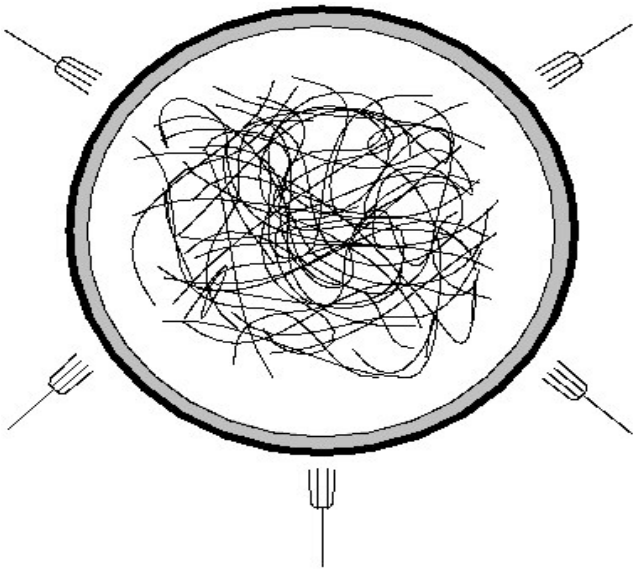
FIRST STEPS IN SCALABLE ARCHITECTURES TO SUPERCOMPUTING

CARLOS JAIME
BARRIOS HERNANDEZ

ABOUT PARALLELISM



Implicit parallelism is a characteristic of a programming language that allows a compiler or interpreter to automatically exploit the parallelism inherent to the computations expressed by some of the language's constructs.

Explicit parallelism is the representation of concurrent computations by means of primitives in the form of special-purpose directives or function calls.

Concurrency is a property of systems in which several computations are executing simultaneously, and potentially interacting with each other.

SCALABLE SYSTEMS

Any scalable system is a distributed system.

Parallel computing uses Scalable Systems

- Many instructions are carried out simultaneously-concurrently.
- High Performance Computing (HPC) implies Parallel Computing

Scalable Systems may be describe in terms of Scalable Architectures.

SCALABLE ARCHITECTURES

Scalable Architectures (hardware point of view) have the characteristics of Scalable Systems.

- Concurrency, Distribution

Scalable Architectures support Parallel Computing.

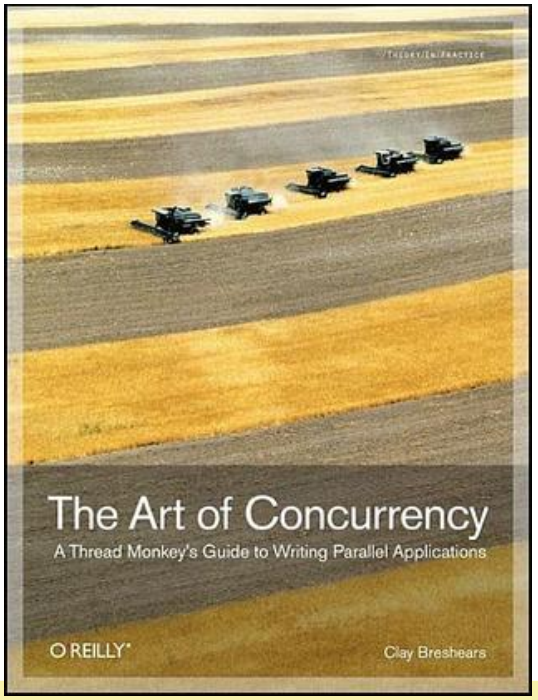
Of course, Parallel Computing implies parallelism.

Obviously, Parallel Computing demads Parallel Machines.

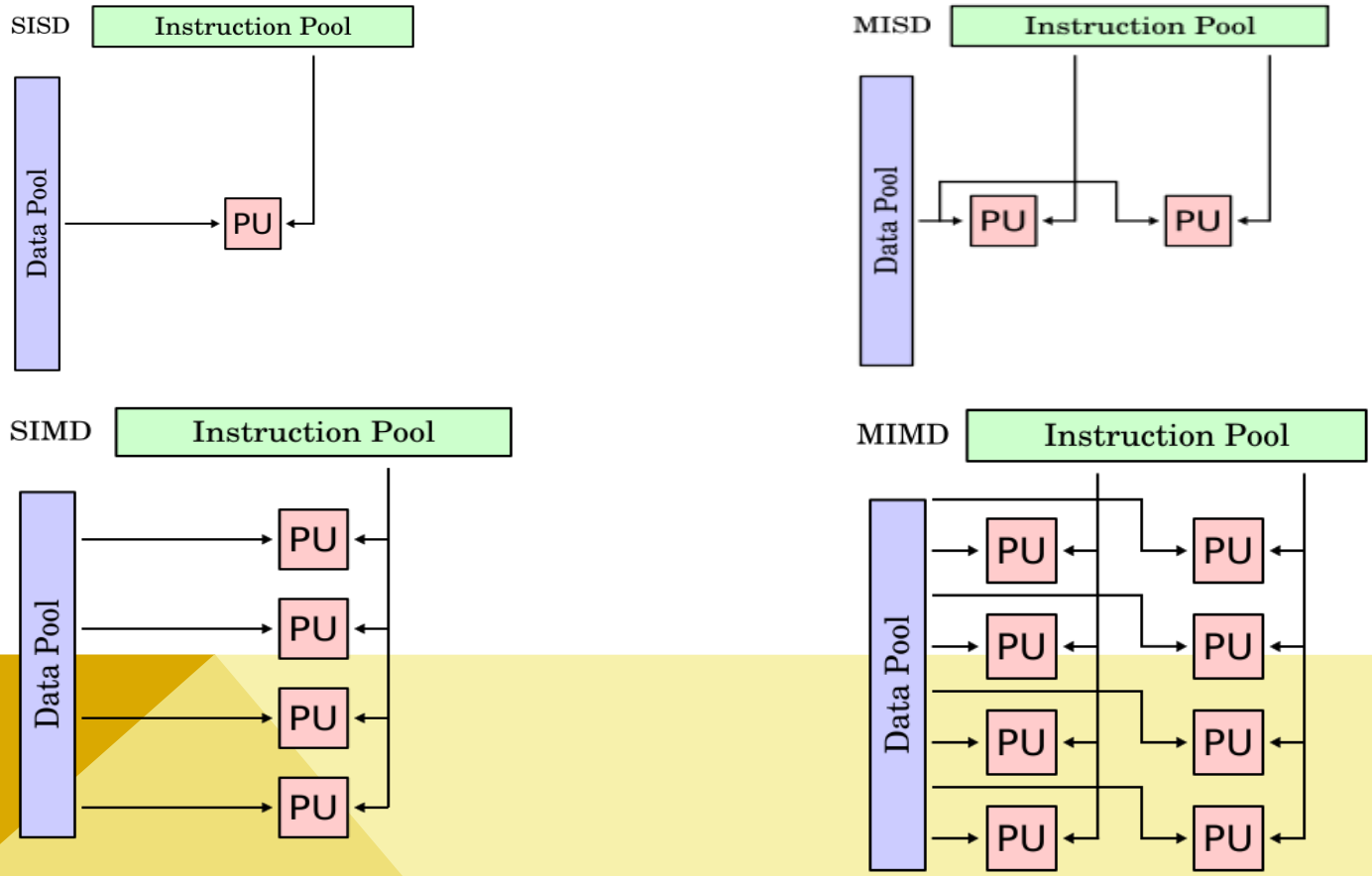
PARALLEL COMPUTING

Parallel Computing exploit Concurrency

- In “system” terms, concurrency exists when a problem can be decomposed in sub problems that can safely executed at same time (in other words, concurrently)



COMPARING FLYNN'S TAXONOMY*



* Proposed by M. Flynn in 1966

FURTHER TAXONOMY
(DERIVATE FROM MIMD FOR DISTRIBUTED MEMORY PROGRAMMING)

