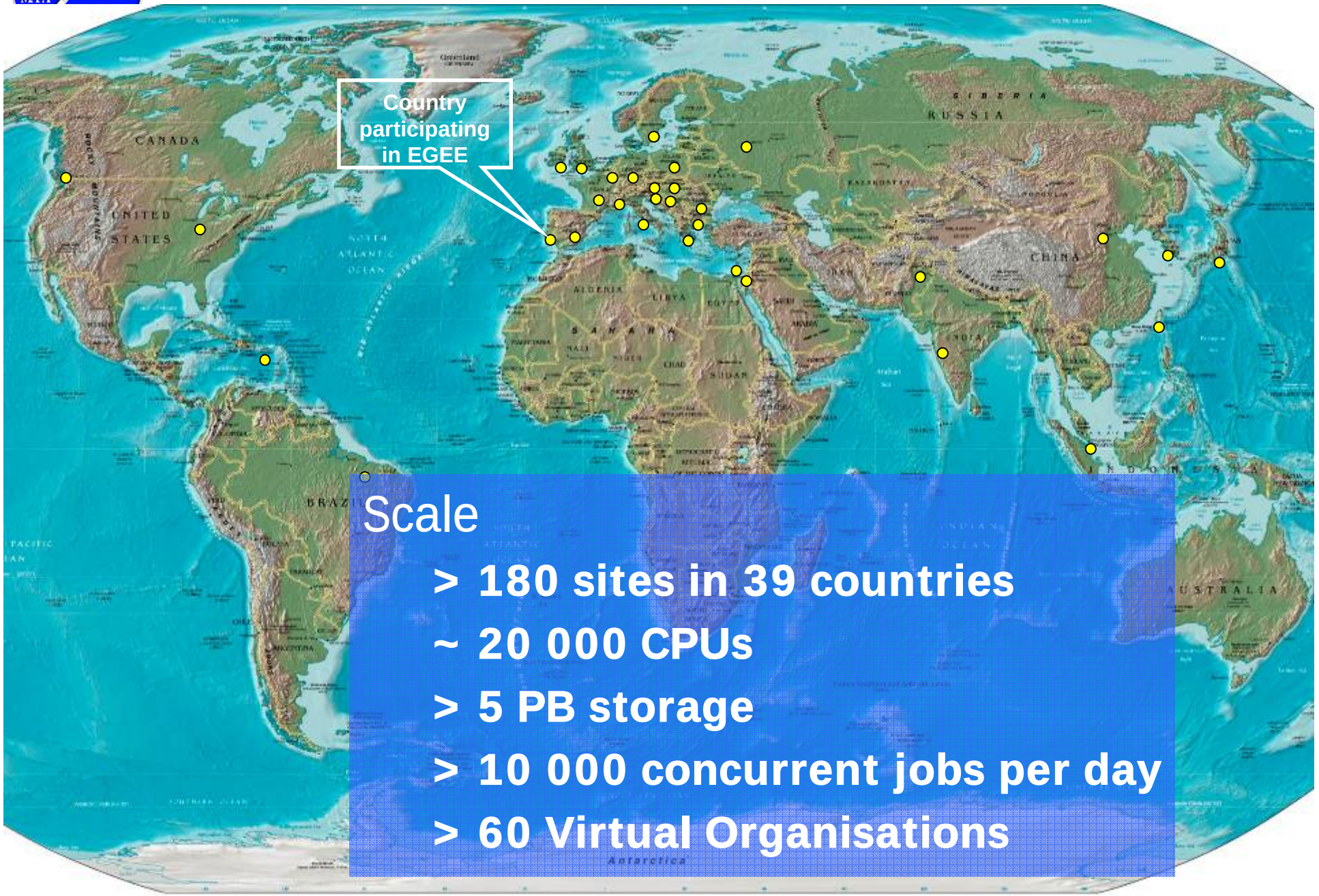


# Characteristics of the utility Grid model

- **Semi-volunteer Grids**: Donors must be “professional” resource providers who provide production service (7/24 mode)
- Typically homogeneous resources
- Anybody can use the donated resources for solving her/his **own** applications
- Asymmetric relationship between donors and users:

  U >> D
- Examples:
  - EGEE -> SEE-Grid, BalticGrid, etc.
  - UK NGS current version, NorduGrid
  - OSG, TeraGrid

# The largest production Grid: EGEE




## Scale

- **> 180 sites in 39 countries**
- **~ 20 000 CPUs**
- **> 5 PB storage**
- **> 10 000 concurrent jobs per day**
- **> 60 Virtual Organisations**

