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Testing in a User Environment

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Abstract:

This document reports on the tests performed co-operatively with a small number of user groups. The aim was to validate that Premium IP service can meet actual user requirements and to demonstrate that it can be successfully implemented in a multi domain networking environment. The project was able to set-up Premium IP connection for three user groups, the IST Projects AQUILA, MOICANE and LONG. The provisioning of Premium IP to these projects will extend beyond the runtime of SEQUIN. In addition, SEQUIN is engaged in cooperations with other groups, which will receive Premium IP service at later stages in the context of GÉANT.

Keywords:
Premium IP, Differentiated Services, Service Provisioning, QoS in multi-domain environments, user group trials, SLA, SLS,

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EXECUTIVE SUMMARY

This document describes the user group trials performed in the SEQUIN project. The ultimate goal of SEQUIN is to ensure that researchers across Europe have access to networking facilities with QoS support that can be tailored to the requirements of individual user groups. In order to approach this goal SEQUIN has set up cooperation with other user groups that act as beta-testers for the provisioning of Premium IP service over GÉANT.

The report starts with listing the objectives for the user group experiments, it describes the selection procedure that was followed in setting up the cooperations and develops a provisioning model for Premium IP service in a multi-domain environment. At the current state there are three user groups, for which Premium IP had been configured: the IST projects AQUILA, MOICANE and LONG. These projects are presented together with an overview on their planned trials and the topologies of their testbeds. Further early adopters of Premium IP will be served after the termination of SEQUIN in the context of GÉANT TF-NGN activities. A final section discusses the major achievements that could be reached in the experiments and recommends further steps for a wide-scale provisioning of Premium IP service in Europe.

1 INTRODUCTION

The objective of the SEQUIN (*Service Quality across Independently Managed Networks*) project is to define and implement an end-to-end approach to Quality of Service for IP networks that will operate in a heterogeneous environment across multiple management domains. SEQUIN has defined a Premium IP service that provides assured bandwidth, low delay and negligible packet loss. It realises a service that is capable to offer predictable and stable quality across multiple domains and various networking technologies. SEQUIN has started first field trials that implemented Premium IP in the pan-European GÉANT backbone. In the last project phase, SEQUIN performed trials with user groups from outside the project. The purpose of these experiments was to further examine the Premium IP provisioning process and to derive recommendations for a future production use of the service. These trials form the major focus of this report.

The ultimate goal of SEQUIN is to ensure that researchers across Europe have access to networking facilities with QoS support that can be tailored to the requirements of individual user groups. This scenario depends on the cooperation on the part of many different networks including GÉANT, the NRENs and campus networks from the institutions of the end-user groups, and it includes some national networks which themselves have regional networks as independent management domains within their own networks. In addition, as ATM is being phased-out in most European NRENs, a migration from ATM to IP based QoS, needs to be addressed.

SEQUIN approached its task with a definition of QoS [13] which is based on a synthesis of user requirements and the QoS features supported in emerging networking technologies. It addresses both technical aspects of Quality of Service and organisational aspects. Organisational aspects include procedures for installing the service in a production network, and processes for interacting with users. These organisational aspects have to be considered as equally important as the pure technical issues of service implementation. They are relevant for the individual research network, but they also extend to interactions between networks for the provisioning of the service on a pan-European basis.

Extensive testing of networking equipment in SEQUIN allowed to determine the QoS capabilities of today's SoA core routers. A larger number of international end-user groups had been interviewed for their higher level requirements on QoS of their applications. This data lead to the design of a model and implementation architecture for a Premium IP QoS service, and the specification of the technical parameters necessary to implement the service. The main challenge was to ensure that the proposed Quality of Service model is capable of being managed across multiple management domains. The architecture had subsequently been tested and validated in a two phased approach. The initial establishment of a proof-of-concept testbed allowed to carry out an initial set of tests in a pilot environment [16][20]. After successful proof-of-concept testing, the proposed Premium IP service has been offered to selected international user groups. The aim of this testing series is to fine-tune the implementation architecture and to develop operational processes for requesting and provisioning QoS in a multi-domain environment.

SEQUIN uses the experience gained in testing, to define the following items:

1. Recommendations for the parameterisation of Quality of Service technology to enable end-to-end Quality of Service to be provided across different technical platforms.

2. A proposal for operational and organisational implementation which can become a common solution for the national research networks across Europe. In order to implement this the consortium will co-operate with the other research networks to create a European solution.

The pilot service will be followed by a more general deployment both within National Research Networks in Europe and in the pan-European network interconnecting them.

2 TESTING IN A USER ENVIRONMENT

2.1 Objectives of SEQUIN User Group Testing

The key feature of the SEQUIN project has been the implementation of an IP QoS service. The Premium IP service has been demonstrated in a two phases approach. A proof-of-concept testbed showed the technical feasibility under tightly controlled conditions and allowed to gain experience with handling the equipment and setting up the service. The following phase of user group trials described in this report continues these activities and puts them in a wider context.

The main objectives of the user group trials are to extend those first results on several levels. Besides purely technical aspects they also include organisational, managerial, educational and policy issues.

- On the technical level the goals are:
  - to reproduce technical results in a wider, more heterogeneous multi-domain networking environment
  - to gain further experience on configuring a wider selection of router platforms that are representative for those most commonly deployed in European NRENS

- With regard to end-users the goals are:
  - to see the extent of which the service meets actual user requirements
  - to make use of the testbed for traffic with real requirements for QoS
  - to offer to European research groups a platform providing a high quality networking service that allows them to perform demanding advanced application experiments

- with regard to service provisioning the goals are
  - to learn on the provisioning process of QoS services
  - to find adequate ways to coordinate between the different involved parties: service end-users, network administrators at the customer sites, at the NRENs and at GEANT
  - to define rules and clarify responsibilities and to install efficient communication processes between those parties
  - to consolidate these practises into the production of SLS/SLA documents for the interdomain operation of QoS

- with regard to educational and training aspects
  - to disseminate the expertise on Premium IP configuration and operation on a wider scale to networking engineers of other NRENs participating in the user trial experiments
  - to produce informational and training material that helps in these processes

- with regard to service management and monitoring
  - to refine the QoS measurement strategies to be used for service validation and diagnosis
  - to propose a QoS monitoring infrastructure for Premium IP

2.2 Selection of User Groups

In the starting phase of the project, SEQUIN contacted about 20 international user groups and interviewed them on their QoS requirements on network services. These groups included ambitious research in the area of grid networking, aerospace, virtual reality and cooperative work environments and several of them had been invited to act as early test users of an IP QoS service. In addition there had been approached other newly started IST projects, which showed a profile that fits to the target

user group of Premium IP, and concertation events were used as means to get in contact with potential cooperation partners.

User groups needed to fulfil a set of criteria to qualify as potential partner for the planned user experiments. On the side of the user there must be a willingness to act as a beta tester with all the pitfalls and constraints of an experimental environment. It requires an advanced level of networking expertise and active participation, as users cannot expect a production style plug-and-play solution. The user applications should be technically interesting, and they must pose challenging requirements on the network service with regard to bandwidth and QoS parameters. Finally there are topological constraints on reachability and access to GÉANT. A minimum requirement was that the international user groups will have at least two connections to the testbed in two different countries.
The participating sites must be appropriately located, and also the connecting NRENs must be able to provide facilities and resources to support the experiments.

SEQUIN organised a one-day workshop which allowed to explore mutual cooperation interests. Seven IST projects had been invited to present their research activities, out of which a group of four could be singled out for subsequently setting up common experiments.

2.3 Communication Processes and Supporting Material

The H.323 experiments for the proof-of-concept trials performed by the SEQUIN consortium [20][21] involved a relative small number of active participants, therefore much of the work could be organised in a more spontaneous ad hoc manner. For the coordination with outside user groups, however, this approach is no longer viable. Service provision depends on a more disciplined and organised process. SEQUIN has developed for this purpose a provisioning model that identifies roles, assigns responsibilities and defines communication disciplines between those partners and is included as Appendix 1 to this deliverable.

For the particular situation in the user group experiments, this model has been imposed in a relative light version. Though there is a need for orderly communication and clear assignment of responsibilities, such roles should not be interpreted in a too restrictive manner. At least for the beta phase testing it is necessary to favour fast responses against overly strict rules, and to use a more redundant communication model with broader distribution and room for broader discussion. It is however evident that for a future production use, it is necessary to streamline and standardize the communication processes for efficiency.

For each participating user group, a separate mailing list has been created by which the experiments are coordinated and the exchange of relevant information is achieved. These mailing lists include as mandatory members, the experiment coordinator from the side of the user group and a coordinator person on the side of SEQUIN, at least one technical contact person at each participating user site and a technical contact person at each connecting NREN, and the networking engineers at GEANT responsible for Premium IP configuration. In addition, interested networking experts from the SEQUIN consortium are subscribed who can provide fast support and expertise when problems occur.