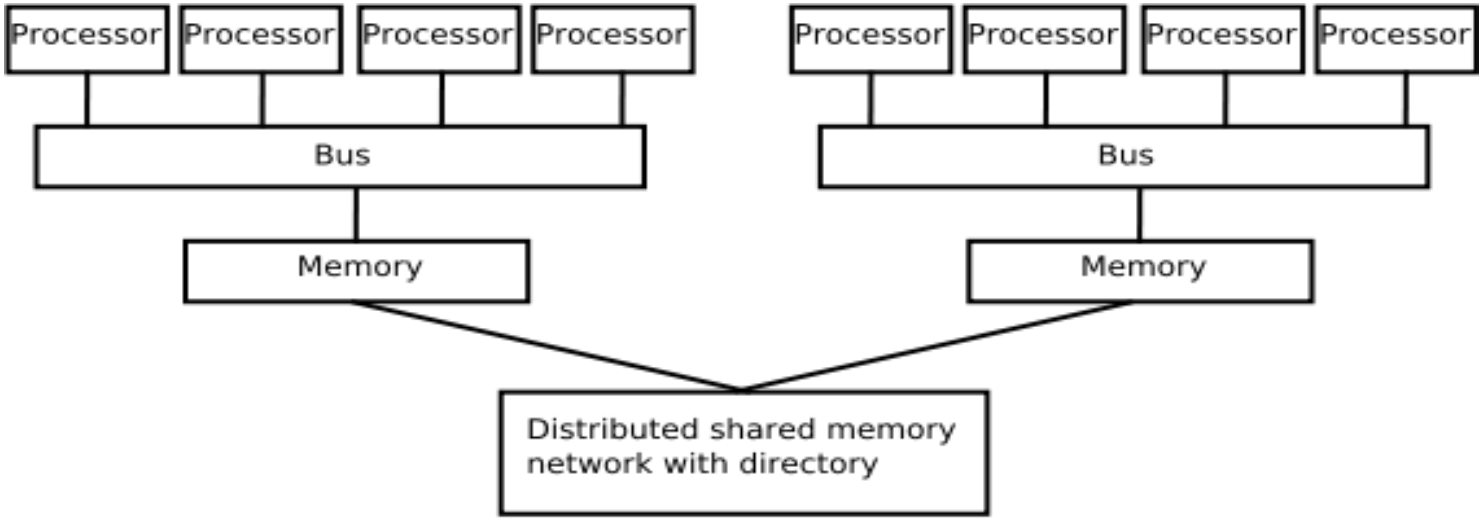
SPMD (Single Program, Multiple Data streams or Single Process, Multiple Data)

- Multiple autonomous processors simultaneously executing the same program on different data.
- It is the most common taxonomy.

MPMD (Multiple Program Multiple Data)

- Multiple autonomous processors simultaneously operating at least 2 independent programs.

THE DISTRIBUTED SHARED MEMORY ACCESS

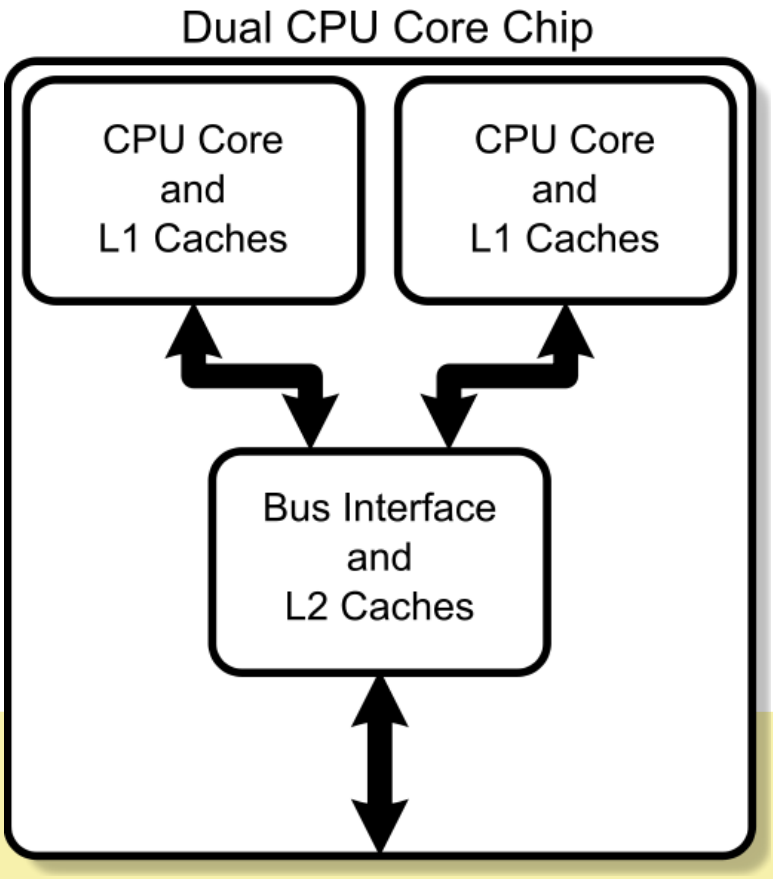


- Main Memory in Parallel Machines is a hybrid between shared memory and distributed memory.
- Distributed memory systems have Non-Uniform Memory Access (NUMA) architecture

MULTICORES

Multicore Computer:

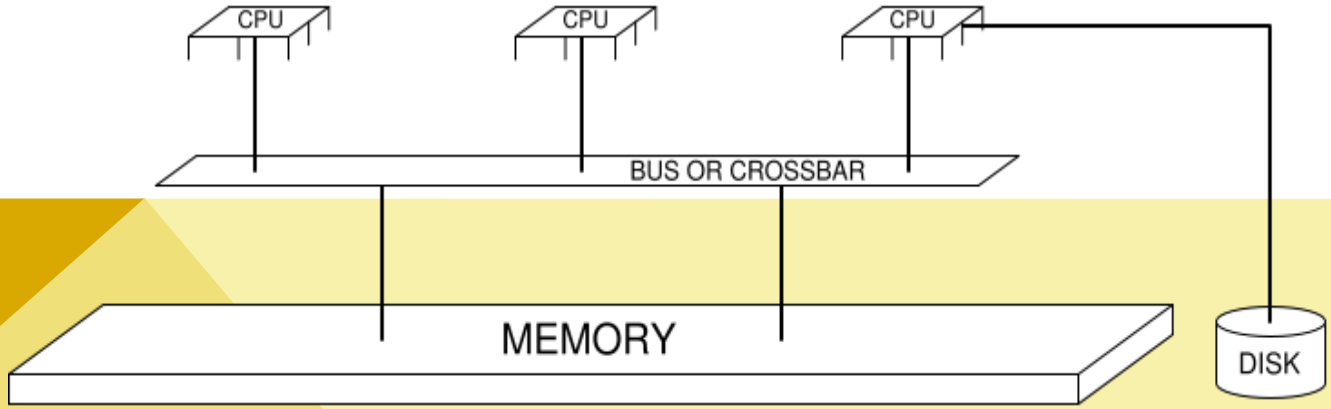
- Multicore Processor includes multiple execution units (cores)
- Intel's Dual Core, Intel's QuadriCore
- Play Station 3



SYMETRIC MULTIPROCESSING

Symmetric multiprocessors:

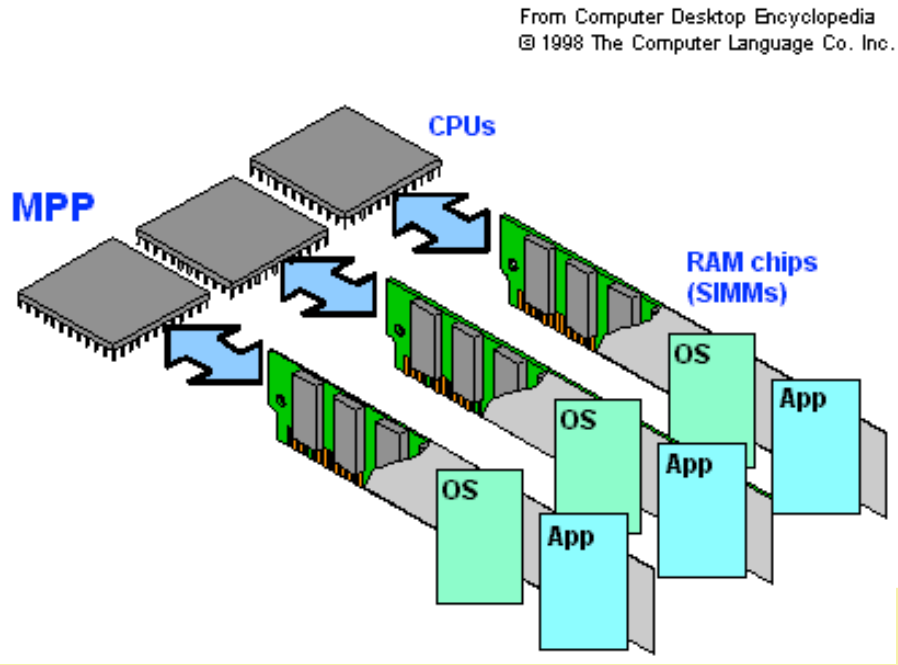
- A symmetric multiprocessor (SMP) is a computer system connected to a main shared memory.
- Intel's Xeon.
- Sun Microsystems UltraSPARC.



MASSIVE PARALLEL PROCESSING (MPP)

Computer system with many independent arithmetic units or entire microprocessors, that run in parallel

MPPA is a MIMD (Multiple Instruction streams, Multiple Data) architecture, with distributed memory accessed locally, not shared globally



MORE OF PARALLEL COMPUTERS

Reconfigurable Computing with Field-Programmable Gate Arrays (FPGA).

General-Purpose Computing on Graphics Processing Units (GPGPU).

