

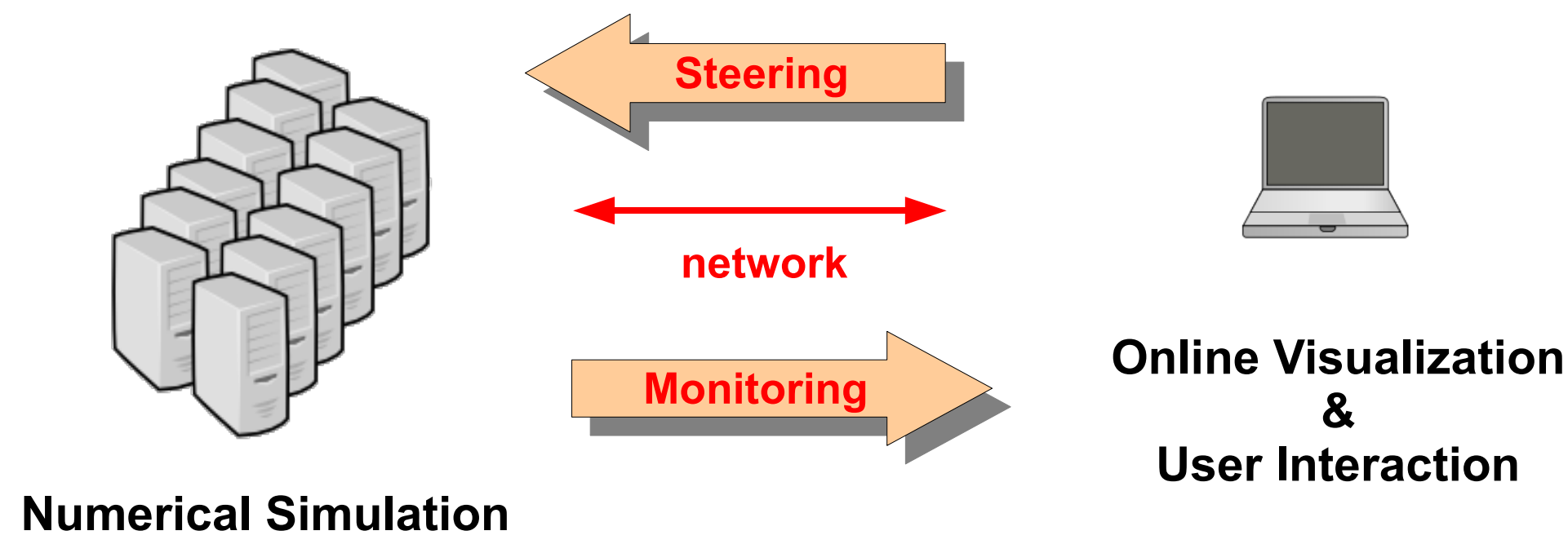
EPSN

A MxN Computational Steering Environment for Complex Numerical Simulations

What is Computational Steering?

A modern approach to make the "simulation cycle" more interactive

- Runtime coupling of simulation and visualization through the network "instead of performing analysis as a post-processing step (batch mode)"
- Monitoring:** data exploration, online visualization of intermediate results, ...
- Steering:** control of the execution flow, change of simulation parameters on-the-fly, user interaction, ...



⇒ Drive the simulation more rapidly in the right direction!

