

Distributed Computing Services on top of a Research and Education Network: GARR

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Abstract

Since the beginning of 2013 the Italian National Research and Education Network GARR has started a new Distributed Computing and Storage Department (DCSD). The new DCSD in the Italian NREN, follows the new mission of GARR that will not only provide very advanced Network services to the Research community, but also manage, consolidate and expand an Italian Distributed Computing and Storage Infrastructure based on Grid and Cloud.

This paper provides state of the art information on the planning and deployment of such infrastructure presenting the motivations, the objectives and the vision that will bring this infrastructure into the next Horizon 2020 programme of the European Commission. The first pillar of this strategic evolution of GARR is the new project "GARR-X Progress" which has been recently approved by the Italian Ministry of Research and Education and that aims to deploy an advanced e-Infrastructure in the south of Italy (Regions of Convergence). GARR-X Progress will use a new fibre optics backbone and deploy a new distributed system of 6.000 Virtual CPUs and more than 6 PB of storage.

Keywords

Cloud, NREN, Distributed Computing, Distributed Storage, Advanced Services

1. Introduction

GARR is the Italian Research & Education Network (NREN). It plans and operates the national high-speed telecommunication network for University and Scientific Research. Its shareholders are four major Research and Academic organizations in Italy, CNR, ENEA, INFN and Fondazione CRUI, representing the Conference of Italian University Rectors.

GARR plans and operates the national high-speed telecommunication network for University and Scientific Research. All Academic and major Scientific organizations in Italy connect to the GARR network. The institutional mandate includes the following:

- to implement and operate the national high-speed telecommunication network for University and Scientific Research, and to interconnect to other NRENs in Europe and worldwide, as well as with the Global Internet;

- to provide the user community with network operation and application services;
- to facilitate cooperation in the field of research through the exploitation of leading-edge e-Infrastructures, both at a national and international level;
- to disseminate advanced knowledge about network infrastructure, and to stimulate the exchange of technical knowhow within the user community.

The GARR network infrastructure covers the whole national territory in a wide spreading way and its backbone is based on leading-edge optical circuits and technologies. The broadband access fully supports innovative applications such as Grids, Telemedicine, e-Learning, Multimedia, High Energy Physics, Radioastronomy. It is interconnected with all European and worldwide Research Networks and supports collaboration among national and international research activities. From the second half of 2009, the current infrastructure will be gradually replaced by GARR-X, the next-generation, multi-service network that will dramatically enhance global performances.

GARR-X is the design of next-generation multiservice communication network dedicated to the Italian university and research community, which will gradually replace the current network infrastructure GARR. The evolution network, both quantitatively and qualitatively speaking, indicates that the demand for bandwidth and value added services is increasing and in order to meet these new needs, it is no longer sufficient to expand and further strengthen the existing network.

GARR provides connectivity services with upstream/downstream symmetric guaranteed bandwidth to the Research and Educational Network system and to Internet. Accessing GARR network, like the other NREN linked with GÈANT, implies a use of a network exclusively dedicated to the research and educational institutes, which guaranties reliable, high-quality internet site-to-site connections, wherever they are in the GARR network or outside national boundary and located on the other NREN in Europe and world-wide.