- Programmin with CUDA and OpenCL (i.e.)

Application-Specific Integrated Circuits (ASIC).

Vector Processors. (SIMD)

DISTRIBUTED COMPUTERS

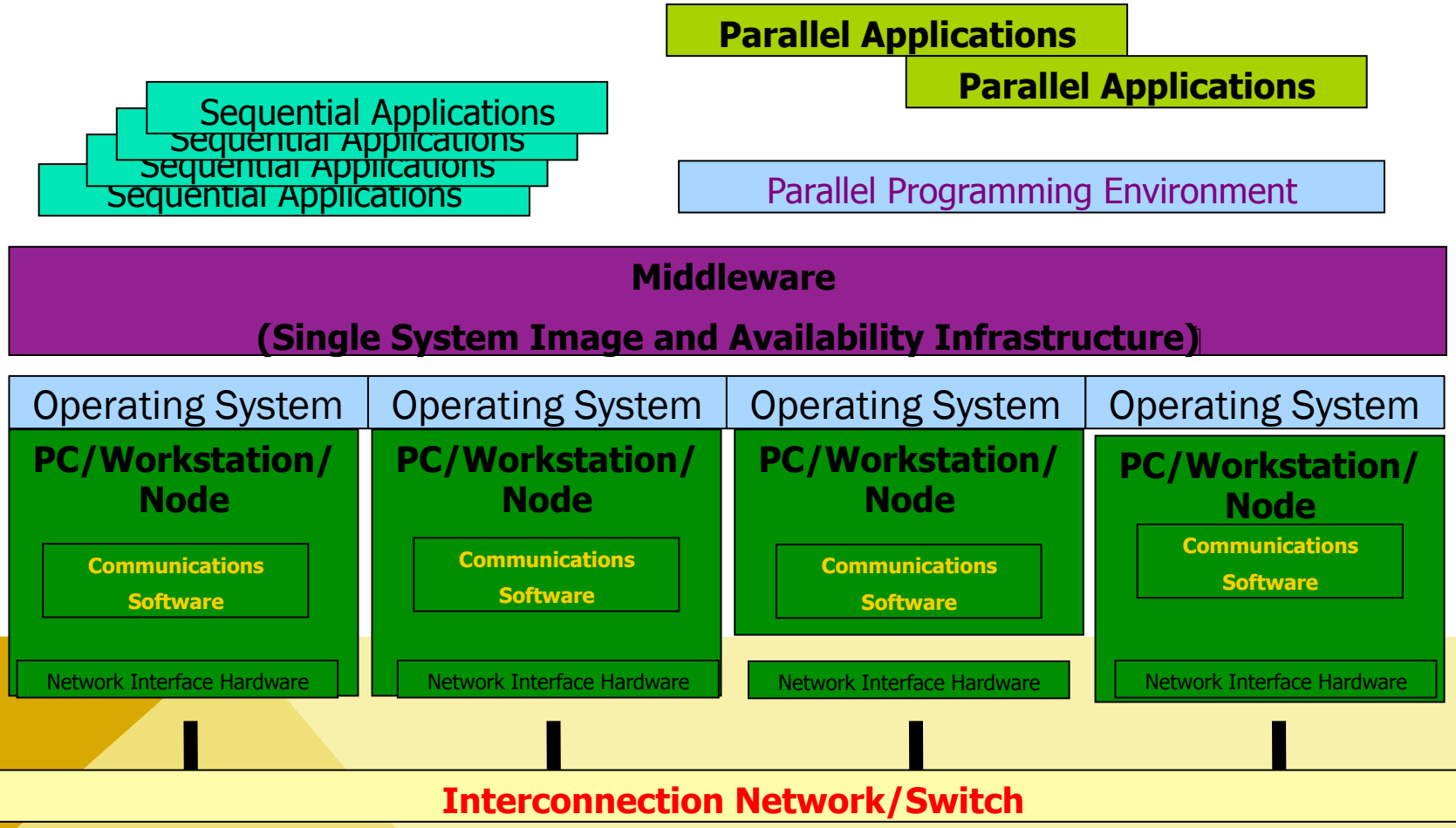
- **Distributed computing:**
  - Distributed Computing is a Distributed Memory Multiprocessor System connected by a network.
  - Distributed computers are **highly scalable!**
  - Cases of Distributed Computing:
    - Cluster computing (Parallel Distributed Computing)
    - Grid Computing

LARGE SCALE ARCHITECTURES

Large Scale Architecture (LSA) allows to trait large scale problems.

- LSAs need Large Scale Sotware
- LSAs are distributed systems.
  - Cluster Computing Platform
  - Grid Computing Infrastructure
- The Fault tolerance is a critical problem in LSA systems.

CLUSTER COMPUTING ARCHITECTURE



CLUSTERS EXEMPLES (1/4) (ARCHITECTURE VIEW)

MARENOSTRUM

EXCELENCIA SEVERO OCHOA

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

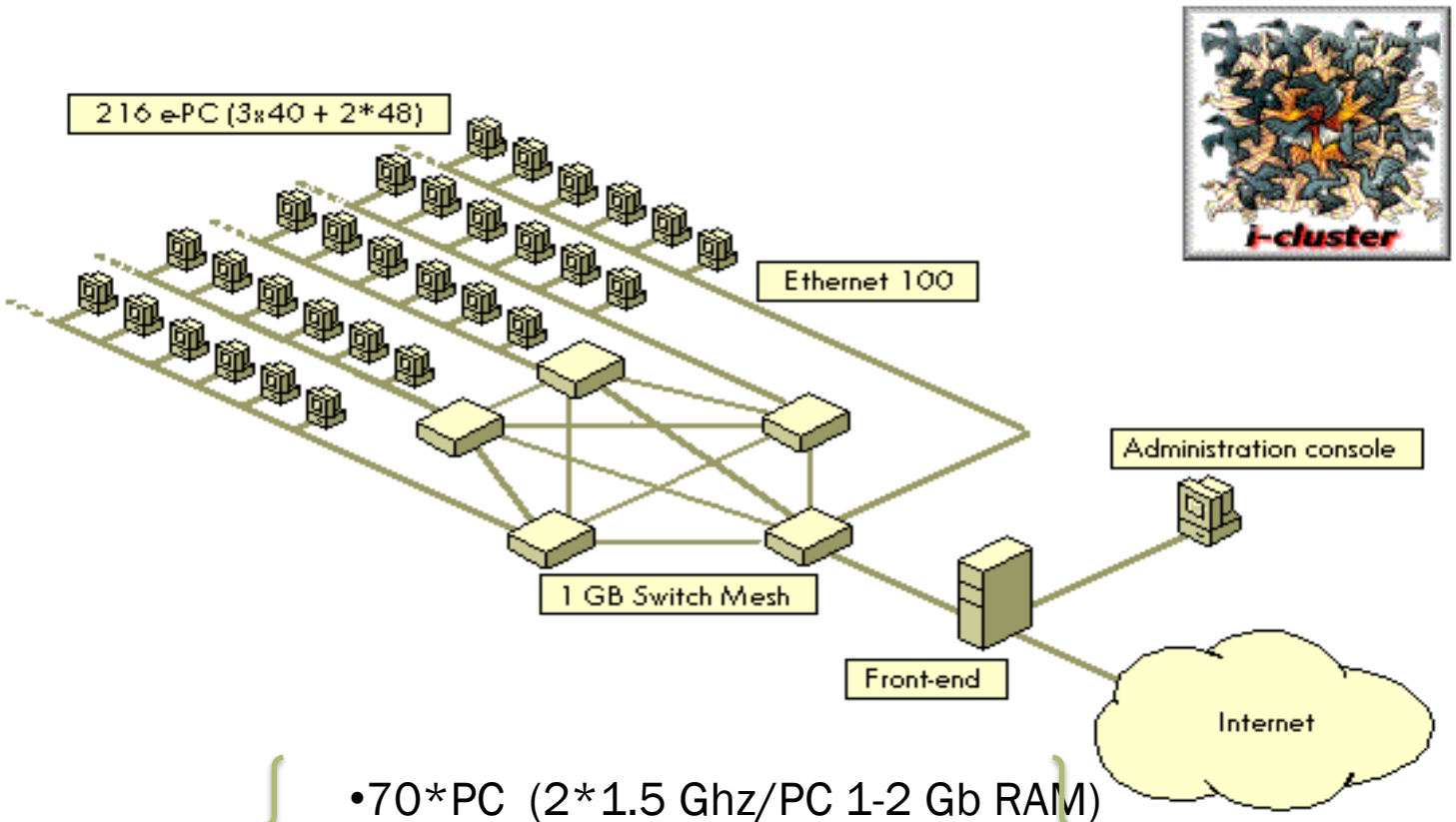
GOBIERNO DE ESPAÑA

Generalitat de Catalunya

UPC

CLUSTERS EXEMPLES (2/4)

