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Deliverable DS1.3.2,1: Annual Advanced Services Usage Report

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Abstract

This deliverable reports on the take-up and usage of GÉANT's advanced services, GÉANT Plus and GÉANT Lambda, during Year 1 of the GN3 Project. It introduces each service and the End-to-End Coordination Unit (E2ECU) that supports their operation, and provides figures for new point-to-point links delivered, the overall status of advanced services, and the E2E circuits and outages managed by the E2ECU.

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Executive Summary

GÉANT is a hybrid network, combining the operation of a shared Internet Protocol (IP) infrastructure with the ability to provide additional dedicated point-to-point links reserved exclusively for particular user groups.

GÉANT's point-to-point services, GÉANT Plus and GÉANT Lambda, optimise the latest developments in technology and the telecommunications market to meet an ever-growing demand from the user community, not only for a high-capacity network, but also for guaranteed availability and performance. The point-to-point services offer circuits of between 1 Gb/s and 10 Gb/s that provide dedicated, guaranteed network capacity to the user group concerned, ensuring reliable, secure, high-bandwidth, end-to-end (E2E) connectivity.

GÉANT's point-to-point circuits are offered between National Research and Education Networks (NRENs) in Europe where it has been possible to procure at an affordable price the necessary network infrastructure – usually dark (unlit) fibre optic cables on which circuits can be incrementally added as demand requires.

A total of 12 new point-to-point circuits were delivered on the GÉANT infrastructure during Year 1 (1 April 2009 – 31 March 2010), with the projects supported this time being LHCOPN, FEDERICA, DEISA, HPDMnet and AtlantIC. Of the 12 circuits, 8 were GÉANT Plus links; 4 were GÉANT Lambda.

The total number of GÉANT Plus and GÉANT Lambda links in use at Year 1 end was 64. The FEDERICA and LHCOPN projects have the most circuits with 17 and 15 respectively, followed by DEISA with 7 circuits.

The total of 64 excludes wavelengths used to provide either GÉANT Plus capacity or IP trunks between GÉANT backbone routers. It also excludes links used for AutoBAHN testing, and Layer 2 Virtual Private Networks (L2 VPNs, also known as Label Switched Paths (LSPs)). Demand for L2 VPNs has been largely superseded by advanced point-to-point services; there are currently only 3 live GÉANT VPNs.

Reflecting the increased scope and sophistication of the point-to-point links, a significant coordination and monitoring effort is required to ensure their optimum availability. A global monitoring function, the End-to-End Coordination Unit (E2ECU) is in place to provide this. During Year 1, the E2ECU tracked the resolution of 613 incidents such as connectivity problems, circuit monitoring faults and planned maintenance occasions. Overseen by DANTE Operations, the processes, procedures and tools used by the E2ECU are subject to continuous review and improvement.

Planned service developments for advanced services include the ongoing enhancement of a web interface, to improve communication with service requesters and allow them to track the progress of their service requests.

This interface is now at the prototype stage and a programme of user testing is ongoing pending release in Quarter 2 2010.

This deliverable reports on the use of advanced services during Year 1, and their status as at Year 1 end. As such it is a snapshot of ongoing developments and achievements; further work is still required to realise fully the services' many potential benefits.

1 Introduction to Advanced Services

Optimising the latest developments in technology and the telecommunications market, the GÉANT network offers the European research and education community a unique range of opportunities for international collaboration. In addition to the standard service, known as GÉANT IP, which provides access to the shared European Internet Protocol (IP) research and academic network, advanced services are available, delivering international point-to-point network connections free from the constraints inherent in a shared, routed infrastructure. Foremost among the advanced services are GÉANT Plus and GÉANT Lambda. Each of these is described below. (A description of the standard service, GÉANT IP, is included to provide a context for the advanced services; the remainder of the deliverable is concerned with the advanced services only.)

For a map of the GÉANT network, see "GÉANT Topology Map 2009" [5]. For a more detailed description of GÉANT's services, see "DN4.2.1 GÉANT Services Portfolio" [1].)

1.1 GÉANT IP Service

1.1.1 Overview

The standard service, known as GÉANT IP, provides access via the GÉANT network to the shared European Internet Protocol (IP) research and academic network. It offers a robust, high-bandwidth solution to the international connectivity requirements of the majority of academic users, allowing transit for IP traffic between European NRENs, and between European NRENs and associated networks globally. Part of the European research and education backbone, the GÉANT IP network is over-provisioned by design, to allow small-to-medium-sized traffic flows an uncongested path. The IP service is resilient in the case of hardware failure or fibre cuts, and uses advanced routing equipment to ensure fast recovery from unexpected events.

GÉANT IP access is available to members of the GÉANT consortium at capacities of up to 20 Gb/s (subject to technical and commercial considerations) and is paid for by an annual subscription. Access can be given to non-consortium NRENs by special agreement.