In order to support non-project members in the setting up of Premium IP service supporting material has been produced. When conducting the H.323 experiments a set of supporting tools had been tried out and a selection of simple free open source tools had been chosen that proved to be highly efficient in setting up, debugging and validating Premium IP connectivity. Those tests used *Ping*, *RUDE/CRUDE* and an enhanced version of *Traceroute* that allows to check for DSCP changes along the forwarding path. These tools were also recommended to the user groups to be used in the debugging process of their testbeds.

2.4 Provisioning Model for Premium IP

The SEQUIN consortium proposes a provisioning model for Premium IP that is specified in an addendum document to this report [22]. The following section summarizes the main concepts and features from this model.

2.4.1 IP Premium Provision phases

The provisioning process of IP Premium connectivity between two end-users consists of a number of phases, as depicted in Figure 2.4-1. A negotiation phase collects information on the parties involved and the data needed for service configuration. In the set-up phase node configurations have to be performed according the service requested in the SLA/SLSs. During the service operation phase a monitoring of service behaviour has to be performed to detect service degradation and failure, and if this occurs, measures have to be taken to restore service operation. Monitoring comprises continuous QoS measurements verifying the service quality. In case that service performance deviates from the contracted level a service adjustment phase is initiated, involving adjustment of configuration along the service provisioning path. When the service provision timeframe expires, the service termination phase is introduced, that disables the configuration and frees bounded resources .

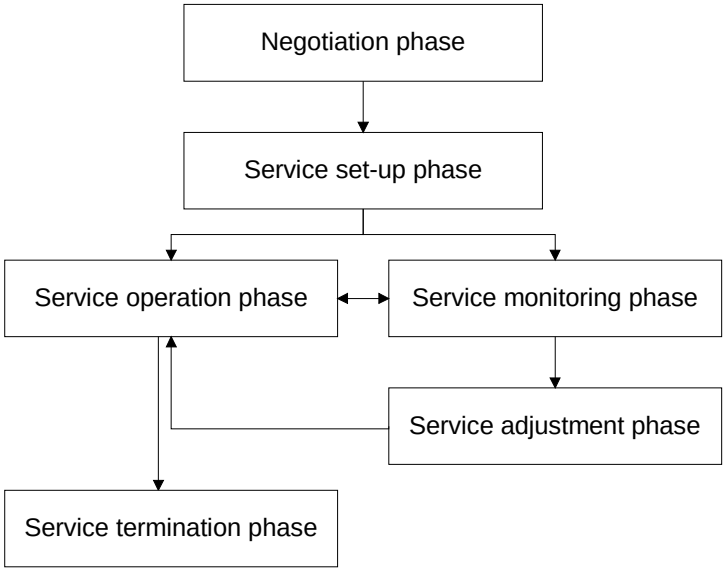

Figure 2.4-1. Phases for IP Premium provision

2.4.2 Parties Involved in Service Provisioning

The provisioning of Premium IP involves the participation of multiple domains, and a number of different parties have to cooperate. For the co-ordination of the negotiation, set-up and operation phases and for the orderly flow of information, the consortium requesting the service appoints a common representative that acts as a single contact point towards GEANT. The *Service Provisioning Coordinator* (SPC) will be the mediator between GEANT and the end-user sides, coordinating the service provision establishment procedure and communications during the operation phase.
For each of the end-user sides, a technical contact person is named as the local responsible for service provisioning and implementation. As depicted in Figure 2.4.2 , a *Technical Contact* (TC) should be responsible for the local service set-up and maintenance from an end-user domain up to the egress interface of the adjacent NREN at each of the participating sites. Ideally these technical contacts should belong to the NOC of each side's NREN.
Similarly, GEANT appoints a technical person for the IP Premium service provision and maintenance. The GEANT technical contact (GEANT TC) will be responsible for the IP Premium service provisioning from the ingress to egress interface of GÉANT.

The TCs, being responsible for IP Premium set-up and provisioning at each end-user's side, will have under their supervision the set-up and operation of IP Premium for more than one domains including at least NREN domain and end-user domain and in some cases it may include still other domains such as regional and metropolitan networks. Their duties, apart from communicating with the GEANT TC will include providing technical assistance to all the sub-domain administrators involved in their authority.

In this way, IP Premium provisioning will be performed in a hierarchical manner, with the GEANT TC and each end-user side TC being on the top of the hierarchy and any other technical entities involved in each end-user side, being co-ordinated by the corresponding end-user side TC (see Figure 2.4.2).

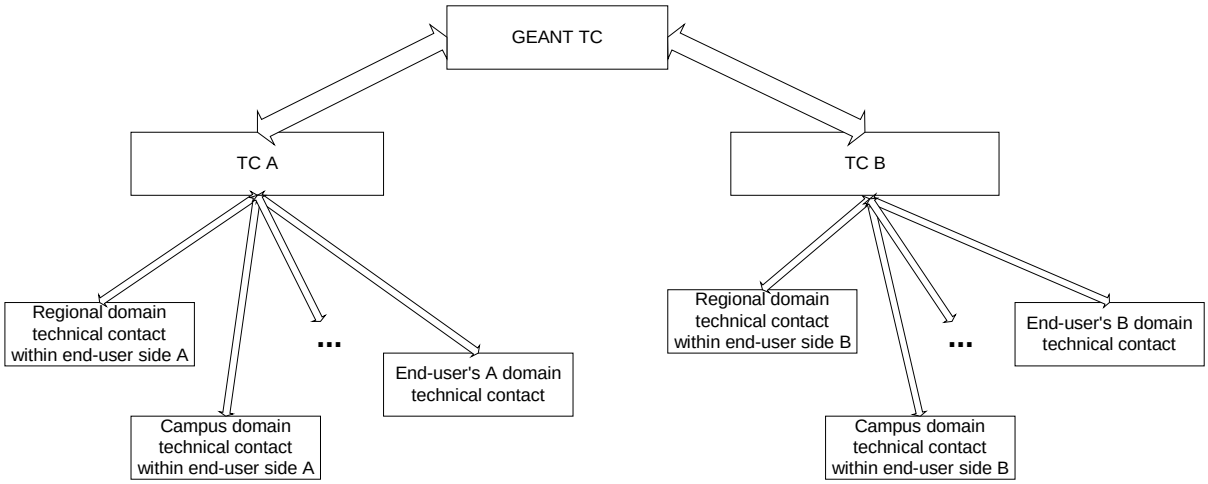

Figure 2.4.2. Hierarchical communication between technical contact persons

Apart from the technical responsibility, it is required that each end-user side appoints a person responsible for the performance evaluation of the service from the involved applications' point of view. These *Performance Evaluation Contacts* (PEC A and PEC B) are responsible for checking whether the IP Premium implementation is delivering to the end-users the quality they need and if not will advice adjustments to the SLA/SLSs.

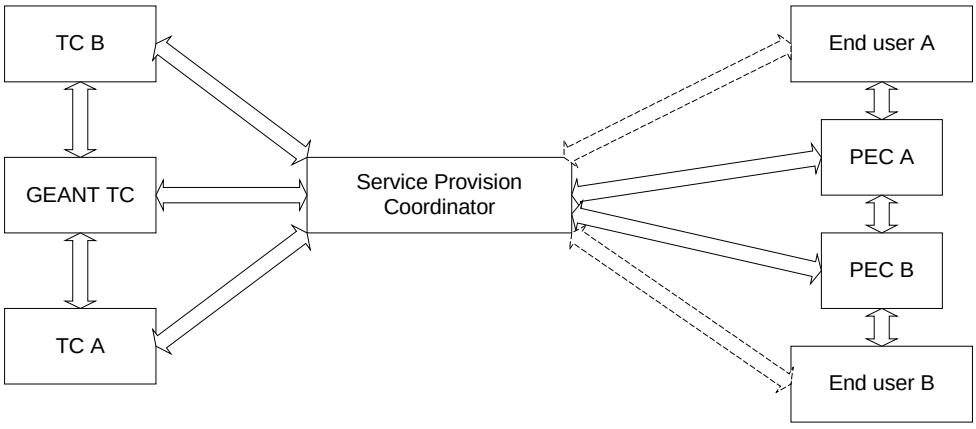

Figure 2.4-3. Parties involved in the provisioning of Premium IP service

Figure 2.4-3 depicts a possible way for the proposed entities' communication, with the SPC acting as an intermediate between TCs, PECs and the user sides. Alternatively, in order to reduce communication overhead, end-users could avoid direct contact with the SPC and communicate any information via the PEC of each end-user side.