Desktop Cluster or NOW-Cluster



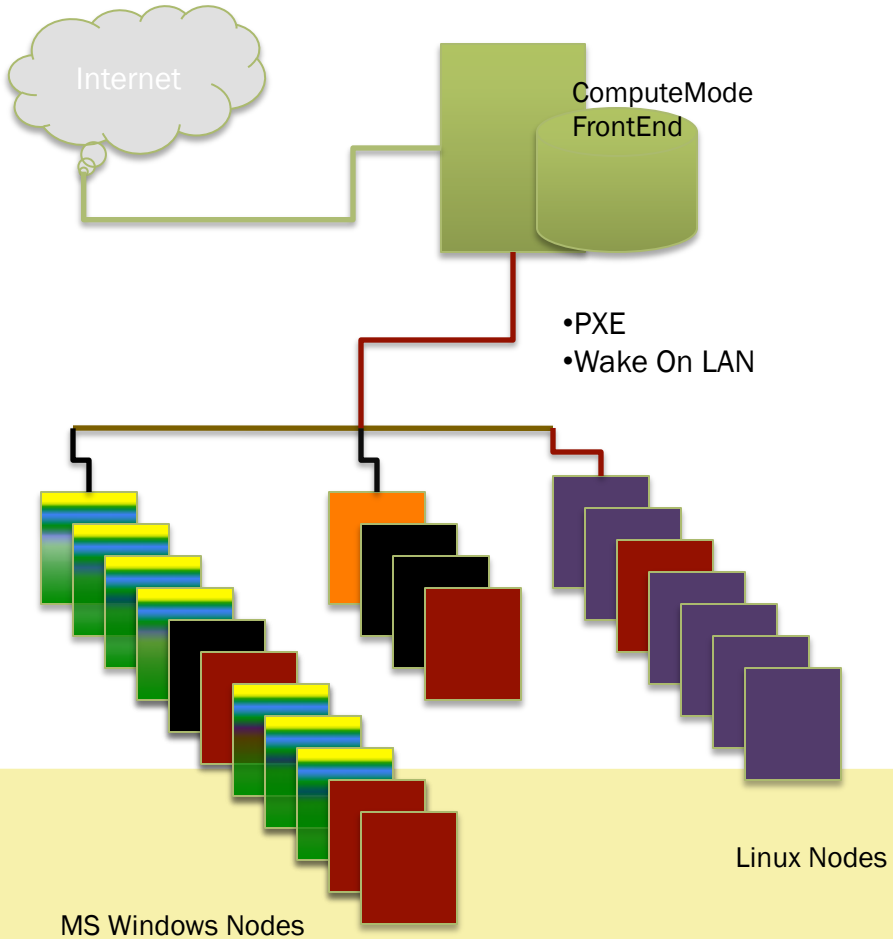
- 70*PC (2*1.5 Ghz/PC 1-2 Gb RAM)
- Ethernet 100/1000

COMPUTEMODE CENTIC

ComputeMode: (Ligthweight Clustering Framework).

- Easy Deployment and Integration
- Not uses Local S.O.

http://computemode.imag.fr



Super Computacion y Calculo Cientifico UIS

CLUSTERS EXEMPLES (3/4) (ARCHITECTURE VIEW)

G.U.A.N.E. (**G**PU**s** **A**dvanced computi**N**g **E**nvironment)

Universidad Industrial de Santander

CONSTRUIMOS FUTURO

Super Computacion y Calculo Cientifico UIS

Guatiguará PARQUE TECNOLÓGICO

CLUSTERS EXEMPLES (4/4) (ARCHITECTURE VIEW)

BIOS

GRID COMPUTING

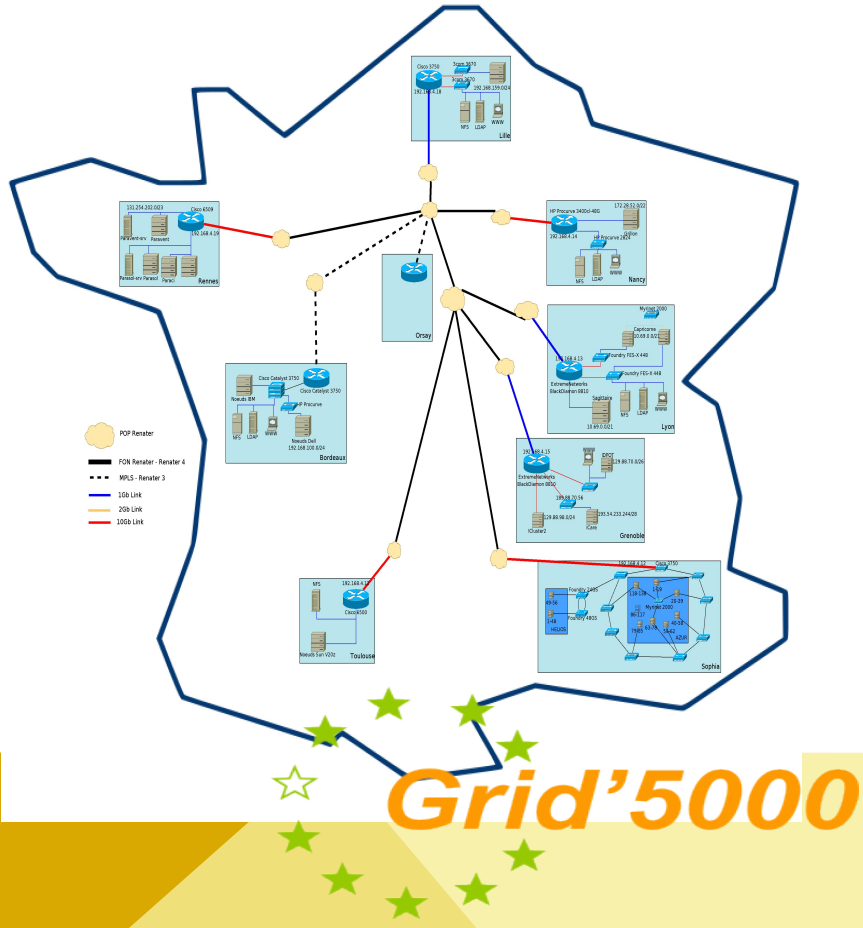
Grid Computing implies technology, technics and methodology to support Parallel*/ Distributed Computing.

Grid Computing needs Grid Computing Infrastructure and dedicated and high disponibility networks or interconexion.

Different Types or Possibilities:

- Experimental Testbeds
- Production Grids
- Lightweigth Grids
- Desktop Grid Computing (May be Lightweigth too)

GRID COMPUTING FEAUTURES



Grid Computing Features:

Infrastructure

- High Availability
- High Performance
- Heterogeneity
- Pervasive
- Scalability

Methodology

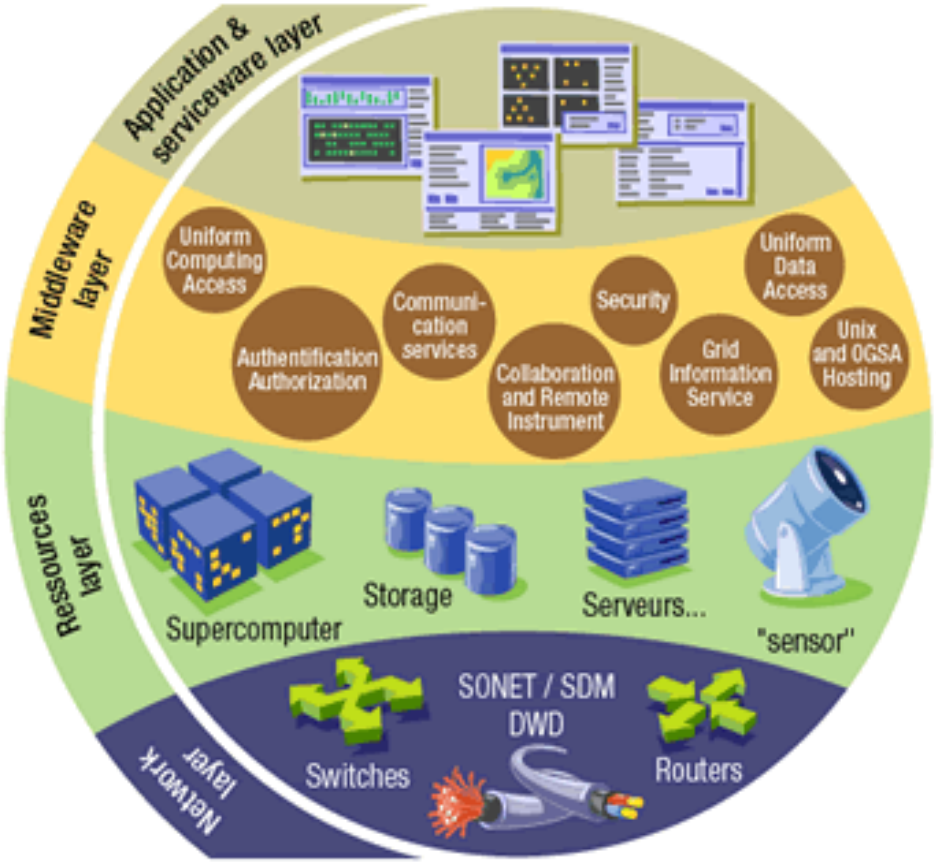
- Different User Levels
- Multi Administration