1.1.2 Features

GÉANT IP provides the following features:

- A standard “best effort” IP service, i.e. with no bandwidth or performance guarantee between any communicating pair of addresses.
- Dual-stack (IPv4 and IPv6) core backbone based on packet-switching routers. The provision of IPv6 services means that GÉANT IP forms part of the world’s first global next-generation Internet network.
- Multicast enabled, efficiently delivering data traffic in both one-to-many and many-to-many scenarios.
- Layer 2 Virtual Private Network (L2 VPN) facility, built on the common IP infrastructure yet appearing to the user as a dedicated protected circuit. Configured using Multi-Protocol Label Switching (MPLS) and including multi-domain VPNs. Delivery time is 1 week. There is no extra charge for GÉANT L2 VPN services.
- Backup protection against circuit failure at up to the full subscribed bandwidth on an appropriate interface is included in the standard IP subscription. Alternative dedicated backup capacity is available to those NRENs on the fibre cloud, as part of their GÉANT Plus subscription (see Section 1.2.1 below).
- IP peering. Transit for IP traffic is offered to a defined set of NRENs and networks beyond the area covered by the GÉANT backbone and partner networks.
- Physical interface types range from T3 (34 Mb/s) to STM-64 or 10 GE (10 Gb/s). Access is available at capacities of up to 20 Gb/s, subject to technical and commercial considerations.
- Setting up a new connection from an NREN to the GÉANT IP network is a bespoke activity; delivery time will depend on NREN requirements.

1.2 Advanced Services

Despite over-provisioning, unmanaged flows above 1 Gb/s introduce the risk of impacting other traffic on the GÉANT IP network and causing congestion. The GÉANT point-to-point advanced services offer circuits of between 1 Gb/s and 10 Gb/s that avoid congestion and provide uncontended bandwidth over the GÉANT domain.

GÉANT offers two distinct classes of point-to-point services to National Research and Education Networks (NRENs) who require dedicated international circuits for their users: GÉANT Plus and GÉANT Lambda. The principal benefits of each are identical: they provide dedicated, guaranteed network capacity to the user group concerned, ensuring reliable, secure, high-bandwidth, point-to-point connectivity.

1.2.1 GÉANT Plus

1.2.1.1 *Overview*

The GÉANT Plus service allows NRENs to request point-to-point circuits of between 155 Mb/s and 10 Gb/s across an existing network of pre-provisioned links. It provides a reliable, high-speed, secure, end-to-end service with guaranteed bandwidth. GÉANT Plus is built on common infrastructure, but appears to its private users to be dedicated to that user’s needs, thus combining the privacy and availability of a private circuit with the cost efficiency and robustness of a shared, managed infrastructure.

The service provides the NREN with up to 10 Gb/s of pre-provisioned point-to-point capacity between the GÉANT Point of Presence (PoP) in its own country and other GÉANT PoPs connecting similarly subscribing

NRENs. Because the capacity is provisioned in advance, circuits can be implemented or reconfigured at short notice and without incremental cost to the NREN (provided the NREN subscription or interface is not full; if it is full, a new interface can be ordered, at a cost to the NREN and with the appropriate lead time). The circuits can also be extended across the Atlantic.

This capacity can be used to provide connections dedicated to individual research and education projects, particularly those with participants in multiple locations who wish to collaborate as if they were operating on the same local network.

The GÉANT Plus service is paid for by an annual subscription, which secures a 10 Gb/s circuit capacity allocation to the NREN.

Additional capacity and interfaces are available.

1.2.1.2 *Features*

GÉANT Plus provides the following features:

- Dedicated sub-wavelength point-to-point circuits configured over a network of dark fibre[1] links and Time-Division Multiplexed (TDM) switches.
- Circuits can be provided to the NREN at a granularity of 155 Mb/s (VC4) up to a total of 10 Gb/s (64 x VC4).
- Each NREN subscribing to the service is allocated 10 Gb/s of circuit capacity, which may be used flexibly for different services to multiple locations.
- The 10 Gb/s capacity allocation is fixed, regardless of the capacity of physical interfaces.
- Each NREN subscribing to the service is provided with access to the circuit on a single dedicated 10 Gigabit Ethernet (GE) or STM-64 interface on the GÉANT equipment at the national GÉANT PoP, as agreed by DANTE and the NREN.
- A circuit can be configured or reconfigured on the GÉANT plus interface within 5 working days of receipt of request, assuming that sufficient capacity is available in both the subscribing NRENs' capacity allocations.
- Circuits may be configured for any specified service period.
- Circuits can be established between many European NRENs and from many European NRENs to a non-GÉANT organisation/destination, such as those behind Internet2, ESnet, CANARIE and USLHCnet. The transatlantic E2E links use existing 10 Gb/s circuits between New York and various points in Europe.
- A further 10 Gb/s of capacity on a new interface can be provided at a fixed annual cost.

[1] *GÉANT Plus* subscriptions are usually only applicable to NRENs where the GÉANT backbone infrastructure supports multiple wavelengths. In most cases, this is over a dark fibre connection.

1.2.2 GÉANT Lambda

1.2.2.1 *Overview*

The GÉANT Lambda service provides private, transparent 10 Gb/s wavelengths between GÉANT NRENs. It is only available to NRENs connected to the GÉANT dark fibre cloud.

The GÉANT Lambda service is paid for by an annual flat-rate fee for each 10 Gb/s wavelength deployed.

