OVERVIEW OF REQUIREMENTS FOR BALTIC GRID AND INTERCONNECTION TO OTHER GRIDS

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Abstract: BalticGrid network infrastructure is being built upon services provided by the National Research and Education Networks and pan-European GEANT-2 research network. This document describes local BalticGrid network resource requirements along with the best practices of Grid and Network interaction, already captured in other projects like EGEE, GEANT, PortaOptica

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Contents

1. INTRODUCTION

1.1. PURPOSE

The purpose of this document is to describe the collected requirements for SA2 (Network Resource Provisioning) activity from BalticGrid users in order to model the Baltic Grid network usage and to develop and integrate the research, educational computing, and communication infrastructure in Estonia, Latvia and Lithuania into the emerging European Grid infrastructure. Requirements summarised in this document take into account local existing infrastructures, which are also briefly described here.

The main focus of this document is the involved National Research and Education Networks and pan-European GEANT-2 research network. Additionally, this document captures the best Grid and Network interaction practices achieved in other related projects, like EGEE, GEANT, and PortaOptica.

All identified requirements are merged in the document with remarks made by SA2 members.

1.2. APPLICATION AREA

This document shall form the fact-basis for further SA2 deliverables, namely, drafting of network Service Level Specification (SLS) and its implementation through Service Level Agreements (SLA) with interacting National Research and Education Networks (NREN) and pan-European GEANT-2 network.

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1.4. TERMINOLOGY

ACRONYMS	EXPLANATION
Abilene	National Research Network in the US
AMPS	Advanced Multi-domain Provisioning System

API	Application Programming Interface
ATLAS	LHC physic experiment
BAR	Bandwidth Advance Reservation
CE	Computing Element
CERN	European Organisation for Nuclear Research
CMS	LHC physic experiment
DEISA	Distributed European Infrastructure for Supercomputing Applications
diffserv	Differentiated services
EGEE	Enabling Grids for E-sciencE
EGO	European Grid Organisation
ESNet	National Research network in Japan
EU	European Union
GARR	Italian National Research and Education Network
GE	Gigabit Ethernet
GEANT	European Academic Network
GGF	Global Grid Forum
GN2	Codename for GEANT-2 (the successor to the GEANT network)
GOC	Grid Operating Centre
GridICE	Grid monitoring software
GRnet	Greek National Research and Education Network
GUI	Graphical User Interface
HEP	High Energy Physics
IETF	Internet Engineering Task Force
JRA	Joint Research Activity
LBE	Less Than Best Effort
LHC	Large Hadron Collider
MAN	Metropolitan Area Network
MPI	Message Passing Interface software
NM-WG	Network Measurement Working Group
NOC	Network Operation Centre
NPM	Network Performance Monitoring
NREN	National Research and Education Network

NSAP	Network Service Access Point
OGSA	Open Grid Services Architecture
OSG	Open Science Grid
PoP	Point of Presence
QoS	Quality Of Services
ROC	Regional Operation Centre
SA	Specific Service Activity
SLA	Service Level Agreement
SLR	Service Level Request
SLS	Service Level Specification
VO	Virtual Organization
VoIP	Voice Over IP
VOMS	VO Management Service
WMS	Workload Management System

2. BALTICGRID NETWORK TOPOLOGY

The goal of the BalticGrid project is to establish a production-quality Grid in the Baltic region, based on the EGEE software. The main goal of the SA2 activity is to manage:

- network access to the resources of the BalticGrid partners;
- relationships between BalticGrid users and respective NRENs interacting via the network;
- overall reliability of BalticGrid networking services.

In order to ensure the goals mentioned above the first task of SA2 shall be to capture network requirements from various projects and model Baltic Grid network. This activity will also develop Service Level Specifications for network provisioning, and work with network providers to establish Service Level Agreements (SLAs) and monitor SLA adherence.

Cluster nodes of the BalticGrid shall be certified in the pan-European EGEE Grid network and shall have adequate network resources to support HEP experiments at CERN (apparently the source of the most network resources demanding real-time applications), as well as any other likely BalticGrid applications identified and supported by NA3.

This chapter describes connectivity of the present BalticGrid sites, along with the overview of the involved NRENs and relevant international networking activities such as GEANT2 and Porta Optica.

2.1. PRESENT BALTICGRID SITES AND THEIR CONNECTIVITY

At the moment six partners have merged their computing resources within the BalticGrid project. All the resources can be monitored through GridICE monitor http://voms.balticgrid.org/gridice/:

Partner	CE name(s)	Location	Connection
EENet	pinguin.mt.ut.ee kriit.eenet.ee	Tartu, Estonia	622Mbps connection to GEANT network from Tallinn to Copenhagen. 1Gbps connection between Tartu and Tallinn
NICPB	cerncms.nicpb.ee	Tallinn, Estonia	1Gbps connection to EENet network
IFJPAN	ares02.cyf-kr.edu.pl	Cracow, Poland	Connected to Polish national network POL-34 with 2.5Gbps link
VU	grid.mif.vu.lt	Vilnus, Lithuania	622Mbps GEANT connection to Stockholm; 1Gbps connection between Vilnius and Kaunas; 1Gbps connection between institutions in Vilnius.
ITPA	atomas.itpa.lt	Vilnus, Lithuania	622Mbps GEANT connection to Stockholm
IMCSUL	puduris.latnet.lv	Riga, Latvia	155Mbps connection to GEANT to Stockholm

Refer to Fig. 1 for current BalticGrid sites and network topology.