2.4.3 Responsibilities and communication

The SPC (service provisioning coordinator) is responsible for coordinating the negotiation and set-up phase for IP Premium provision. The SPC acts as channel for distribution of information material on Premium IP to the involved parties, such as 'Guidelines and Recommendations for IP Premium provision' and 'IP Premium characteristics' documents. The SPC then requests and compiles information from the end user sites and TC of the adjacent NRENs required for setting up the SLA/SLSs, which is filled-in and submitted to the GEANT TC for an application of IP Premium connectivity on behalf of the end-users. In addition, the SPC is coordinating the flow of questions and answers between the GEANT TC, TC A and TC B and local end-users.

The service set-up phase has to conclude by a simple set of tests that will verify the successful set-up of the service between end-users A and B. These tests should verify preservation of DSCP values along the data path and the QoS values guaranteed by the end-to-end SLA/SLS.

The technical coordinator TC of GEANT cooperates with the TCs of the involved NRENs for service operation, monitoring and adjustment for indications of service failure or insufficient operation.

More specifically, the following indications might occur:

- The end-users notify the SPC that the service is not functioning
- The monitoring procedures demonstrate inadequate performance of the service
- The local performance evaluation coordinators PEC A and/or B advise adjustments to the service provision (SLA/SLSs) due to insufficient performance of the service, as perceived from the applications' point of view.

3 DESCRIPTION OF USER GROUP TRIALS

3.1 IST MOICANE

3.1.1 Project Description

MOICANE [7][9](Multiple Organisation Interconnection for Collaborative Advanced Network Experiments) has as its main goal the realisation of a distributed test-bed interconnecting several remote network islands, characterised by different access technologies and supporting different services, such as tele-lecturing, virtual-classroom, virtual-laboratory. Each island will be based on the IETF architectural models for IP QoS, and will constitute a test-field to assess their effectiveness.

The MOICANE consortium comprises 10 partners from the area of manufactures and technology suppliers (Alcatel Italia (coordinator), Flextel, Temex Tekelec), telecom operators (Infostrada , OTE, RomTelecom) and research institutes and universities (ICCS-NTUA, CPR, INESC). The project duration is from Jan 2001 – Dec. 2002.

3.1.2 Description of the Testbed and Planned Trials

MOICANE testbed is composed of 6 interconnected network islands located in Athens, Ivrea, Lisbon, Milan, Pisa Bucharest. Some of these islands are composed of sub-islands: the Athens network integrates two sub-islands deployed at ICCS and OTE premises. The Pisa island includes networks at CPR and University of Pisa premises, and the Bucharest island is composed of networks at ROM Telecom and UPB premises. The remaining network islands are deployed as follows: Ivrea at in the Infostrada premises, Lisbon at the Inov premises and Milan at the Alcatel premises. The island will be interconnected via the local NRENs and GÉANT. This refers to GARR for Italy, FCCN for Portugal, GRNET for Greece and RoEduNet for Romania.

Originally it was planned to interconnect the Romanian network island via Greece. Due to technical problems at GRNET in providing QoS guarantees on the link between their routers in Athens it was necessary to find another solution and a direct connection of the Bucharest island to GÉANT is attempted and RoEduNet is going to configure Premium IP on its core and border routers for this link. FCCN and GARR interconnect the respective MOICANE network islands via ATM PVCs to the national GÉANT PoP. The configuration for Greece is currently still under discussion.

The configuration on GÉANT is currently being set up and first connectivity trials are conducted by mid of May. Full MOICANE experiments are planned to continue on this multinational testbed until Dec. 2002.

In the experiment MOICANE will use EF and AF DSCPs, therefore there is configured IP tunnelling using IP Premium and thus EF DSCP only inside the GEANT network.

Requested unidirectional Connectivity Bandwidth Matrix:

From To	Italy	Portugal	Romania	(Greece)
Italy	--	1.5 Mbps	2 Mbps	(2 Mbps)
Portugal	1.5 Mbps	--	--	--
Romania	2 Mbps	--	--	--
(Greece)	(2 Mbps)	--	--	--

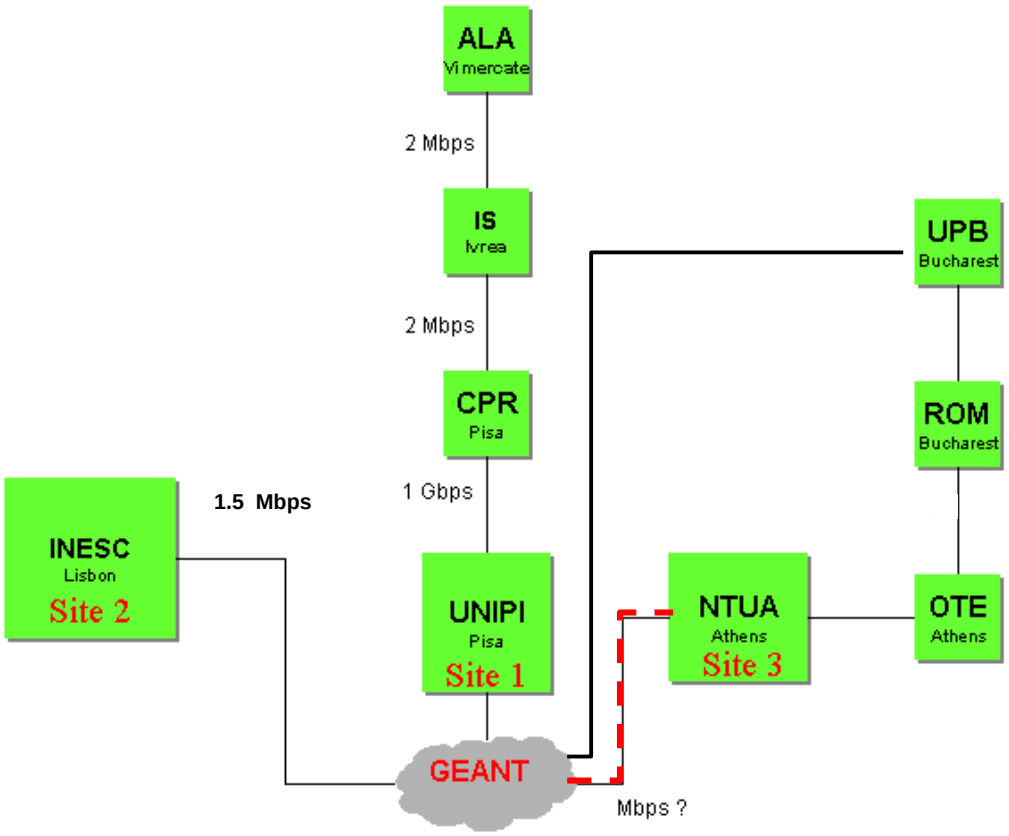

Figure 3.1-4: MOICANE pilot description

In Figure 3.1-4 is described the MOICANE pilot. Green boxes represents the different MOICANE islands.

3.2 IST AQUILA

3.2.1 Project Description

AQUILA [1][2](Adaptive Resource Control for QoS Using an IP-based Layered Architecture) defines, evaluates, and implements an enhanced architecture for QoS in the Internet. Existing approaches e.g. Differentiated Services, Integrated Services and label switching technologies will be exploited and significantly enhanced, contributing to international standardisation. The architecture will be designed to be cost-effective and scalable. It introduces a software layer for distributed and adaptive resource control and facilitates migration from existing networks and end-user applications. Technical solutions will be verified by testbed experiments and user trials, including QoS-enhanced on-line multimedia services.

The AQUILA consortium comprises 12 partners: Siemens (Co-ordinator), National Technical University of Athens, Bertelsmann mediaSystems, Elisa Communications, Dresden University of Technology, CoRiTeL, Salzburg Research, Q-Systems, T-Systems Nova, Telekom Austria, Polish Telecom, Warsaw University of Technology.

The project will end Dec. 2002.

The main objectives of AQUILA are
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- Investigation of dynamic end-to-end QoS Provisioning in IP Networks
- Implementation of Prototypes of a QoS Architecture for a Carrier Grade DiffServ Core Network
- Support for a wide Range of Applications by providing a QoS Toolkit / API
- Distributed measurement and management for continuous analysis of Customer Requirements, Market Situations and Technological Trends
- Development of Business Models for further exploitation

The AQUILA architecture defines a Distributed Resource Control Layer for IP networks that performs resource control and admission control functions. Network services are mapped onto five traffic classes based on the diffserv model.

3.2.2 Description of the Testbed and Planned Trials

The AQUILA testbed is located at two sites: at Polish Telecom in Warsaw and Austria Telecom in Vienna. The sites are interconnected to GEANT via the national research networks POL-34 and AcoNet. The connectivity from the user sites to the NRENs is based on ATM PVC - CBR contract with 2.5 Mbps PCR. from the Warsaw testbed via POLPAK (Polish
Telecom network to POL-34) and from the testbed in Vienna to AcoNet.
Connectivity on GEANT is provisioned by the diff-serv techniques described in D3.1. The connectivity for AQUOLA is an example of delivering premium IP using a combination of diff-serv and ATM

It is planned to test inter-domain aspects of the AQUILA architecture providing new QoS IP mechanisms and network services. The tests will be based on objective and subjective measurement of network services and associated applications. A first trial period is performed during the integration phase of AQUILA experiments, where it is validated whether the characteristics of the Premium IP connection are suitable for the planned project trials.