1.2.2.2 *Features*

GÉANT Lambda provides the following features:

- Transparent 10 Gb/s wavelengths between transmission equipment in GÉANT PoPs.
- Two standard interface types are available: 10 GE or STM-64.
- Circuits can be configured with one of the following optics, specified at each NREN interface and provided by GÉANT: 10GBaseLR (1310 nm), intra-office STM-64 (1310 nm), or short-reach STM-64 (1550 nm).
- If dissimilar interface types are required on each end of a single 10 Gb/s circuit, this can be accommodated using the GÉANT MCC switching equipment.
- A Lambda takes up to 10 weeks to establish, due mainly to the lead time for the GÉANT optical equipment.
- An additional charge is raised to cover the cost of each Lambda requested.
- A Lambda can be used as part of an E2E link, and in conjunction with a partner organisation, to connect to a non-GÉANT organisation/destination.
- If protection against fibre cuts or equipment failure is required, a full 10 Gb/s back-up Lambda can be provided on an alternative, resilient route. This secondary Lambda will be configured over a fully diverse path to the specified primary Lambda.

1.2.3 Dark Fibre Dependency

The provision of point-to-point services is dependent on the use of dark fibre for the underlying infrastructure. For reasons relating to the availability and/or economic viability of dark fibre, it is not possible to offer point-to-point services to all GÉANT-connected NRENs.

2 Use of Advanced Services in Year 1

2.1 Overview

12 new point-to-point links were delivered in Year 1 (1 April 2009 – 31 March 2010). This compares with 22 delivered during the previous year (Year 4 of GN2). All the links were in addition to those ordered and delivered in previous years. 5 links were cancelled (3 GÉANT Plus, 2 GÉANT Lambda), bringing the total number of links in use at Year 1 end to 64.

This section summarises the new links delivered in Year 1 and provides statistics for the total number of links in use as at Year 1 end. Further information about the projects is given in Appendix A “Projects” on page 22.

2.2 New Links

Table 2.1 shows all new point-to-point links delivered in GN3 Year 1. Further analysis is provided in Table 2.2.

SRF No.[1]	Bandwidth assigned (approx.)	A-End Domain	B-End Domain	Project	Production Date[2]
09-004	1 Gbps	REDIRIS	CERN	LHCOPN	16-Feb-2010
09-008	10 Gbps	CERN	USLHCNET	LHCOPN	28-Aug-2009
09-007	1 Gbps	JANET	Netherlight	HPDMnet	30-Sep-2009
09-010	1 Gbps	DFN	Netherlight	HPDMnet	30-Sep-2009
08-030	1 Gbps	HEANET	NORDUNET	FEDERICA	30-Apr-2009
08-036	10 Gbps	DFN	SURFNET	DEISA	17-Mar-2009
09-005	10 Gbps	DFN	NORDUnet	DEISA	27-Aug-2009
09-001	1 Gbps	JANET	Internet2	AtlantIC	20-May-2009
09-002	10 Gbps	NORDUNET (DK)	NORDUNET (UK)	(NREN Backbone)	08-Apr-2009
09-006	1 Gbps	JANET (UK)	JANET (IE)	(NREN Backbone)	03-Jul-2009
09-009	1 Gbps	GRNET	AMS-IX	(IX)	20-Aug-2009
10-002	2.2 Gbps	BELNET	LINX	(IX)	18-Mar-2010

Table 2.1: New point-to-point links delivered in Year 1 – 1 April 2009 to 31 March 2010

Key:

1. SRF = Service Request Form. Each order is placed using such a form and assigned a unique SRF number, which is then used to designate the point-to-point link.
2. The project name “IX” is used where an NREN uses GÉANT to connect to a commercial Internet Exchange.
   The project name “NREN Backbone” refers to the situation where an NREN uses the GÉANT Plus or Lambda service to connect two areas of their backbone.
3. Production Date = Date that DANTE Operations handed the link over to the NREN for the project to use.

Note: The links described in the table and throughout the document do not include those point-to-point links created between partner NRENs over the GÉANT production and testbed network for AutoBAHN testing.

Project	# GÉANT Plus	# GÉANT Lambda	Total
AtlantIC	1	-	1
DEISA	-	2	2
FEDERICA	1	-	1
HPDMnet	2	-	1
IX	2	-	2
LHCOPN	1	1	2
NREN Backbone	1	1	2
Total	**8**	**4**	**12**

Table 2.2: Number of new links by project and type

2.3 Total Links in Use

2.3.1 GÉANT Plus

As at the end of Year 1, 41 GÉANT Plus links are in use. The total reflects all currently installed links, both those installed in previous years and during Year 1. Figure 2.1 shows these links broken down by project.