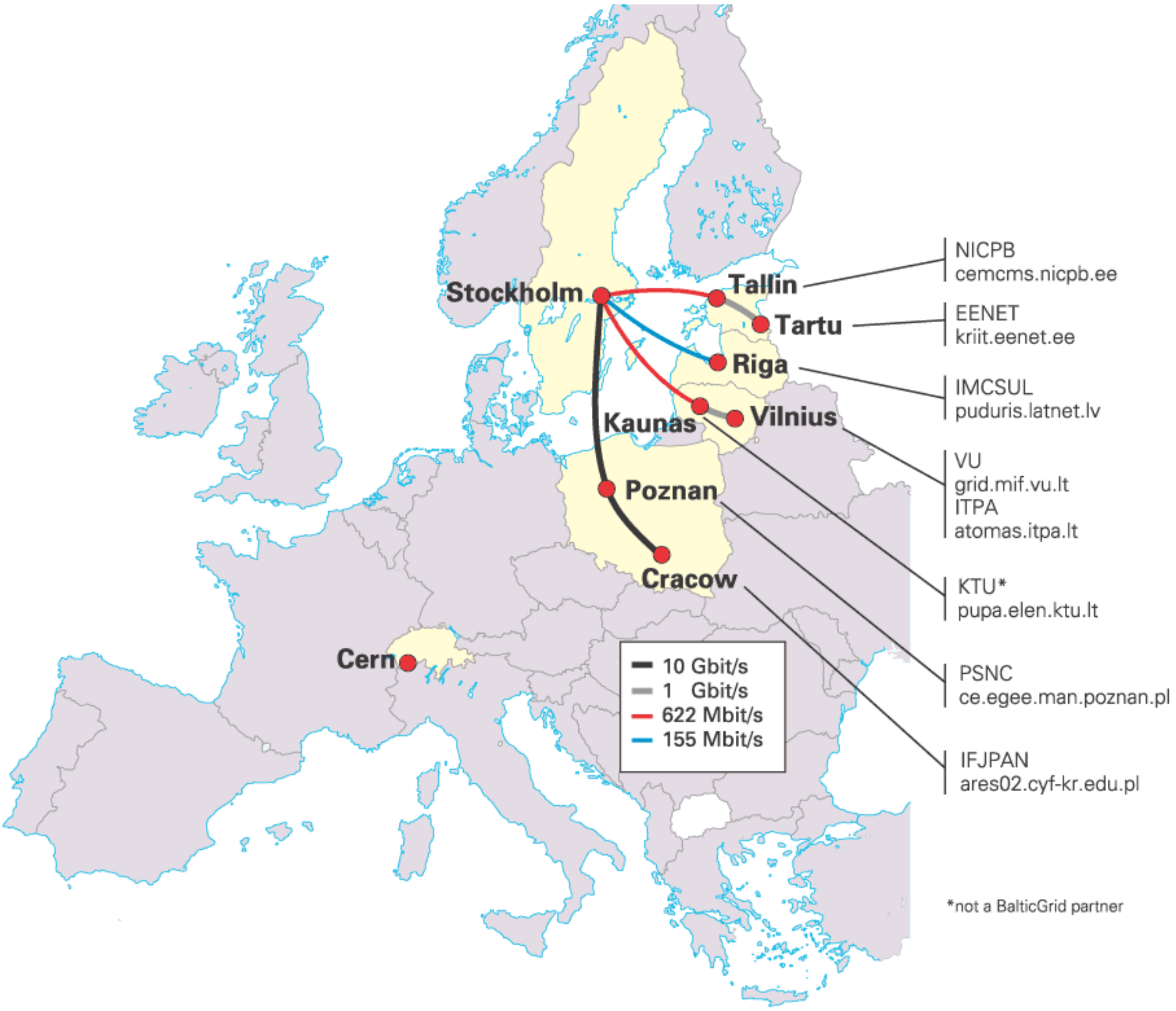

Fig. 1 Current Baltic Grid resources and network Topology

In Lithuania there are 14 small clusters. In big projects, such as EGEE, small clusters are not considered as valuable as the big ones. However, in the BalticGrid project which is aimed at the inclusion of Baltic countries into European GRID community, every cluster is of an importance for the overall success of the project. Still, there is a problem regarding certification of small clusters. Obviously they will not be certified by EGEE.

Another important matter to attend to is a cluster of the Military Academy of Lithuania. Due to its specific character the question of its security rises significant issues regarding security of connectivity and usage, i.e., certification of users, in particular.

User certification and access control in the BalticGrid project is addressed by SA1. The high level of data transfer security can be achieved by encrypting Grid traffic. Unfortunately that would slow down the data transfer speed substantially and also add significant overheads for implementation and monitoring of the network services. Since BalticGrid is a scientific research project it has not been foreseen to implement military-grade security and therefore encryption of the traffic suggested by one node of the network is not justifiable.

In this stage of the project it is also essential to identify current and potential bottlenecks of network connections. BalticGrid network will be built upon the GÉANT2 network. Current GEANT international connectivity for Estonia and Lithuania is 622Mbps and for Latvia – 155Mbps. Those links are not used with full capacity yet (for the future development of GÉANT in the Baltics see Chapter 2.2 "GÉANT2 TOPOLOGY" and for the present link utilization see Chapter 3.11 "CURRENT LOAD CHARACTERISTICS").

The present capacity problem is clearly seen when using the GEANT Premium IP (PIP) service specification, which by design is limited to only 10% of upstream bandwidth and shall be shared among all potential requestors (see chapter 3.5). This means that if high network demand applications are used (like CERN Atlas application that demands 12Mbps upstream per CPU), only few CPUs can be used for that application from the partners with limited GÉANT link (like IMCS UL or VU, or EENET).

Currently GÉANT link usage in Baltic NRENs exceeds 50%, which leaves limited capacity for PIP and Grid users. That can be improved with the implementation of GÉANT2.

2.2. EENET – ESTONIAN NREN

2.2.1. Historical background

Estonian Educational and Research Network (EENet) is a governmental non-profit organization established in August 1993 by the Ministry of Education with the task of managing, coordinating and developing the computer network for science, education and culture. Since 1997 EENet operates as a state agency administered by the Estonian Ministry of Education and Research.

In 1993 the whole network consisted of less than two hundred computers in Tartu and Tallinn. In the beginning of the year 2005 the number of end-users of Estonian academic network was approximately 228,000 people: researchers, students, teachers, pupils etc. The network extends to most counties in Estonia. Most universities, higher education institutions and research institutes are connected to the academic data communication network managed by EENet.

The objectives of EENet are to ensure:

1) the functioning of an academic data communication network corresponding to the specific needs of educational, research and cultural institutions and its compatibility with new innovative projects (e-training, e-research, e-health, e-information, e-state, Estonian GRID);
2) correspondence of the provided data communication and content services (information technology based services which are not necessary for ensuring data communication but are needed for the existence of information exchanged in the network) to the customer needs;
3) the due administration of the DNS Top Level Domain .ee based on the country code Estonia.

As a state-owned institution EENet offers it's services to educational, scientific, or cultural establishments located in Estonia. The other important requirement is that the establishment must refrain from commercial activities in the educational and research network.

2.2.2. Current development of EENET

At present the international connection of the Estonian academic data communication network is a 622 Mbps link Tallinn–Copenhagen to GÉANT network. The internal backbone connects most counties of Estonia: Tallinn and Tartu are connected by a EENet-operated 1 Gbps link on dark fibre (xWDM technology), other connections to counties are 2-10 Mbps. Universities are connected with 1Gbps or 100Mbps links. EENet participates in deploying dark fibre technologies to other bigger cities of

Estonia. In 2005 there was built municipality fibre network in Paide, which enabled the high speed connections for educational, research and cultural institutions in that city.

The Estonian Educational and Research Network (EENet) is the coordinator of the Estonian Grid project. Estonian Grid initiative was started in 2003 and its main objective is to introduce, initiate, and promote grid computing and grid technologies in Estonia.

The history of EENet's participation in IST projects is as follows:

1) GN2 (contract number 511082) - participant,
2) GN1 (IST-2000-26417) - participant.

In 1995-1997 EENet provided services to the research and academic community in Estonia which were financed from the PHARE 1994 R&D Networking Project (via Delivery of Advanced Network Technology to Europe Limited (DANTE)).