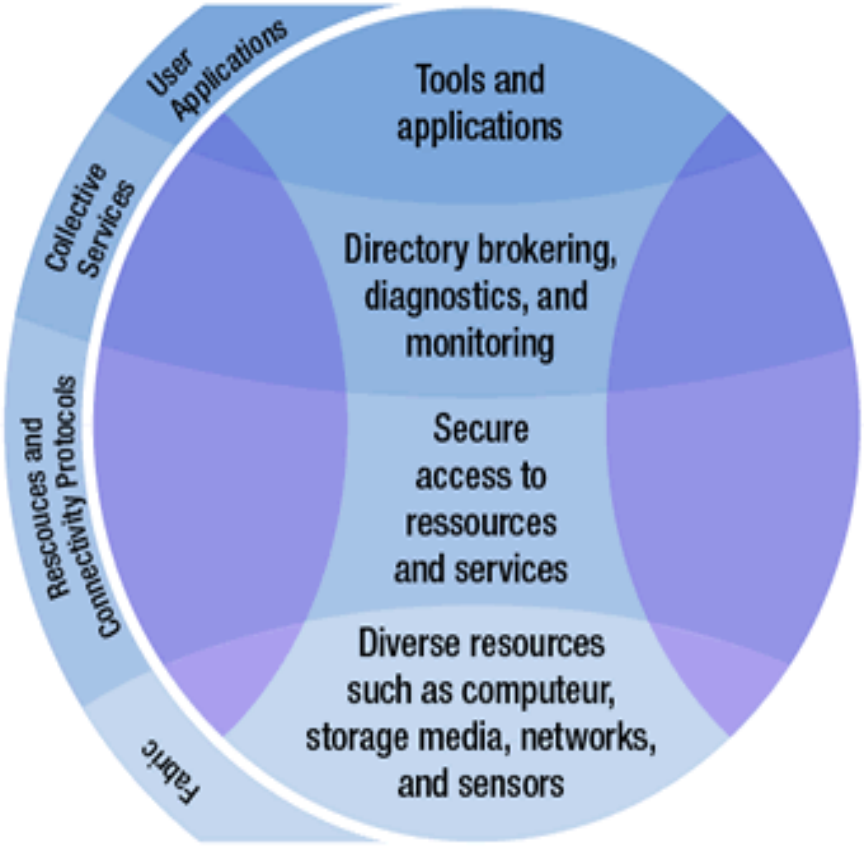
Politics

- Security
- Use
- Privacy

http://www.grid5000.fr

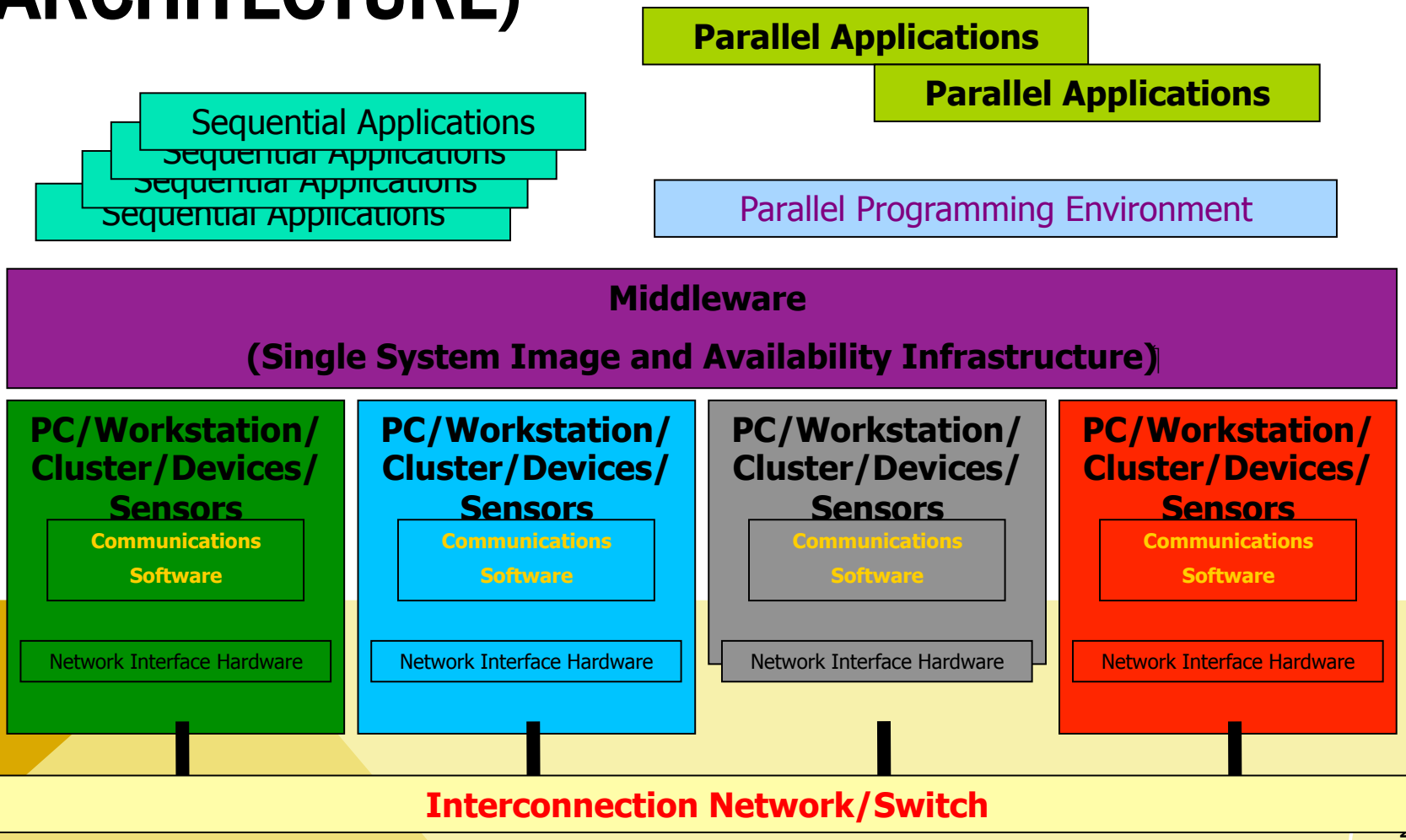
Grid Computing Architecture (Typical Diagram)