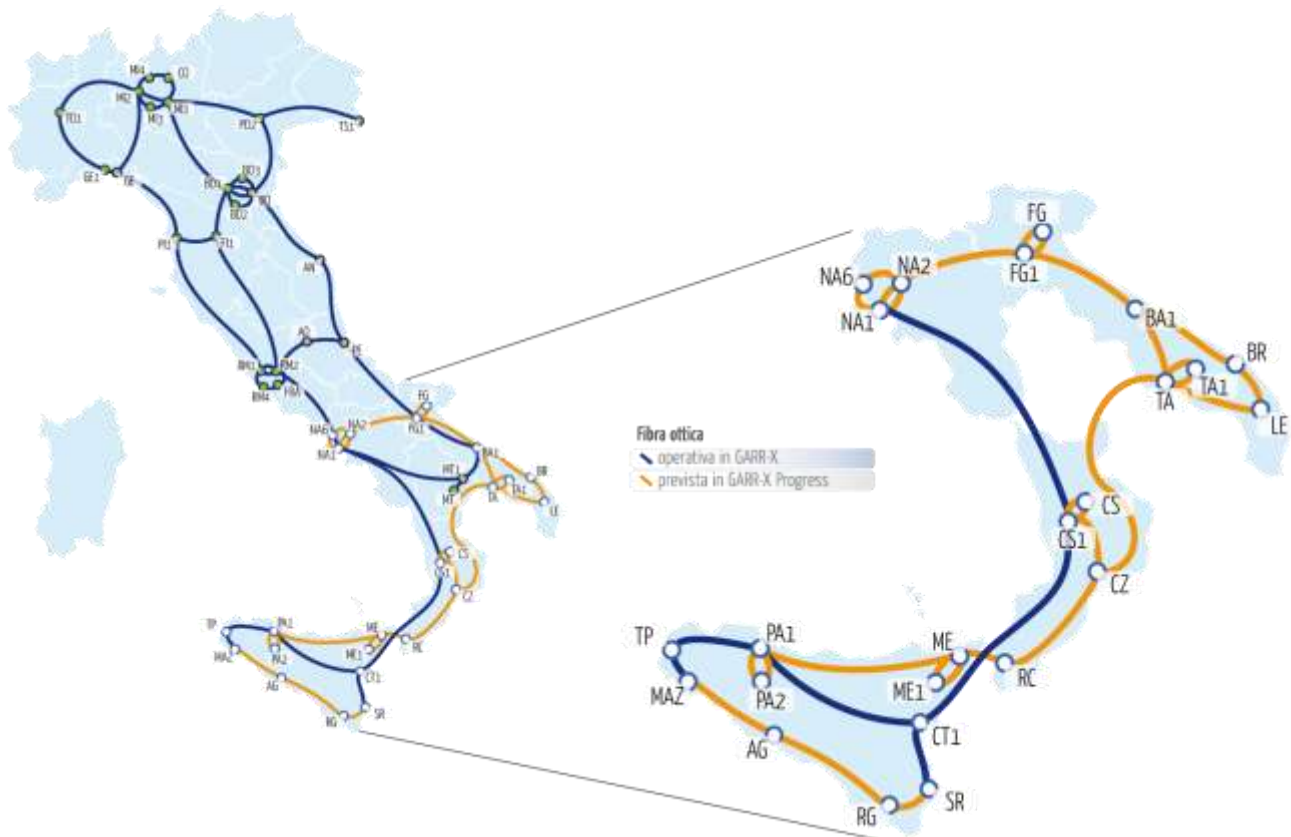


Figure 1 GARR-X (blue) and GARR-X Progress (yellow) fibre backbone.

2. Advanced Connectivity

A new project “GARR-X Progress” has been recently approved by the Italian Ministry of Research, University and Education. The new project is mainly focused on extending the current GARR-X infrastructure in the south¹ of Italy completing a full fibre optics backbone and bringing fibre accesses to GARR users. Access circuits to GARR network uses dark fibre links and gives the user a high technical flexibility as it allows to set-up bandwidth upgrade up to 100 Gbit/s, via technical action on the termination equipment managed by GARR. These activities are carried out leading to effective user needs.

The services offered are distinguished on the basis of three profiles depending on the capacity and reliability of the circuit, and service level management associates. The three profiles correspond to two types of typical users:

- Base access – schools and small institutes (branches and operating units of research institutes, libraries, arts academies, local public administrations, university spin-off, etc). It provides a 100 Mbit/s or 1Gbit/s circuit with an Ethernet interface based on a single fibre link. The link will terminate in an intermediate Point of Aggregation (PoA)⁷ or in a GARR Point of Presence (PoP).

¹ Four regions of convergence: Campania, Puglia, Calabria, Sicilia

- Advanced access – research centers, universities and institutions requiring data intensive connectivity. Advanced connectivity service provides, with one or more Ethernet interfaces, a 100 Mbit/s/1Gbit/s/10 Gbit/s and 100 Gbit/s circuit based on a single or double fibre link. The links are terminated in a GARR Point of Presence (PoP).

Accessing GARR network the user are allowed to use all the features implemented on the network, and all operational and application services. Operational services are related to the network infrastructure control and management (NOC-GARR, GARR-TOC, Operations support, GARR-LIR, GARR-NIC), and application and security services are more oriented to the use of infrastructure by the users (GARR-CERT, GARR-Scarr, Secondary DNS, Eduroam, Mirror, IDEM, GARR-Vconf, Certification Service).