# NorduGrid


## Dynamic Grid

~ 33 sites, ~1400 CPUS

## Production Grid

Real users, real applications

It is in 24/7 operation, unattended by administrators for most of the time

# TeraGrid

**Caltech**: Data collection analysis

0.4 TF IA-64
IA32 Datawu
80 TB Storag

IA64 Sun

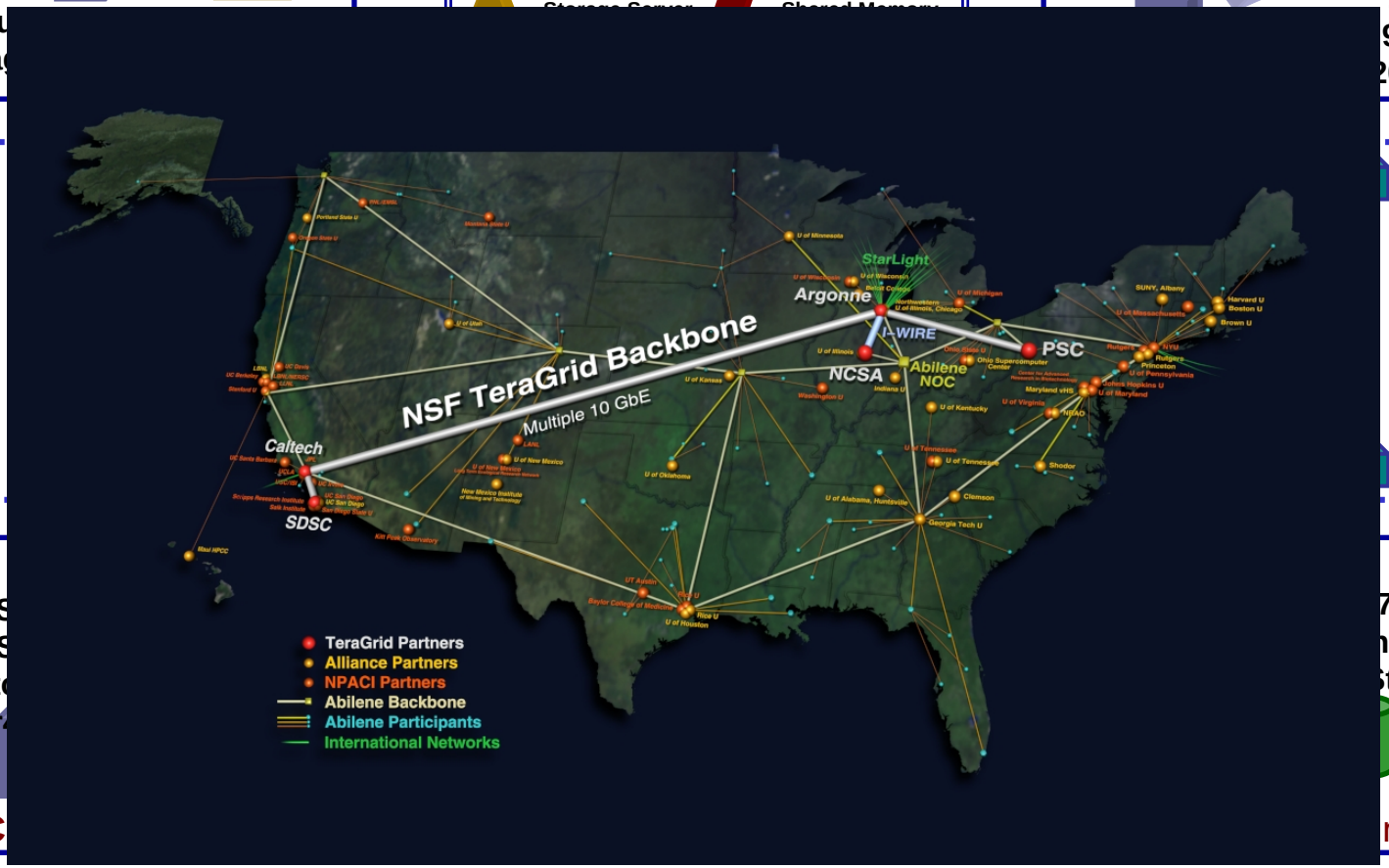
LEGEND

Cluster
Visualization Cluster

**ANL**: Visualization

IA32

1.25 TF IA-64
96 Viz nodes
20 TB Storage




4 TF IA-64
DB2, Oracle S
500 TB Disk S
6 PB Tape St
1.1 TF Power

SDSC

6 TF EV68
71 TB Storage
hared-memory
torage Server

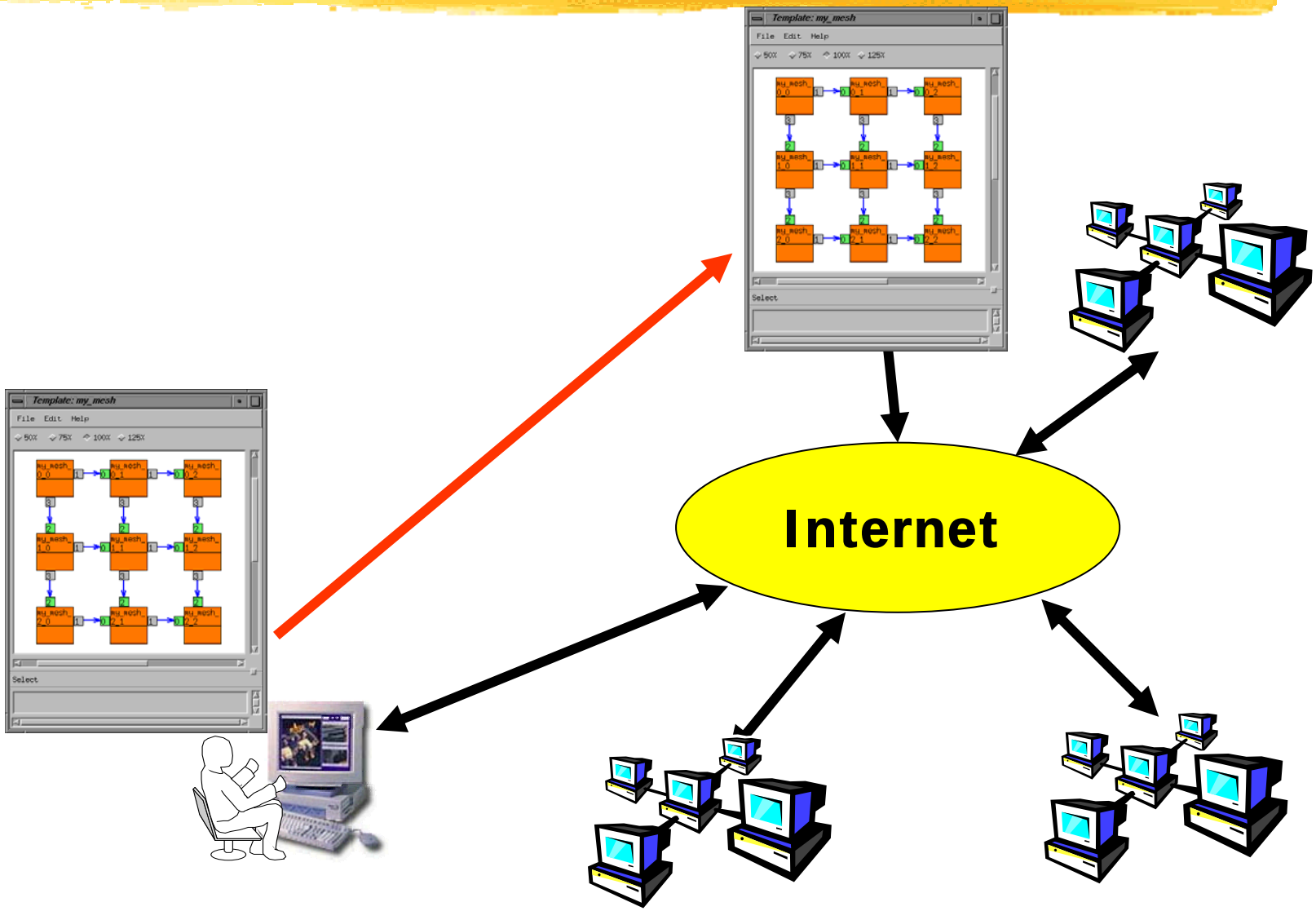