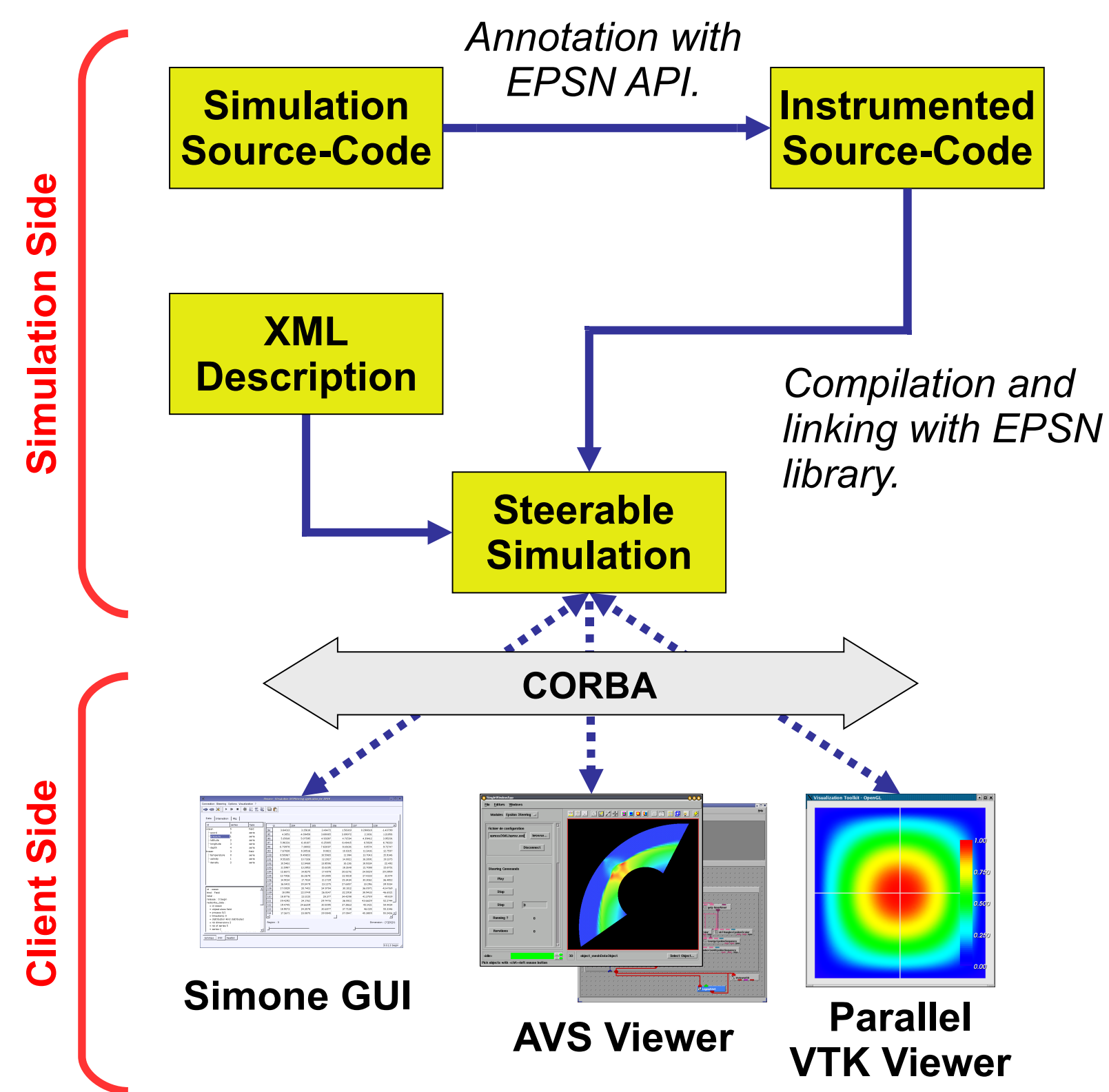
Crucial Issues

The coupling of parallel simulations and parallel visualization systems leads to several open and crucial issues:

- How to transfer data distributed on a parallel application directly to another parallel application?
 - EPSN has developed a **MxN redistribution library** called RedGRID.
- How to represent complex simulations within the steering environment and to assign precise date in the execution flow?
 - EPSN uses a **Hierarchical Task Model (HTM)** of the steerable simulations.
- How to ensure the steering treatments to occur at the same "date" in parallel without strongly synchronizing the simulation?
 - EPSN **schedules** the treatments with a **weak synchronization** algorithm and the parallel processes execute them independently.

Instrumentation of a Simulation with EPSN

How to integrate a legacy simulation code in the EPSN framework?