The testbed will provide 2 Mbps capacity at the IP layer. Taking into account ATM overheads (6 bytes in CBR) there has been set up in the ATM access networks some excess capacity of 2.5 Mbps.

The 2 Mbps IP connection will be used by different traffic classes (Network Services). There will be mixed different classes using mechanisms in the border routers in Warsaw and Vienna. The exact capacity split between classes will be investigated during the tests. E.g. one class will be CBR type and a second will be VBR. Tests include QoS applications such as for example: voice transfer (PC to PC), videoconference but also streaming applications like Real Player and Server, and interactive games.

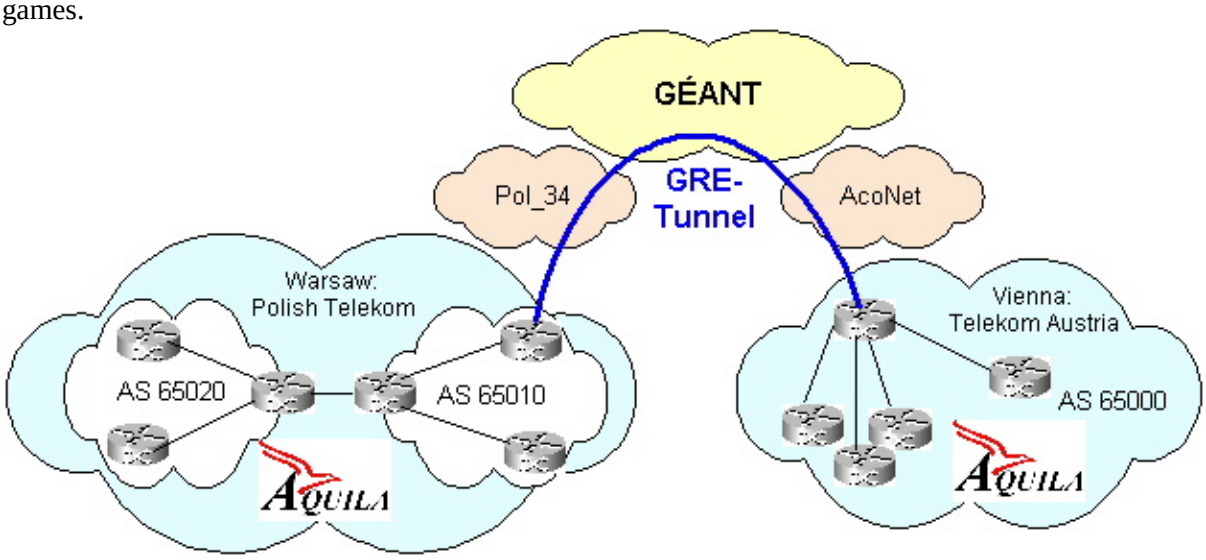

Figure 3.2-1: AQUILA testbed description

Premium IP connectivity between sites in Warsaw and Vienna has been established successfully in mid-April and has been tested using a video conferencing session set-up. A first set of trials has been performed in April and further trials will continue in the period of June to October 2002.

3.3 IST LONG

3.3.1 Project Description

LONG [5][6] aims to foresee and solve problems related to the design and deployment of Next Generation Networks and Advanced user applications. LONG is focused in IPv6, since this protocol is expected to become part of NGN networks. LONG experiments cover Network Access Systems (ADSL, CATV, ISDN) and Transport Technologies (ATM, POS, GE) as well as IPv6 nodes (hosts, routers).
To achieve a complete study, LONG also includes studies and tests related to advanced network services (Mobility, Multicast), end-user IPv6 applications (CSCW, Videoconference) and IPv4-IPv6 Transition Mechanisms.

LONG plans to set up an Collaborative Work Environment over an advanced network infrastructure including a mixture of different access (ADSL, CATV, ISDN) and transport technologies, where the project will address issues of IPv4/IPv6 transition, IPv6 and advanced services integration, the interworking of heterogeneous access scenarios and the adaptation of applications to the Next Generation networks.

3.3.2 Description of the Testbed and Planned Trials

The project intends to conduct internal and public trials between project partners premises, located in Portugal and Spain. These will be mainly supported by the Isabel application [7] complemented by network and application level services, like IP Mobility, Multicast, IRC, Web, LDAP, video streaming, just to mention some, running in both IPv4 and IPv6. At partners premises different access technologies (CATV, ADSL, ATM, ISDN, WLAN, ...) will be included, as well as appropriate transition mechanisms to support the mixed Ipv4/v6 operation of the tested services.

Trial Sites is in Spain include sites in Madrid (Telefónica Investigación y Desarrollo (TID), University Carlos III of Madrid (UC3M), Technical University of Madrid (UPM)) and Barcelona (Technical University of Catalunya (UPC), Nortel Spain (NOR)). Sites in Portugal include PT Inovação (PTIN, Aveiro) and University of Évora (UEV). Adjacent NRENs are Rediris for Spain and FCCN for Portugal.

The requested provisioning period for Premium IP is May 2002 until Nov. 2002.

The connection from PTIN premises in Aveiro to the GÉANT PoP in Lisbon, at FCCN premises, will be supported by a CBR ATM connection, provided as a commercial service from PT Prime. For UEV, it will be supported by internal FCCN infrastructure of 2 Mbps, sharing bandwidth with Internet services and traffic to other Portuguese Universities, but using the diff-serv techniques to ensure guarantees. The connection from UPM and UC3M to Rediris PoP is supported by internal Rediris connections based on an ATM infra-structure. For UPM there is 4 Mbps available and for UC3M there is 2 Mbps. For UPC there is 155 Mbps, also shared with Internet traffic and traffic to other Spanish Universities.

As for the other cases Premium IP for LONG is offered by a mixture of diff-serv techniques and ATM.

To / From	TID	PTIN	UEV	UPC	UC3M	NOR	UPM
TID	--						2
PTIN		--					2
UEV			--	2			
UPC			2	--	2	2	2
UC3M				2	--		
NOR				2		--	
UPM	2	2		2			--

Table 3.3-1 Interconnection Matrix for LONG Sites (bandwidth in Mbps)

3.4 IST DATAGRID

The goal of DATAGRID [3][4] is to develop and test the technological infrastructure that will enable the implementation of scientific "*collaboratories*" where researchers and scientists will perform their activities regardless of geographical location. The project will devise and develop scalable software solutions and testbeds in order to handle many PetaBytes of distributed data, tens of thousand of computing resources (processors, disks, etc.), and thousands of simultaneous users from multiple research institutions. Data intensive computing applications areas covered by the project are High Energy Physics, Biology and Medical Image processing, Earth Observations

Datagrid has expressed interests to cooperate with SEQUIN as user group for Premium IP service and means for provisioning of Premium IP connectivity over GEANT to the project are currently under discussion.

4 TRIAL EVALUATION

4.1 Major Achievements

SEQUIN set out a list of objectives for the user trials. This section discusses efforts that were undertaken to meet these objectives.

Technical Advances

With the experiments of SEQUIN it was for the first time that a diffserv-based IP QoS service had been demonstrated on a trans-national production network. SEQUIN was able to show how to provision an end-to-end QoS service over heterogeneous networking technologies spanning multiple administrative domains. With the H.323 experiments SEQUIN could demonstrate the technical feasibility of Premium IP over GÉANT. These results could be generalised in further experiments performed in cooperation with user groups from other IST projects. The configurations for Premium IP were installed on a variety of today's most common router platforms including Juniper M160 and Cisco GSR, 7200 and 7500 series.

Service Provisioning

SEQUIN has defined a provisioning model that identifies the provisioning phases, the entities involved and their roles in the provisioning process, it defines the responsibilities and communication process occurring between these parties (cp. Sec. 2.4 and [22])

The experiments helped to gain insight in the requirements of service provisioning. The co-operations lead to a better understanding of the provisioning process and resulted in the production of guidelines and recommendation documents for Premium IP service usage; a template has been proposed that is applicable for specifying SLAs between GÉANT and adjacent NRENs, and for end-to-end SLAs with end-customers.

End-user Requirements

The user group experiments allow to check Premium IP against requirements of real end-users. The experiments can demonstrate the usefulness of the service for the European research community. But as the provisioning of Premium IP to other IST project is a still on-going effort only preliminary evaluations can be given at the present state.