ntensive

**PSC integrated Q3 03**

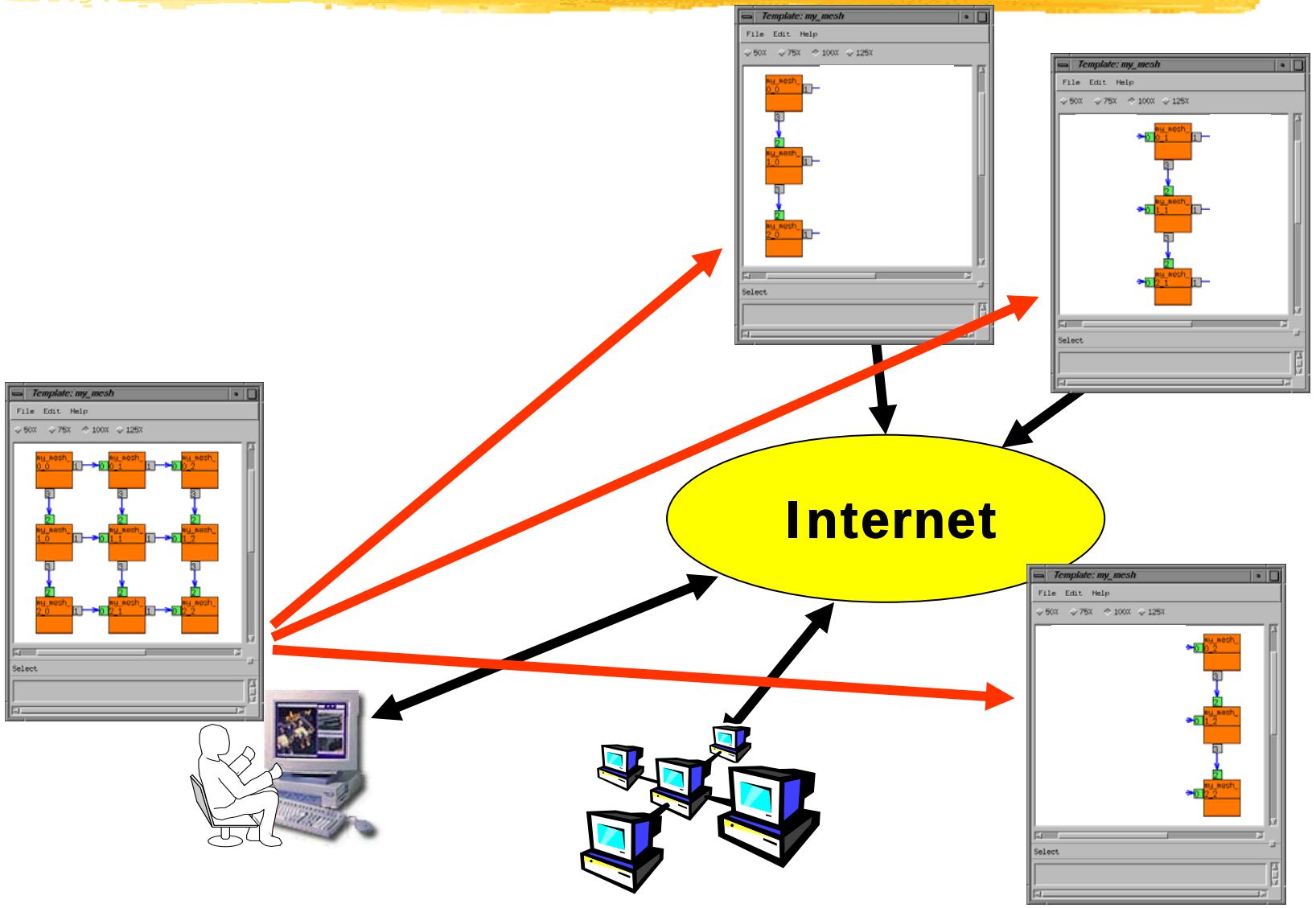

# Exploiting parallelism

- Single parallel application
  - Single-site parallel execution
  - Multi-site parallel execution
- Workflow branch parallelism
  - Sequential components
  - Parallel components
    - Two-level single-site parallelism
    - Two-level multi-site parallelism
- Parameter sweep (study) applications:
  - The same application is executed with many (1000s) different parameter sets
  - The application itself can be
    - Sequential
    - Single parallel
    - workflow

