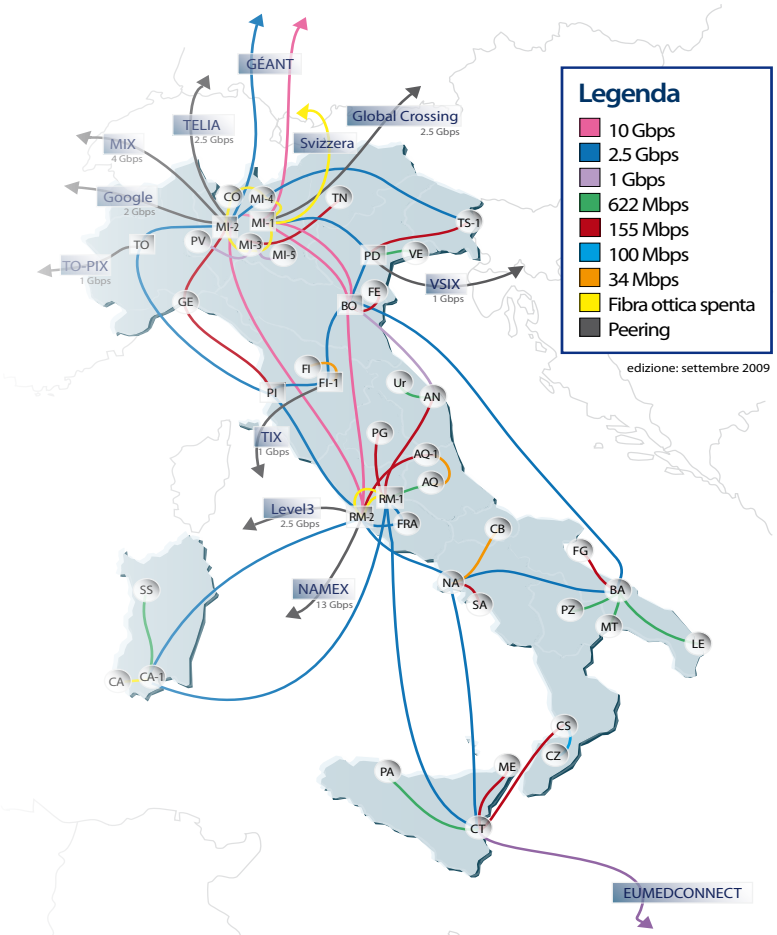
GARR: the Italian Research and Academic Network

www.garr.it/reteGARR

GARR-Giganet (GARR-G in short), the current generation of the Italian Research and Academic Network, is operational since the end of 2003.

The GARR-G backbone is based on high-bandwidth circuits up to 10 Gbps, using various technologies such as DWDM, SDH and MPLS. The meshed topology, interconnecting 45 network Points of Presence (PoP), ensures a high level of resilience and reliability of the network; thanks also to its wide coverage of the country, it interconnects more than 400 user organizations all over the national territory.

GARR-G Network Topology



Leveraging the high-bandwidth of user access, GARR-G provides its community of users, in addition to standard IPv4, a series of advanced network services such as IPv6, Multicast IPv4, L2 and L3 VPN, IP QoS. The GARR network also supports a variety of innovative applications, including Grids and Distributed Computing, Telemedicine, e-Learning and Multimedia, High Energy Physics, Radio astronomy, Earth Observation, Supercomputing.

The GARR-G project

The GARR-G project has been developed in phases:

Pilot phase: on-the-field experimentation of new transmission, multiplexing and switching to be implemented in GARR-G (started in 2001);

Phase 1 (2002-2004): implementation of the new backbone, with 2.5 Gbps or higher links. In this phase, part of PoPs moved to their new locations;

Phase 2 (2003-2005): expansion of the new backbone and activation of new PoPs; de-activation of the previous network's backbone and start of users' migration;

Phase 3 (2005-2008): migration of all users to the new backbone and upgrade of access links.

During the GARR-G project, the Consortium GARR was founded as legal entity and the network was smoothly upgraded from the previous version (GARR-B), keeping the production environment in operation.

The effort devoted in GARR-G engineering and implementation, was targeted to allow Consortium GARR to build a larger and faster national network infrastructure, characterized by:

- about 100 network nodes (router, switches, D/CWDM, etc.) located in 45 PoPs distributed on the whole national territory and directly operated by GARR technical staff;
- aggregated backbone capacity of more than 100 Gbps and access capacity of about 50 bps, peering (international and national) capacity of about 80 Gbps;
- adoption of leading-edge technologies such as DWDM and MPLS;
- provision of advanced network services such as IPv6, Multicast, QoS and VPN(L2 and L3).

