Visualisation à distance avec ParaView client/serveur sur le supercalculateur Olympe de CALMIP

Maxime PIGOU$^{1,2,4}$
Hervé NEAU$^{1,2,4}$
Nicolas RENON$^{3,4}$
2018-2022: neptune_cfd Meso- and Grands-Challenges from Tier2 to Tier0

Olympe @ CALMIP (2018)
- Tier2 / ATOS Sequana
- Perf. Peak: 1.37 Pflop/s
- 13,392 cores Intel (2.3 GHz)
- 360 nodes / 192 GB/node

Gaia @ EDF R&D (2018)
- Tier1 / ATOS
- Perf. Peak: 3.05 Pflop/s
- 42,912 cores Intel (2.3 GHz)
- 1,192 CPU nodes / 192 GB/node

Jean-Zay @ IDRIS (2019)
- Tier1 / HPE SGI 8200
- Perf. Peak: 16 Pflop/s
- 61,120 cores Intel (2.5 GHz)
- 1,528 CPU nodes / 192 GB/node

Joliot-Curie Irene-AMD @ TGCC (2020)
- Tier0 / ATOS Sequana
- Perf. Peak: 11.75 Pflop/s
- 293,376 cores AMD (2.6 GHz)
- 2,292 CPU nodes / 256 GB/node
25s simulated $\Rightarrow$ physical and statistical analysis
$\Rightarrow$ $\sim 10$ TB saving 16 variables (EnSight Gold binary) for 660 time steps on 12 selected planes, cylinders and external surface
$\Rightarrow$ Large data set post-processed after transfer on standard workstation

**Application case:** Olefin polymerization in industrial gas-solid fluidized bed reactor

$\Rightarrow$ Polydispersed multi-scale turbulent and reactive flow
$\Rightarrow$ JCAD’18, JCAD’20

**CALMIP/EDF: Worldwide Premiere with $10^9$ hexahedra unstructured mesh**

**Meso-challenges Olympe@CALMIP**

**Grands-Challenges Gaia@EDF**
Industrial Scale Bidispersed Reactive Fluidized Bed Reactor
100 tonnes of particles - D~5m - H~30m - Unstructured Mesh: 1,002,355,456 cells

NEPTUNE_CFD HPC at CALMIP
HPC Center: 13 032 cores
Skylake 6140 2.3GHz

Solid Volume Fraction

Time = 0.03s.
2018-2022: neptune_cfd Meso- and Grands-Challenges from Tier2 to Tier0

**2018**
- CALMIP/EDF: Worldwide Premiere with $10^9$ cells unstructured mesh

**2019**
- Meso-challenges Olympe@CALMIP
- Grands-Challenges Gaia@EDF

**2020**
- IDRIS: 8 times bigger mesh*
  - 8 billions cells

**2021**
- Grands-Challenges Jean-Zay@IDRIS
- Meso-challenges Olympe@CALMIP
- Grands-Challenges Gaia@EDF

*Automated mesh refinement* (split by 2 in each direction using code_saturne features) coupled with the interpolation of latest time step results onto the new refined mesh

- $10^9$ cells mesh (25s)
- ⇒ interpolation onto a $8.10^9$ cells mesh (26.7s)
- ⇒ 2nd interpolation up to $64.10^9$ cells

**Teratec 2022**

1.7s simulated ⇒ limited physical analysis
⇒ 57 TB of visualization data
⇒ Simulation time: x20 slower
2018-2022: NEPTUNE_CFD Meso- and Grands-Challenges from Tier2 to Tier0

- **2018**: CALMIP/EDF: Worldwide Premiere with $10^9$ cells unstructured mesh
- **2019**: Meso-challenges: Olympe@CALMIP
- **2020**: IDRIS: 8 times bigger mesh
  - 8 billions cells
- **2021**: Grands-Challenges: Gaia@EDF
  - Grands-Challenges: Jean-Zay@IDRIS

**Huge data volume to analyze and visualize**

Moving data from IDRIS to lab:
- slow, insufficient space
- transfer directly to CALMIP

Post-processing of heavy data requires significant RAM and CPU resources

- 1.7s simulated \(\Rightarrow\) limited physical analysis
- 57 TB of visualization data
- Simulation time: x20 slower
- Reaching post-processing limits: storage of 53 TB of data, data transfer limitations, limited toolset for visualization, …
Industrial-scale Polydispersed Reactive Fluidized Bed
3D simulation with NEPTUNE_CFD on Jean-Zay (IDRIS)

Unstructured mesh of 8,018,843,648 cells
8,560 to 51,840 MPI processes

Solid Volume Fraction

Time = 25.0006s.
Remote display solutions considered:

⇒ **Turbo VNC** solution as suggested by CALMIP


⇒ 1 node Volta max (4 cores max), 50GB max of RAM and variable display quality and latency

⇒ **ParaView Client/server:**

A solution presented by Jean Favre (CSCS)
in 2017 at Toulouse (CUTIS, Groupe Calcul CNRS)