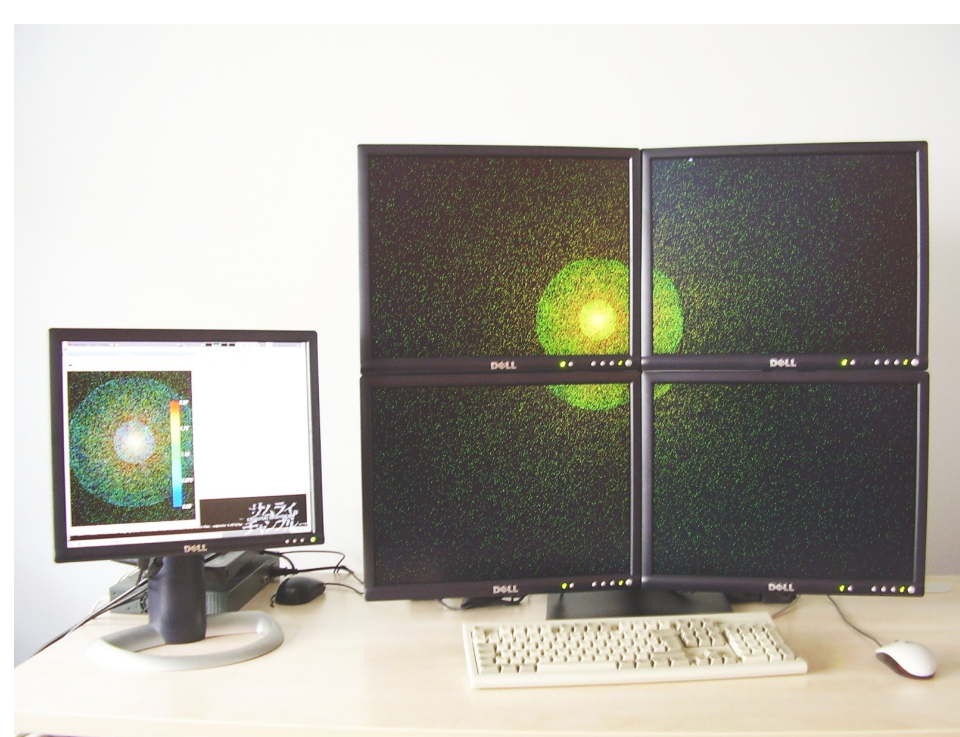
Case Study in Astrophysics: Gadget2

Gadget2: the Cosmological Simulation of a Galaxy Birth

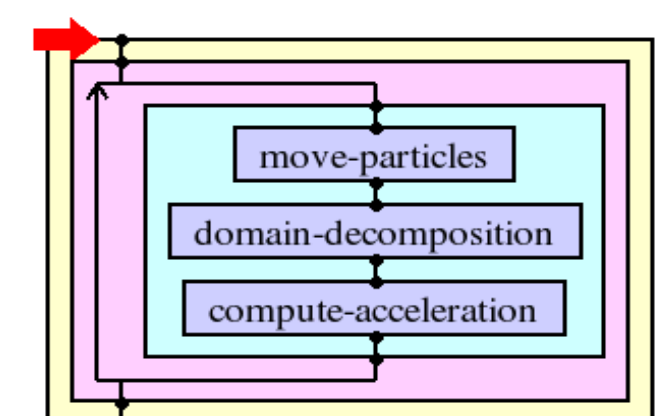
- A parallel legacy code (MPI/C) developed at the *Max-Planck Institute of Astrophysics*
- 1 million particles distributed on 60 processors on Grid'5000 Bordeaux

Results

- No overhead for the instrumented simulation without visualization
- Huge overhead with sequential visualization (+21%)
- Very small overhead for parallel visualization (4 PCs, +2%)
- Huge overhead for higher global resolution (network bandwidth not adapted!)