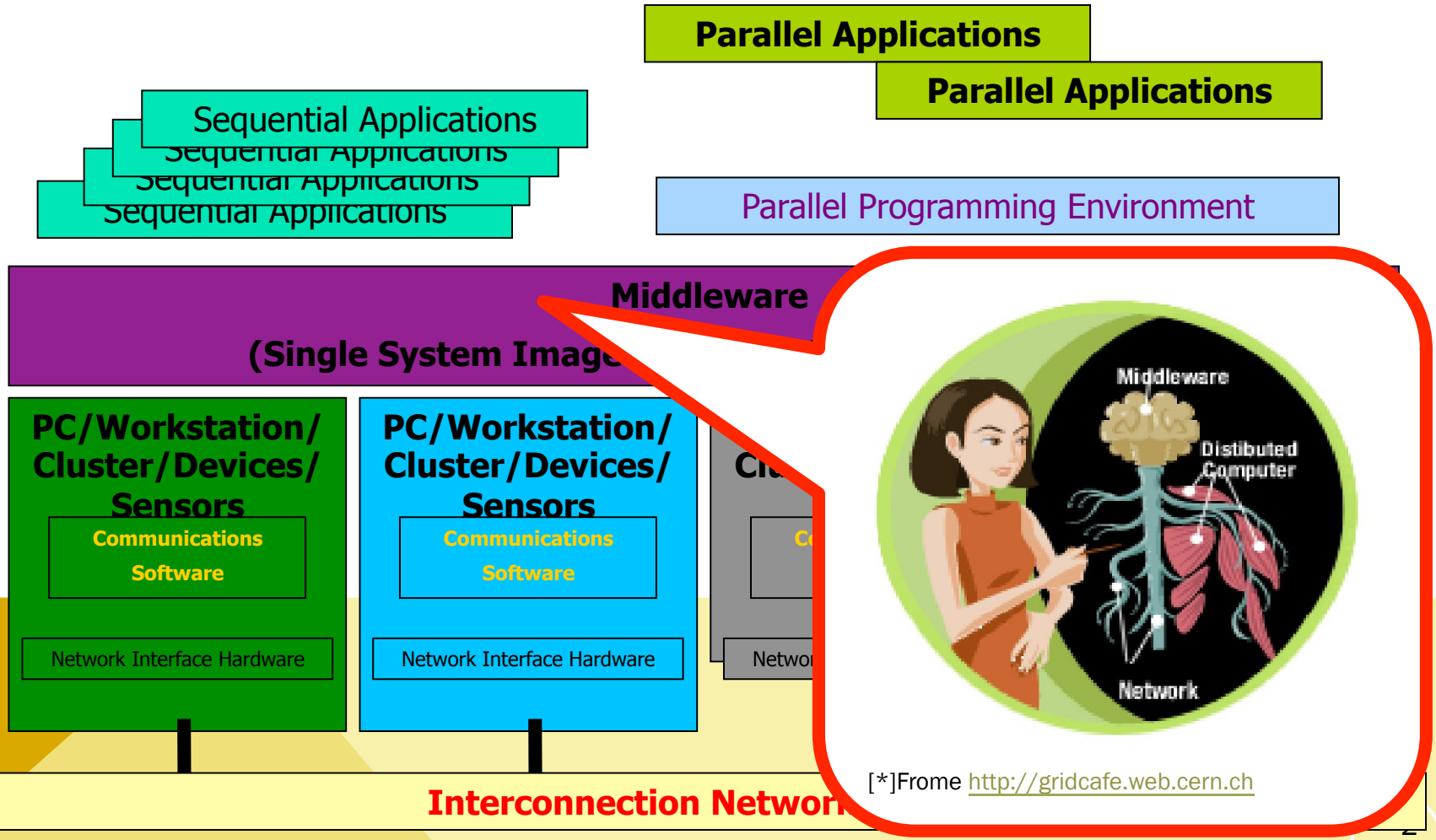


[*]From http://gridcafe.web.cern.ch

GRID COMPUTING ARCHITECTURE (REMEMBER THE CLUSTER ARCHITECTURE)

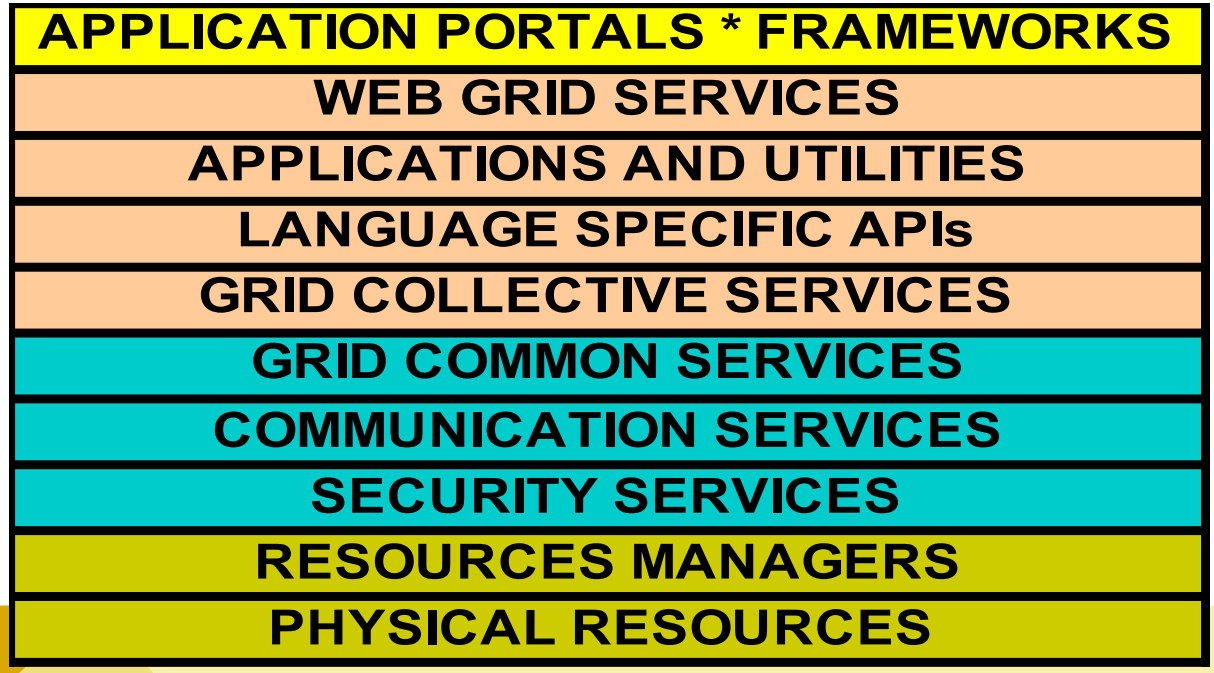


GRID COMPUTING ARCHITECTURE AND THE MIDDLEWARE



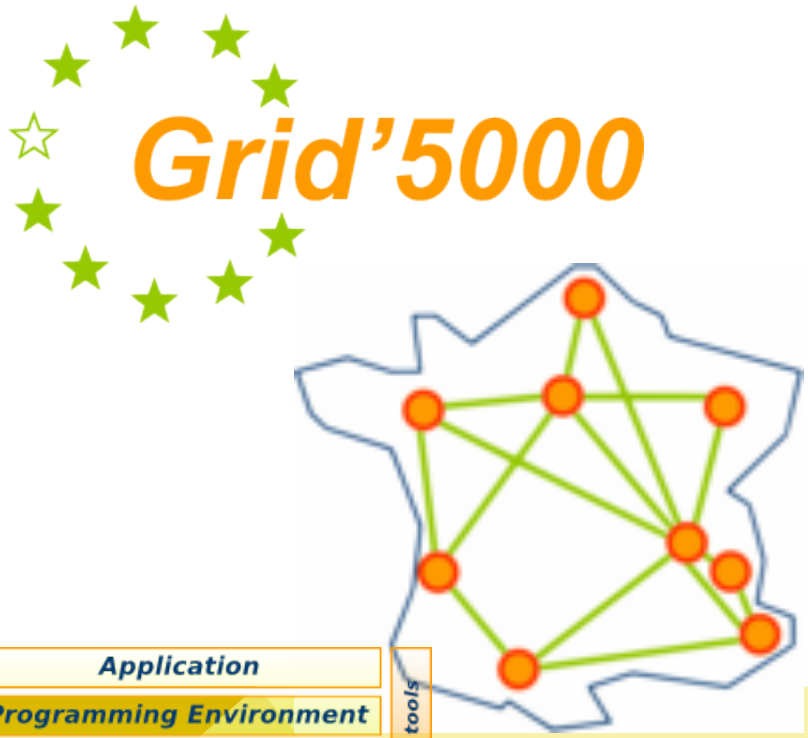
[*]Frome http://gridcafe.web.cern.ch

GRID COMPUTING ARCHITECTURE



[*]From: Grid Computing: Making The Global Infrastructure a Reality

GRID5000 (G5K)