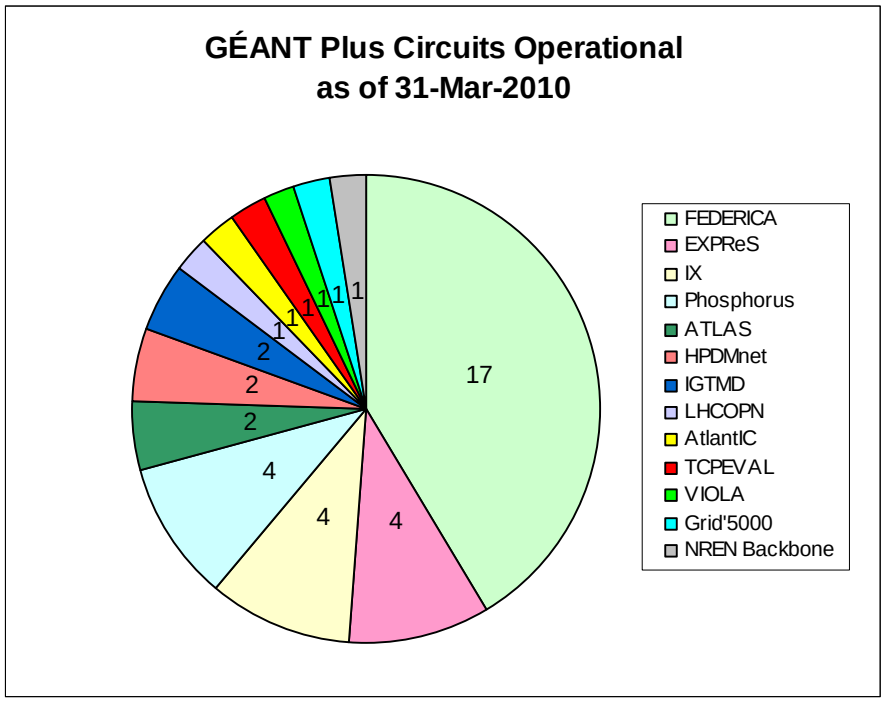

Figure 2.1: Number of GÉANT Plus links as at the end of Year 1

2.3.2 GÉANT Lambda

As at the end of Year 1, 23 GÉANT Lambda links are in use. The total reflects all currently installed links, both those installed in previous years and during Year 1. Figure 2.2 shows these links broken down by project.

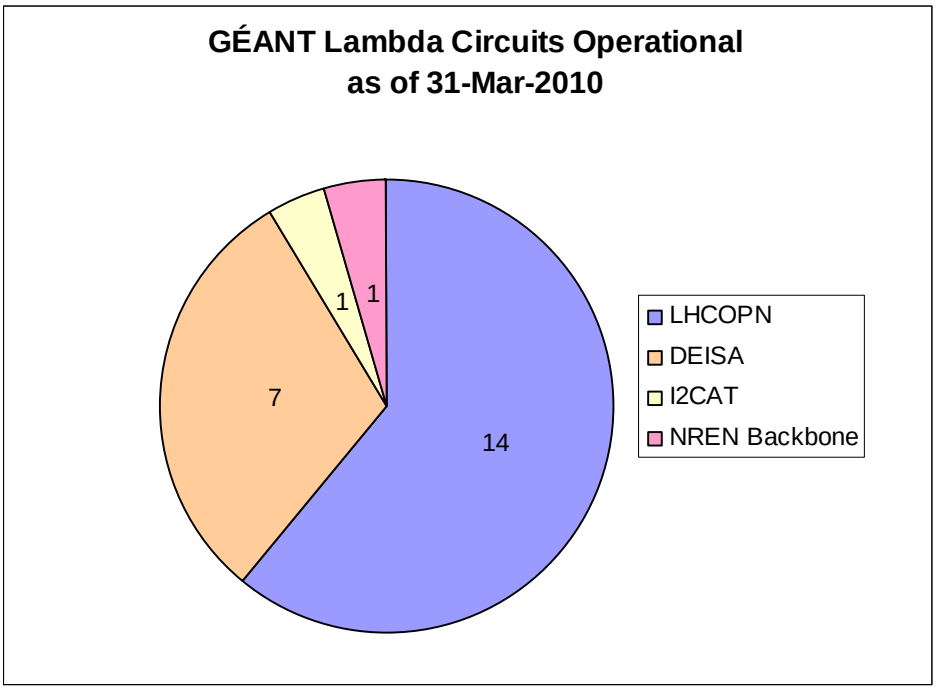

Figure 2.2: Number of GÉANT Lambda links as at the end of Year 1

2.3.3 Combined Totals

Figure 2.3 shows the project use of both link types, expressed as a percentage. The largest users of the GÉANT Advanced Services are FEDERICA (17 links, 27%) and LHCOPN (15 links, 23%).