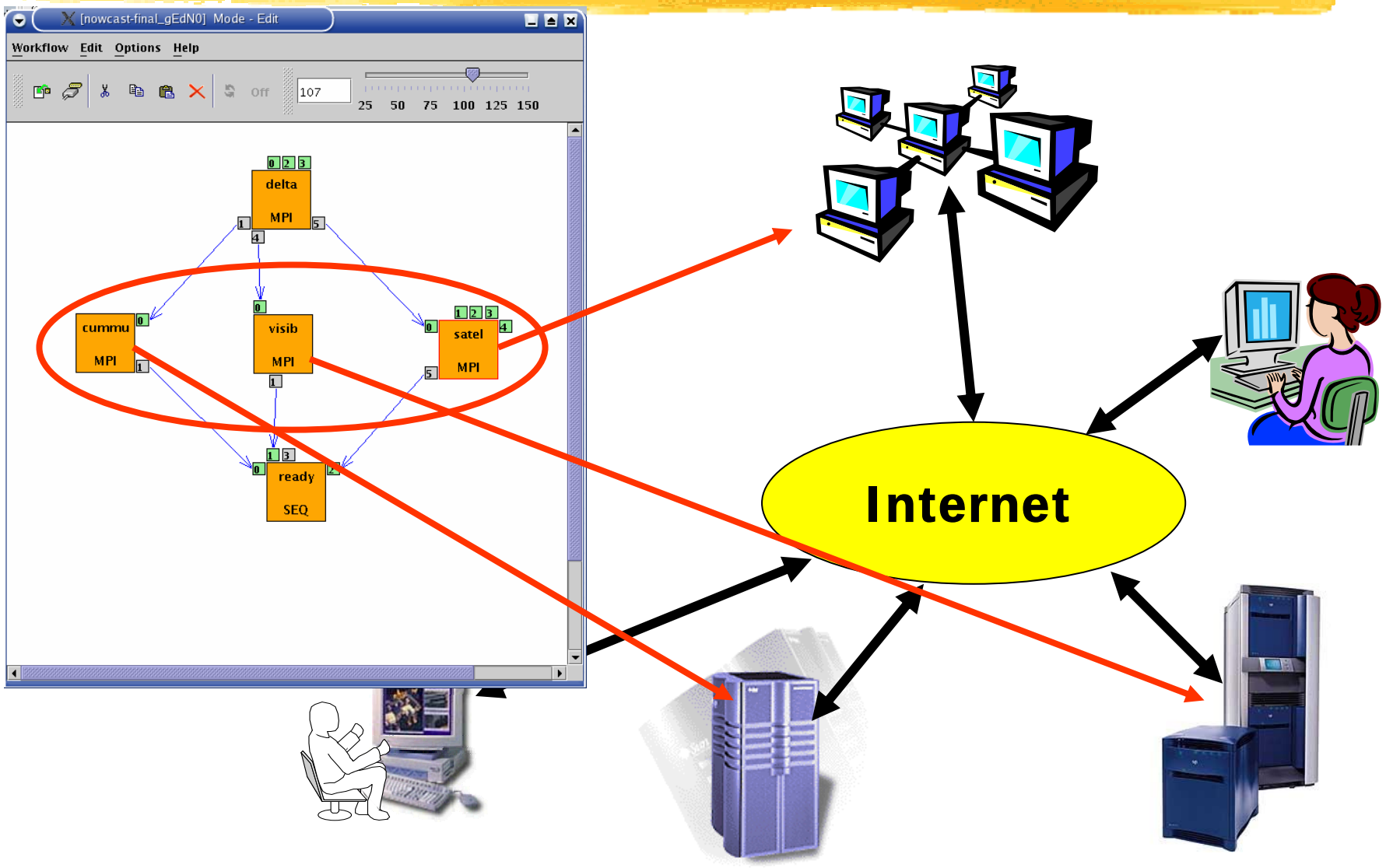
# How to use a Grid for single-site parallelism?