3. Advanced Services

The last ten years have seen a constant development of Distributed Computing Infrastructures (DCI) in many regions of the world with Europe and specifically Italy leading the experimentation. The need for such shared e-Infrastructures has been recognized by several scientific domains and the European Digital Agenda includes Cloud Computing as one of the topics that have to be addressed.

Several Italian nationally funded projects have deployed relevant facilities in the regions of convergence in Italy. There is the need to consolidate these infrastructures in a large national infrastructure that could both: fully exploit such facilities and evolve into a stable and sustainable service for the Research and Education in Italy enabling Italian Research Organisations and centres, Universities and other research institutions to participate to large European (e.g. ESFRI) and international projects.

GARR has recently started the creation of a new department that has the mission to provide advanced computing services to its users. The activities described in this chapter are thus related to such new strategy that has been favoured by the Universities and research organisations members of GARR or users of the GARR infrastructure.

3.1 The technology

The Distributed Computing Infrastructure (DCI), cloud based, will complement the resources already deployed by previous projects and support further future complementary investments. The proposed infrastructure will complement existing initiatives and support the transition to a production service made available to a large number of researchers granting them the opportunity to use non-trivial computing resources for new and relevant scientific applications.

GARR will also play the role of a broker between users (researchers, professors, etc.) and resource providers (Universities, Research Centres, Private companies and GARR itself) defining the technical requirements, and performances needed to deliver service that are easy to use, dependable, upgradable and sustainable.

The initial phase of planning will specify the components and solutions adequate to deliver the requested functionalities and the choice will be made taking into consideration the maturity and their spread among national and international infrastructures.

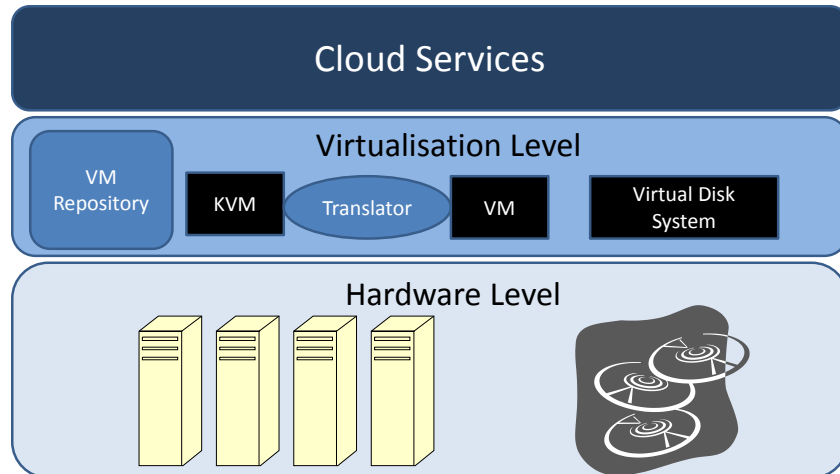


Figure 2 Layered structure of the ICT Infrastructure .

The services provided by the ICT infrastructure will be based on a Cloud platform that will be Open and where virtualized resources will allow for an easy allocation to the users with the possibility of

- Migrating the resources in case of need
- High Availability and disaster recovery on user request
- Elastic provisioning of resources following the users' requests
- Transparent provisioning towards public and private resource providers

The proposed infrastructure is composed by a core system of dedicated hardware that will be the starting core of a larger infrastructure that will see the consolidation of other resources deployed in other projects or made available by Universities and Research Centres.

The hardware infrastructure will be distributed in the Regions of Convergence to maximise the availability and synergy. Very high speed links (10-100 Gbps) will interconnect the sites allowing: distribution of data, data redundancy, fast alignment of replicas and disaster recovery.

There are several Cloud technologies used in Europe and other regions of the world. Recently EGI (European Grid Infrastructure) has launched a Task Force for Federated Cloud that has compared the different solutions with the requirements of the Research and Education community.

GARR starts from the work done so far by the EGI Task Force and CHAIN-REDS to define an autonomous implementation strategy, yet compatible with the European one, that could lead to the deployment in the short term of 12-18 months.

The technologies considered so far have been selected with two main criteria: availability of Open Source code and compliance with the standards that allow federating resources of different clouds with a reasonable level of interoperability.