2.2.3. EENET topology

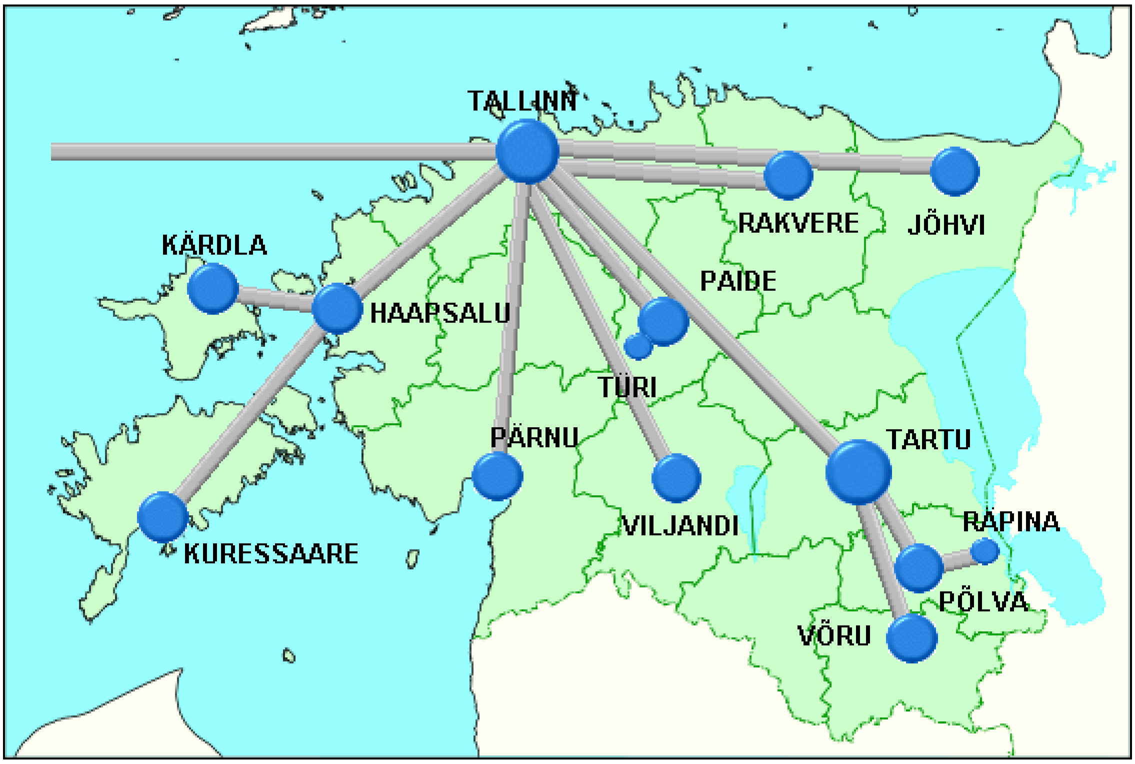

Fig. 2 EENet topology map

622 Mbps Tallinn-Copenhagen (GEANT)

1 Gbps Tallinn-Tartu

1 Gbps Tallinn-Paide

11 Mbps Tallinn-Haapsalu

8 Mbps Tallinn-Viljandi

4 Mbps Tallinn-Pärnu

4 Mbps Tallinn-Rakvere

2 Mbps Tartu-Põlva

2 Mbps Tartu-Võru

2 Mbps Paide-Türi

2 Mbps Haapsalu-Kärdla

2 Mbps Põlva-Räpina

4 Mbps Tallinn-Jõhvi

4 Mbps Tallinn-Kuressaare

2.2.4. International connectivity

Currently EENet has one link for international connectivity – 622 Mbps connection to GÉANT PoP in Copenhagen.

In future, there will be additional link to GÉANT PoP in Warsaw through Riga and Vilnius.

2.3. LATNET – LATVIAN NREN

2.3.1. Historical background

The Academic Network LATNET was founded in 1992 as a separate unit of the Institute of Mathematics and Computer Science in order to provide Internet services to academic community of Latvia. Now as a separate activity the Internet services are provided also on commercial base to wide range of business and state organizations, as well as individuals.

LATNET created the network that connects all the higher education institutions throughout the country. To achieve this goal LATNET took part also in international projects supported by EC - Baltbone-1, Baltbone-2, Baltic Information Infrastructure Pilot Project BIIP, etc.

LATNET also was the pioneer of wireless Internet in Latvia. Now LATNET in cooperation with LATNET Serviss Ltd. is very successful in implementing the wireless access to the Internet. As the result a radio network of Latvia scale was built that with more than 15 wireless nodes covers the capital Riga and has expanded wireless Internet services to 25 of Latvia's regions.

LATNET participated in various international projects related to the information technology and to the presenting of databases on the Internet, e.g., the project ICTIN (supported by the World Trade Organisation UNO), LinkGuide, INSIGHT and INTACCOMP (Copernicus programme), EASYCRAFT, etc. Currently LATNET participates in the Pan-European Gigabit Research Network GEANT project in the capacity of the National research and education network.

All the activities of LATNET are supported by its communication infrastructure that comprises its own optic fibre connections, satellite antennas and other equipment, a local telephone station, Latvian GIX, interconnections with telecommunication operators and other communication technique. LATNET staff mainly consists of University of Latvia master degree graduates and is educated also in various courses organised by international corporations.

LATNET is a member of the following international organisations - RIPE, TERENA, CEENet, ICANN.

2.3.2. Current development of LATNET

LATNET is developing the further coverage of academic network in Latvia to schools and other education institutions with the goal to reach also more remote places, including the eastern regions of Latvia. Still many connections are planned to be wireless because not all education institutions can be reached by optical lines.

There is planned the development of optical lines inside Riga to connect main universities situated in the capital (University of Latvia, Riga Technical University, etc.) The next step should be to install optical connections with Latvia University of Agriculture in Jelgava and with Daugavpils University in Daugavpils.

One of the main activities is the promotion of the European gigabit academic network GEANT. As the largest higher education institutions are already connected to this network, the main efforts will be concentrated on provision of high quality Internet services to high schools, libraries, hospitals, etc. Important task of the nearest future is the creation of GEANT PoP in the premises of LATNET, because the former network provider Lattelekom can not provide GEANT services from its PoP anymore.

The development of Latvia's Grid network is considered as one of the most important tasks. The Grid cluster will be made more powerful and new technologies such as Infiniband will be studied and implemented in 2006.

2.3.3. LATNET topology

Historically LATNET has been developing mostly on wireless technologies.

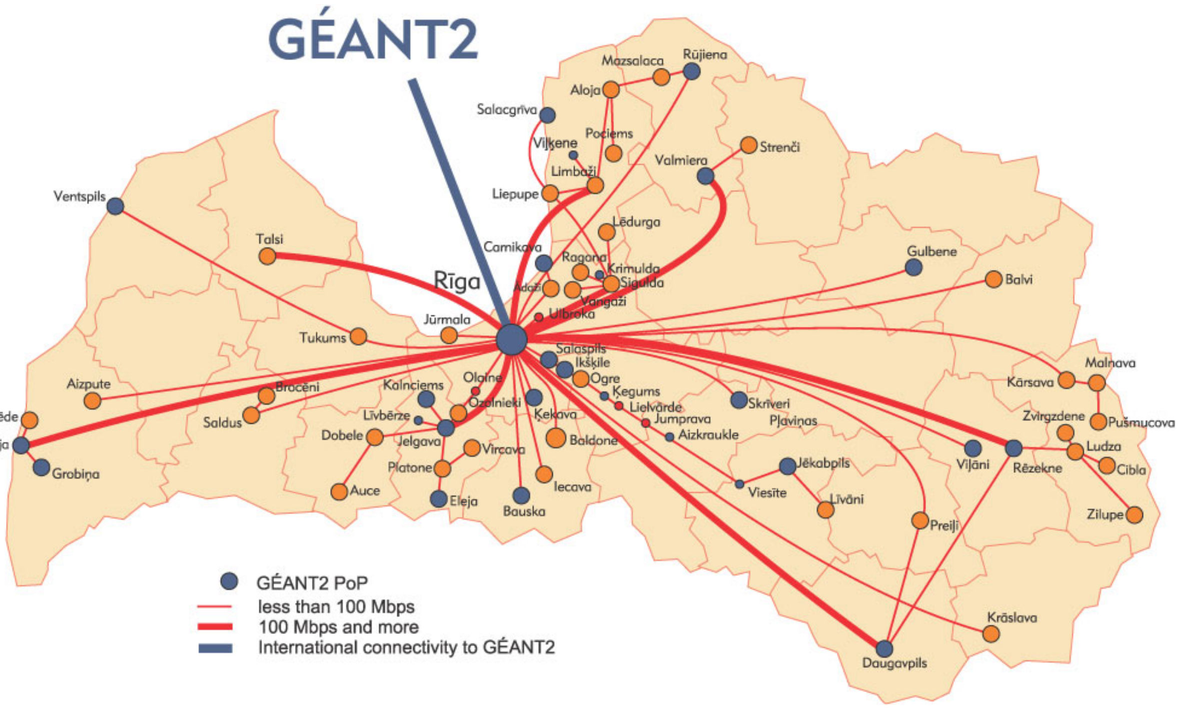

Fig. 3 LATNET topology map

2.3.4. International connectivity

The main international connection of LATNET NREN is the connection to the GEANT network with 155Mbps bandwidth. According to the rules this connection is used by the academic community only. Other categories of clients use the international connection provided by LATNET Serviss Ltd. with bandwidth of 50Mbps. This connection may also be used in the case of interruptions in the main channel of GEANT.

2.4. LITNET – LITHUANIAN NREN

2.4.1. Historical background

Academic and Research Network in Lithuania (LITNET) is an association of Academic research and other non-profit organizations. The members of this association use, manage, and develop the network.

The highest governing body of LITNET is the LITNET Board whose structure and regulations are confirmed by the Ministry of Science and Education in Lithuania. The LITNET Board coordinates the development and the management of the network.

The LITNET Network Operating Center (NOC) carries out about network activity. LITNET NOC is located in the Kaunas University of Technology. The main expert of this network is LITNET Technical Expert group. LITNET gets financial support from Ministry of Science and Education.