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GARR-G User community

The GARR network and its services are dedicated to the Italian Research, Academic and Education communities. Currently the GARR network connects approximately 450 end sites, including research centers, laboratories and other facilities, universities, Institutes for Research in Health Care (IRCCS), Music Conservatories and Academies of Art (AFAM), Libraries, Archives, Schools, Museums and other R&E institutions of national relevance, for overall 2.000.000 end users:

- 129 Laboratories and Research centers of major Scientific organizations in Italy, including CNR, ENEA, INGV, INFN and ASI,
- 88 Universities,
- 31 Music Conservatories and Academies of Art (AFAM),
- 38 Institutes for Research in Health Care (IRCCS),
- 26 National and University libraries ,
- 17 Astronomical and astrophysical observatories,
- 74 other Research and Education facilities of national and international interest,
- 77 Schools and Hospital Special Schools for children who are patients (HSH), funded by a specific action of the Ministry of Education until 2009.

Network Topology

GARR-G is a Wide Area Network composed by a set of equipments and links between them. The GARR-G network exploits several technologies, such as Ethernet, ATM, SDH, serial HDLC, C/DWDM, xDSL, ISDN, etc. TCP/IP both v4 and v6 is the only data transmission protocol used. Almost all network equipment is owned by Consortium GARR, which directly operates them through its Network Operation Centre (GARR-NOC). Circuits between the equipments are implemented on optical fiber or copper wires and they are either owned by GARR or leased (in long-term rental or IRU) from telecom operators. There are only few cases in which a medium speed radio circuits is used.

GARR-NOC liaises with the telcos' operation centers for any scheduled or unscheduled maintenance on the equipments and circuits.

On the GARR-G transmission infrastructure a nation-wide IP network has been implemented. The GARR-G IP network links can be divided into two classes:
- backbone links between GARR-G network equipments (i.e. backbone routers);
- access links between user's network equipment and GARR-G network equipment.

The core of GARR-G is the set of the PoPs hosted in Rome, Milan and Bologna, which hosts the main peering circuits and are interconnected with each other at 10 Gbps. 2.5 Gbps links interconnect other important national PoPs, providing redundancy to the network, while more peripheral PoPs, that aggregate a limited amount of user traffic are interconnected at 155 Mbps and 34 Mbps.

Routing

IPv4 and IPv6 are the data transport protocols on GARR-G. The routing architecture for both protocols is identical. OSPF (v2 and v3) is the protocol deployed for internal routing in GARR-G. It is used to distribute reachability information of all IP backbone router interfaces and loopbacks. The iBGP protocol is used to propagate in GARR-G the information on user networks' prefixes. eBGP is then used as inter-domain routing protocol to exchange routing information between the AS (autonomous system) GARR (AS137) and all other public ASes on the Internet.

External connections

The GARR-G network is interconnected with the rest of Internet through General Internet connections, Research connections and National peerings.

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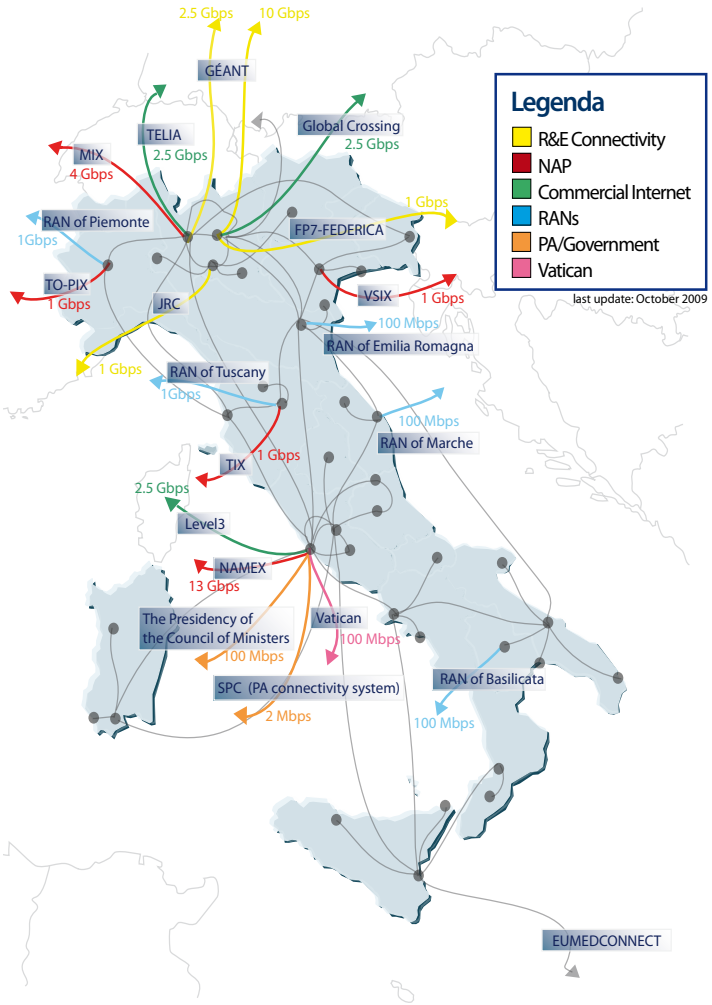
GARR-G Peering Points