The reference Cloud technologies considered are:

- **OpenStack** is a cloud operating system that controls large pools of compute, storage, and networking resources throughout a datacenter, all managed through a dashboard that gives administrators control while empowering their users to provision resources through a web interface.

- **CLEVER** is a cloud middleware fully designed at the University of Messina, Italy. CLEVER simplifies the access management of private/hybrid clouds and provides simple and easily accessible interfaces to interact with different interconnected, clouds, deploy Virtual Machines and perform load balancing through migration.
- **OKEANOS** is a comprehensive cloud middleware with web graphic interfaces for users and cloud tenant. It has been developed, using governmental funding, by GRNET the Greek NREN that intends to deploy and manage a large Cloud infrastructure for the Research and Education in Greece.

The international standards of reference for federating clouds are:

- The **Open Cloud Computing Interface (OCCI)** comprises a set of specifications delivered through the Open Grid Forum. OCCI is a Protocol and API for all kinds of Management tasks. Originally initiated to create a remote management API for IaaS model based Services, OCCI is now suitable to serve many other models, including PaaS and SaaS.
- The **Cloud Data Management Interface (CDMI)** defines the functional interface that applications will use to create, retrieve, update and delete data elements from the Cloud. As part of this interface the client will be able to discover the capabilities of the cloud storage offering and use this interface to manage containers and the data that is placed in them. In addition, metadata can be set on containers and their contained data elements through this interface.

3.2 The services

The services offered by the ICT infrastructure will be based on a layer of basic services of virtualised Servers and Storage. On top of these basic services other high value services will be configured to target different types of users and needs.

Basic services are:

- **Virtual Server** - The service makes available virtual systems equipped with one or more virtual CPU, RAM and Disk.
- **Data storage** - GARR designed the service for delivering a cloud personal or group storage solution letting users to maintain and share research and education data in a simple, quick, secure and controllable way.

The storage service offers some unique features:

- It is managed entirely in Italy and by Italian subjects. This allows enforcing conformity to Italian data management laws, ensuring constraints, policies, discretion and copyright on users' data.
- It is intended to be a common effort by education and research institutions. This allows

obtaining economies of scale and to better share benefits in a community context.

- It leverages existing infrastructure optimizing the usage of underutilized resources, thus consisting in an overall reduction of rollout costs and facilitating the service sustainability over the years..
- It is operated by GARR which exploits both its own resources and resources made available by the R&E Community, thus ensuring a clear sustainability and data preservation strategy for many years in the future.

The storage services offered can be divided in two categories: GARRbox (Personal Storage) and GARRstore (Storage for Groups and/or larger size).

GARRbox offers functionally similar to commercial solutions, like Dropbox, Google Drive and SugarSync, while GARRstore is targeted to users that need larger storage space and better performances in the data access.

On top of the services described above, other pre-configured services are offered; here follow some examples:

- **High Availability Support to critical ICT Services** - Application and data services are replicated in the Cloud providing high availability through redundancy and avoiding Single Point of Failure (SoF). Overprovisioning will also ensure good performances in all the service of the GARR-X Progress platform. The High Availability Support Service will be delivered exploiting the combination of Virtual Server and Storage services of the ICT platform and will encompass critical services such as DNS.
- **Scientific Portal** (Science Gateway) - Thematic portals will be preconfigured with CMS systems, tools and applications, needed by the users, with a Web Graphic Interface. The service will include user support for application porting in the framework of the portal and customisation of authorisation and authentication systems.

IdP in the Cloud - A preconfigured virtual appliance offered as a Service in the Cloud, including an Identity Provider system and optionally an identity management system, that allows the Single Sign On authentication towards many services using Federated Identities.

IdP in the Cloud is operating in a Virtual Machine that is pre-configured with the following software installed:

- Shibboleth IDP
- uApprove
- Custom login page for the user authentication that can be customised for the organisation.
- Apache2 Server with a system to verify the validity of the digital certificates
- OpenLDAP - LDAP Server: for those organisations that do not have such service internally.
- phpLDAPadmin interface to facilitate the identity management by the organisations using

the LDAP server

- MySQL Server used for the DataBase of the IdP
- IPTABLES Firewall
- Rsyslog demon for the centralised logging
- Nagios server for monitoring and alarms
- Collectd demon to collect system statistics
- A backup system for the data.