One of its major goals is to provide high quality, reliable, fast and secure interconnection between institutions for information technology projects. BaltGrid is among the major priority projects.

2.4.2. Current development of LITNET

The LITNET backbone has 1 Gbps links between Vilnius and Kaunas and a ring between the 5 major cities 155-200 Mbps. Leased lines provide 4-30 Mbps connectivity to other 20 cities.

Number of PoPs on the network (defined as the number of sites where the NRENs manages routing or switching equipment) is 25.

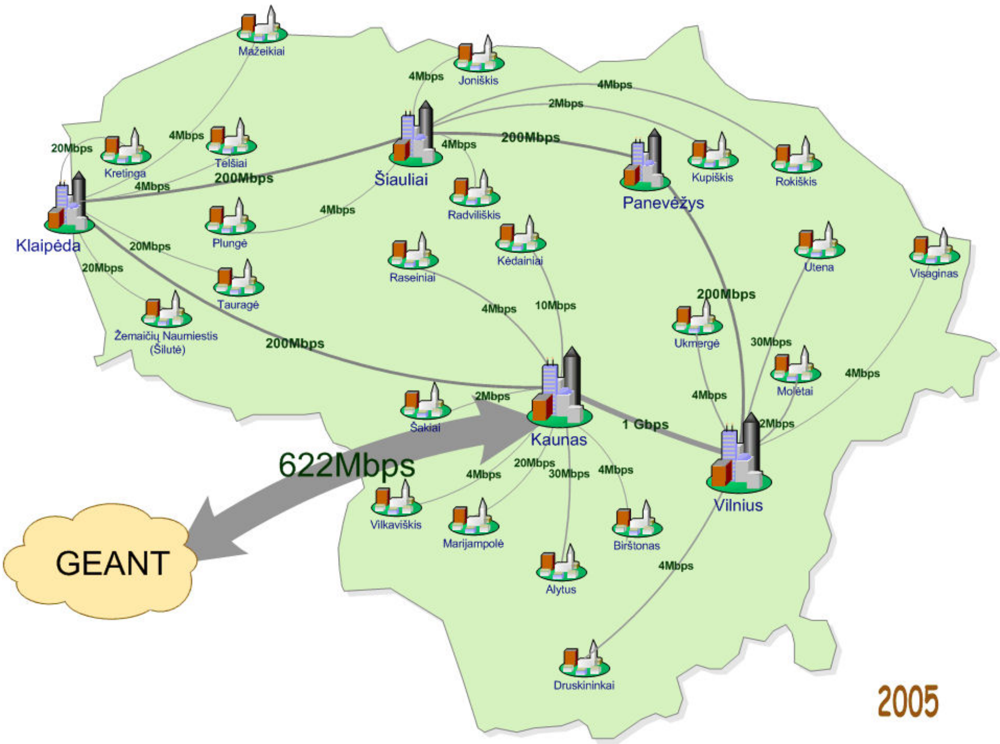

Fig. 4 LITNET topology map

Vilnius and Kaunas are interconnected by 1 Gbps fibre optics. A new fibre optics cable is laid down between two cities and the new 10 Gbps equipment will be launched in the beginning of 2006. Very fast 10Gbps line connecting Vilnius University and LITNET will be launched at the same time.

It is necessary to connect BaltigGrid nodes to LITNET by fast connections. Currently a node at ITPA is connected to LITNET by 100Mbps Internet connection; a node at MII by 10Mbps network; a node at VDU by 100Mbps internet connection; a node at KMU PRI by 1000 Mbps internet connection; a node at BGM by 1Mbps internet connection.

For successful fulfilment of BalticGrid project all connections have to be improved to at least 100Mbps and preferably to 1Gbps.

2.4.3. International connectivity

A 622 Mbps link connects LITNET to GÉANT. A backup link 25 Mbps connection to Bite. A second high capacity link is urgently required.

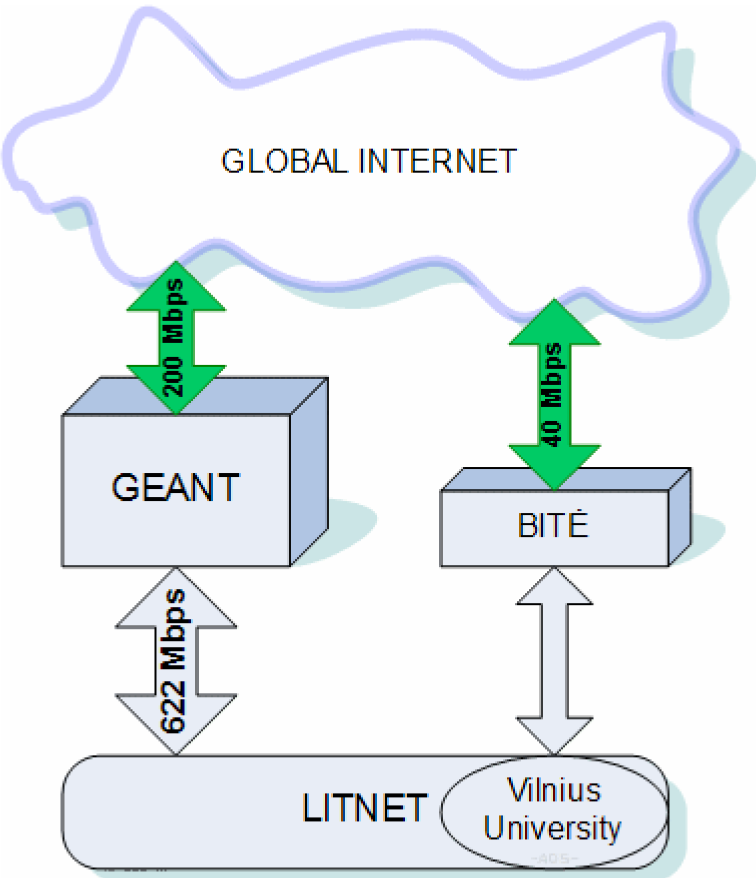

Fig. 5 LITNET international connectivity

In 2006 the two new 622 Mbps lines will be established to two European countries (not yet defined which countries). The capacity of such lines will be increased to 10 Gbps until end of 2008.

2.5. PIONIER – POLISH NREN

2.5.1. Historical background

The first Metropolitan Area Networks appeared in Poland in 1992. From the very beginning they have been built using an optical fibre connections, carrying Ethernet, FDDI, ATM and later gigabit Ethernet signals. In 1997 they have been connected when the first National Research Network (POL-34) was built with ATM technology over heterogeneous environment. The network initially carried the signals with the speed of 34Mbps, then 155, and 622Mbps.

It has been replaced entirely by the high speed 10GE optical core in 2003, with subsequent upgrades in 2005, allowing to transport multiple 10Gbps lambdas to the end users. Since 2003, the network bears the name of PIONIER – Polish Optical Internet.

The PIONIER network idea emerged in 2000, and its deployment started in 2001, with the fibre acquisition process. As the availability and quality of the existing fibres were not satisfactory for current and future demands of optical networking, the decision to build new fibres with the cooperation of telecommunication carriers, using a cost-sharing model was taken. 2650km of fibre lines were laid until June 2003, connecting 16 MANs. In this model the NREN shares the minor quantity of fibres in a common fibre cable with the telecom operator.

The main purpose of the Polish NREN is to provide the Internet connectivity to the academic users (universities, libraries, R&D institutes), advanced research infrastructure (such as High Performance Computing - HPC systems, archives, visualization engines, labour facilities e.g. radio-telescope, medical equipments, spectroscopes etc.), or for national and international projects' purposes.

2.5.2. Current development of PIONIER

The subsequent developments in 2004 and 2005 were commenced using a slightly different model, where the NREN was the main investor, and the focus was put on the construction of complete fibre routes consisting of several ducts, which were then shared with co-operating and co-financing telecom. This way the NREN remained the owner of the whole fibre cable and some fibre ducts, allowing for easy future upgrades. Also the number of fibres in the NREN cable was increased, compared to the previous model, and the new links usually consist of 24 fibres (18xG.652+6xG.655)

Currently PIONIER is connecting 21 academic MANs and 5 High Performance Computing Centres. The length of the PIONIER-owned fibres on January 2006 is 4051 km.