GARR-G network ensures its community the **interconnection with General Internet** using three of the main international commercial upstream providers (Global Crossing, Level3 and TELIA). The interconnections are located in three different PoPs for resiliency. The total aggregated capacity of the links is 7.5 Gbps.

The GARR-G network is part of the worldwide system of Research and Education Networks (NRENs). It connects to other NRENs in Europe and worldwide through a 10 Gbps link (plus 2.5 Gbps backup link) to the GÉANT2 pan-European backbone. Other interconnections, such as LHCOPN, DEISA, EXPRes, FEDERICA, have been set up within specific projects and to provide connectivity to specific groups of users.

The GARR-G network is interconnected with all major Italian commercial ISPs (Telecom Italia, Wind, Fastweb, etc.) at the main public Internet Exchange Points in the country, namely MIX (in Milan) [R 17], NAMEX (in Rome), TOP-IX (in Turin), TIX (in Florence) with an aggregated capacity of about 20 Gbps.

Furthermore, GARR-G peers with Local Public Administration Network Infrastructures. Currently, peering agreements are operational with the Regional Area Networks of Basilicata, Emilia Romagna, Marche, Toscana and Piemonte Direct peerings have been also established with the networks of Presidency of the Council of Ministers and Vatican. GARR recently activated a direct connection with the Central Administration National Network (SPC, Public Connectivity System), for those users that need connectivity with specific applications provided in this environment.

Network Services

GARR-G network provides its community of users a series of advanced network services.

IP Multicast

IP multicast is a technique for one-to-many communication over an IP infrastructure. Multicast uses network infrastructure efficiently by requiring the source to send a packet only once, even if it needs to be delivered to a large number of receivers. The nodes in the network take care of replicating the packet to reach multiple receivers.
IPv4 multicast is implemented over GARR-G using the PIM Sparse Mode protocol (PIM-SM). This protocol sends multicast data flows only to users that require explicitly the data flow, avoiding unnecessary traffic flows. IPv6 Multicast setup has been deployed and there is a plan to offer it as a fully monitored and controlled service in the next months.

IPv6

Since 2005, GARR-G network natively supports **IPv6, the next generation IP protocol** and supports users in its implementation. The key feature of IPv6 is a much wider addressing space. Furthermore, the new version of the protocol may simplify the configuration and management of IP networks and may enable innovative services and new functionalities in applications.he GARR network is dual-stack, i.e. it is capable of providing both IPv4 and IPv6 connectivity to all its end sites independently, wherever located, thus allowing end-users to connect to services provided via both protocols.

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Premium IP

Since 2007, GARR provides **Premium IP** over GARR-G. Premium IP is a service that implements QoS mechanisms for IP traffic flows. Premium IP traffic takes priority over all other services, such as Best Effort (BE) and Less Than Best Effort (LBE). During network congestion, Premium IP traffic receives a better, and guaranteed, level of network performance, controlling the amount of IP delay variation and imposing an upper bound on network delay. This can be particularly suited for real-time applications, such as Voice Over IP (VoIP) and video conferencing.

Premium IP is deployed on the GÉANT network and on other NRENs on the basis of common specifications: for this reasons it can be used as well for international collaborations.

