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INAF Trieste Astronomical Observatory Information Technology Framework

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Abstract. INAF Trieste Astronomical Observatory (OATs) has a long tradition in information technology applied to Astronomical and Astrophysical use cases, particularly for what regards computing for data reduction, analysis and simulations; data and archives management; space missions data processing; design and software development for ground-based instruments. The ensemble of these activities, in the last years, pushed the need to acquire new computing resources and technologies and to deep competences in theirs management. In this paper we describe INAF-OATs computing centre technological stuff, our involvement in different EU Projects both in the path of building of EOSC, the European Open Science Cloud; in the design and prototyping of new Exascale supercomputers in Europe and the main research activities carried on using our computing centre.

1. Introduction

INAF-OATs commitment in the application of information technology to Astronomical and Astrophysical use cases involves a variety of activities. It participated, since the beginning, in Italian Grid and Cloud initiatives gaining a major role in Italy and in Europe in large projects for the development of a multidisciplinary platform for distributed computing and data resources sharing. Recently it participated in EU EGI.eu projects, coordinating the Astronomy and Astrophysics community, for the development of a cloud based infrastructure in Europe with the aim to spread the IVOA standards based interoperability with CANFAR in Canada. Now it is active in the design of the SKA regional centres. INAF-OATs participats also in different EU projects for the design and prototyping of new Exascale supercomputers in Europe gaining a leading position.

To cover the requirements raised by these activities, INAF-OATs deployed a computing centre that offers HPC, HTC and cloud resources for internal users, INAF and large international projects. In this paper we describe INAF-OATs computing centre technological stuff, our involvement both in the ESCAPE EU Project in the path of building of EOSC, the European Open Science Cloud, and in the EU projects in the path toward the exascale era and the main research activities carried on using our data and computing centre.

2. Computing and Data Infrastructure

INAF-OATs acquired a set of computing resources thanks to the DHTCS-IT project (Distributed High Throughput Computing and Storage in Italy) founded by the Italian "Ministero dell'Istruzione, dell'Università e della Ricerca" and other EU funded projects to deploy two computing clusters to satisfy different requirements: one targeted to HPC, named HOTCAT, and another one targeted to HTC, named CloudCAT.

HOTCAT manages computing resources through PBS (Portable Batch System), a job scheduler and workload management software optimized in HPC environments (clusters, clouds, and supercomputers) fast, scalable, secure, and resilient. It provides storage resources, distributed on 3 nodes, using BeeGFS, a parallel file system developed and optimized for high-performance computing, granting a 2 GB/sec of throughput. It is equipped with an Infiniband interconnect allowing high throughput and low latency (1 μs). Moreover, it supplys users with more than 60 software environment for Astronomical data reduction and analysis and it offers tools for software development, profiling and debugging.

CloudCAT provides cloud resources using OpenStack and Openstack Swift as object storage. Computing and storage resources are provided to users with Virtual Machine images pre-configured with Astronomical Software (e.g. ESO Scisoft) and remote desktop capabilities to allow easy access and usage. CloudCAT is compliant with EGI-Federated cloud resources.

Table 1. **HOTCAT Cluster Hardware**

Computation nodes:	
Cores	1400 INTEL Haswell E5-4627v3
RAM	6 GB RAM/Core (8.5 TB total)
Available Storage	500 TB (BeeGFS)
Storage nodes :	
Cores	24 INTEL Haswell E5-4627v3
RAM	256 GB RAM per node
Network connection :	
Infiniband ConnectX -3 Pro Dual QSFP+ 54 Gbps	

Table 2. **CloudCAT Cluster Hardware**

Computation nodes :	
Cores	200 INTEL Westmere E5620 @ 2.40GHz
RAM	8 GB RAM/Core
Available Storage	75 TB Object Storage Swift
Network connection :	
Infiniband 10 Gbps	

2.1. The CHIPP project

The INAF researcher perform tasks like hydrodynamical N-body simulations; instruments performance simulation during designing phases; testing of computing intensive analisys algorithms; testing and exploiting software efficiency improvement through

parallelization of known complex algorithms. High computing resource intensive programs are generally run exploiting specialized infrastructures outside INAF (e.g. GARR) but there was a lack in resources to fine satisfy small/medium sized programs requirements. CHIPP born to fill this lack. It is an INAF pilot project to proof the benefit to provide Italian Astronomers with a distributed medium sized computing infrastructure, currently based on already existing resources at Trieste and Catania, and making available Tier-2/Tier-3 systems (1,200 CPU/core) for all the INAF community. The run programs are HPC, data reduction and analysis, machine learning.