Remote Visualization of the galaxy performed with VTK on a tiled-display wall



Simple HTM for Gadget2

Publications

- A Steering Environment for Online Parallel Visualization of Legacy Parallel Simulations (DSRT, 2006)
- A Time-Coherent Model for the Steering of Parallel Simulations (EuroPar, 2004)

Web Sites

- EPSN Project <http://www.labri.fr/epsn>
- EPSN at INRIA Gforge <http://epsn.gforge.inria.fr>
- RedGRID at INRIA Gforge <http://redgrid.gforge.inria.fr>

Overview of the EPSN Framework

A Software Environment for MxN Computational Steering

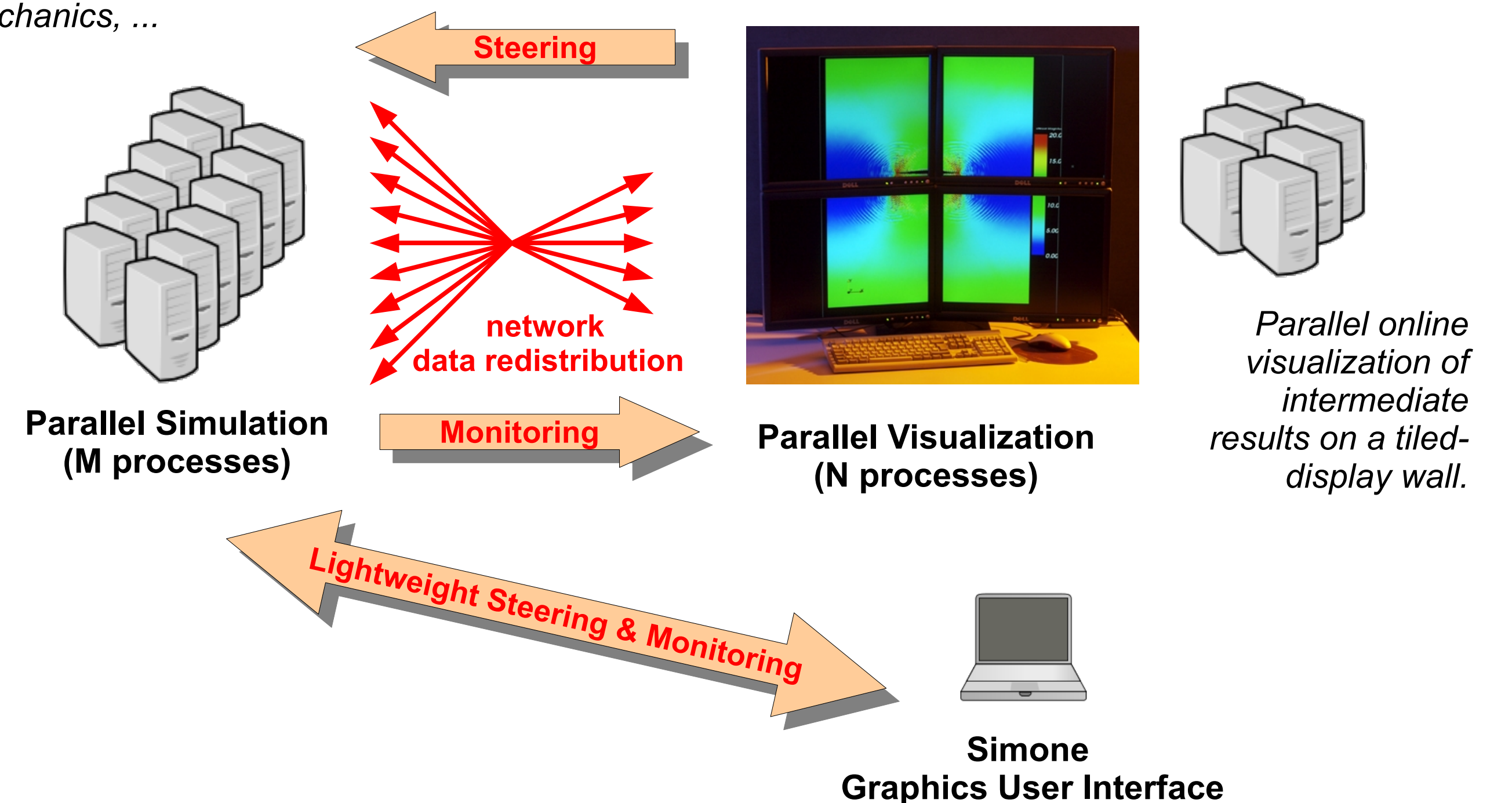
- Legacy parallel simulations in C/C++ or Fortran (M processes)
- Sequential or parallel visualization application (N processes)