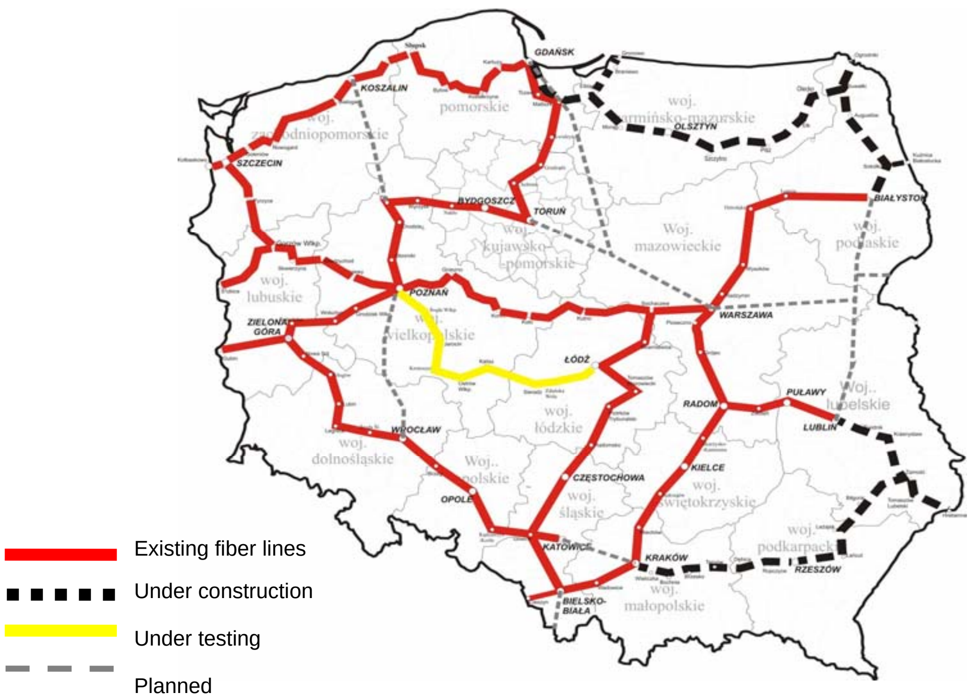

Fig. 6 The fibre network topology

Since the late 2005, the network has been gradually equipped with an additional 10Gbps lambda (mainly dedicated to HPC), thus increasing the backbone capacity to 20Gbps on all major links.

The current connectivity status is as follows:

- 10 MANs are located on own 20Gbps backbone;
- 9 MANs are located on own 10Gbps backbone;
- 2 MANs are connected using 1Gbps leased channels.

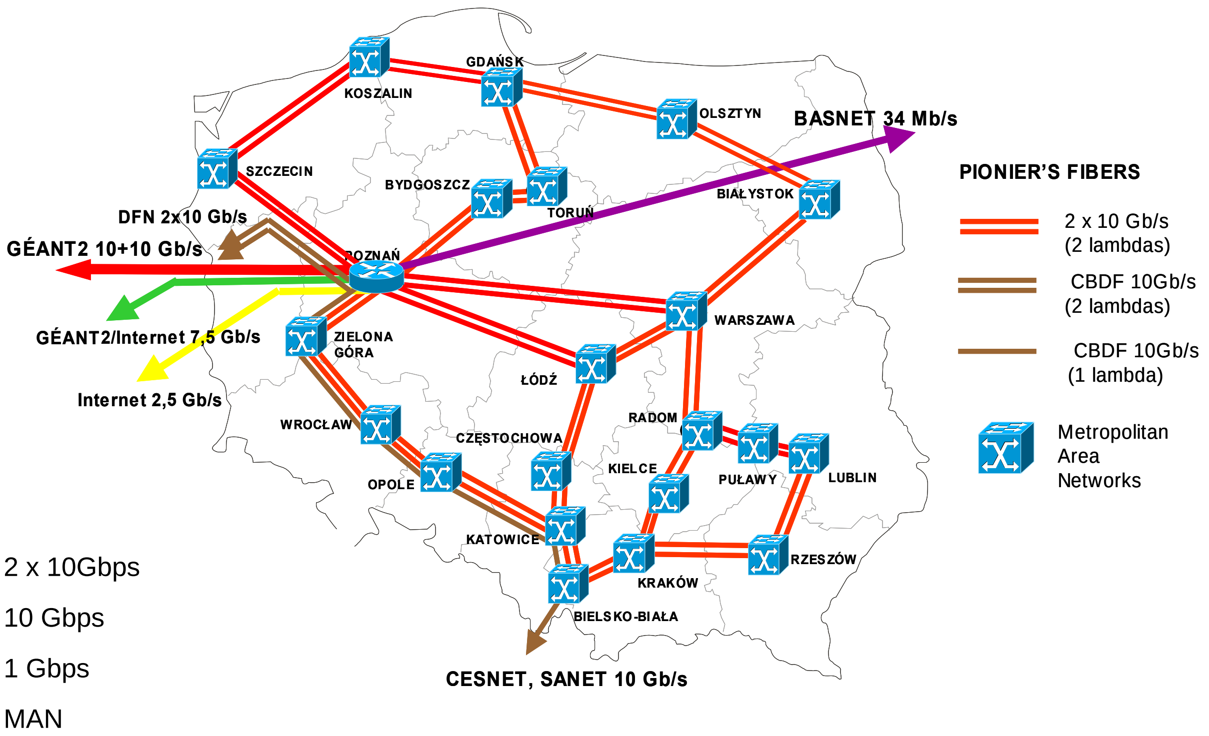

Fig. 7 Logical network connections (4Q2006)

2.5.3. International connectivity

The international connectivity is ensured by dedicated links to GEANT network (2x10Gbps) and to numerous commercial operators with the total capacity reaching 8Gbps.

The PIONIER fibres are present not only in the country's interior but also on the national borders, allowing for an easy interconnection with neighbouring countries. Currently the fibre links are installed on the border with Germany (3 exchange points) and Czech Republic (1 exchange point). The connections to Russia, Ukraine, Belarus and Lithuania are currently under construction. It is expected that all Cross Border Fiber (CBDF) links will be operational by the end of 2006.

The topology of the PIONIER network will be extended by an additional 1500 km of optical cables, what will allow us to close the networking loops and increase the network reliability. There is a plan to build direct connection (CBDF) to all neighbouring countries (Fig. 8).

It will be added additional two lambdas (3 and 4) for 10 Gbps connections with optical switches. The mentioned new infrastructure will be used for new generation services and applications.

Fig. 8 PIONIER plans in terms of CBDF connections

2.6. GÉANT2 TOPOLOGY IN THE BALTIC REGION

The GÉANT project was aiming at the development of the GÉANT network - a multi-gigabit pan-European data communications network, reserved specifically for research and educational use.

GÉANT provides a system of high performance links in order to establish connectivity between PoPs. There is one PoP in each partner country that is a member of the European consortium of NRENs. At the PoPs the national infrastructures of the NRENs are connected to the GÉANT backbone.