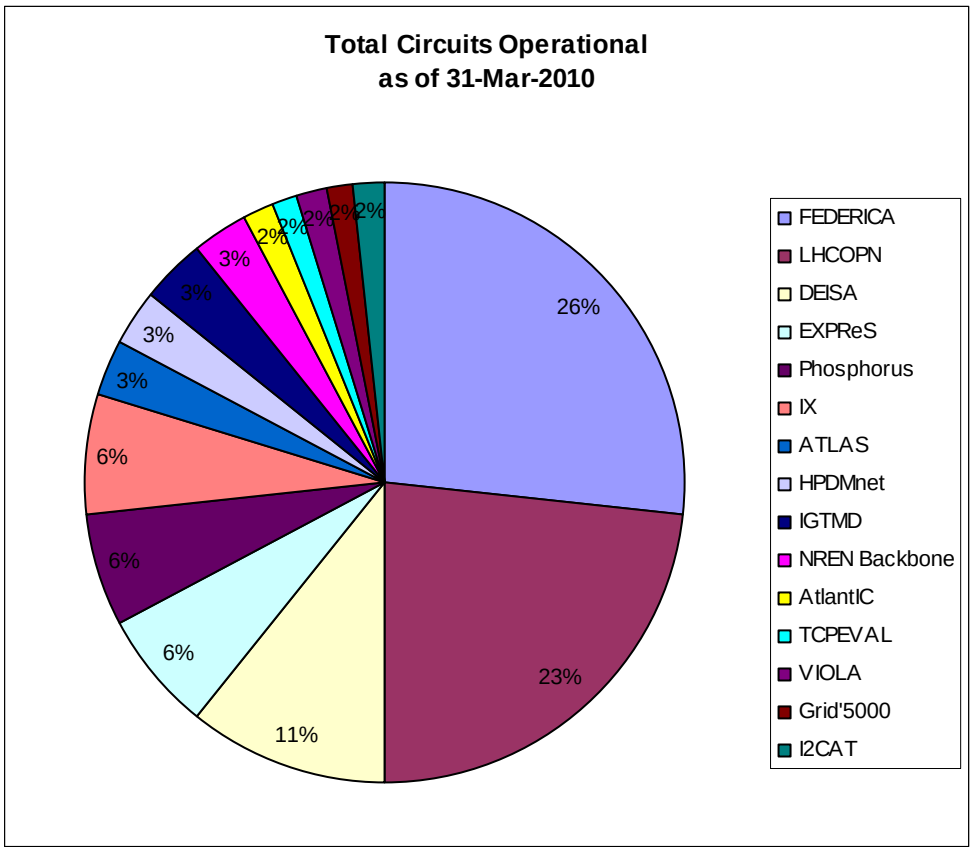

Figure 2.3: Project use of both link types combined as at the end of Year 1

3 The E2ECU Function

E2E circuits are multi-domain, that is, they are composed of multiple sections, each administered by a different domain, usually but not always including the GÉANT backbone. At least two domains will therefore participate in circuit provisioning and management.

Key to the successful delivery of the point-to-point services is the End-to-End Coordination Unit (E2ECU), which is responsible for the overall monitoring of E2E circuits and for coordinating the information flow and communications between the actors in the different domains involved in each E2E circuit. The constituent links in the circuit are also monitored by the appropriate national or international Network Operations Centre (NOC), such as the NREN NOC or the GÉANT NOC.

This section describes the responsibilities of the E2ECU, the role of the central End-to-End Monitoring System (E2EMon), the Trouble Tickets (TT) procedure, and plans for future service development.

For more information about the E2ECU's processes, procedures and tools, including the role played by the GÉANT network-monitoring service PerfSONAR and the End-to-End Monitoring System (E2EMon), see [2].

3.1 E2ECU Responsibilities

For the E2E circuits under its supervision, the E2ECU ensures that:

- All the domains are aware of how to install the different PerfSONAR Measurement Points (MPs) and/or Measurement Archives (MAs) so that they can send up/down alerts for the E2E circuits that traverse or terminate in their network.
- All the domains populate the MPs/MAs with the correct data.
- All the E2E circuits are named uniquely and each relevant domain is informed of the name.
- All E2E circuits appear correctly in the E2EMon overall visualisation tool.
- Trouble Tickets (TTs) are opened when a fault occurs, such as a fibre cut, that affects the E2E circuit. (The engineers at the E2ECU use plug-ins for their proprietary monitoring system so that it receives alerts from E2EMon whenever an E2E circuit has an outage on any of its constituent parts.)
- TTs related to any fault affecting an E2E circuit are updated and forwarded to all the domains involved.
- TTs are raised for any scheduled outages (due to planned maintenance, for example) about which the E2ECU has been notified by the constituent networks (such as GÉANT).

- TTs related to any scheduled outage affecting an E2E circuit are updated and forwarded to all the domains involved.

Connectivity incidents detected through the multi-domain monitoring systems are reported to all the parties involved on a 24x7 basis via emailed Trouble Tickets. Updates on incident resolution are given 06:00 to 22:00 CE(s)T Monday to Friday. During this time the E2ECU will contact the NOC of the domain in which the fault has occurred to obtain further details, and will forward this information to the other parties involved.

The E2ECU creates monthly reports, made available to the NRENs, which include availability statistics for the various point-to-point links and a list of point-to-point links recently added to E2EMon.

The E2ECU is currently resourced at the level of 0.5 full-time equivalent.

3.2 Role of E2EMon

The central End-to-End Monitoring System (E2EMon) represents each physical E2E link as being formed of "domain links" and "inter-domain links". In E2EMon, a domain link is a link that is contained within a single network, such as across the GÉANT network. An inter-domain link (IDL) is a link between two neighbouring domains, such as GÉANT and RENATER; it is divided into two parts, with half of the link in each domain. In reality, an IDL may be a patch cable between two pieces of transmission equipment or a telco-provided circuit between sites.

E2EMon polls the individual domain MPs and MAs every five minutes to gather information about the constituent domain and inter-domain links. Since each domain and link is tagged as belonging to a particular E2E circuit and names its neighbour domains, E2EMon can concatenate the status of the constituent links to represent the E2E circuit; this is shown on a graphical display that can be viewed with a web browser. The E2ECU receives alerts from E2EMon whenever an E2E circuit has an outage on any of its constituent parts.

Any errors relating to the population of the XML files used by the MPs and MAs are listed on the central E2EMon Domain View.

3.3 Trouble Tickets Procedure

The E2ECU may be notified of an outage either by E2EMon or by someone in the domain. On being notified, the E2ECU raises a Trouble Ticket (TT) containing information such as the names of the domain link or inter-domain links affected, the name(s) of the domain(s), the name of the project affected, and the time of the outage.

The E2ECU then contacts the relevant domains to request information regarding the outage and to assist them in interpreting the errors; in the case of an inter-domain link, the E2ECU will contact both domains involved.

The E2ECU distributes any updates regarding the outage to all partners in the project affected.

4 E2ECU Activity in Year 1

4.1 Overview

During Year 1, the scope of the E2ECU was to monitor 35 end-to-end links for 3 projects: LHCOPN, DEISA and IGTMD. These links require global monitoring because multiple networks, some outside Europe, contribute sections of the links from end to end. A total of 613 Trouble Tickets (TTs) were tracked and closed. The E2ECU's scope may be extended to other projects in the future.