# How to use a Grid for multi-site parallelism?



# How to use a Grid for two level single-site parallelism?



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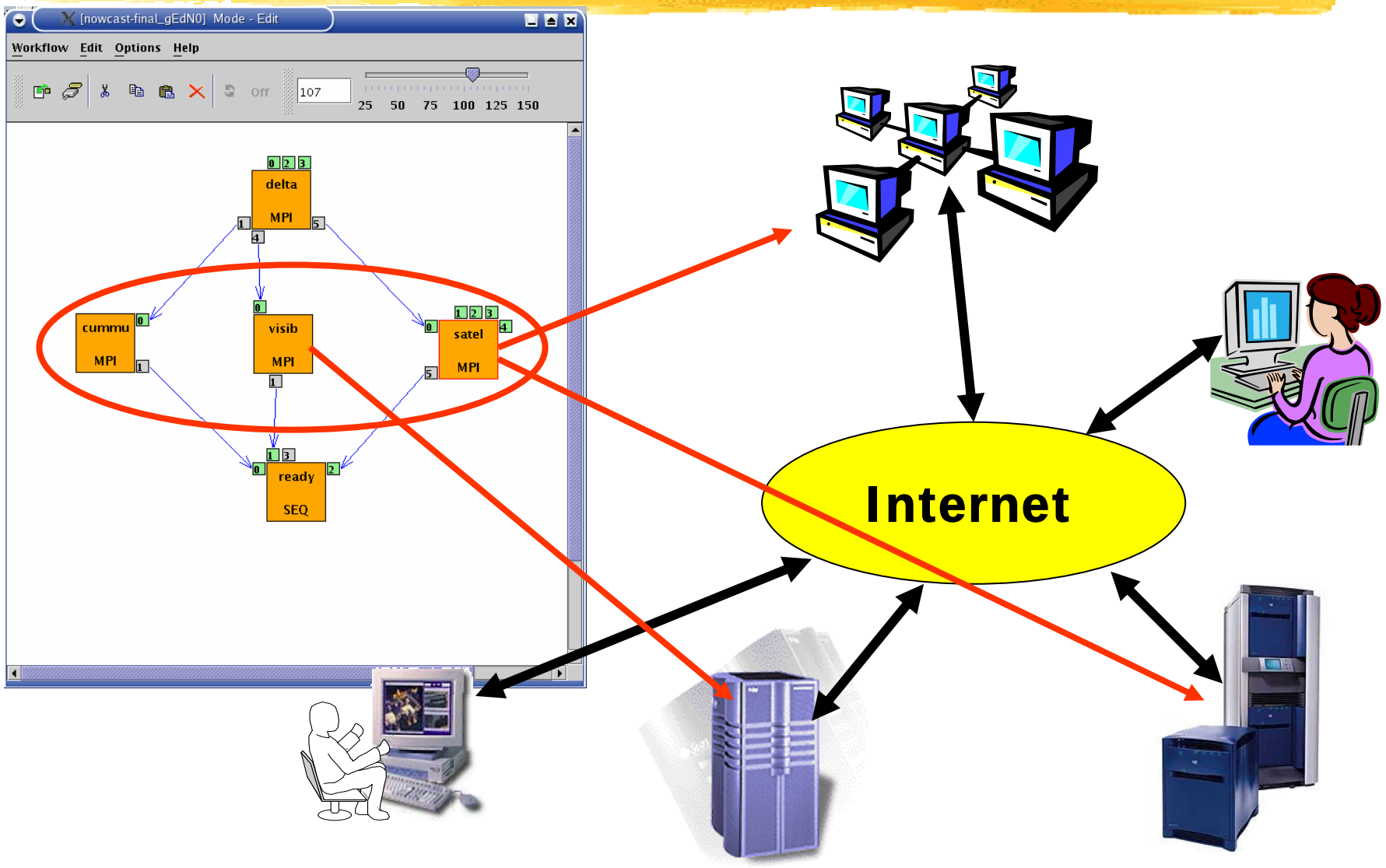
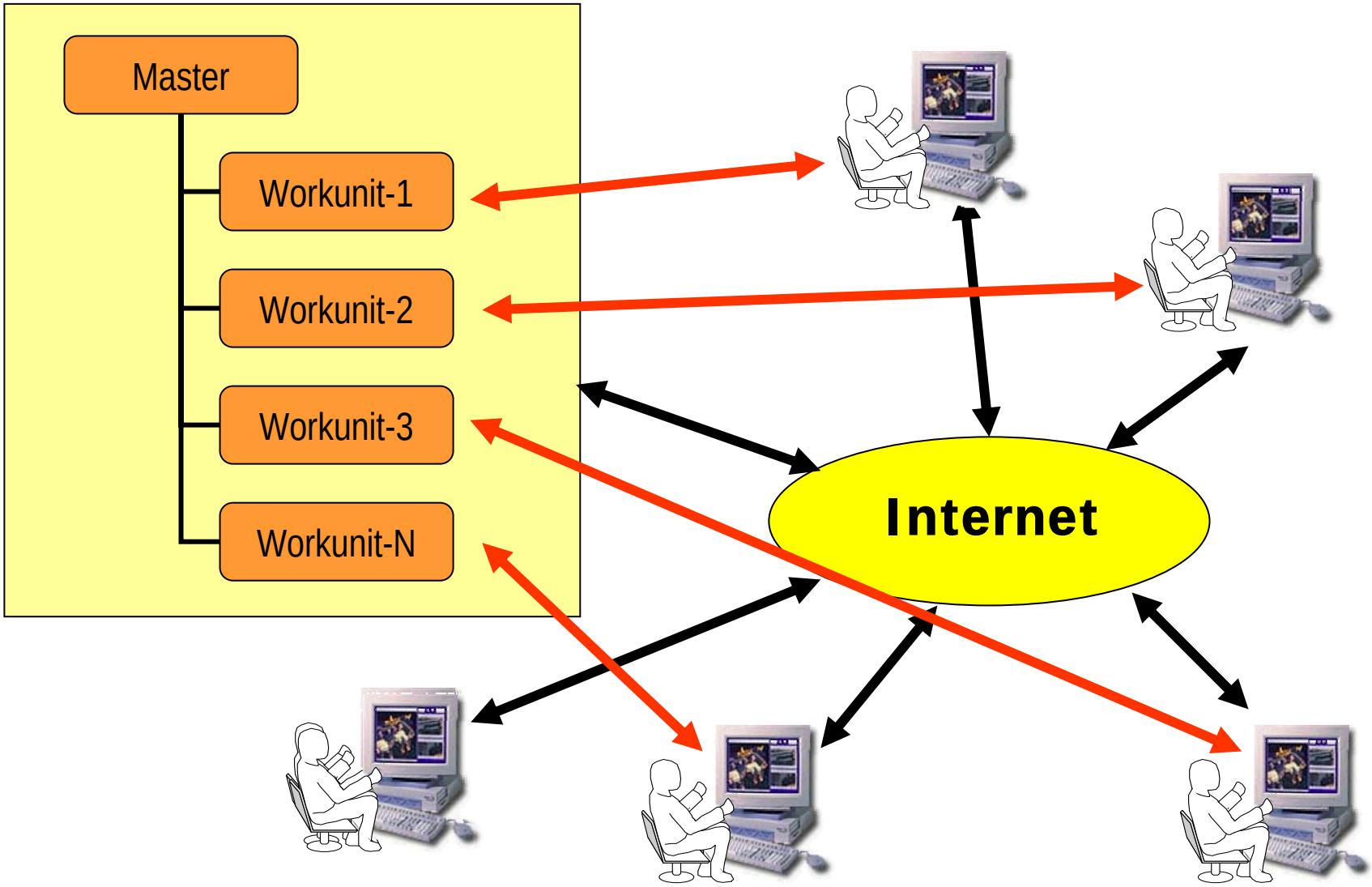
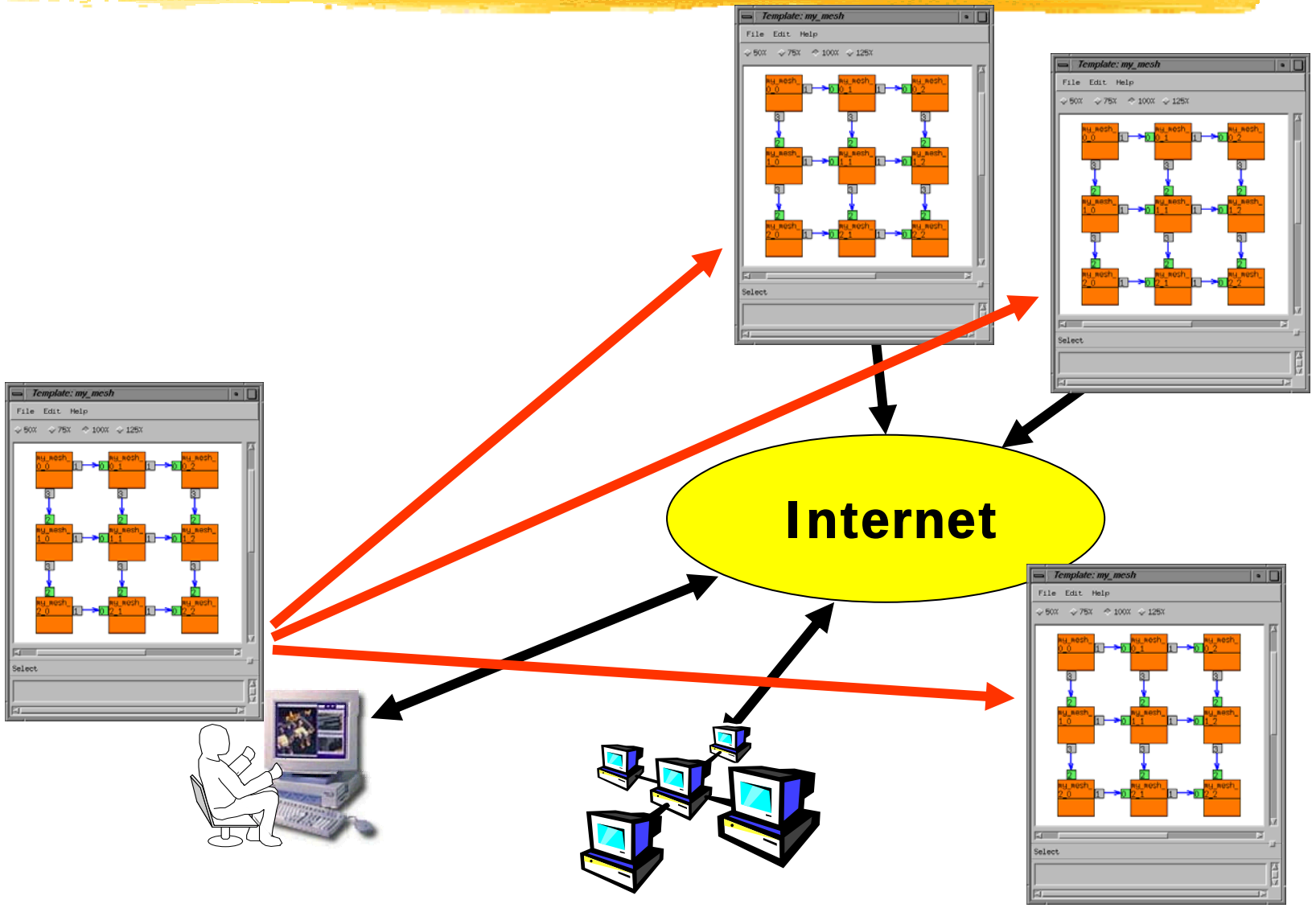


