APPLICATIONS FOR PHYSICAL SCIENCE

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NATIONAL INSTITUTE FOR ASTROPHYSICS (INAF)

• The National Institute for Astrophysics (INAF) is the main Italian Research Institute for the study of the Universe.

• It promotes, implements and coordinates national and international researches in the fields of astronomy and astrophysics.

• It designs and develops innovative technologies and state-of-the-art instrumentation for the study and exploration of the Universe.
ASTRONOMY

➤ *Astronomy*, a *physical science*, is the study of celestial objects.

➤ Astronomers and Research Engineers:
   - design and build **telescopes**, that can be organised in Astronomical Observatories. Telescopes works from space (on-board of artificial satellites) or on Earth.
   - perform **simulations** of mathematical models of natural and artificial processes
     - to understand complex theories,
     - to predict the behaviour of a natural or artificial system,
     - to design instruments for new experiments.
NATIONAL INSTITUTE FOR ASTROPHYSICS (INAF): INFRASTRUCTURES

• INAF, as R&D alone and with all R&D institutes of MIUR (Ministry of Education, Universities and Research), is involved in the development of the e-infrastructure need for scientific research:
  • Network
  • Computing
  • Big Data
• H2020 Projects: INDIGO, ASTERICS, EGI
• All these point are strategic to allowing the INAF researchers to be involved on the future challenges.
NETWORK

- GARR is our backbone
- All infrastructures are connected mainly with
  - 1 G (less 150 Mb)
  - Backbone 10 G
COMPUTING

• HPC
  • 9/18 center are working with HPC
  • 159 +70 Billion hours @ BGQ Cineca (2013)
  • 16 research program (70 people)
  • 2.7 PB of data.

• HTC
  • DHTCS project (Cloud under development)
    • Cluster @ PON (Catania, Palermo, Cagliari (2010))

• Local Cluster :
  • ~20 “group” cluster

• Most of our CPU time obtained with competitive grants at CINECA
  (INAF-CINECA convention, ISCRA) and CASPUR

• Two PRACE projects with local PI (development)

• Involved in several Class-A PRACE projects

• A DECI project under review
DATA ARCHIVE

• All INAF structures have archives
• About 54 archives (some under development)
  • 59% public,
  • Policy INAF: raw data are public after 1 year
• Centro Italiano Archivi Astronomici (IA2)
• Some examples:
  • GAIA (on-fly) ➔ DPAC Center (1 of 6) @ OATorino
    • 1 PB (mainly part of the DBMS, Oracle partnership)
  • Euclid ➔ > 10 x GAIA (2020)
  • CTA (ASTRI) ➔ > 10 TB/day
  • SKA ➔ > 100 TB/day
ASTRONOMICAL OBSERVATORIES

➤ The Astronomical Observatories of the next decades will be dominated by huge data volume and rates with:

➤ multi-year temporal coverage

➤ of the multi-wavelength (from radio to gamma-rays)

➤ and multi-messenger (photons, gravitational waves, neutrinos) domains
COMMON PROBLEMS

• There seems to be a common workflow from the experiment to the data center, which could include:
  • data capturing from instruments,
  • buffering of data close to the instrument,
  • on-site and real-time data analysis: due to the location of the experiments (e.g. under the sea or on top of a mountain)
  • transferring of data to the data center,
  • simulations,
  • archiving of data
    • data preservation (data will be maintained for tens of years)
  • remote access to them.

• Some of these steps require real-time control and monitoring
• The Astronomical Observatories could manage arrays of tens or hundreds of telescopes.
SPACE TELESCOPES IN WHICH INAF IS INVOLVED

courtesy of MEDIA INAF
GROUND TELESCOPES IN WHICH INAF IS INVOLVED

Future projects: CTA, SKA, E-ELT
COMPUTATIONAL ASTROPHYSICS

• DATA ANALYSIS

• SIMULATIONS: computational astrophysics was focused on simulation of mathematical models of natural and artificial processes. Simulations could be carried out to understand complex theories, to predict the behaviour of a natural or artificial system, to design instruments for new experiments, and to characterize the statistical behaviour of complex phenomena.

  • GRAVITY – long-range, all-to-all calculus elements communication needed (in principle)
  • HYDRODYNAMICS – short-range, but a small number of calculus elements needs many time steps
  • ASTROPHYSICAL PROCESSES – (radiative cooling, star formation, black holes evolution, energy exchanges between BH/stars and gas) partially subgrid: the exchange part needs communications
INSTRUMENT SIMULATIONS

- Instrument simulation for ground and space missions
  - A lot of proposals for ESA calls
  - European Space Agency proposals and missions
  - Italian Space Agency missions

courtesy of Valentina Fioretti, INAF
A partial view of the astronomical observatories of the next 10 years. Some observatories work from space.

What is missing:
- some observatories are missing
- no planetary missions
- no exoplanets and Sun observatories.
- no cosmic rays experiments
OpenPOWER @ INAF

• Web site and mailing list
• In this context
  • Collaboration with IBM on
    • performance optimisation
    • porting of astrophysical code on POWER systems.
  • Collection of use cases as a preparatory phase for the OPF for Physical Science WG
• Data Intensive Science Client Tour EMEA / IBM Team with INAF (2 December)
• The OpenPOWER workgroup for Physical Science (see dedicated session)
CONCLUSIONS

• Telescopes and simulations: physical science projects
• To develop in a more effective way these projects
  • what is needed is a strong connection with the hardware and software developers of the market, to understand the direction of the ICT of the next years.
  • more than 65% of the programs requires porting to use the new HPC generation based on accelerators (GPUs). This exchange of expertise could span from an access to new hardware and software platforms to test astrophysical code, to a connection with software developers expert on code optimization for new hardware architectures, new compilers and hardware accelerators.
  • The sharing between INAF and private companies of the roadmaps of the hardware and software development of the next years should be important, to understand in advance where INAF people should focus their effort in the porting of astrophysical code.
• New frontiers of Astrophysics require advanced HPC and ICT infrastructures