However, the cooperation with three IST projects allowed them to create trans-European testbeds interconnecting their various network islands through Premium IP connections. It is worthwhile to mention that all three projects are working in the area of IP QoS themselves and Premium IP is used here as tunnelling mechanism for interconnection of local testbeds, thus Premium IP acts as a unique enabler of advanced research in networking technologies on a Europe-wide scale. Instead of being confined to local lab experiments those projects are able to test their approaches towards such challenging tasks like large scale resource control or IPv4/IPv6 transition scenarios within a real networking environment.

Educational and Training Activities

In cooperation with user groups the expertise gained in configuring and operating an IP QoS service could be disseminated to other NRENs outside the SEQUIN consortium. The user group experiments involved the participation of AcoNet (AT), FCCN (PT) and RoEduNet (ROM). The SEQUIN consortium could provide here recommendations and support on how to best interconnect end-user sites to the GÉANT Premium IP service.

Configuration examples for Premium IP on Juniper and Cisco router platforms are made publicly accessible through the SEQUIN technical information web page [12].

The configuration guide for the Juniper M router series gives detailed instructions for the input and output interfaces of routers acting as core backbone and node to or from a customer network, respectively. It specifies classification, packet marking, policing filters and WRR (weighted round robin) priority queuing for Premium IP packets.

For Cisco routers examples are given for how to realize EF PHB on IOS. Realisation of Premium IP based on LLQ (low latency queuing), WRR / WFQ / MDRR and Rate Shaping mechanisms, respectively are discussed and examples for rate limiting incoming EF aggregate traffic are presented.

Service Management and Monitoring

SEQUIN has explored several possibilities in the area of QoS measurement. The experiments detected interesting issues related to running an IP QoS service, performing QoS measurements and interpreting those measurements. Several supporting applications for debugging and measurement had been tried out, which lead to a selection of a suitable toolset and the implementation of smaller enhancements and assisting scripts that help in Premium IP measurements.

The use of tunnelling in the user group experiments poses additional challenges on QoS measurement and monitoring, as now traffic sources and sinks may differ from the start and end point of the Premium IP tunnel, and debugging, troubleshooting and QoS verification become even more trickier.

As outlined in the phases of the Premium IP provisioning model, QoS monitoring is a continuous activity that has to accompany the service operation phase. QoS monitoring has to comprise end-to-end monitoring, intra-domain monitoring and inter-domain monitoring issues, and the methods applied have to comprise active and passive components [19]. SEQUIN proposes here an initial monitoring infrastructure based on rude/crude software tools to collect data on QoS performance on a Europe-wide scale [21].

Further Outcomes

The experimental work of SEQUIN directed attention to the fact that today's distributed router architectures lead to a higher degree of packet reordering between packets of different size. Since the IPDV metric of IETF IPPM is computed on equal sized packets, this raises the issue of finding adequate metrics for packet reordering, to investigate applications whether this particular type of reordering has negative impact on the performance. If this is the case, then reordering would need to be quantified explicitly in the SLS of the QoS service contracts.

It is obvious that QoS mechanisms cannot magically make a network perform better, and it is hard to quantify any actual improvements in quality for Premium traffic in comparison to ordinary best effort traffic, as long as network links are only lightly loaded as it is currently the case with the GÉANT backbone. However the aim of QoS mechanisms is to provide increased *assurance* that an previously agreed level of service quality will be maintained and from this perspective it is less of a concern that the actually measured values between Premium IP and Best Effort configuration in GÉANT didn't differ. What still remains to be validated is to show that the QoS mechanisms do improve the level of assurance, mainly as there was no practical way to create congestion in the GÉANT and NREN networks without risk of adverse impact on other production traffic.

The experimental work done in SEQUIN raised interesting issues. Its project results act as seminal impetus to jump-start further research activities in the areas of provisioning procedures, configuration on other router platforms, diagnosis and validation tools.

4.2 A Transition Model towards Premium IP

The Premium IP service model supports end-to-end QoS across multiple management domains. It is based on the EF PHB of diffserv. The service performs scheduling and policing at network boundaries on flow aggregates, and it is 'destination-aware', i.e. policing is performed on the granularity of the source and destination pairs. Aggregation of flows ensures scalability and manageability of the service.

In its initial phase, there can be only expected restricted support of Premium IP from NRENs due to restrictions of capabilities of equipment and limited administrative resources. In fact, this has been the situation in the trials performed in SEQUIN. However, the Premium IP model is flexible enough to allow for an evolutionary provisioning scheme with a stepwise roll-out of the service. Premium IP does not prescribe a particular implementation or technology, therefore ATM VCs, dedicated link, MPLS or overprovisioned links can be used within an NREN domain to fulfill the QoS requirements of a Premium IP service contract. The service assumes however certain actions to be performed by an NREN close to the service user including verification of packet marking with the correct DSCP and policing according to the end-to-end SLA.

Coherently with the technical service specification, a practical approach to provisioning is adopted, that emphasizes applicability and fast provisioning over completeness. In intermediate phases where an NREN cannot fully comply to these requirements, these functions can be delegated to the ingress border of GÉANT. It is however assumed that NRENs gradually start to extend Premium IP service support, so that more of these functions migrate towards the customer boundary at the NREN while the management overhead on the side of GÉANT can be reduced to free effort for the servicing of an increased number of IP Premium requests.

With regard to Premium IP provisioning an NREN can be categorised as

- incompatible:
  if a NREN resets or discards packets with Premium IP DSCP values, or re-interprets the Premium IP DSCP value in an incompatible way, it will be hard if not impossible to connect users via such an NREN

- indifferent:
  NREN preserves Premium IP DSCP value but applies BE treatment, the network is not highly overprovisioned and there are risks of congestion along the path of Premium IP traffic

- supportive:
  NREN preserves Premium IP DSCP value and offers an environment were in general Premium IP characteristics hold, (e.g. by overprovisioned links) without being able to give further guarantees, enforcing compliance and/or explicit monitoring

- compliant:
  NREN offers a realisation of Premium IP that is fully compliant with the specification. The chosen realisation method may vary using DiffServ, ATM VC, MPLS etc. The NREN performs all required functions of admission control and aggregate policing and also comprise facilities for monitoring Premium IP provisioning

A major outcome from our user group exercises has been to identify suitable transition scenario in cooperating with NRENs with different involvement and commitments towards Premium IP.

To achieve a wider deployment of Premium IP, the following milestones are foreseen for the near future:

- approval by the policy committee of GEANT.

- approval from NRENs
  the largest number possible, not necessarily simultaneous, however it should include at least three or four major NRENs in the initial phase

For the approval it is needed to provide evidence of

- technical safety,
  i.e. the enabling of the service features does not adversely affect the best effort production traffic
- technical soundness
  i.e. Premium IP is able to achieve the claimed QoS values and to provide substantial benefits to its users to warrant for the increased complexity, and it must prove to be sufficiently scalable to service the planned target community
- economical soundness
  costs for additional equipment and manpower needed for the introduction of Premium IP must remain reasonably moderate
- interest from NRENs
  Premium IP must meet the individual QoS policies of the NRENs and must fit their QoS deployment plans

The results achieved by SEQUIN generated positive outcomes that substantiate and confirm those claims for Premium IP.

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APPENDIX-1 Provsioning mechanis,s for Premium IP between End-Users

Table of Contents

1 INTRODUCTION

The IP Premium service provision from GEANT will apply to cases where the transportation of IP traffic between two or more end-users having IP connectivity to their countries' NRENs is required (see Figure 5). For the purposes of this document, end-users are considered to be either sources or sinks for the IP Premium traffic. Thus, the service provision and SLA/SLSs establishment will be examined only on a uni-directional basis. For the sake of simplicity, this document will refer to the case where one aggregate of IP Premium traffic has to be transported from the premises of a source user (A) to the premises of a sink user (B).
The source user's traffic will thus be transported through one or more involved domains reaching a GEANT ingress interface (*I*) via NREN A. GEANT will then be responsible for the transportation of the eligible to IP Premium treatment aggregate of user A according to the IP Premium specification across the GEANT domain and up to the GEANT egress interface (*E*) towards the sink user's NREN B. SEQUIN will provide guidelines to the involved NRENs and other domains involved on how to configure their equipment for supporting the IP Premium service. Provided that each involved domain follows these recommendations or already demonstrates an implementation of an EF-based service compatible with IP Premium, then the end-to-end support of the service is possible. Still, it will have to be carefully engineered and the corresponding SLA/SLAs have to be established.