# Master/slave parallelism and parametric studies in utility Grids



# How to use a Grid for HPC parameter study?

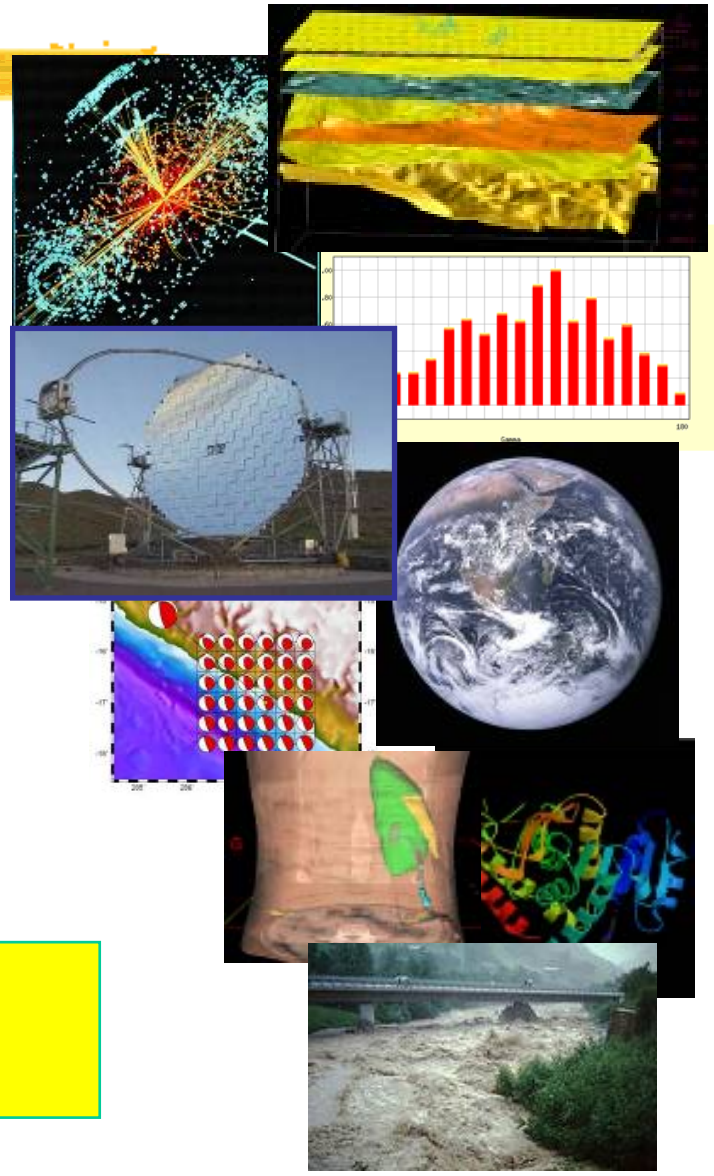



# Typical Grid Applications

- **Computation intensive**
  - Interactive simulation (climate modeling)
  - Very large-scale simulation and analysis (galaxy formation, gravity waves, battlefield simulation)
  - Engineering (parameter studies, linked component models)
- **Data intensive**
  - Experimental data analysis (high-energy physics)
  - Image and sensor analysis (astronomy, climate study, ecology)
- **Distributed collaboration**
  - Online instrumentation (microscopes, x-ray devices, etc.)
  - Remote visualization (climate studies, biology)
  - Engineering (large-scale structural testing, chemical engineering)
- **In all cases, the problems were big enough that they required people in several organization to collaborate and share computing resources, data, instruments.**

# EGEE Applications

- >20 applications from 7 domains
  - High Energy Physics
  - Biomedicine
  - Earth Sciences
  - Computational Chemistry
  - Astronomy
  - Geo-Physics
  - Financial Simulation
- Further applications in evaluation