4.2 Trouble Ticket Statistics

Figure 4.1 shows the number of Trouble Tickets (TTs) closed each month for these projects over the past year.

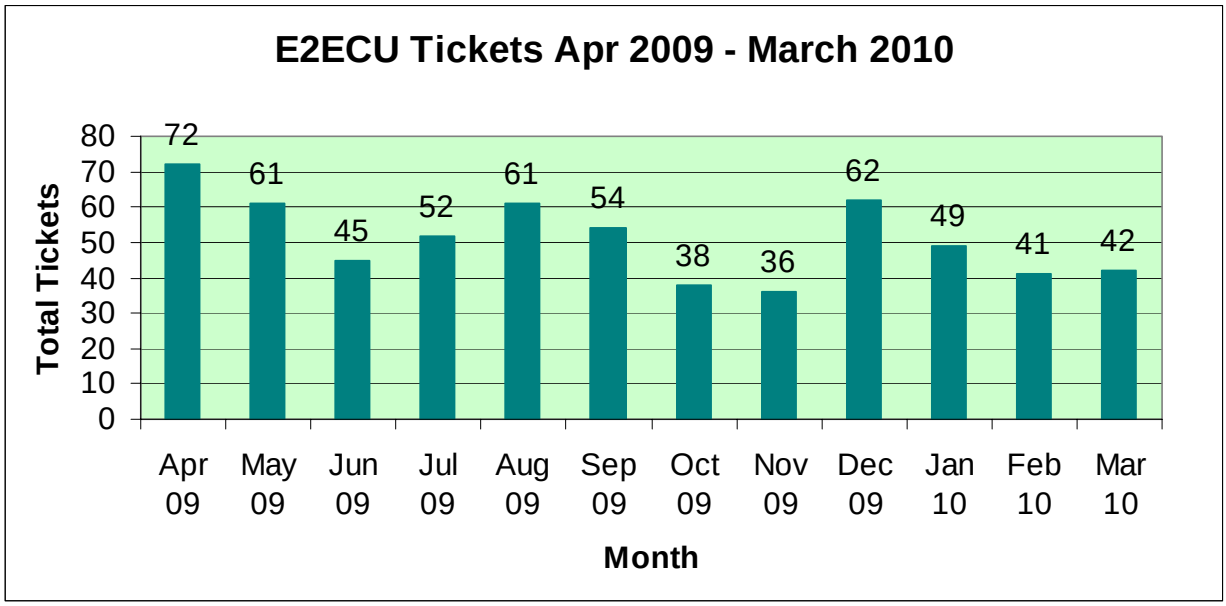

Figure 4.1: Number of E2ECU tickets closed each month in Year 1 – 1 April 2009 to 31 March 2010

The mean time to resolve TTs was 122 hours 42 minutes.

5 Plans for Service Development

5.1 Advanced Services

Development of a web interface for users of GÉANT's advanced services is ongoing, to improve communication with service requesters and allow them to track the progress of their service requests. This portal is now at prototype stage (see Figure 5.1 and [3]), undergoing testing with a representative group of NRENs pending release in Quarter 2 2010.

Figure 5.1: Prototype of GÉANT Tools Portal

5.2 E2ECU

Overseen by DANTE Operations (the E2ECU is part of the DANTE operational function), the processes, procedures and tools used by the E2ECU are subject to continuous review and improvement. To this end, DANTE Operations are also in close cooperation with the GÉANT PerfSONAR and E2EMon software developers.

A web interface has been developed and implemented in Y1 that allows service users to track the progress of the Trouble Tickets (TTs) raised by the E2ECU (see Figure 5.2).