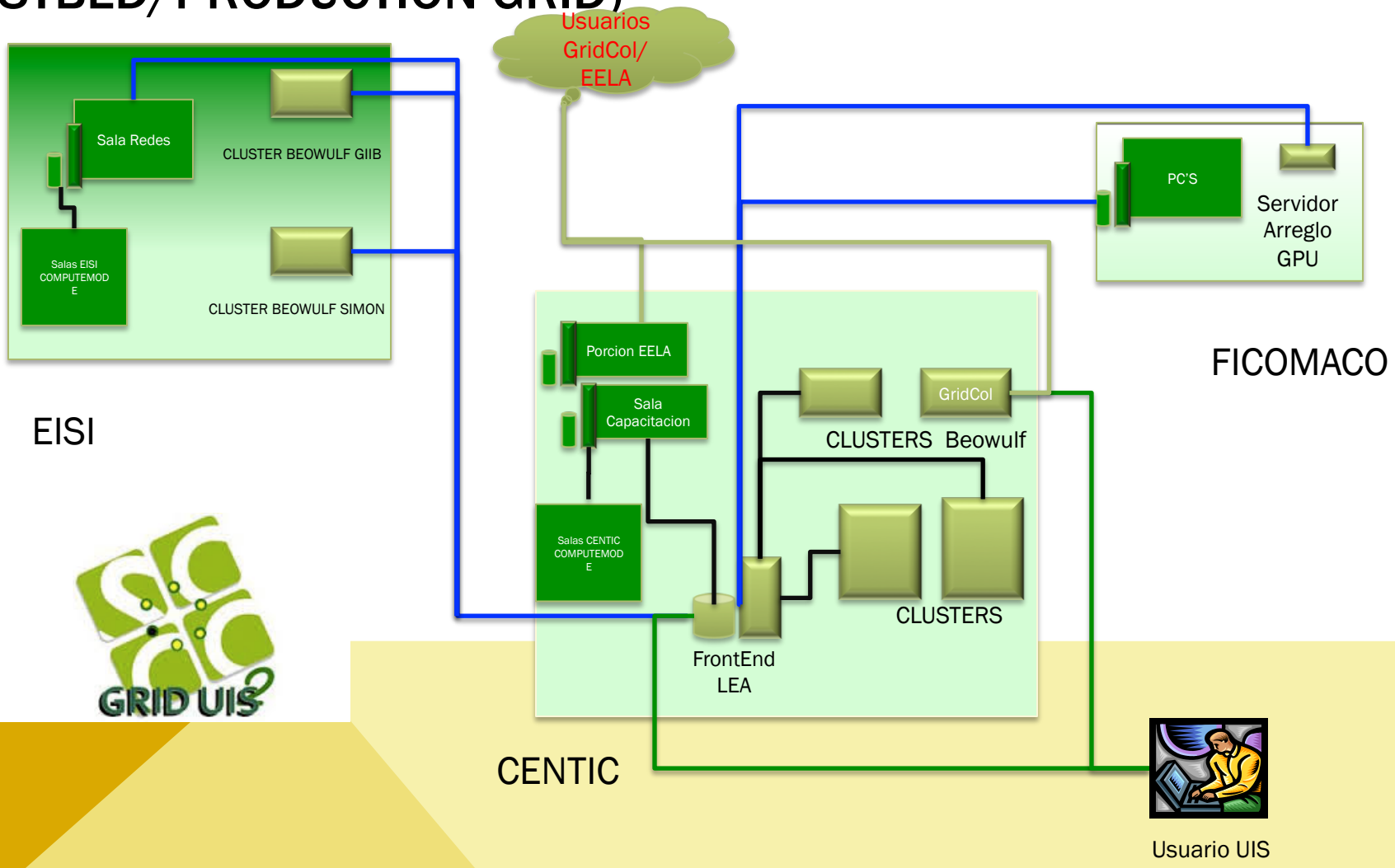


- G5K has 5000 processors distributed in 9 sites France wide, for research in Grid Computing, eScience and Cyber-infrastructures
- G5K project aims at building a highly reconfigurable, controlable and monitorable experimental Grid platform

www.grid5000.org

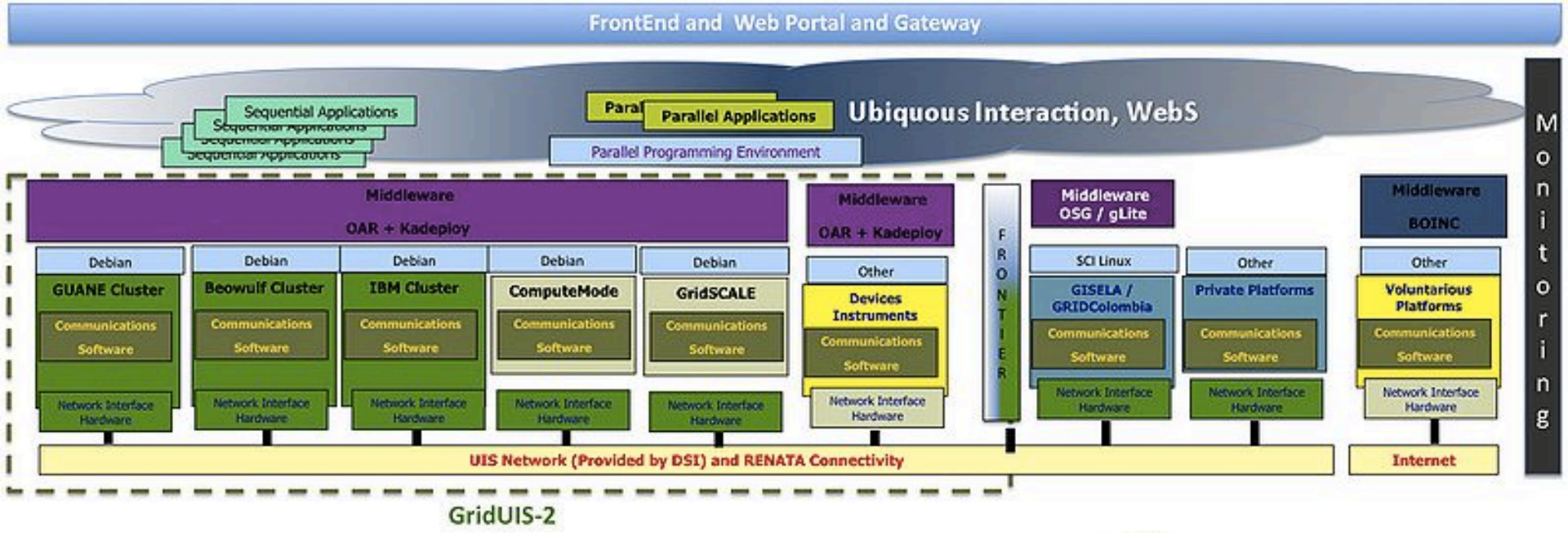
GRIDUIS-2

TOPOLIGY: LIGTHWEIGHT GRID INFRASTRUCTURE AND TESTBED/PRODUCTION GRID)



GridUIS-2

(Architectural Mix: Ligthweight Grid Infrastructure and TestBed/Production Grid)



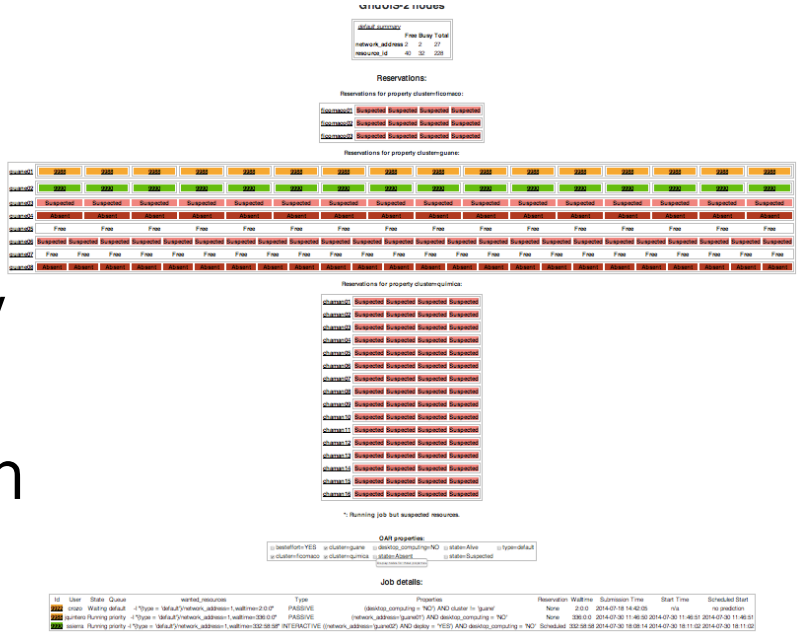
Performing HPC as a Service...

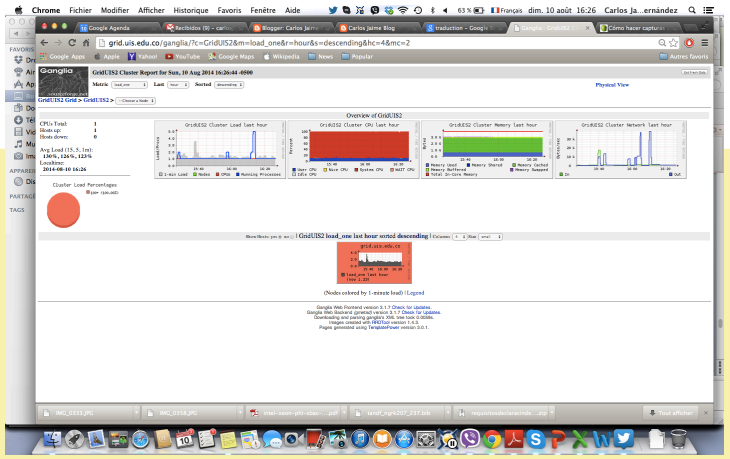
GRID UIS 2

GridUIS-2

Using Mix: Multi-users // Administration)

- **More of 500 Users**
- Centralized Management
- 24h/24h 7h/7h Availability (Almost)
- External Projects Connexion (G5K, SCALAC)
- Scheduling via OAR (+RDMAAs soon)
- Kadeploy, LXC, Virtualisation…
- In Situ Monitoring
- Monika, Ganglia, GANTT…



