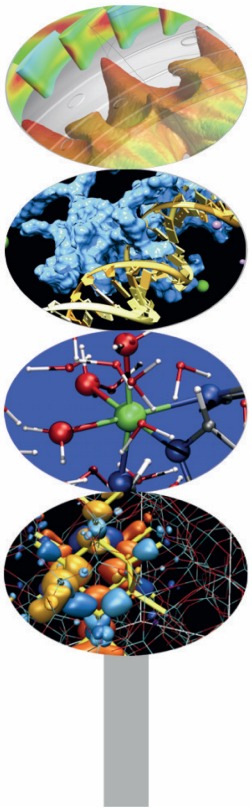
CINECA SCAI
SuperComputing Applications and Innovation

Cineca TRAINING High Performance Computing 2016

HPC enabling of OpenFOAM® for CFD applications



Welcome to CINECA and presentation

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PRACE

CINECA

What is CINECA

- Cineca is a non profit Consortium, made up of 70 Italian universities, 4 Italian Research Institutions and the Italian Ministry of Education.
- Today it is the largest Italian computing centre, one of the PRACE Tier-0 hosting site, one of the most important worldwide.
- With more 700 employees, it operates in the technological transfer sector through high performance scientific computing, the management and development of networks and web based services, and the development of complex information systems for treating large amounts of data.
- Cineca has three locations: Bologna, Milan and Rome

Mission: Cineca offers support to the research activities of the scientific community through supercomputing and its applications

SCAI department

- **SCAI**(**S**uper**C**omputing **A**pplications and **I**nnovation) is the High Performance Computing department of CINECA, the largest computing centre in Italy and one of the largest in Europe.
- The mission of SCAI is to accelerate the scientific discovery by providing high performance computing resources, data management and storage systems, tools and HPC services, and expertise at large
- aiming to develop and promote technical and scientific services related to high-performance computing for the Italian and European research community.
- CINECA enables world-class scientific research by operating and supporting leading-edge supercomputing technologies and by managing a state-of-the-art and effective environment for the different scientific communities.
- The SCAI staff offers support and consultancy in HPC tools and techniques and in several scientific domains, such as physics, particle physics, material sciences, chemistry, fluid dynamics

HPC @ CINECA at glance

Cineca is currently one of the Large Scale Facilities in Europe and it is a PRACE Tier-0 hosting site.

http://www.hpc.cineca.it/content/hardware

1. FERMI (Tier-0): It is a IBM BG/Q supercomputer, classified among the most powerful supercomputers in the Top500 List: rank 7th in June 2012. On June 2012 it was ranked 11st in the Green500's energy-efficient supercomputers list.
   It will be replaced by a new Tier-0 system MARCONI
2. GALILEO (Tier-1): it is a IBM NeXtScale cluster accelerated with up-to-date INTEL accelerators (Intel Phi 7120p) and NVIDIA accelerators (GPUs Nvidia K80 Gpu): in full production February the 2nd, 2015. It has reached around 100th position in the Top500 List.
3. PICO: BigData infrastructure has been recently acquired (Nov 2014) devoted to "Big Analytics".

FERMI

High-end system, devoted for extremely scalable applications

- IBM PowerA2 running @ 1.6 GHz
- 10240 computing nodes, 16 core each (163,840 total)
- 16 GB or RAM per computing node (1Gbyte per core), 163 TB of Total RAM
- Internal Network: Proprietary Network (5D torus)
- Peak performance 2PFlops

GALILEO

x-86 based system for production of medium scalability applications

- Intel Xeon E5-2630 v3 @2.4 GHz (a.k.a Haswell)
- 516 computing nodes, 16 core each (8,256 total)
- 128 GB of RAM per computing node, 66 TB of Total RAM
- Internal Network: Infiniband QDR switches ($\simeq 40 Gb/s$)
- 768 Intel Phi 7120p (2 per node)
- Nvidia K80 ($O(10)$)
- 8 nodes devoted to login/visualization
- Peak performance 1.2 PFlops
- $\simeq$ 480 GFlops single node LINPACK (only CPU) sustained performance

PICO

Storage and processing system for large volumes of data

- Intel Xeon E5 2670 v2 @2.5 GHz (a.k.a Ivy Bridge)
- 66 computing nodes, 20 core each (1320 total)
- 128 GB or RAM per computing node, 8.3 TB of Total RAM
- Infiniband FDR ($\simeq 56 Gb/s$)
- 4 nodes devoted to login/visualization
- Peak performance $\simeq 40 Tflops$
- $\simeq$ 400 GFlops single node LINPACK (only CPU) sustained performance

Storage

- Each system has:
  - a */home* area
  - a */scratch* area
  - a */work* area (project-based)
- a common */gss* area ($\simeq 3PB$)
  - shared by all login nodes
  - shared by all PICO computing nodes
  - Tape subsystem (LTFS, up to $\simeq 12PB$)

OpenFOAM @ CINECA

Experience:

- OpenFOAM installed and tested on our clusters: GALILEO, FERMI, PICO
- Used in Several Academic project: $\simeq$ 40 ISCRA + $\simeq$ 10 LISA + 1 PRACE + 2 SHAPE
- OpenFOAM in FORTISSIMO for the Enabling Manufacturing SMEs to benefit from HPC and Digital Simulation.
  - Cloud-based Computational Fluid Dynamics Simulation in collaboration with Konigsegg, ICON, CINECA and NTUA. DES solvers for Drag and Lift prediction of supercars.
  - Shape Optimization under Uncertainty through HPC Clouds in collaboration with Optimad Eng, University of Strathclyde and Automobili Lamborghini (OF + Dakota)
- Support for industrial development: $\simeq$ 10 projects.
- Analysis of *Current Bottlenecks in the Scalability of OpenFOAM on Massively Parallel Clusters* of OpenFOAM in the framework of PRACE (M. Culpo White Paper)

OpenFOAM Installation 1/2

OpenFOAM can be installed for many users (network installation) or for a single user (local installation):

- Network installation: This installation is suitable when a group of people is supposed to use OpenFOAM, and when not everyone want to learn how to install and compile it. All users will use exactly the same (base) installation.
  Pro: A single installation for each version of OpenFOAM, maintained by the CINECA UserSupport.
  Cons: limited to major release and most common used tools (`swak4foam`, `pyfoam`, `dakota`).
- Local installation: This is the most common way of installing OpenFOAM. The installation will be located in `HOME/OpenFOAM/OpenFOAM-3.x.y`.
  Pro: Each user will 'owns' his proper installation and may update it any time. For info on installation
  Cons: Requires extra disk space for several users with their own installations (minor issue), and all users have to know how to install OpenFOAM and the Third-Party products (major issue)

OpenFOAM Installation 2/2

CINECA policies:

- Network installation only major 2.3.0, 2.4.0, . . . 2.n.0, 3.0.0 by default.
- Minor installation 2.3.1, 2.3.2, . . . 2.3.4 upon request.
- `profile base` ⇒ last two majors + 1 minor.
- `profile advanced` ⇒ other versions
- Git and .x only local installation

Network Installation status on HPC platforms:

- FERMI ⇒ version 2.1.1 (no upgrade possible due to issues with bgq-gnu/4.7.2 compiler)
- GALILEO version 3.0.1 + swak4foam/0.3.1 + pyfoam/0.6.4 + dakota 6.0
- PICO version 2.3.0 + 3.0.1