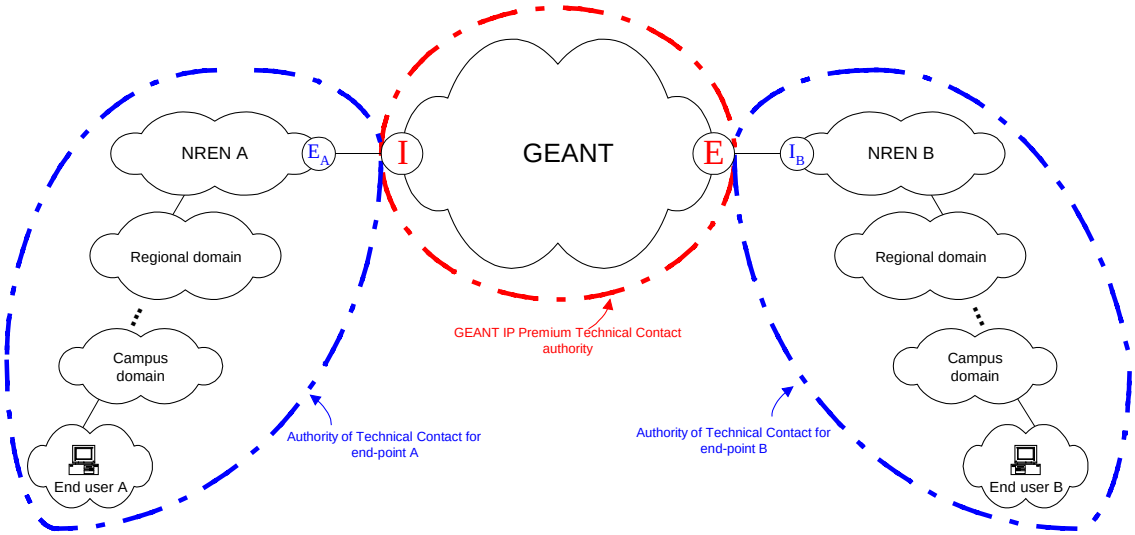

Figure 5. IP Premium provision architecture

This document specifies the relevant procedures and data that has to be collected and processed so that two end-users of the IP Premium service are successfully connected through the GEANT infrastructure by following a service set-up and realisation procedure.

2 IP PREMIUM PROVISION PHASES

The provision of IP Premium connectivity between two end-users has to be established through a number of phases, depicted in Figure 2.4-1. At the beginning, a negotiation phase should clarify the entities involved, the purpose for which IP Premium connectivity will be used, the feasibility of IP Premium provision etc.
During the service set-up phase, all details about the service's provision have to be collected, the necessary SLA/SLSs have to be signed and detailed configuration of the equipment involved must be performed.

During the service operation phase, no specific activities have to be performed unless indications of service failure occur. In such a case, measures have to be taken so that the service operation is restored. In parallel to the service operation phase, the monitoring phase should take place, comprising of constant measurement activities with the purpose of verifying the service's required quality. Within the monitoring phase it might occur that the service's performance deviates from the desired one. At this point a service adjustment phase will have to be initiated, involving adjustment of configuration along the service's provision path.

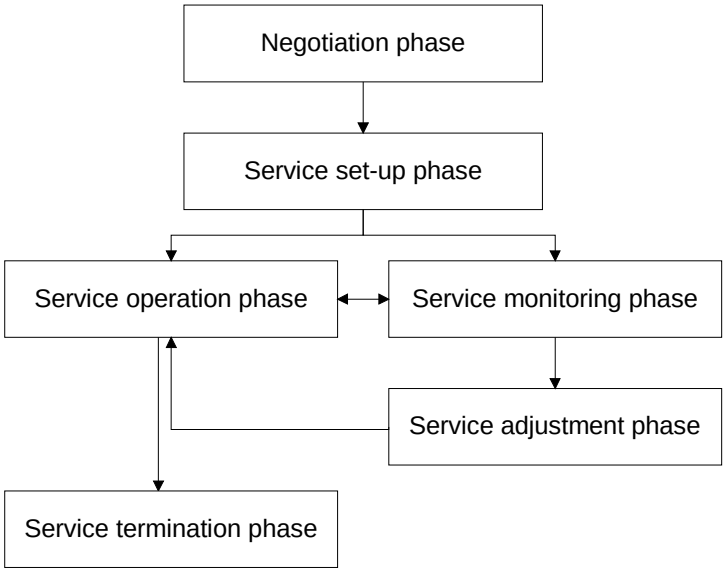

Figure 6. Phases for IP Premium provision

A service adjustment phase always results in new service operation and monitoring phases, running in parallel, until the service's provision time frame expires and the service termination phase is introduced. This document will mainly deal with the negotiation and service set-up phases, while also attempting to assign responsibilities for the rest of the phases. The procedures for service monitoring and adjustment will be covered in detail by a separate SEQUIN document.

3 ENTITIES INVOLVED

Due to the multiple domains involved in the provision of the IP Premium service, it is necessary for a number of entities to be appointed and involved in the different service provision phases.
For the co-ordination of the negotiation, set-up and operation phases it is strongly recommended that the end-users appoint a common representative towards GEANT (the Service Provision Coordinator-SPC) who will be the mediator between GEANT and the end-user sides, coordinating the service provision establishment procedure as well as any tasks required during the operation phase.
It is also strongly recommended that a technical person is appointed as responsible for the service provision and implementation for each of the end-user sides. As depicted in Figure 5, a technical contact (Technical Contact A or TC A) should be responsible for the service set-up and maintenance from end-user's A domain up to the egress interface of NREN A (E_A) and, in an analogous manner, another technical person (Technical Contact B or TC B) should be responsible for the service from the NREN B ingress interface (I_B) up to end-user's B domain. Ideally these technical contacts should belong to the NOC of each side's NREN.
Similarly, GEANT has to appoint a technical person for the IP Premium service provision and maintenance. As depicted in Figure 5, the GEANT technical contact (GEANT TC) will be responsible for the IP Premium service provisioning from I up to E, while at the same time providing any feedback required to the TCs from each end-user's side.

From Figure 5, it is obvious that the A and B TCs, being responsible for IP Premium set-up and provisioning at each end-user's side, will have under their supervision the set-up and operation of IP Premium for more than one domains (at least two: NREN domain and end-user domain). This makes their job quite demanding, in the sense that they he might have to coordinate IP Premium provisioning beyond the borders of the domain they can directly control. Therefore, their duties, apart from communicating with the GEANT TC will include providing technical assistance to all the domain administrators involved in their authority (see 'blue' clouds in Figure 5). This means that, based on consulting and documents provided from SEQUIN and the GEANT TC, TC A and TC B will have to translate IP Premium provision rules to the specific equipment available within their authority whenever they are requested to do so. Moreover, they will be responsible (with the help of the SPC) for collecting and maintaining all necessary contact information for technical contacts within their authority region.
In this way, IP Premium provisioning from a technical point of view will be performed in a hierarchical manner, with the GEANT TC and each end-user side TC being on the top of the hierarchy and any other technical entities involved in each end-user side, being co-ordinated by the corresponding end-user side TC (see Figure 2.4.2).

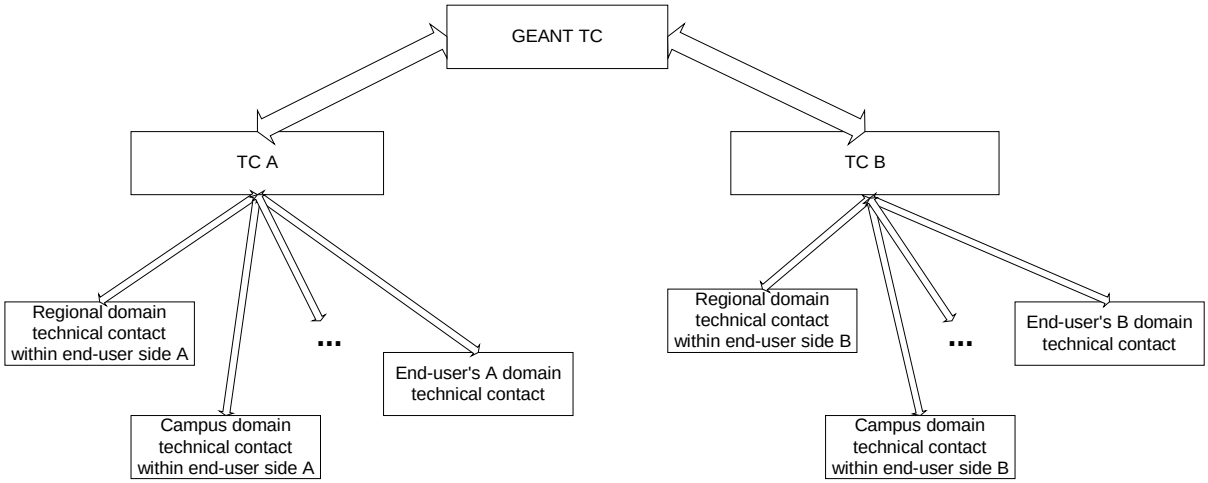

Figure 7. Hierarchical communication of technical contacts

Apart from the technical responsibility, it is required that each end-user side appoints a person responsible for the performance evaluation of the service from the involved applications' point of view. These performance evaluation contacts (PEC A and PEC B) are, in other words, responsible for checking whether the IP Premium implementation is delivering to the end-users the quality they need and if not will advice adjustments to the SLA/SLSs. Their recommendations for adjustments should then be delivered to the TCs of each side via the SPC in order to be translated into re-configuration actions in the equipment involved.