⇒ **Volume rendering of a cylinder close to injectors on 8 billion cells mesh data results using 10 nodes of Olympe CALMIP**
**ParaView client/server**

“ParaView is designed to work well in client/server mode. In this way, users can have the full advantage of using a shared remote high-performance rendering cluster”  

https://www.paraview.org/Wiki/Setting_up_a_ParaView_Server

**Basic principle:** post-process and visualize data using ParaView server on the computing center (where were produced) and remote only display on ParaView Client on a classical workstation or laptop

**Main interests:**
- Better display quality and latency
- Possibility to visualize huge data using HPC resources
- Works directly with pre-compiled ParaView binaries downloaded from ParaView website for both server (osmesa MPI for CPU) and client
- ParaView server span over multi-nodes: many cores, RAM, GPU (ray tracing)
- Solution compatible with co-processing and visualization in situ (catalyst)

https://www.paraview.org/Wiki/File:Two-hop-tunnel.png
Full packaged and secured script to use ParaView from home (Linux) using Client/Server mode on several CALMIP compute nodes

#! /bin/bash

# This script should be used by users willing to run ParaView in a client/server mode with the server part being hosted on Olympe (CALMIP) compute nodes.

# Script developpe par Herve Neau et Maxime Pigou en 2020

# Service CoSiNuS - Institut de Mecanique des Fluides de Toulouse (IMFT)

# STEP I - GET USER INFORMATION #

# Interactive prompt

calmp_username="mpigou" # User login for connecting to calmp
job_node="10" # Number of node requested for allocation
job_ntask_per_node="38" # Number of tasks per node
job_time="0:20:00" # Duration of the allocation
job_start_timeout="600" # How long (in sec.) to wait for the job to start
local_paraview="/home/jcad2022/DemoParaviewClientServer/ParaView/bin/paraview"

# Define script tuning variables

calmp_sname="Olympe" # How the supercomputer should be referenced

calmp_hostname="oyme.calmip.univ-toulouse.fr" # Hostname of the supercomputer

calmp_paraview="/tmpdir/empigou/202209_JCAD_pvserver_demo/ParaView" # Path to ParaView on

# Define script constants

SSH_TIMEOUT=30 # Duration to wait for a SSH connexion to be dropped

# PVSERVER_STARTUP_TIME=20 # how long to wait before the job start and the connect attempt

# EVCLIENT_STARTUP_TIME=20 # How long to wait between client start and the delets of its pyt

Prerequisites:

- ssh public-key authentication
- to ensure data confidentiality
- patch the library libvtkCommonSystem.so (by default pvserver can be accessed by anybody logged on supercomputer)

To use the full packaged script:

- Only 2 fields to adapt
- Fully automatized

Script used at IMFT to access ParaView at CALMIP

Contact your computer center to access similar setup
Trying to connect to Olympe using pubkey authentication...
Successfully connected to olympe
Job name: pvser-38ABFF4E
Submitted batch job 950638
Job submitted, job id: 950638
Waiting for job to start running.
Job has started!
Master node detected: olympecomp207
Waiting 20s for pvserver to be initialized. Done.

Creating a tunnel to the master node: olympecomp207
Tunnel opened.
Starting ParaView with auto-connect.
Waiting for the session to end properly
Warning: Ignoring XDG_SESSION_TYPE=wayland on Gnome. Use QT_QPA_PLATFORM=wayland to run on Wayland anyway.
Warning: Permanently added 'olympecomp207' (ED25519) to the list of known hosts.
Connection to olympecomp207 closed by remote host.
Removing temporary files created on Olympe.
Done!

ParaView Client/Server on Windows

**Same principle but more manual:**
- Allocate Resources on computing center
- ParaView Server (pvserver) and create SSH Tunnel (Putty, mobaxterm ... using Windows)
- Connect Desktop/Laptop ParaView Client to server

Many web sites to find information:
https://hpc.llnl.gov/running-paraview-client-server-mode
https://user.cscs.ch/computing/visualisation/paraview/
https://ciarc.mines.edu/visualization-home/paraview-connection-guide/
Now, the demo
Remote solutions such as ParaView client/server required to post-process results considering the exponential growth of simulated case size.

Solution well deployed at IMFT especially thanks to COVID lockdowns.

Next steps:
- Evaluate co-processing during computation
- Try specific compilation to optimize GPU ray tracing and produce photorealistic visualizations.
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CALMIP/EDF: Worldwide Premiere with $10^9$ cells unstructured mesh

IDRIS: New Worldwide Premiere with 8 times bigger mesh: 8 billions cells

TGCC: $64.10^9$ cells mesh

Meso-challenges
Olympe@CALMIP

Grands-Challenges
Gaia@EDF

Grands-Challenges
Jean-Zay@IDRIS

Grands-Challenges
Irene-AMD@TGCC

25s simulated

1.7s simulated

Only few iterations ⇒ sensitivity studies, profiling
⇒ Reaching limits of both solver, MPI libraries and supercomputers
⇒ Failure when attempting to generate 512 billion cells mesh due to these limitations