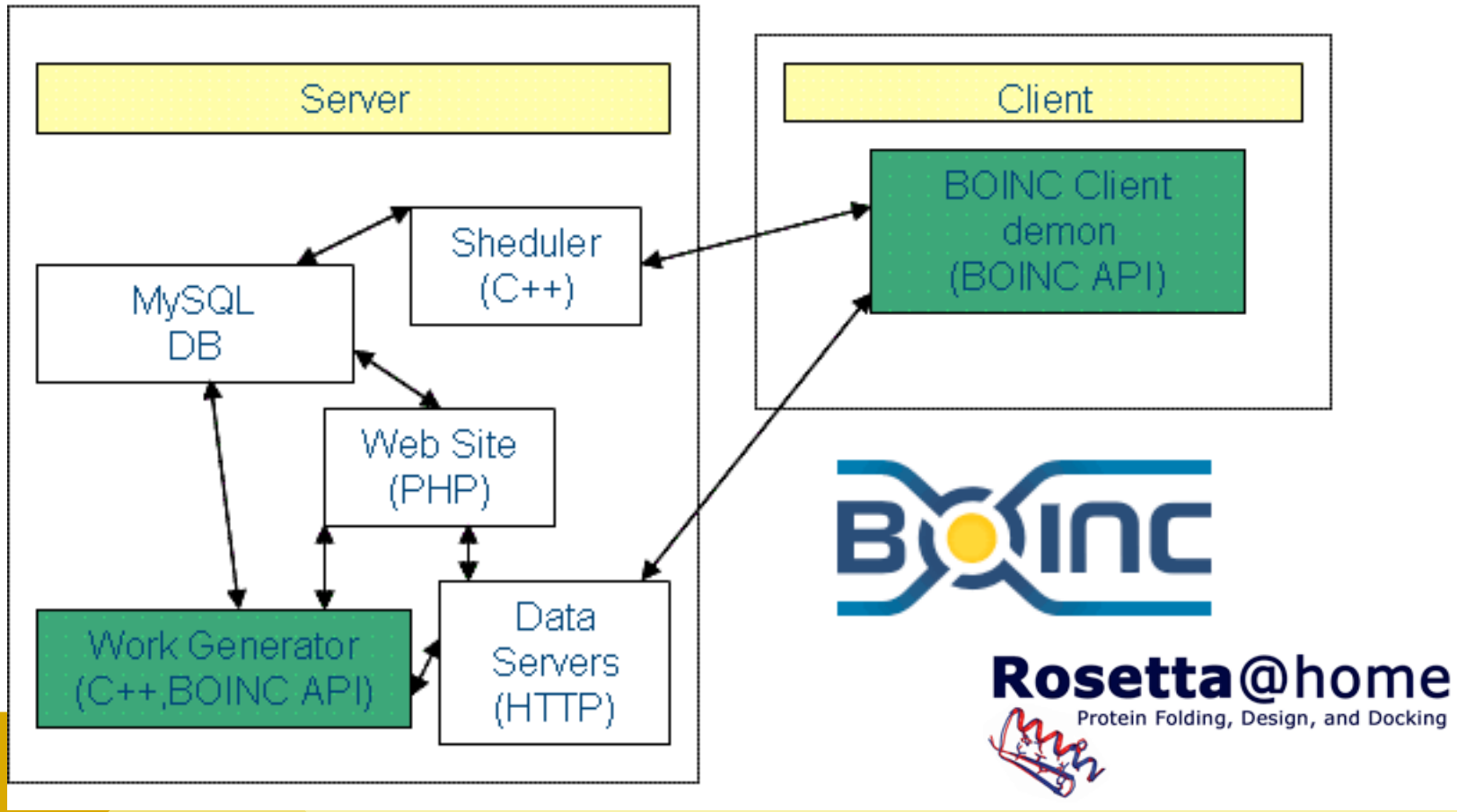


VOLUNTEER COMPUTING

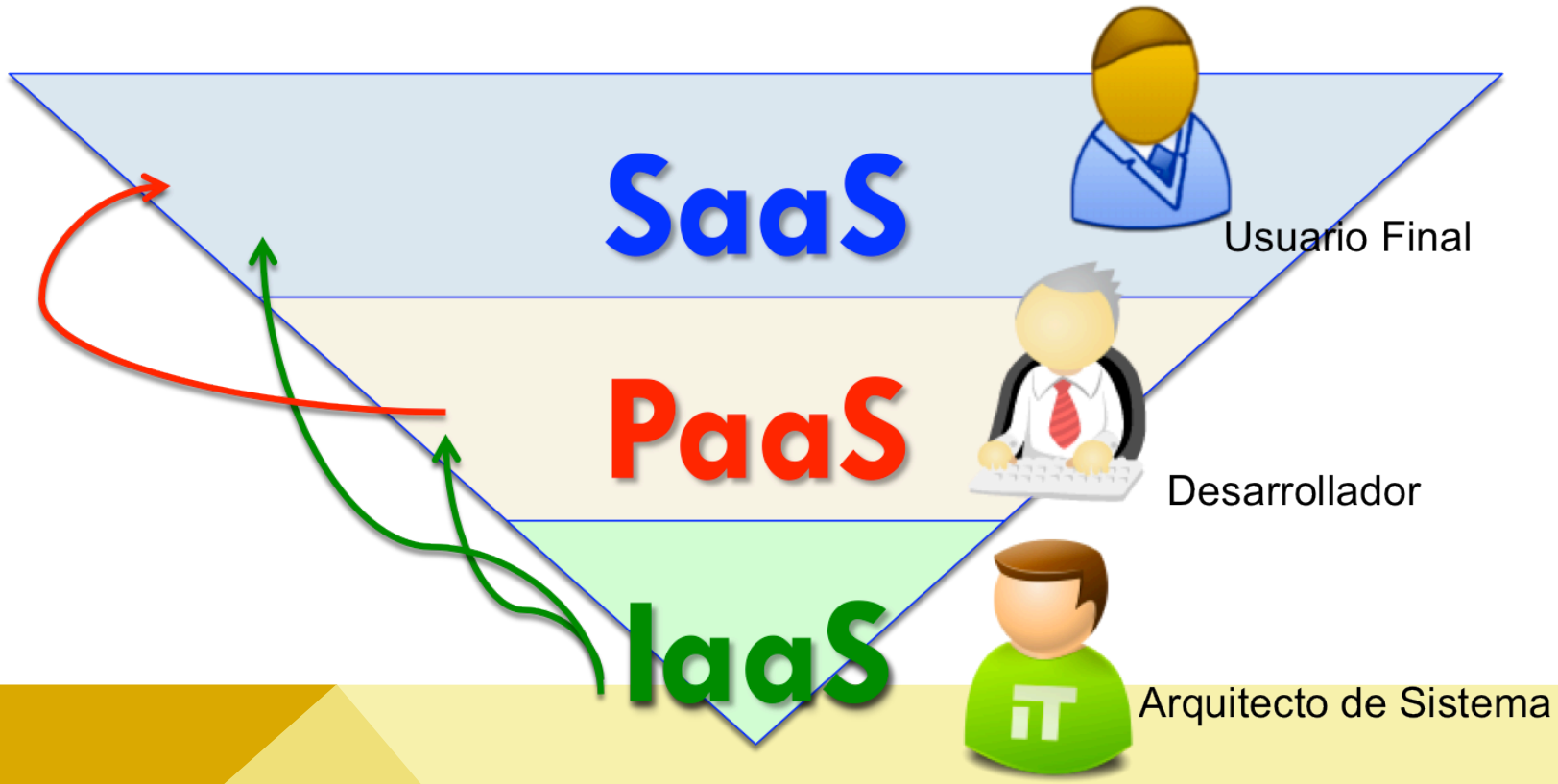
- Volunteer computing is a type of distributed computing in which computer owners donate their computing resources (such as processing power and storage) to one or more "projects".
  - •BOINC (Seti@home)
  - •Xgrid
  - •GridMP

- Associated with P2P
- Can be associated with High Throughput Computing (HTC) or High Performance Computing (HCP)

BOINC ARCHITECTURE



CLOUD COMPUTING VISIBILITY



Visit:
http://prezi.com/i0sretldeyk7/computacion-en-la-nube-y-sus-implicaciones-para-la-industria-del-software-en-colombia/

FINAL COMMENTS

Guidelines to Parallel and Distributed Programming (should) require identify Patterns

- Finding Concurrency
- Algorithm Structure
- Supporting Structures
- Implementation Mechanisms
  - Supported Platforms and Infrastructures

- *Problems need minds, minds need applications, applications need platforms, platforms need infrastructure.*

RECOMMENDED LECTURES

Future of Exascale Computers:
http://www.risc-project.eu/wp-content/uploads/2011/12/mateovalerop1.pdf and
http://www.risc-project.eu/wp-content/uploads/2011/12/mateovalerop2.pdf

Latest Developments and trends in Supercomputing, Part I SAB members presentations. QUB, UK.
http://www.risc-project.eu/wp-content/uploads/2011/12/ronperrot.pdf

Exascale Project http://www.exascale.org

Flynn, M. (1972). "Some Computer Organizations and Their Effectiveness". *IEEE Trans. Comput.* C-21: 948.

AND NOW... THE HANDS ON!