During GEANT project the following connectivity has been set up in the Baltic region[1]:

[1] http://www.geant.net

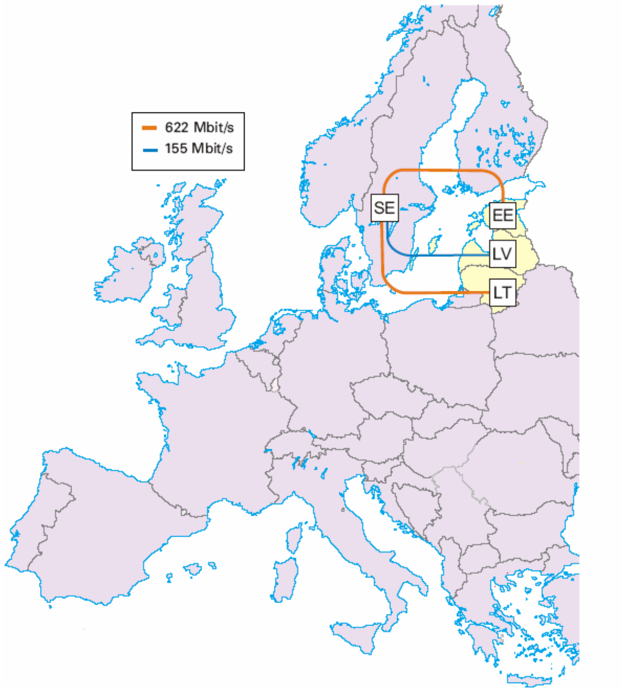

Fig. 9 GÉANT topology in the Baltic region

GÉANT2, the successor to GÉANT, officially began on 1 September 2004. This network will connect a total of 34 countries. Infrastructure development of GÉANT2 is aiming at the active involvement of all partner organizations to create a new generation of research infrastructure to make leading technologies and services available to research and education community without deference to their geographic location. One of the main objectives GÉANT2 has stressed is a narrowing of the digital divide: the networking services available to research communities in some countries are far below the level that is common in other countries. The significant difference exists within a single country as well. GÉANT2 will provide various forms of assistance to the development of academic network in the less advanced countries to improve not only NRENs connectivity to GÉANT2 but also NRENs development at the local level:

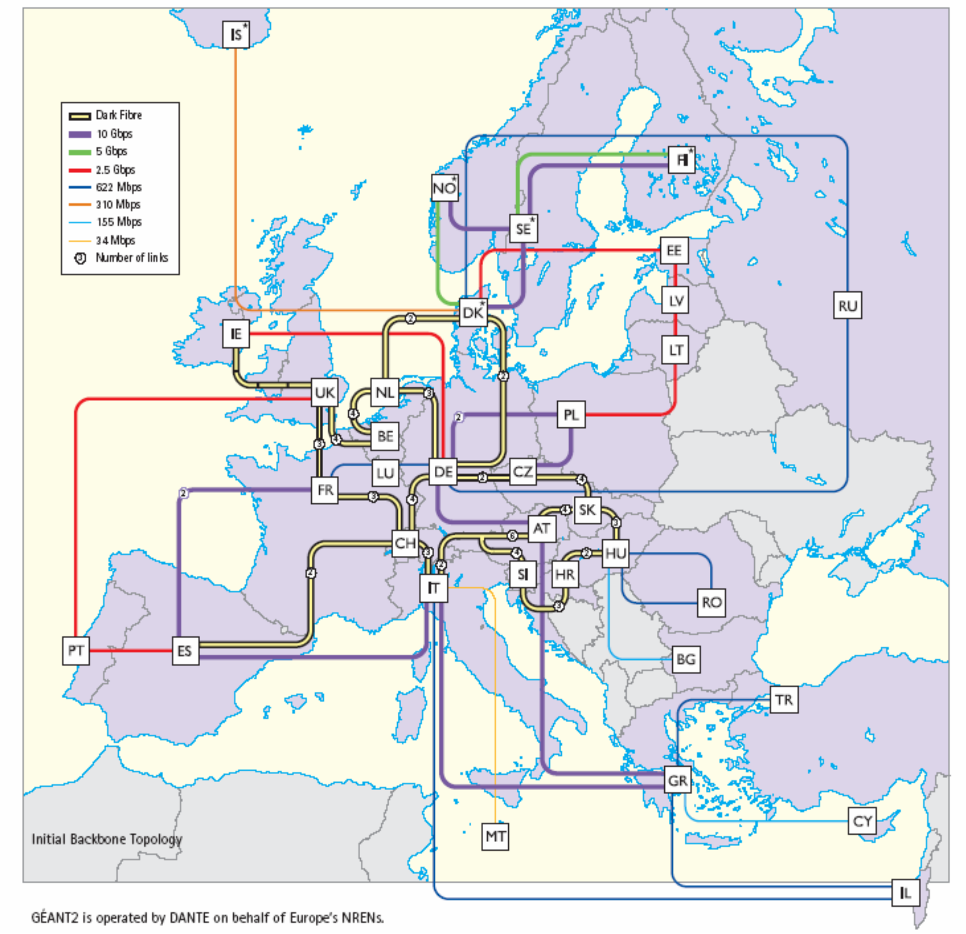

Fig. 10 The planned topology of the whole GEANT2 network

The topology map (Fig. 10) gives information on GÉANT2 backbone connection lines that operate between the partnering NRENs. The roll-out of the GÉANT2 network is progressing well. 13 of the network's 44 routes are fully installed and operational as of December 2005.

The development of GÉANT2 in the Baltic region is not clearly stated yet, therefore BalticGrid should model its network on the base of current GÉANT topology (Fig. 9). Although taking into account the further development of GÉANT2 the connectivity between BalticGrid clusters will improve significantly:

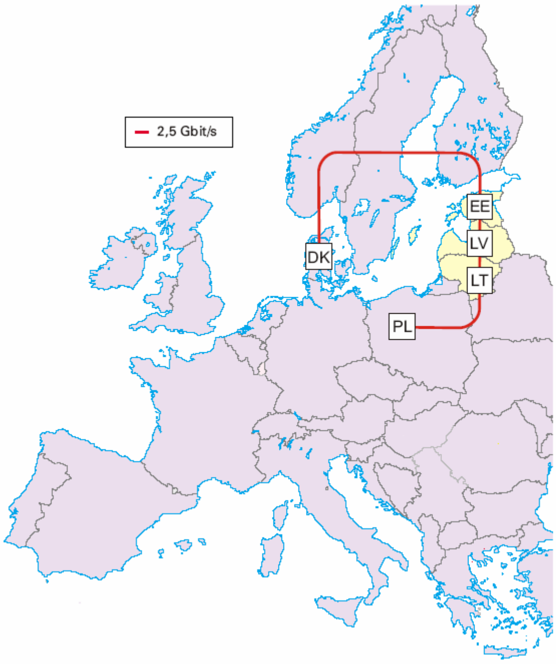

Fig. 11 Planned GÉANT2 topology for the Baltics region

2.7. PORTA OPTICA INITIATIVE

The development of Grid services in the Baltic region depends directly on the infrastructure of communication networks. These networks are important for management and functioning of any Grid, and its bandwidth capacity and service flexibility are crucial for successful usage of the Baltic Grid by research community.

The project Porta Optica Study co-funded by the European Commission as a Specific Support Activity studies the existing network infrastructure, as well as the possible strategies for the development of research and education networking in the region. The start of the project is February 1, 2006. The ultimate goal of the project is the stimulation and consolidation of initiatives to ensure successful research network deployment in the Eastern Europe, Baltic States, and Southern Caucasus regions.

To achieve this goal, it is thought that the most effective way is to create dark-fiber based research networks deployed throughout the whole region of Europe. This network could provide to NRENs the flexibility of network design and technology choice. Such networks allow for fixed cost of use of the infrastructure and at the same time provide upgradeability to Tbps, as the user demands grow.

The Porta Optica will provide detailed study of existing and potential optical fibre in the region, and will analyze the technical options available for the deployment of dark fibre and the management of optical transmission by NRENs in the region. By doing so it will thereby provide guidelines for future implementations,will report on economic aspects and regulations, and will disseminate information - targeting both technical and policy-making actors in the region.

The results of the Porta Optica project can be of some use for the Baltic Grid project, because the Porta Optica project identifies the general users of high quality networks, and the BalticGrid can find out which of them that have interest in Grid based computations.

3. MANAGED NETWORK SERVICES AVAILABLE TO BALTICGRID

This section describes managed network services that are available in the GÉANT network and in the European Grid community as well as techniques that are available for traffic prioritising. These techniques and services can be used for implementing service levels and monitoring their quality.