A generic approach based on an abstract description model

- Description of the simulation program thanks to a Hierarchical Task Model (HTM)
- Description of the data distribution and storage as distributed complex objects "grids, hierarchical grids, particles, unstructured meshes, ..."

⇒ This model intends to clarify where, when and how one can safely interact with the simulation!

Legacy codes in astrophysics, molecular dynamics, fluid mechanics, ...



⇒ Use of parallelism to avoid sequential visualization bottleneck, but it raises the difficult problem of parallel data redistribution!

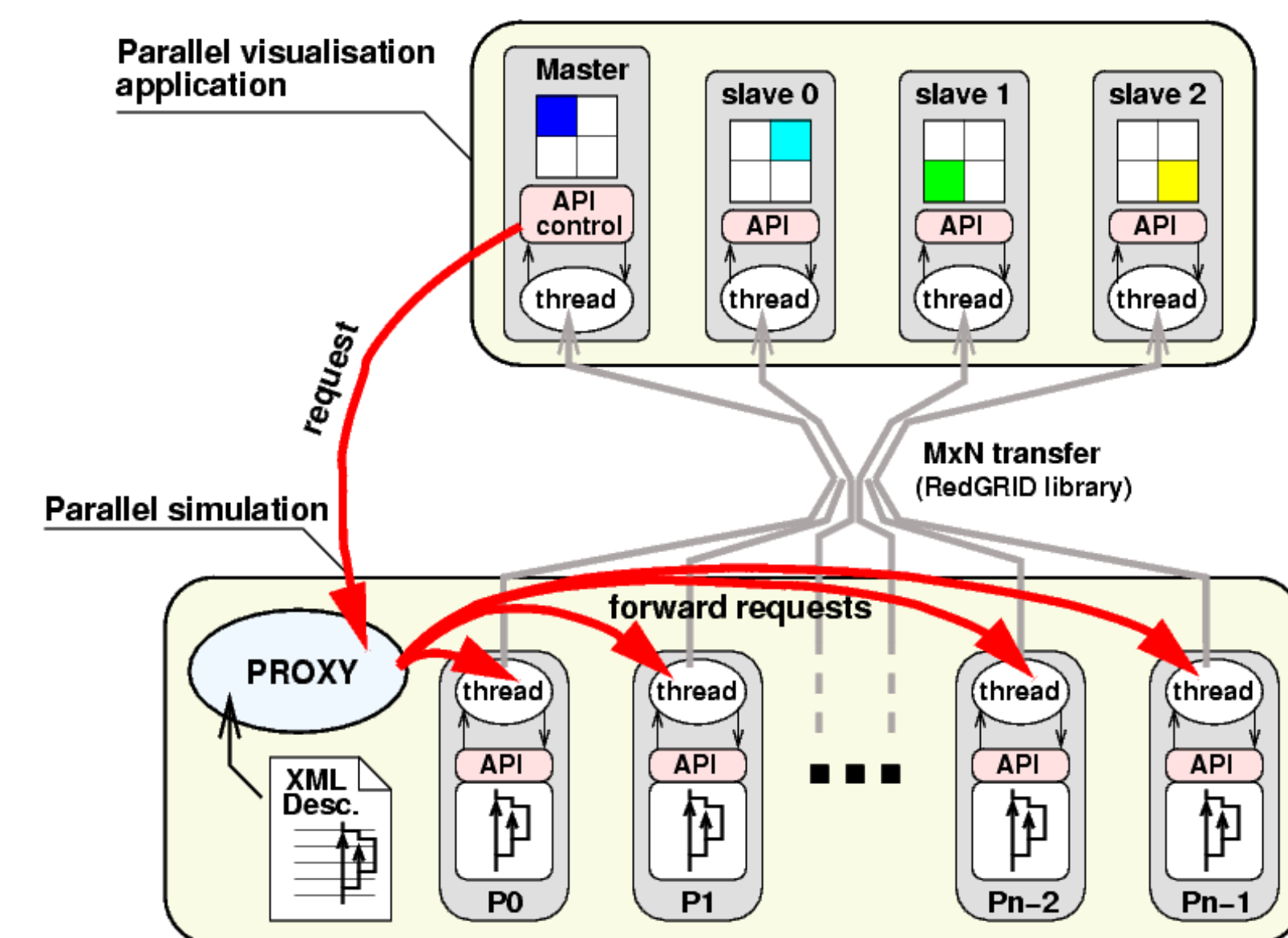
Architecture

Distributed and Dynamic Infrastructure

- Client/server relationship (simulation = server ; visualization = client)