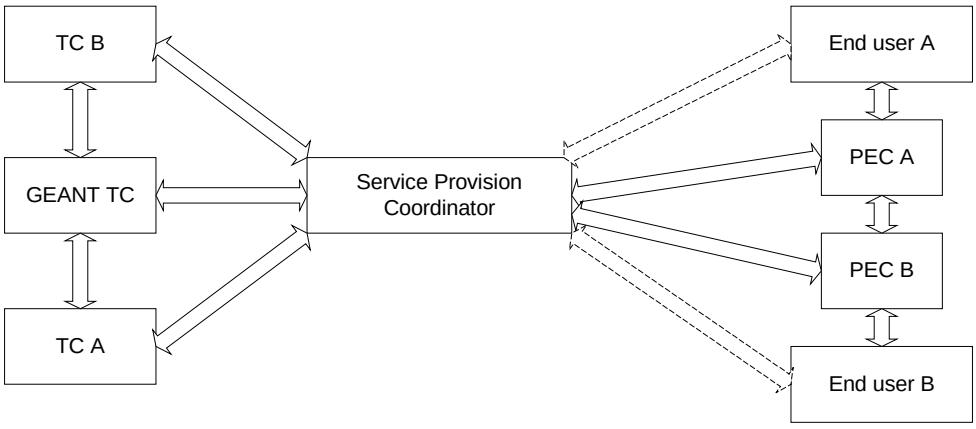

Figure 8. Entities involved in the provision of the IP Premium service

Figure 2.4-3 depicts a possible way for the proposed entities' communication, with the SPC acting as an intermediate between TCs, PECs and the user sides. Alternatively, in order to reduce communication overhead, end-users could avoid direct contact with the SPC and communicate any information via the PEC of each end-user side.

3.1 Responsibilities and communication between entities

The SPC is responsible for coordinating the negotiation and set-up phase for IP Premium provision. During these two phases, the SPC has to request and compile information from TC A, TC B and the GEANT TC. During these phases, the SPC is responsible for distributing the necessary 'Guidelines and Recommendations for IP Premium provision' and 'IP Premium characteristics' documents to TC A and TC B as well as coordinating the flow of answers and questions between the GEANT TC, TC A and TC B. The SPC also has to fill-in and submit to the GEANT TC an application for IP Premium connectivity on behalf of the two end-users. The service set-up phase has to conclude by a simple set of tests that will verify the successful set-up of the service between end-users A and B. These tests should verify the preserving of DSCP values along the data path (e.g. with a modified version of 'traceroute') and the guaranteed by the end-to-end SLA/SLS values for quality metrics (such as jitter by using RUDE/CRUDE).
It has to be stressed here that both TC A and TC B might collect questions from technical staff in the region of their authority (see Figure 5 and Figure 2.4.2) and address them to the SPC and/or the GEANT TC, in case these questions cannot be answered 'locally'. The communication of entities during these two phases is coordinated by the SPC, following a standard procedure of disseminating relevant material and collecting required information. Asynchronous requests are processed as they occur, always under the coordination of the SPC. Dissemination of activities is very important as it is very likely that one or more technical people from different participating domains might have the same questions.
The GEANT TC is mainly responsible for the service operation, monitoring and adjustment phases. For these phases the GEANT TC needs the help of TC A and TC B so that actions can be performed whenever indications of the service's failure or insufficient operation occur. More specifically, the following indications might occur:

- The end-users notify the SPC that the service is not functioning
- The monitoring procedures demonstrate inadequate performance of the service
- PEC A and/or B advise adjustments to the service provision (SLA/SLSs) due to insufficient performance of the service, as perceived from the applications' point of view.

Finally, the SPC is responsible for triggering the service termination phase, when according to the service provision SLA/SLSs, the time frame for service provision has expired. The GEANT TC as well as the TC A and TC B are then required to de-configure the equipment involved (e.g. delete relevant ACLs).

4 APPLICATION FOR IP PREMIUM CONNECTIVITY (NEGOTIATION PHASE)

Prior to the establishment of the SLA/SLS for IP Premium provision between end-users A and B, a negotiation phase has to take place. During this phase, the SPC is required to collect the necessary information and inform GEANT about:

- the framework under which IP Premium provision is required (e.g. project details)
- the end-users involved and their connectivity status, i.e. to which NRENs they have connectivity and how
- an indication of the IP Premium resources (a rough estimation in terms of bandwidth) that the end-users require

Table 2 provides an indicative list of the information that the SPC has to collect and deliver to the GEANT TC during the negotiation phase.

Application for IP Premium connectivity over GEANT
SPC details: • e-mail • telephone • fax • address
Project details • Information on the purpose of requested IP Premium connectivity • Time frame of requested IP Premium connectivity
End-user A: • General info • TC A details (e-mail, telephone, fax, address) • Connectivity to NREN A • Alternate possibilities for connectivity to GEANT • List of equipment likely to be involved in IP Premium provision in end-user A side
End-user B: • General info • TC B details (e-mail, telephone, fax, address) • Connectivity to NREN B • Alternate possibilities for connectivity to GEANT • List of equipment likely to be involved in IP Premium provision in end-user B side
Indication of IP Premium resources required • IP Premium bandwidth between end-user A and end-user B

Table 2. Negotiation phase data

The SPC has to contact the involved sides' TCs directly or with the support of GEANT in order to determine whether the involved sides are willing to support and are capable of supporting the IP Premium service provision in terms of equipment capabilities and resources.
After this initial information is collected, an initial estimation has to be made from the GEANT side on the feasibility of the requested IP Premium provision. This estimation has to be made with respect to the information collected from the end-user sides and the situation within GEANT e.g. the available for IP Premium traffic capacity at the involved GEANT border interfaces and the GEANT backbone or the capabilities of the equipment involved at each end-user side. The GEANT TC has to verify whether resources for IP Premium traffic can be provisioned in all intermediate interfaces within GEANT's domain without exceeding the percentage ratio of bandwidth that IP Premium traffic is allowed to occupy on the backbone of GEANT. The GEANT TC also has to make an initial investigation about the type and location of monitoring equipment that can be used for monitoring the quality characteristics of the IP Premium traffic aggregate between the involved end-users.
If the initial estimation by the GEANT IP Premium TC is positive, then the SPC can on behalf of the involved users initiate the procedure of the SLA/SLS establishment between the end-users and GEANT as well as the end-to-end SLA/SLS. The information that needs to be collected for these purposes will be described in the following sections.

5 RESPONSIBILITIES OF INVOLVED ENTITIES

The following table attempts to outline how each entity is involved in the provision of IP Premium connectivity between end-users A and B.

	Negotiation phase	**Service set-up phase (SLA establishment)**	**Operation, monitoring and service adjustment phase**
SPC	Collects preliminary information from end-users' sides (see section 4) and communicates it to the GEANT TC, in the form of an application for IP Premium connectivity	Fills in the SLA/SLSs established by collecting information from end-users, the GEANT TC, TC A and TC B	Reacts within a short time range to all issues raised either by technical contacts or by end-users or PECs, by disseminating all useful information to interested parties
GEANT TC	Based on the data provided by the SPC, evaluates the feasibility of the requested service provision	Configures IP Premium on the GEANT backbone and provides technical support to TC A and TC B	Decides upon and coordinates any adjustments made to the service's provision by equipment re-configuration
TC A / TC B	Provide to the GEANT TC any information requested for the purposes of filling-in the IP Premium connectivity application (e.g. connectivity to GEANT options for end-user A and end-user B)	Coordinate the configuration of IP Premium in the domains involved at each end-user side	Carry out adjustments made to the service's provision by equipment re-configuration and coordinate all relevant activity within the domains under their authority
PEC A / PEC B			Observe the quality perceived by end-user applications and suggest adjustments to the service's provision
End-user A/ End-user B	Provide to the GEANT TC any information requested for the purposes of filling-in the IP Premium connectivity application (e.g. time frame for the requested service)	Provide to the SPD all required information for the establishment of SLA/SLSs	Report to the SPC any indication of IP Premium connectivity failure

Table 3. Responsibilities of each entity involved in IP Premium provision

6 SLA ESTABLISHMENT

Due to the fact that end-to-end SLA/SLSs are still under deployment within SEQUIN, this section will attempt as a first step to define the data needed for the establishment of a destination-aware SLA/SLS between GEANT and end-user side A towards end-user side B (according to Deliverable D2.1 - Addendum 2: "Service Level Agreements specification for IP Premium Service"). It is envisaged that experience gained from testing of IP Premium provisioning in user environments will provide useful hints for the establishment of end-to-end SLA/SLSs. At this point, it has to be stressed

that end-to-end SLA/SLSs establishment will be greatly depended upon the mechanisms that end-user sides will in practice employ for IP Premium support and the guarantees provided as a consequence of these mechanisms' choices.