End-to-end circuits

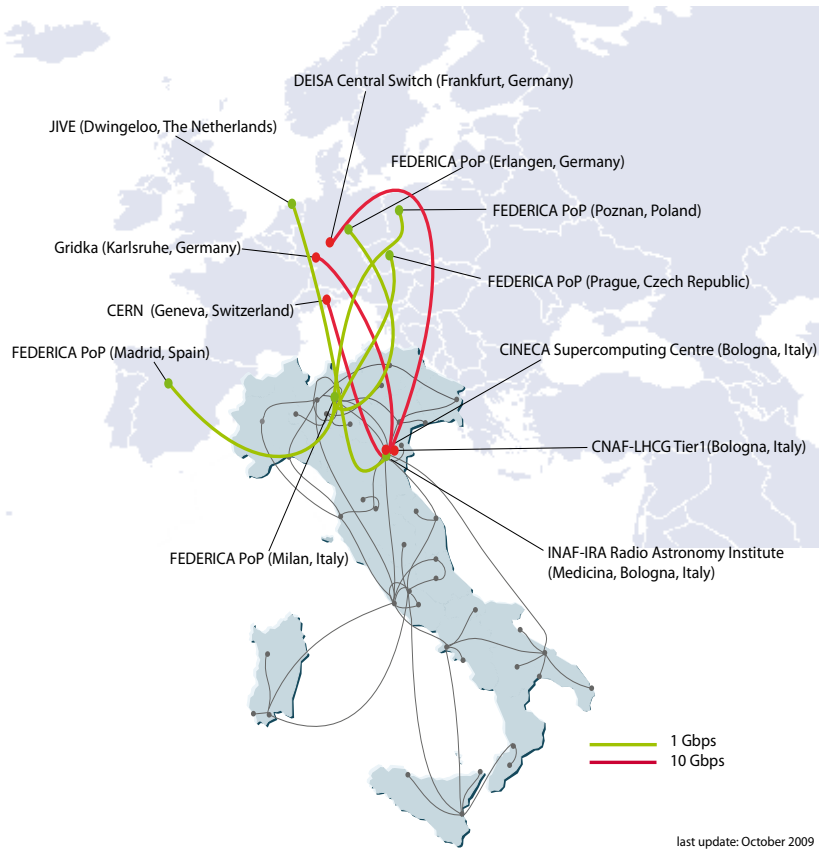
This service is dedicated to the creation of **end-to-end circuits between end-users,** both within the GARR network and outside, involving the creation of interdomain connectivity in cooperation with GÉANT. It can use leading-edge access and transport technologies and provides users with tailored solutions to meet their specific requirements.

Whenever possible end-to-end circuits are implemented through the creation of Layer 1 wavelengths. The existing network architecture poses however certain limitations to the provision of this service, that will be overcome with the upgrade to GARR-X. When solution at layer 1 is not available, the end-to-end connectivity services are implemented using different technologies, including MPLS, Premium IP, Layer 2 and 3 VPNs, and VPLS.

END-TO-END Circuits over GARR-G
FEDERICA PoP at GARR (Milan) - FEDERICA PoP at CESNET (Prague)
FEDERICA PoP at GARR (Milan) - FEDERICA PoP at DFN (Erlagen)
FEDERICA PoP at GARR (Milan) - FEDERICA PoP at REDIRIS (Madrid)
FEDERICA PoP at GARR (Milan) - FEDERICA PoP at PSNC (Poznan)
CNAF-LCG Tier1 (Bologna) - CERN (Geneve)
CNAF-LCG Tier1(Bologna) - GRIDKA-LCG Tier1 (Karslruhe)
INAF-IRA (Medicina, BO) - JIVE (Dwingeloo)
CINECA suoercomputing centre - DEISA central switch (Frankfurt)

Network Monitoring and Statistics

GARR-G status and performances are constantly monitored, in order to ensure an efficient service as much as possible. The monitoring system used in GARR-G is GINS (GARR Integrated Networking Suite), a software suite specifically developed by GARR staff.



GINS integrates in one common framework the following elements:
- all network monitoring tools
- all statistic acquisition tools
- trouble ticket system
- fault and performance reports

GINS has been developed with the following objectives:
- integration of all monitoring and service tools, already available and to be developed;
- dynamic tool configuration, on the basis of the information stored in the GARR database (GARR DB) and those obtained directly from the network equipment.

GINS is operational since 2005 and it is continuously upgraded in order to extend the already available functionalities and to account the requirements deriving from the frameworks in which t is currently used.

Consortium GARR

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