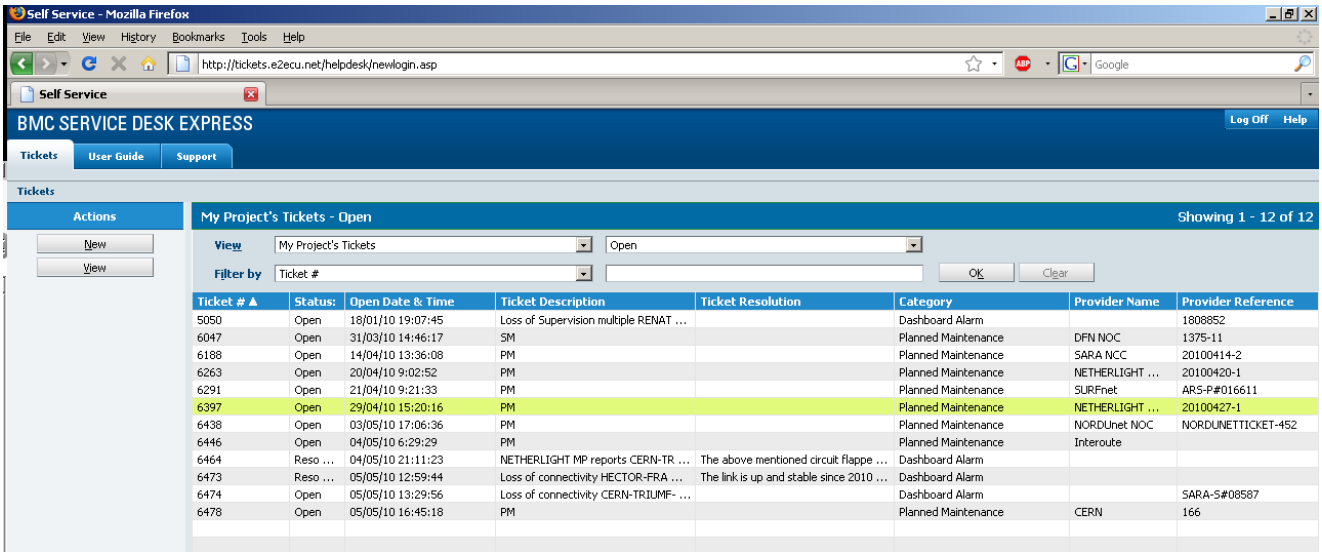

Figure 5.2: Web interface for tracking E2ECU-raised Trouble Tickets

SA2 is re-evaluating the role of the E2ECU to optimise the support it provides to the multi-domain community and the value it can add to as many projects as possible. A requirements gathering exercise is currently underway to progress this.

6 Conclusions

The GÉANT network was the first international production hybrid network, combining the operation of a shared IP infrastructure with the ability to provide additional dedicated point-to-point links. The three levels of connectivity service reflect the immense flexibility that the network has been designed to offer, with the advanced services, GÉANT Plus and GÉANT Lambda, meeting the requirements for privacy, security, availability, capacity, robustness and speed of the most demanding user projects.

Utilisation of GÉANT point-to-point services remains strong and a steady flow of new circuit requests has been received, with 12 new links delivered in Year 1 and 5 cancelled. Whilst GÉANT continues to serve many existing circuit users, the number of new pan-European circuit requests was lower in 2009-'10 due to EC project funding cycles and because the previous period (GN2 Y4, 2008-'09, 22 new links) reflected a latent demand from existing data-hungry research disciplines. The main users of the 64 links in place as at Year 1 end were research projects in the fields of particle physics, networking technology and supercomputing.

Reflecting the increased scope and sophistication of the E2E circuits, a significant coordination and monitoring effort is required to ensure their optimum delivery. The E2ECU therefore makes an essential contribution to the advanced services' success, as demonstrated by the number of Trouble Tickets – 613 – that it tracked and closed in Year 1 for the 35 point-to-point links under its supervision.

Building on the experience gained in recent years, a process of continuous improvement is underway to develop and enhance the point-to-point procedures and service still further.

References

[1] GN3-10-040v2 Deliverable DN4.2.1 GÉANT Services Portfolio http://wiki.geant.net/pub/NA1/DeliverablesAllGN3FinalAttachments/GN3-10-040v2_DN4-2-1_GEANT_Service_Portfolio.pdf [restricted access]

[2] GN2-07-131v08 Deliverable DN3.0.5: Processes and Provision of Point-to-Point Services in GÉANT2 http://www.geant2.net/upload/pdf/GN2-07-131v8-DN3-0-5_Processes_and_Provision_of_Point-to-Point_Services.pdf

[3] Point-to-Point services website http://stats.geant2.net/p2p

[4] GN2-08-118v5 Deliverable DN3.0.3,3 Specific Support Actions: Addressing the Needs of the Network's Most Demanding Users http://www.geant2.net/upload/pdf/GN2-08-118v5-DN3-0-3_3_Specific_Support_Actions_-Networks_Most_Demanding_Users.pdf

[5] GÉANT Topology Map 2009 http://www.geant.net/Media_Centre/Media_Library/Media%20Library/1081%20GN%20Topology%2011.09_5_High%20Res.pdf

Glossary

CE(s)T	Central European (summer) Time
DEISA	Distributed European Infrastructure for Supercomputing Applications
E2E	End-to-End
E2ECU	End-to-End Coordination Unit
E2EMon	End-to-End Monitoring System
FEDERICA	Federated E-infrastructure Dedicated to European Researchers
GE	Gigabit Ethernet
IDL	Inter-Domain Link
IP	Internet Protocol
L2	Layer 2
LHCOPN	Large Hadron Collider Optical Private Network
LSP	Label Switched Path
MA	Measurement Archive
MP	Measurement Point
NOC	Network Operations Centre
NREN	National Research and Education Network
PerfSONAR	Performance-focused Service Oriented Network monitoring ARchitecture
PoP	Point of Presence
SRF	Service Request Form
TDM	Time-Division Multiplexed or Time-Division Multiplexing
TT	Trouble Ticket
VoIP	Voice over IP
VPN	Virtual Private Network
WLCG	Worldwide LHC Computer Grid

Appendix A Projects

A.1 Summary

Table A.1 lists (in alphabetic order) the projects using GÉANT advanced services and/or supported by the E2ECU, and gives the URL of their respective websites, from which further information can be obtained.

Project	URL
AtlantIC	http://www.atlanticcalliance.org/
ATLAS	http://atlas.ch/
DEISA	http://www.deisa.eu
EXPReS	http://www.expres-eu.org/
FEDERICA	http://www.fp7-federica.eu
HPDMnet	http://www.hpdmnet.net/
IGTMD	http://www.ens-lyon.fr/LIP/RESO/Projects/IGTMD/ProjetIGTMD.html
LHCOPN	http://public.web.cern.ch/public/en/LHC/LHC-en.html
Phosphorus	http://www.ist-phosphorus.eu

Table A.1: Projects using GÉANT advanced services – names and URLs

A.2 Key Projects

The projects with most point-to-point links and/or those supported by the E2ECU are briefly described below.