2.2. Activities towards exascale computing

INAF is one of the leading institutions participating in different EU projects aiming at designing and prototyping of new Exascale supercomputers in Europe.

ExaNeSt developed, evaluated, and prototyped the physical platform and architectural solution for a unified Communication Storage Interconnect, plus the physical rack and environmental structures required to deliver European Exascale Systems. (`http://www.exanest.eu/`)

EuroExa joins multiple European HPC projects and partners with industrial SMEs (Small ad Medium Enterprises) to co-design a groundbreaking supercomputing prototype. (`http://www.euroexa.eu`)

2.3. Distributed Computing and Interoperable Data Access

INAF-OATs participated, since the beginning, in Italian Grid and Cloud initiatives for the development of a multidisciplinary platform for distributed computing and data resources sharing. Recently it participated in EU EGI.eu projects, coordinating the Astronomy and Astrophysics community, deploying a set of cloud provided IVOA compliant services with the aim to spread the IVOA standards based interoperability with CANFAR in Canada.

INAF-OATs is involved in International Virtual Observatory Alliance (IVOA) leading the Italian participation. Main activities in this area are the participation in the VO recommendation development; in the VO paradigm and tools dissemination to a wide audience (specialized and not); in the management and providing of web resources for the IVOA members collaboration.

2.4. ESCAPE & EOSC Integration

ESCAPE (European Science Cluster of Astronomy & Particle physics ESFRI research infrastructures) is a European H2020 project to integrate IVOA (International Virtual Observatory Alliance) compliant VO (Virtual Observatory) services within the EOSC (European Open Science Cloud) hybrid cloud scenario and to test containerization of VO aware applications. The ESCAPE project collects outcomes of previous cluster projects ASTERICS (Astronomy ESFRI & Research Infrastructure Cluster) and AENEAS (Advanced European Network of E-infrastructures for Astronomy with the Square Kilometer Array (SKA)). ASTERICS brought together researchers, scientists, specialists and engineers from astronomy, astrophysics and astro-particle physics in order to develop instruments implementing common solutions to common challenges. AENEAS was to develop a science-driven, functional design for a distributed, federated European Science Data Centre (ESDC) to support the astronomical community once the Square Kilometre Array (SKA) becomes operational. Goal of ESCAPE is to

integrate the results of these projects in a platform satisfying the requirements of SKA and the ESFRIs, ready to be part of the EOSC. The INAF-OATS computing facility will be used as an integration testbed in the scope of ESACAPE WP4 (Connecting ESFRI projects to EOSC through VO framework) and WP5 (ESFRI Science Analysis Platform) to integrate IVOA compliant VO standards and services within the EOSC hybrid cloud scenario and to test the containerization of VO aware applications.

3. Main scientific projects

3.1. LOFAR

Since 2018 INAF is one of the partner to the International Low-Frequency Array Telescope (LOFAR), a powerful radio telescope consisting of stations located in various countries in Europe. It operates within the range 10–240 MHz, allowing detailed sensitive high-resolution studies of the low-frequency radio sky and also providing an excellent short baseline coverage to map diffuse extended emission. With its sensibility LOFAR is the most important SKA low frequency precursor.

INAF-OATs implements and coordinates a distributed computing and data infrastructure in Italy to process LOFAR big data and to support scientists for the data reduction and analysis activities.

3.2. EUCLID

Euclid is an European Space Agency (ESA) space mission. Scheduled for 2022, it will place a telescope in space with the aim of studying the properties of the dark universe. Euclid will collect many millions of images for at least 30 Pbytes of data, which will then have to be combined with other large data archives of images acquired with ground-based telescopes. INAF-OATS is involved in the Euclid Consortium Science Working Groups and in the Euclid Consortium Science Ground Segment (ECSGS). It offers computing resources for the distributed computing Infrastructure of Euclid.

3.3. Numerical experiments

The combination of a pre-exascale HPC infrastructure, joined by the development of novel paradigms for massively parallel computing applied to cosmological simulation codes, will enable scientists to carry out a multi-year simulation campaigns, whose final aim will be to provide a unifying interpretative framework for the cosmological experiments of the next two decades. A set of simulations interlaced in dynamic range (mass and force resolution) and cosmic time coverage would be designed to study cosmic evolution from the pre-ionization era, to the low-redshift universe. 2.0M core_hours of INAF-OATS HPC cluster has been used for numerical experiments.

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