- Several clients can connect and disconnect a remote simulation on-the-fly
- Steering of the simulation based on client requests (pause/resume, get/put, user actions...)

Performance Design

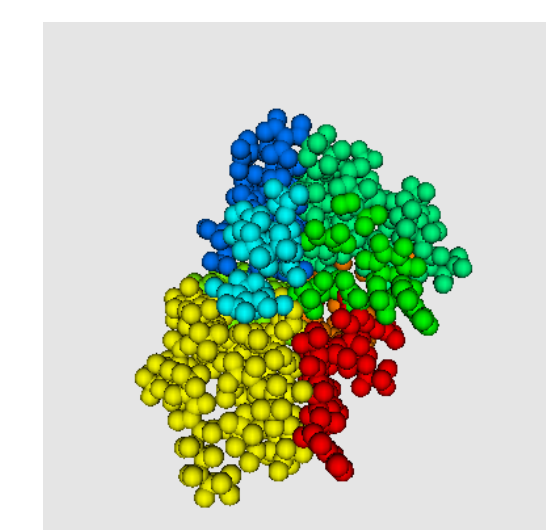
- Low perturbation instrumentation (no request, no overhead)
- EPSN communication overlapping with simulation computations + zero-copy sending
- Weak synchronizations between the simulation and clients



Other EPSN Examples

Fluid Mechanics

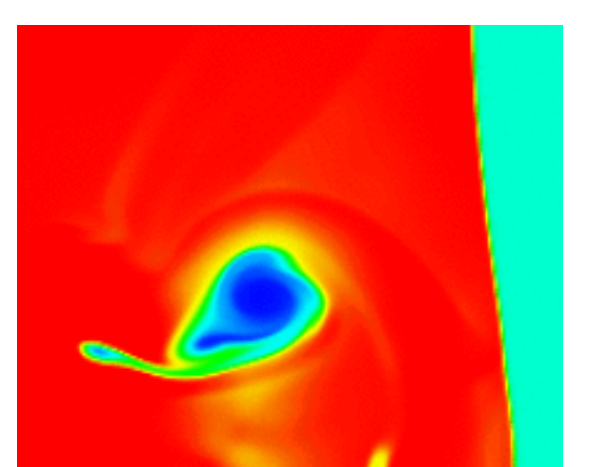
- Fluidbox (ScAlApplix, Univ. of Bordeaux)
- Clawpack (Univ. of Washington)



NAMD

Climate Modeling, Weather Prediction

- POP: Parallel Ocean Program (Los Alamos National Laboratory)
- ESMF: Earth System Modeling Framework (National Center of Atmospheric Research)