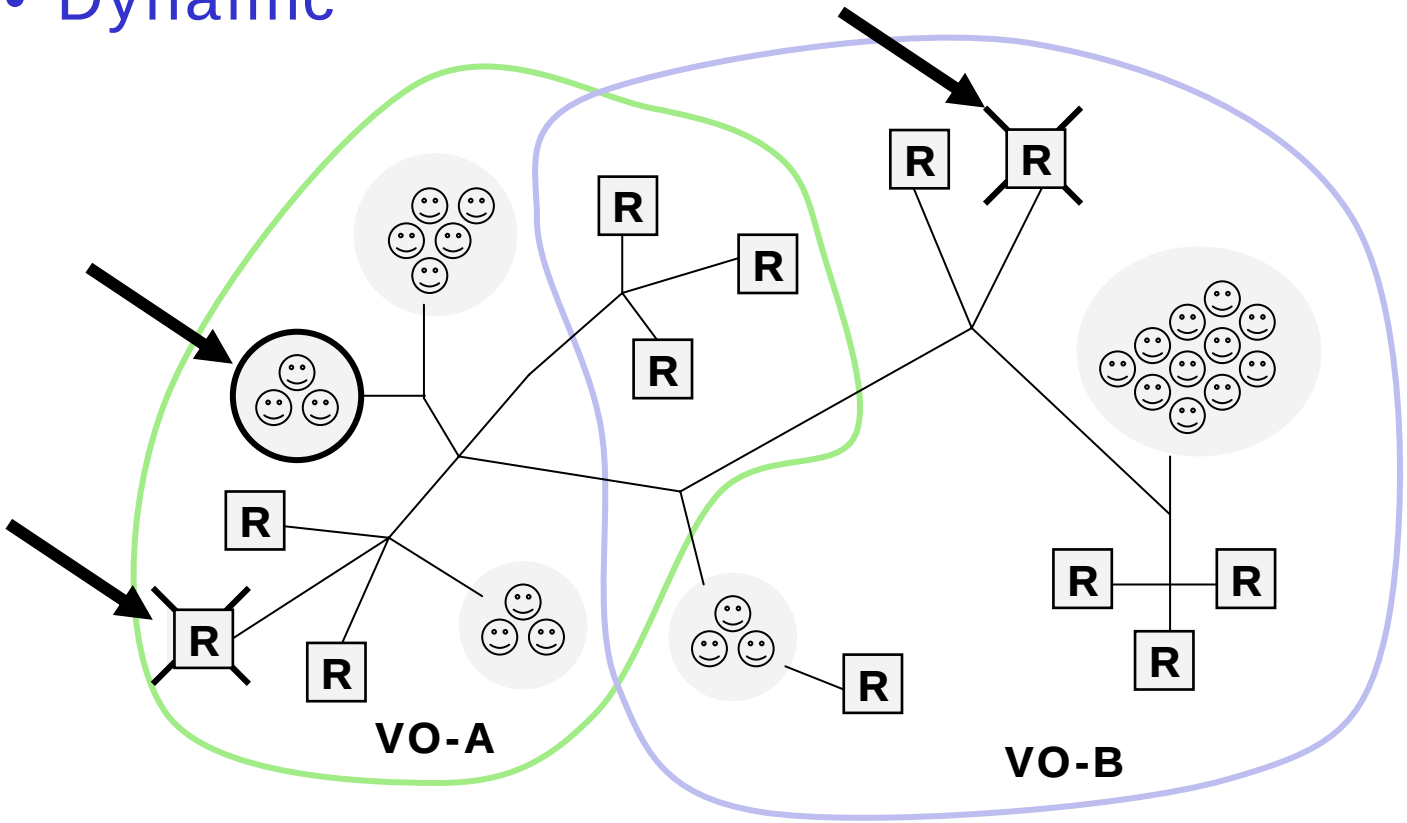
**Applications now moving from testing to routine and daily usage**

# An Example Problem tackled by EGEE

- The Large Hadron Collider (LHC) located at CERN, Geneva Switzerland
- Scheduled to go into production in 2007
- Will generate 10 Petabytes ($10^7$ Gigabytes) of information per year
- This information must be processed and stored somewhere
- It is beyond the scope of a single institution to manage this problem -> VO is needed

# Virtual Organizations

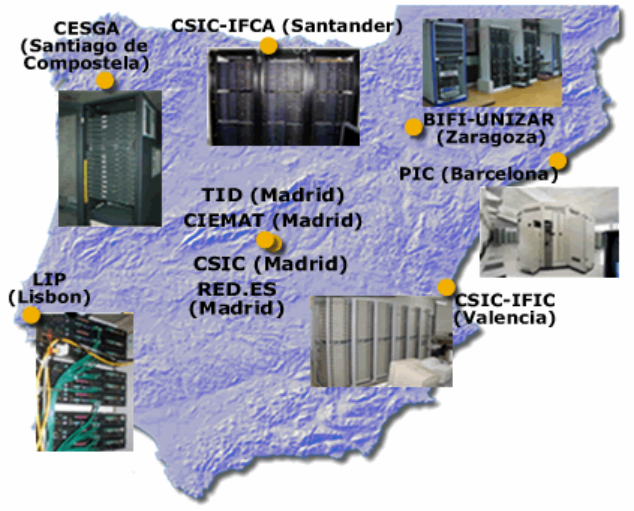
- Distributed resources and people
- Linked by networks, crossing admin domains
- Sharing resources, common goals
- Dynamic



# Local EGEE related activities

- Portugal and Spain are part of South West EGEE Federation (SWE)