For further information about GÉANT's most demanding users, see [4].

A.2.1 AtlantIC

The AtlanTIC Alliance is a tripartite alliance between three scientific research centres in the UK and US: Imperial College London, Georgia Institute of Technology and Oak Ridge National Laboratory. The remit of the Alliance is to develop and exploit the results of innovative research and training that plays to the complementary strengths of all three partner institutions. The research being carried out by the Alliance is currently divided into three themes: Biomass to Biopower, Biofuels and Bioproducts (B2B3), Materials for Energy, and Enabling Technologies.

For more information, see http://www.atlanticcalliance.org/.

A.2.2 ATLAS

ATLAS is a particle physics experiment at the Large Hadron Collider at CERN. The ATLAS detector searches for new discoveries in the head-on collisions of protons of extraordinarily high energy. ATLAS will learn about the basic forces that have shaped the Universe since the beginning of time and that will determine its fate. Among the possible unknowns are the origin of mass, extra dimensions of space, unification of fundamental forces, and evidence for dark matter candidates in the Universe.

For more information, see http://atlas.ch/.

A.2.3 DEISA

The Distributed European Infrastructure for Supercomputing Applications (DEISA) is a consortium of leading national supercomputing centres. It aims to foster pan-European world-leading computational science research and to build and operate a distributed terascale supercomputing facility.

For more information, see http://www.deisa.eu.

A.2.4 EXPReS

EXPReS is a three-year project to create a distributed astronomical instrument of continental and intercontinental dimensions using real-time, electronic Very Long Baseline Interferometry (e-VLBI). e-VLBI uses fibre-optic networks, including GÉANT links, to connect 16 radio telescopes on 6 continents to the central data processor at the Joint Institute for Very Long Baseline Interferometry in Europe (JIVE), in the Netherlands, a purpose-built supercomputer which correlates data from the telescopes in real-time. Transferring data electronically and correlating it in real-time eliminates weeks of waiting from the current VLBI method of storing data on disks and shipping them to the correlator for processing. This allows researchers to take advantage of Targets of Opportunity for conducting follow-on observations of transient events such as supernova explosions and gamma-ray bursts. e-VLBI also allows for high precision tracking of space probes.

For more information, see http://www.expres-eu.org/.

A.2.5 FEDERICA

The Federated E-infrastructure Dedicated to European Researchers (FEDERICA) is a project designed to implement an experimental network infrastructure for trialling new networking technologies. The infrastructure is intended to be neutral as to the type of protocols, services and applications that may be trialled, whilst allowing disruptive experiments to be undertaken. The aim is to develop mechanisms that will allow such experiments to be run over existing production networks without adverse effect.

For more information, see http://www.fp7-federica.eu.

A.2.6 HPDMnet

The High Performance Digital Media Network (HPDMnet) and its related activities comprise an experimental network research initiative that is designing, developing and implementing the world's first international high-performance service specifically created for high-quality, large-scale digital media, including support for extremely high-volume media streams. By using advanced concepts, architecture, and technology, the initiative is providing a foundation for future digital media services, as well as for other data-intensive applications. HPDMnet was established as a cooperative partnership by several major network research centres.

For more information, see http://www.hpdmnet.net/.

A.2.7 IGTMD

IGTMD (Interopérabilité des Grilles de Calcul et Transferts Massifs de Données) is a Franco-American project whose goal is the interoperability of two grids: Enabling Grid for E-scienceE (EGEE) and (Open Science Grid OSG14). The project is particularly concerned with addressing the challenges of transferring vast quantities of data over very long distances. The two main centres are the National Institute of Nuclear and Particle Physics (IN2P3) in Lyon and the Fermi National Accelerator Laboratory (FNAL15) in Chicago.

For more information, see http://www.ens-lyon.fr/LIP/RESO/Projects/IGTMD/ProjetIGTMD.html.

A.2.8 LHCOPN

The Large Hadron Collider (LHC) is the most ambitious project undertaken by CERN to date.

CERN is the world's largest organisation for research into particle physics. Based in Switzerland and funded by 20 European member states, CERN is a world-wide enterprise involving scientists of many nationalities. It is a prime example of international collaboration, as many experiments conducted at CERN are on such a scale that no single state could afford to fund them.

The LHC project is now live and has already demonstrated some exciting results. The project accelerates particles to previously impossible energies, producing short-lived and never-before-seen results. It is predicted

to produce data at the rate of 15 Petabytes (15 million Gigabytes) per annum. It has been decided to process all this data not in one institution, but using a grid – the Worldwide LHC Computer Grid (WLCG) – so the results will be distributed by GÉANT and connected NRENs to analysis sites around the globe.

For more information, see http://public.web.cern.ch/public/en/LHC/LHC-en.html.

A.2.9 Phosphorus

Phosphorus addresses some of the key technical challenges involved in enabling the on-demand end-to-end (E2E) high-bandwidth network services across multiple domains required for scientific and collaborative applications. The Phosphorus network concept and testbed will make applications aware of their complete resources (computational and networking) environment and capabilities, and enable them to make dynamic, adaptive and optimised use of heterogeneous network infrastructures connecting various high-end computing resources. The Phosphorus project ended in September 2009.

For more information, see www.ist-phosphorus.eu.