Most of the services that are available in the GÉANT network will be available for the Baltic Grid partners, but some of these services are not fully functional yet and their implementation will imply various technical challenges. The challenges in more details are described in Chapter 7.

3.1. QUALITY OF SERVICE IN GÉANT

The GÉANT network uses a variety of techniques to provide services to the NRENs. As a whole these techniques are know as Quality of Service (QoS). The basic goal of QoS is to provide service differentiation between IP packets in the network. This service differentiation is noticeable during periods of network congestion and results in different levels of network performance.

Currently, three service classes are offered that can be used for traffic transmission in the GÉANT network:

1) The Best Effort service does not provide any performance guarantees. However, the goal is to give a fair share to each traffic flow. Best effort is the default class of service and is useful for traffic from non-real-time applications e.g. FTP, email, P2P applications.
2) The Premium IP service provides guarantees on one-way delay, jitter and packet loss. Applications with real time constraints may benefit from this service; i.e. Voice over IP (VoIP), video conferencing. Many GRID-based applications are exchanging messages between the GRID-involved sites, therefore delay and packet loss are vital parameters to the whole operation of GRID and to the GRID-based application performance.
3) The Less than Best Effort (LBE) service will utilise the capacity that is not used by best effort and premium IP traffic. This may be useful to transfer vast amounts of (non real-time) data for applications such as GRID computing without adversely affecting other traffic.

If enabled, both Best Effort and Less than Best Effort services are available to peer networks. The Premium IP service, however, is only available after a reservation has been made[8].

3.1.1. Implementation of QoS

The implementation of QoS in the GÉANT network is based on the Differentiated Services (DiffServ) model as defined by the Internet Engineering Task Force (IETF). This implies that each packet is marked with a DiffServ CodePoint (DSCP) in its header. The DSCP value is stored in the first 6 bits of the Type of Service (ToS) field that is part of the standard IP header. The DCSP values are associated with a certain forwarding treatment, also called Per Hop Behaviours (PHB). By configuring PHBs in each router of the network an edge-to-edge service can be provisioned.

The packets from a research network arriving on a GÉANT router with a given DSCP value (incoming DSCP value) will be retagged (new value - rewritten). At the ingress interface the packets are classified, i.e. put into a certain queue depending on their service class. Best effort and LBE traffic is classified by means of the DSCP value. Premium IP traffic is classified by means of a packet filter according to the source/destination address and optionally the DSCP value of the packet. Furthermore, the Premium IP traffic is policed such that it will not exceed the agreed traffic profile. Excess Premium IP traffic is discarded.

Within the backbone and at the egress interface of GÉANT classifying is done solely based on the DSCP value. No policing is performed at these interfaces.

Shaping is not performed in the GÉANT network in order to avoid shaping delay. End users and/or NRENs may, however, perform shaping actions if necessary.

The GÉANT core network is built on Juniper routers, but the following implementation is also available on Cisco and other vendor routers.

In the GÉANT network different queues (four per interface) are served by a Weighted Round Robin (WRR) scheduler. A weight, representing a percentage of the total capacity, is assigned to each queue. The queue for best effort traffic is assigned 90%, the LBE queue 5% and a queue for network control traffic is assigned 5%. The Premium IP traffic has absolute priority over all other queues. Rate limiting (i.e. policing) at the ingress prevents other traffic classes from being starved by Premium IP traffic[8].

3.2. PREMIUM IP SERVICE

Premium IP is a service that offers network priority over other traffic on GÉANT. Premium IP traffic takes priority over all other services, such as Best Efforts (BE) and Less Than Best Efforts (LBE). During times of congestion, Premium IP traffic receives a better, and guaranteed, level of network performance. This can be particularly useful for real-time applications, such as VoIP and video conferencing. In the BalticGrid context usage of the Premium IP class service will keep GRID-based application performance at the top level and ensure that no GRID resources are wasted even during the periods of network congestion.

Premium IP provides a service similar to that of a virtual leased line. Data packets that are sent using the Premium IP service will experience no congestion in the network regardless of the load of the other traffic classes. As a result, delay and packet loss are kept to a minimum. This, in turn, will reduce the time one GRID application module wait for the messages from other GRID application module.

In order to effectively send and receive data using Premium IP, each network on the end-to-end path travelled by the data must support the same Premium IP service model. As GÉANT interconnects most of the European National Research and Education Networks (NRENs), it has implemented the Premium IP service model defined by the SEQUIN project[7].

The Premium IP service on GÉANT provides the following performance metrics:

1) Upper-bounded one-way delay;
2) Upper-bounded Instantaneous Packet Delay Variation (IPDV);
3) No packet loss due to congestion;
4) Guaranteed capacity.

3.2.1. Requesting Premium IP

In order to use the Premium IP service on GÉANT, the organisation should contact the NREN of their country, who can make a reservation. The NREN usually requires the following information:

1) Email address and telephone number for a technical contact and a backup technical contact;
2) Contact details for the end-site technical contact, if possible;
3) Source IP addresses that will send Premium IP data;
4) Destination IP addresses that will receive Premium IP data;
5) The amount of capacity requested, in Mbps;
6) Details of the application used and project description;
7) Request start and end dates (granularity of service duration is one day);
8) Whether the Premium IP service should be uni-directional (source to destination only) or bi-directional (Premium IP from destination to source as well).

The NREN will require notice of at least 2 working days in advance.

There are several other limitations for Premium IP reservations. The maximum length of time a reservation can be made for is 3 months. A reservation can be made up to 3 months in advance. A request for more than 250Mbps Premium IP will require additional approval, and therefore more time in advance will be required.

Any traffic which exceeds the agreed data rate will be dropped or can be re-marked as Best Effort. To avoid re-marking a careful planning from GRID participants is required. NRENs side must have a more sophisticated rate limiting policy to avoid packet loss at the entrance into GÉANT network.

While traffic sent using Premium IP is guaranteed to be given the fastest possible transit through GÉANT, the availability of the service itself is not guaranteed[8].

3.2.2. Using Premium IP

To be treated as a Premium IP service level traffic in the GÉANT network packets should be tagged with DSCP 46. Any packets tagged as Premium IP that are sent to GÉANT without prior reservation will be considered unauthorised and will be re-tagged as Best Effort (DSCP 0 or DSCP 6). They will then be treated as Less Than Best Effort on the first GÉANT router and as Best Effort on subsequent GÉANT routers.

Packets that are tagged with DSCP 40 will always be forwarded as Best Effort traffic, but without the packets being re-marked. This means that packets can be tagged so that they receive Premium IP in the peer networks (i.e., NRENs) and Best Effort in the GÉANT network.

Packet tagging should be performed on GRID nodes if possible otherwise it should be done on NRENs ingress router as soon as possible[8].

3.2.3. Monitoring

The available network capacity for the Premium IP traffic is currently monitored for each GÉANT link by a tool called Taksometro, developed in the framework of GÉANT. Long-term statistics of GÉANT and NREN access traffic, including class-of-service information are available in the password protected area of GÉANT:

http://stats.geant.net/taksometro/GEANT-normal/taksometro-topology.html

All NRENs have access to this statistics and can use it to monitor class-of-service delivery and provision availability of Premium IP.

3.2.4. Premium IP Service Level Agreement

Currently in the GÉANT network, no Service Level Agreement (SLA) is offered for Premium IP as the monitoring infrastructure allowing the SLA metric verification is still under study.

To get best possible performance from GRID applications in the framework of SA2, SLA enforcing Premium IP class service should be established with all the involved NRENs. Also the ways of monitoring the network performance should be agreed upon and implemented.

3.3. LESS THAN BEST EFFORT

The Less Than Best Effort (LBE) service has been implemented on GÉANT at the request of NRENs, researchers, and GRID projects. It provides a traffic class that is able to make use of unused bandwidth on the GÉANT network. It allows high volume, low priority applications to run in the available bandwidth without affecting regular Best Effort and Premium IP traffic. This service level traffic is most appropriate for large volume data transfer to and from GRID without disturbing the normal operation.