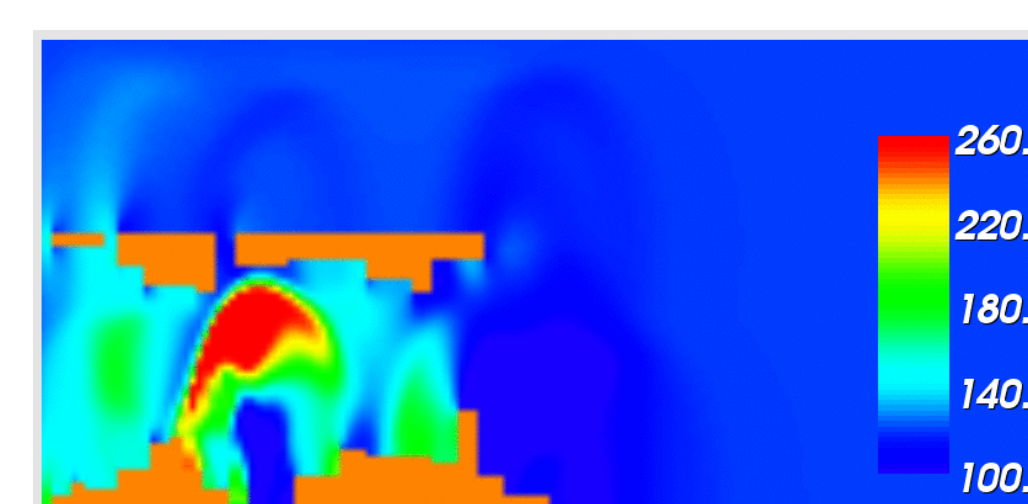
Clawpack

Molecular Dynamics

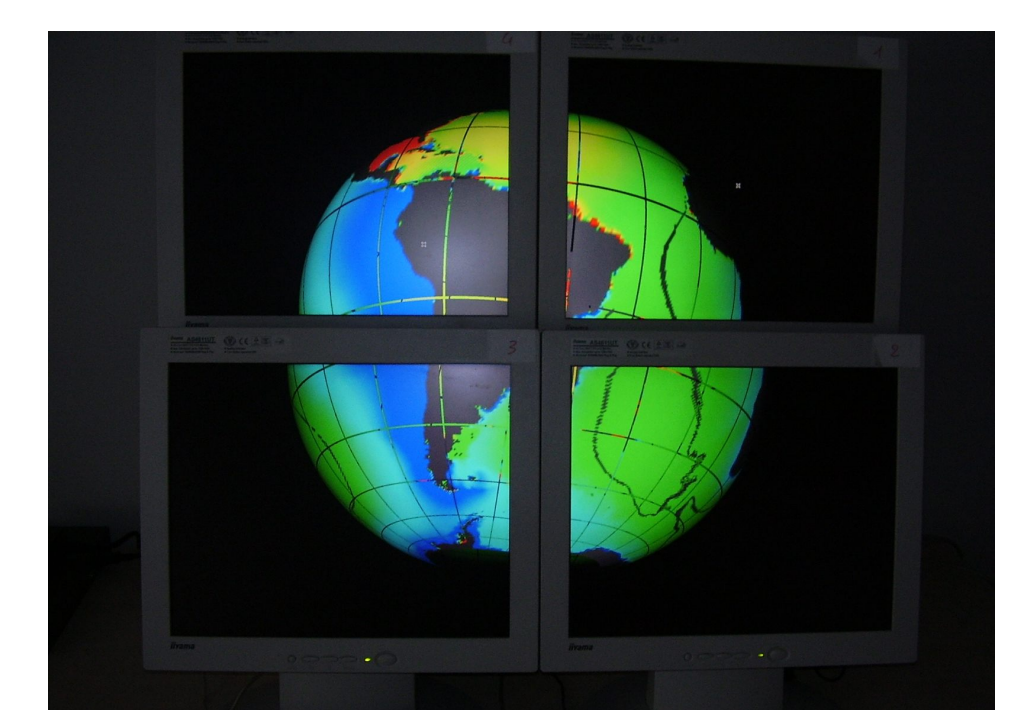
- NAMD (Theoretical and Computational Biophysics Groups, Univ. of Illinois)
- Lammps (Sandia National Laboratories)
- Stamps (CEA)

Miscellaneous

- Vlasov 4D (CALVI)
- Astrophysics: Gadget2 (Max-Planck Institute of Astrophysics)



ESMF



POP