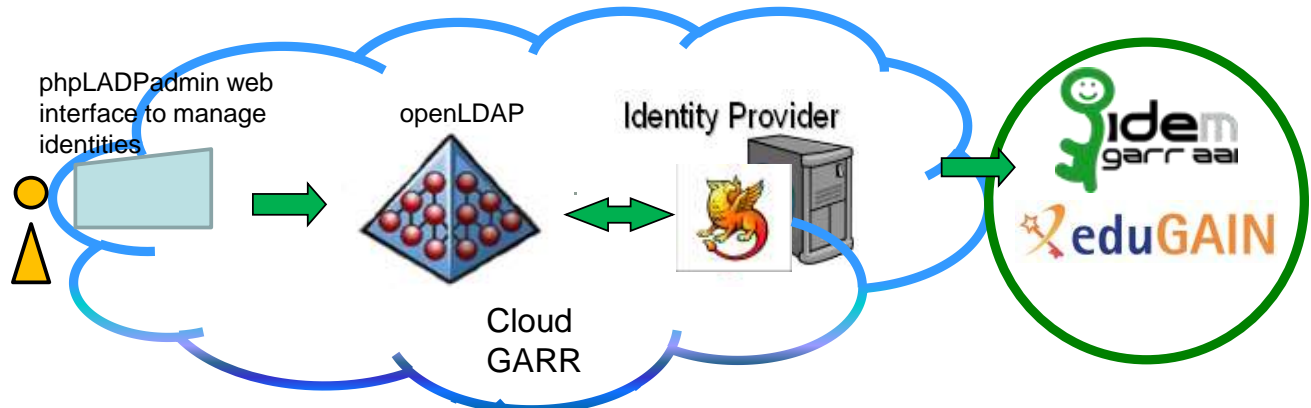


Figure 3 IdP in the Cloud schema.

Providing PaaS or SaaS like IDP in the Cloud on a large scale is made possible thanks to Configuration Management tools like Puppet.

Using the same approach it will be possible to offer also a variety of preconfigured PaaS, like portals, collaboration tools and other useful services.

One of GARR's intentions is to offer the "Federation as a Service" (FaaS), a preconfigured PaaS environment including a number of Identity Providers, Service Providers, a Federation Registry, a Metadata Distribution Service and a Discovery Service. The FaaS will make a NREN, at the beginning of the process of building a National Identity Federation, ready to deploy an entire Identity Federation. The preconfigured Federation as a Service could allow to faster convergence towards more consistent rules allowing more interoperability between services. The standardization reached thanks to the FaaS could steer the market, allowing the acknowledgement of NRENs as a driving leader for technology and in a special way access technology.

4. Conclusions

Many NRENs are deploying new services on top of their connectivity offered to the users. GARR has started a process for providing very advanced services in Italy based on fibre connectivity and distributed computing and storage facilities.

Several of these services can be of interest for many other NRENs in Europe and in other regions of the world and especially Africa.

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Biographies



Federico Ruggieri, is Director of Research at INFN (Italian National Institute for Nuclear Physics) and, currently, Head of the Distributed Computing and Storage Department at GARR (the Italian National Research and Education Network). He worked on On-Line and Off-line Computing Systems for High Energy Physics experiments at CERN and at Frascati, INFN National Laboratory. He promoted the first GRID project co-funded by the European Commission: EU-DataGRID and started the Tier1 of INFN-CNAF in Bologna where he was the Director from 1998 to 2004. He played an important role in the development of the Communication Networks for Research and Education in Italy and GARR. He led several projects co-funded by the European Commission and he is presently the coordinator of the CHAIN-REDS project. He is also professor of Data Acquisition at the University of Roma TRE. He has a list of more than 400 articles and publications.



Maria Laura Mantovani, is officer at the University of Modena and Reggio Emilia (Italy) and since 4 years is working at GARR in leading IDEM, the Italian Identity Federation for Research and Education. Previously she was Chief Security Officer at the University of Modena and Reggio Emilia. She has expertise in Identity and Access Management, Federated Identity Authentication and Authorization Infrastructure, System and Network security, Computer forensics. She achieved a Master Level Degree in Mathematics and a Master Second Level Degree in Computer Security and Forensic Discipline.