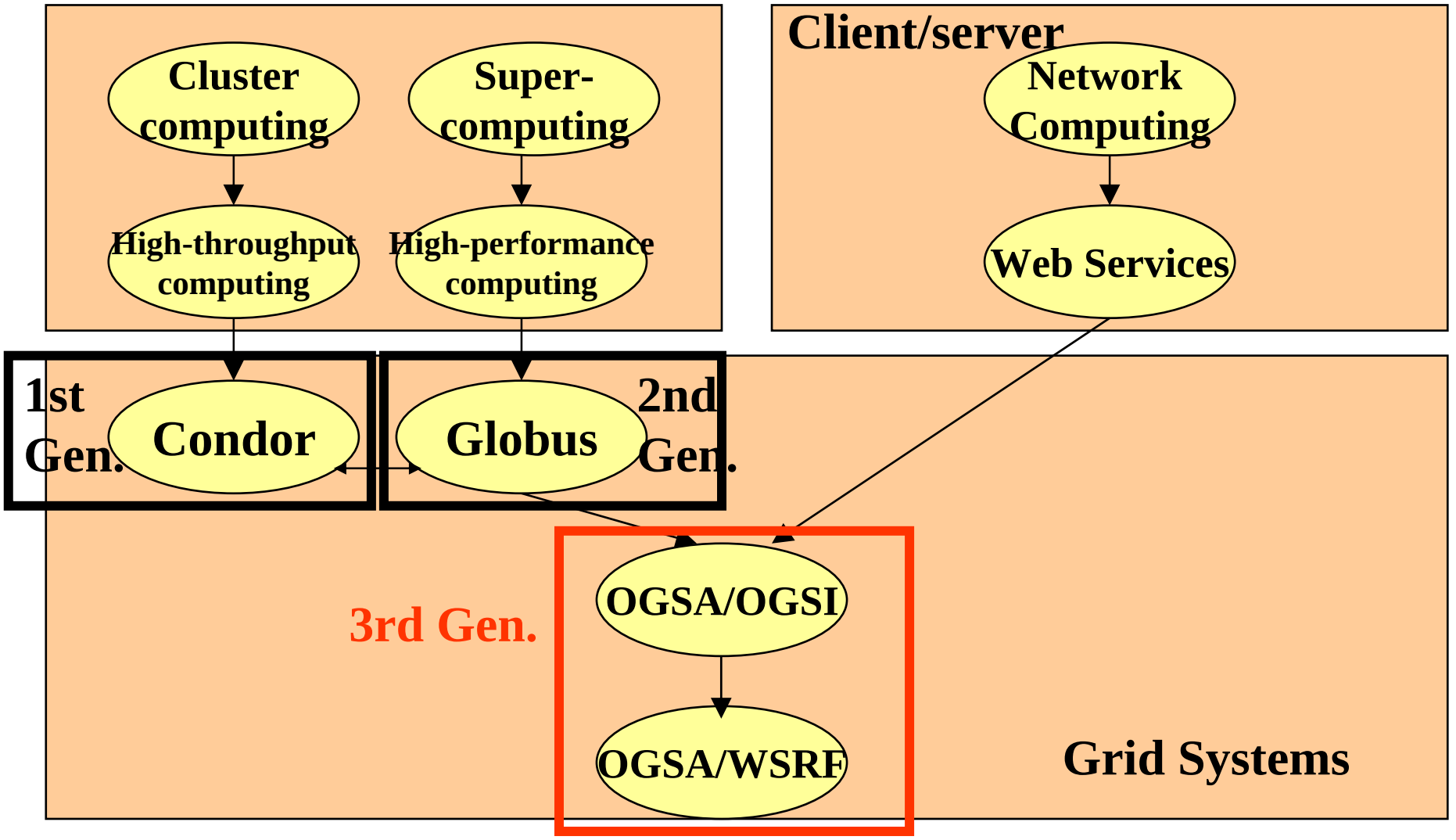
**grid.ifca.unican.es/egee-sa1-swe**



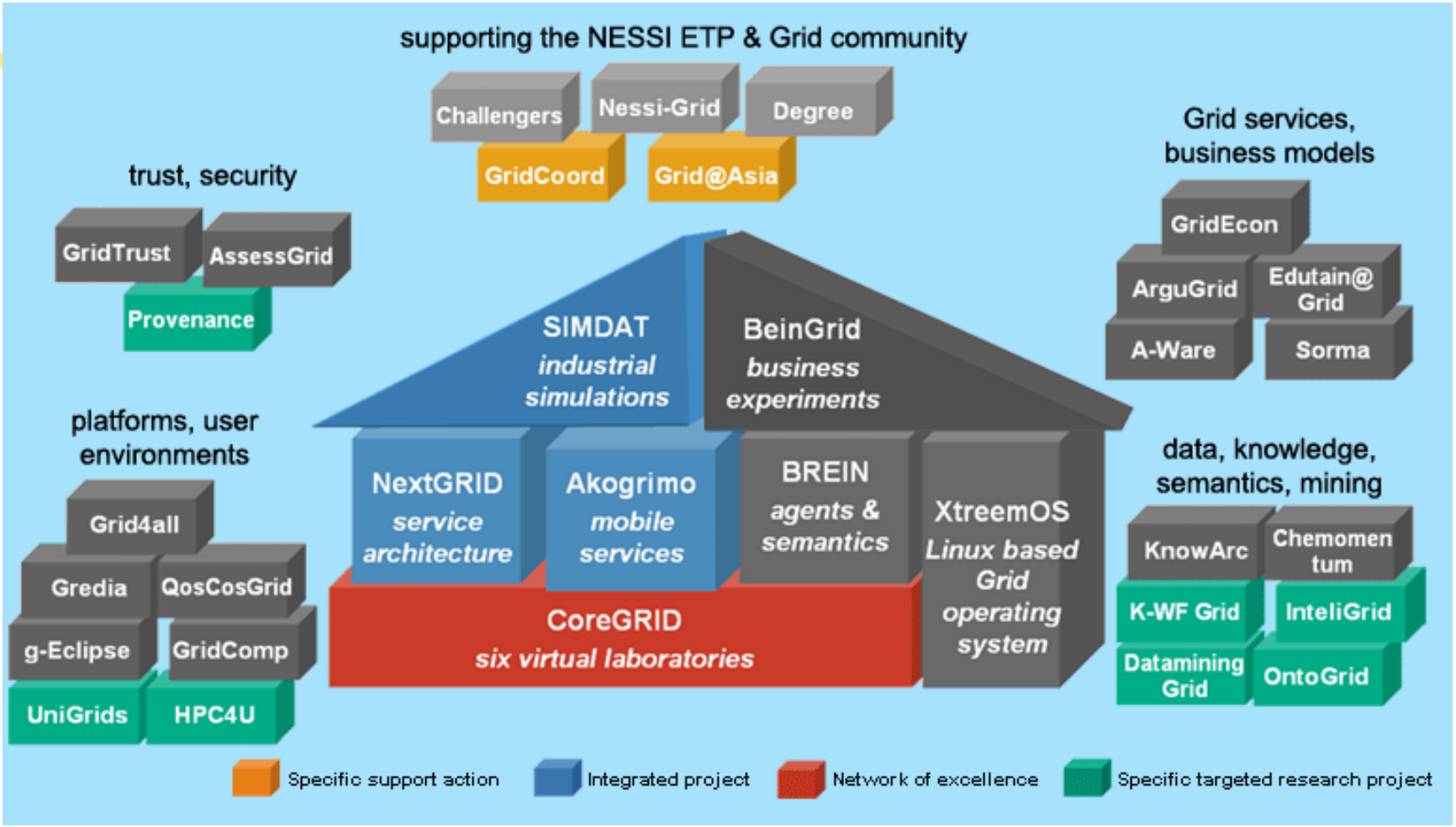

- Also involved in "E-infrastructure shared between Europe and Latin America" project (EELA)

**www.eu-eela.org**

# Progress in Grid Systems



# Other EU Grid projects




*Training and Education:* *ICEAGE*

International Collaboration to Extend and Advance Grid Education

www.iceage-eu.org


# Structure of the current course

- **Day 1**
  - **Introduction to grid technologies**
  - **Detailed study of GT4 technology and usage**
- **Day 2**
  - **Application development on Grids**
  - **Portal technology**
- **Day 3**
  - **GT4 Grid installation**
  - **Portal installation**