

# Standard-based Interoperability amongst HPC, Grid and Cloud Resources Distributed Worldwide with Catania Science Gateways

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The availability of powerful COTS computers and the decrease of costs of LAN components triggered in the first half of 90's the emergence of cluster computing for High Throughput Computing (HTC) applications. "Farms" of computers with many-core processors, interconnected by very low latency networks, have become the norm also in the domain of High Performance Computing (HPC) and in the last five years about 80% of the Top500 machines are based on a distributed architecture.

Moreover, the steep decrease of costs of large/huge-bandwidth WANs has fostered in the recent years the spread and the uptake of the grid computing paradigm. Grid infrastructures are being built in several areas of the world but, despite the huge investments made by the European Commission and by other funding agencies, both at national and international level, the total number of users is in the order of magnitude of 104 that is much less, for example, than 106 which is the order of magnitude of the number of EU researchers in the public sector. The reasons for this have been investigated through studies promoted by the European Commission itself and mostly reside in the complexity for non-IT-expert users of the Grid Security Infrastructure, based on a Public Key Infrastructure, in the little adoption of standards to let different middleware be interoperable among each other, and in the lack of general frameworks to build easily customizable and easy to use high-level user interfaces. Indeed, several, and quite different, middleware have been deployed on the grid infrastructures existing in the world with no (or very little) interoperability amongst each other.

The distributed computing ecosystem has become even more complex with the recent emergence of cloud computing. Private cloud providers rely on "non-disclosed" architectures and have business models that leave very little (if any) room to interoperability and "federability". Open federated clouds for research have also started to be created the interaction between computing clouds and storage clouds is in many cases not straightforward.

This complexity keeps most of non-IT expert research communities away and forces early adopters to have several accounts on several services if their research communities span across different e-infrastructures.

Recently, the Grid team at INFN Catania has developed the Catania Science Gateway Framework to easily and quickly build Science Gateways which can be configured as Service Providers of Identity Federations and then potentially accessible by huge numbers of users. The framework makes use of the SAGA and OCCI standards, defined by the Open Grid Forum, to perform middleware-independent job and data management as well as cloud management and operation.

In this contribution we will present the Catania Science Gateway Framework and the results of the program outlined by the CHAIN-REDS project to demonstrate standard-based interoperability amongst high performance computing, grid and cloud resources distributed worldwide and based on several different middleware stacks.

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