6.1 The administrative/legal part

The fields recommended to comprise the administrative/legal part of the SLA are:
1) Full contact info about the SPC as well as general information about the project and the framework within which IP Premium is requested. Suggested fields are:

(a) Project Name
(b) Project description
(c) SPC contact info (e-mail, telephone, fax, address)

2) All details about the technical people involved have to be included in the SLA/SLS. Corresponding fields are:

(a) TC A contact info (e-mail, telephone, fax, address)
(b) TC B contact info (e-mail, telephone, fax, address)
(c) GEANT TC contact info (e-mail, telephone, fax, address)
(d) PEC A contact info (e-mail, telephone, fax, address)
(e) PEC B contact info (e-mail, telephone, fax, address)

3) Contact information for administrative entities at each of the involved sites are also required

(a) Side A administrative person contact info (e-mail, telephone, fax, address)
(b) Side B administrative person contact info (e-mail, telephone, fax, address)
(c) GEANT administrative person contact info (e-mail, telephone, fax, address)

Administrative entities are responsible for any political decision that needs to be taken during the service provision
4) The duration for which the provision of the IP Premium service will be valid has to be specified by the SPC, after negotiating with the end-users and GEANT.
5) Availability guarantees for the IP Premium service. GEANT has to add to the SLA a specification for the service's availability during the requested service provision period (for example exclude maintenance periods etc.)
6) Technical and topological details about the monitoring equipment available:

(a) within the GEANT domain and interfaces
(b) at each end-user side, along the path over which the IP Premium traffic will be carried

This information should be collected per each interface to which monitoring infrastructure is attached or adjacent, along the IP Premium data path. Each entry of this field should contain:

(i) type of monitoring equipment (passive or active)
(ii) interface(s) to which this equipment is attached
(iii) exact measurements that this equipment supports with respect to the qualitative metrics for IP Premium: end-to-end delay, jitter and packet loss
(iv) how these metrics will be processed locally in order to determine whether the service provision is successful
(v) the time scale at which measurements will be processed and the service performance will be evaluated
(vi) the metrics that will be visible to the end-users (if any) and how will the end-users have access to this monitoring data obtained by the particular monitoring equipment

7) The timescale within which GEANT will be able to deliver the adjustments to service provision that are considered necessary. This field applies to the cases when the PECs will observe that the service deviates from the expected quality from the applications' point of view and will recommend adjustments to the service provisioning and the SLA/SLSs
8) The procedures that will be followed by using the available monitoring infrastructure data, in order for (a) GEANT TC and (b) TC A and TC B to verify whether network performance obeys to the IP Premium specification and implementation. This field should also describe the actions taken if the network does not behave as planned and the time scale for these actions on behalf of (c) the GEANT TC as well as (d) TC A and B.

9) The procedures that will be followed and the timescale under which service failures will be dealt with and resolved on behalf of (a) the GEANT TC and (b) TC A and B.
10) Charges for the provision of the IP Premium service (if any)
11) Description of the type of use for which the IP Premium service is required (including for example the type of applications for which the service is required) and the users' expected results by the service use
12) Information about a Web-based public point of information (if any) of how the IP Premium provision has been realized
Although the SPC is mainly responsible for the establishment of the SLA/SLS between GEANT and end-user side A towards end-user side B, Table 4 provides a more detailed list of the entities responsible for providing information and preserving integrity for each aforementioned field. Some fields, marked with a (*) are envisaged to remain constant for all similar SLA/SLSs signed between GEANT and two interconnected via IP premium end-users.

Part A: The administrative/legal part	**Responsible**
(1) General Information (a) Project Name (b) Project description (c) SPC contact info • e-mail, • telephone, fax, • address	SPC
(2) Technical Contacts Information (e-mail, telephone, fax, address) (a) TC site A (b) TC site B	SPC
(c) TC GÉANT	GEANT
(d) PEC site A (e) PEC site B	SPC
(3) Contact Information for Administrative Contact Person (a) Site A (b) Site B	SPC
(c) GÉANT	SPC
(4) Service Duration	SPC
(5)* Availability Guarantees	GEANT
(6) Monitoring Equipment (technical and topological details) (vii) type of monitoring equipment (passive or active) (viii) interface(s) (ix) qualitative metrics (x) measurement procedure (xi) time scale (xii) access to monitoring data (a) * within GEANT domain	GEANT
(b) at end-user side	SPC
(7)* Timescale for Service Adjustments	GEANT
(8) Monitoring Procedures (a) * by GEANT (c) * Time Scale for Recovery Actions	GEANT
(b) by TC A and TC B (d) Time Scale for Recovery Actions	TCs
9 Service Failure Procedures (a) * by GEANT and Time Scale for Recovery Actions	GEANT
(b) by TC A and TC B Time Scale for Recovery Actions	TCs
(10) * Service Charges	GEANT
(11) Description of the planned Type of Use	SPC
(12) Web-based public point of information	GEANT

Table 4. Entities responsible for filling-in the legal/administrative part of the SLA/SLS

6.2 SLS part

The SLS part of the SLA should contain the following fields:
1) A scope field defining the topological region to which the IP Premium service defined at the SLS will be provided. This field should include the interfaces (a) I, E and (b) E_A, I_B as depicted in Figure 5.
2) (a) Information on the ACL addresses that should be configured on the GEANT equipment, in order for the required portion of end-user's A traffic to be served as Premium IP. (b) The list of addresses should include the address of any monitoring equipment at the end-user's side, used for monitoring the IP Premium service provided to the end-users and injecting traffic to I.
3) Constantly updated and detailed information on the technical profiles of all equipment involved in the service provision for this specific SLS both (a) within GEANT and (b) at each end user's side. This information should include HW and SW specifications, configuration details etc. for each network element in the current data path
4) (a) Information on whether the end-user A is able to mark his IP Premium packets and with which DSCP value. (b) Information on which DSCP value is assigned to packets obeying to the ACL by GEANT (at interface I)
5) The performance guarantees field comprised by the following performance parameters:

(a) One-way delay. The SLS should specify a limit to the one-way delay perceived by IP Premium packets and the points between which this metric will be guaranteed (I, E). A quintile will be necessary to anticipate for very rare cases of deviation from the guaranteed value
(b) IPDV: The SLS should specify a limit to the jitter perceived by IP Premium packets between two specific points (I, E). Again, a quintile will be necessary to anticipate for very rare cases of deviation from the guaranteed value
(c) One-way packet loss: This metric will specify the upper limit to the ratio of lost in-profile packets between the scope endpoints and the injected in-profile packets at I as defined by the scope field. Its value should anticipate both for packet losses caused by the transmission lines and possible service-induced losses
(d) Throughput: It has to provide a guaranteed minimum throughput to the IP Premium traffic of end-user A as measured (if possible) at interface E
(e) MTU: It is the largest physical packet size in bytes that the SLS guarantees to be transmitted over GEANT without being fragmented

6) (a) The traffic envelope of the IP Premium traffic injected from end-user A to interface I, according to which, (b) the CIR and burst size for policing IP Premium traffic obeying to the already specified ACL entries will be configured at I. It has to be (a)=(b).
7) A field that will specify how excess traffic (or out-of-profile traffic, according to aforementioned traffic envelope field) is treated by GEANT. Non- legitimate IP Premium packets can be either dropped or remarked as best effort
8) A field to define allowed mean downtime of the service provision per unit of service provision duration and the maximum allowed time to repair (TTR) in case of breakdown of the service set-up.
Again Table 5 provides a detailed list of the entities responsible for providing information and preserving integrity for each aforementioned field, with the SPC being responsible for collecting the data and coordinating possible negotiations. Fields, marked with a (*) are envisaged to remain constant for all similar SLA/SLSs signed between GEANT and two interconnected via IP premium end-users, or at least be updated at longer intervals.

Part B: SLS Part	**Responsible**
1 Topological Scope (a) Ingress / Egress Interface GÉANT	GEANT
(b) Egress_A / Ingress_B Interface	TC A-TC B

2 ACL Addresses for GEANT (a) Endsystem Subnetworks (b) Measurement Equipment Subnetworks	TC A
3 Technical Equipment Profiles (a)* within GEANT	GEANT TC
(b) * at each end user side	TC A-TC B
4 Paket Marking (a) Marking Capabilities	TC A
(b) DSCP value used	GEANT TC
5 Performance Guarantees (a) One-way delay (b) IPDV (c) One-way packet loss (d) Throughput (e) MTU size	GEANT TC
6 Traffic Profile (a) traffic envelope (b) CIR and burst size	GEANT TC & TC A
7 * Excess Traffic Treatment	GEANT TC
8 * Mean Downtime	GEANT TC

Table 5. Entities responsible for filling-in the SLS part