LBE traffic is allocated any bandwidth not used by Premium IP and Best Effort services. If the network becomes congested, Premium IP and Best Effort traffic will take precedence – LBE packets are always the first to be dropped. LBE traffic is therefore subject to a relatively high risk of packet loss. To guarantee that received data are in-tact it is appropriate to relay on already existing network protocol recovery mechanisms[8].

LBE service is particularly useful for researchers who need to ship huge amounts of data where the speed of transfer is not so important, or where they do not want to risk affecting Best Effort or Premium IP traffic from other users. Some examples include:

1) Data mirroring, where the mirror is updated continuously rather than once every night;
2) GRID data transfers, where time is not a constraint;
3) Non-invasive test traffic;
4) Network backups that need to be performed continuously throughout the day.

3.3.1. Requesting Less Than Best Effort

The LBE service on GÉANT is enabled by default. To use it, sent packets must be tagged with DSCP 8. Any packet arriving on GÉANT with DSCP 8 is treated as Less than Best Effort. The tagging should be agreed with the NRENs and performed on Grid nodes if possible otherwise it should be done on NRENs ingress router as soon as possible[8].

3.3.2. LBE traffic Monitoring

The available network capacity for LBE traffic is currently monitored for each GÉANT link by the Taksometro tool, which is described in the chapter 3.2.3. The statistics, including traceroute with TOS (DSCP) change is available in the password protected area.

3.3.3. Service Level Agreement

No end-to-end guarantees are provided for flows adopting the LBE service. This means that the LBE service is not parameterised - no performance metrics are needed to quantitatively describe the service. The LBE service is currently available at most PoPs in GÉANT.

Therefore there is no specific Service Level Agreement for LBE. This does not mean that any problems experienced by LBE users should be overlooked. In the event of problems, the Network Operators should thoroughly investigate them and the user should be notified of the cause.

Regardless that no traffic guarantees are specified in the SLA, packet drop levels should have to be monitored and recovery actions should be specified and performed.

3.4. GÉANT2 JOINT RESEARCH ACTIVITY

In the GÉANT2 project substantial funding is provided for innovations. All innovative developments are carried out in the framework of Join Research Activities (JRA). There are five JRAs in the GÉANT2 project; two of them are relevant to the BalticGrid SA2 activity. JRA1 is addressing performance measurement challenges and JRA3 is covering Bandwidth on Demand issues. The objective of JRA1 is to build a platform to exchange multi-domain monitoring information through a well-specified interface common to all networks. JRA3 is investigating a number of possible options for offering bandwidth on demand, and for managing its provision.

Only GÉANT2 project partners can directly participate in the JRAs, but there is a possibility to interact with them via the TERENA's (www.terena.nl) task force TF-NGN (Next Generation Networking). TF-NGN brings together experts in the lower layer technologies, network monitoring, bandwidth provisioning and is closely collaborating with the GÉANT2 JRAs. The participation in TF-

NGN is free of charge and involvement could be beneficial for the BalticGrid network monitoring related activities.

3.5. GÉANT2 BANDWITH ON DEMAND (BOD)

In response to new requirements from the Grid community for dedicated high-speed connections several initiatives are started to create network services that could provide guaranteed bandwidth to the end users. The Bandwidth on Demand (BoD) service which is still under development has been proposed by GÉANT2 Joint Research Activity 3 (GN2 JRA3).

The BoD service provides guaranteed capacity, connection oriented, and point-to-point service between two end points. The end points can be located in different domains, and in this case the service will be built by connecting the different BoD services in each domain to provide the end-to-end path.

The BoD service relies very much on existing services available in the involved networks. The initial focus of BoD is on point-to-point Ethernet services, although usage of packet based technologies at Layer 3 is also possible.

To use the requested capacity, reservation of bandwidth has to be made in advance. Reservation can be made for a specified limited time. The GN2 JRA3 aims to create the interfaces for resource reservation and monitoring of the end-to-end BoD provisioning path. The resource provisioning currently can be done manually, but eventually the process will be automated[9].

3.6. GÉANT NETWORK MONITORING

General monitoring information of the GÉANT network is made available through the stats.geant.net portal. Publicly accessible is the Access Link weathermap and the looking glass. The Access Link weathermap shows the current load of the national connections. The looking glass service can be used for diagnosing various network related problems. More statistics and history is available in the GÉANT password protected area; access to it is granted to all NRENs. Some BalticGrid partners might have access to these statistics (as NRENs), but it should be investigated whether access could be granted by DANTE for the BalticGrid project.

During BalticGrid project all ongoing monitoring activities for GÉANT2 should be followed, and when possible, close cooperation should be achieved.

3.7. BANDWITH ALLOCATION AND RESERVATION SERVICE (BAR)

BAR similarly like BoD is a bandwidth allocation request management service. BoD is developed and implemented by GÉANT2 while BAR by the EGEE project. In both cases network devices are controlled by special software that processes bandwidth allocation requests tuning network behaviour to guarantee required bandwidth.

BAR is not interacting with network devices directly. Instead it talks to the Network Service Access Point (NSAP) for the configuration of the QoS-enabled network and to the Local NSAP (L-NSAP) for the configuration of the local network. An implementation of the NSAP is the GEANT2 Advanced Multi-domain Provisioning System (AMPS) [14]; which does not yet actually configure routers, though it performs all the communication with its peers on the path to assess the feasibility of a reservation and emails the administrators to effect the configuration. On the L-NSAP front there is a web service that deals with the BAR communication required but not with router configuration[11].

BAR is not deployed on a production scale in the EGEE project, nor will it be as BAR is not part of EGEE-II (the EGEE project successor). BAR is available to download and deploy (https://edms.cern.ch/document/700686/1).

EGEE suggestion for future work is to modify the NRS software to perform the missing functions. The ESLEA project (http://www.eslea.uklight.ac.uk/) is considering taking BAR forward and implementing the L-NSAP as suggested.

If some Grid application traffic crosses both GÉANT/GÉANT2 and EGEE network domains, then special care should be taken to synchronize bandwidth allocation requests. If bandwidth allocation is synchronized, the customer gets uniformed network behaviour from QoS perspective. If synchronization is not achieved, traffic flow between Grid sites might be disturbed and application performance hindered.

There is a close cooperation in place between GÉANT2 and EGEE. GÉANT2 AMPS (deployed in the framework of GÉANT2 SA1) is used as NSAP for BAR and deployed in a federated manner on GÉANT2, GARR, and GRNet. The production AMPS is available only on GÉANT2 for bureaucratic reasons. For BalticGrid network it is possible to use and deploy BAR software and to follow BAR future developments.

3.8. PERFORMANCE ENHANCEMENT AND RESPONSE TEAM (PERT)

The Performance Enhancement and Response Team (PERT) has been created as part of the GÉANT2 project's PACE (Performance and Allocated Capacity for End-users) activity. The team assists users in troubleshooting network performance issues, and is producing user guidance on QoS matters.

The pilot service was launched with funding from the GÉANT2 project on 1 November 2004, with full service beginning on 1 March 2005, offered initially over GÉANT. Anyone who needs the PERT's help can log a problem using their normal IT support channels. The issue can then be escalated to the PERT as appropriate. The PERT will respond to all NREN queries by next business day, and all help provided is on a best-efforts basis.

The team is operating a ticket system for handling performance issues that are reported. The information collected in this system will be used to provide documentation targeted at end users and at PERT members themselves, including a comprehensive knowledgebase.

The PERT service could be used for BalticGrid needs in case a complex cross-domain performance problem is encountered.

3.9. EGEE NETWORK PERFORMANCE MONITORING (NPM)

The EGEE project JRA4 activity has been working on creating a universal tool for network performance monitoring - NPM. In the framework of EGEE, the interface has been standardised for publishing NPM data using GGF NM-WG (Network Measurement Working Group) version 1 schemas. At about the same time GÉANT2 was also adopting NM-WG, first with Perfmonit (Multi-domain Monitoring) and then with the PerfSonar (infrastructure for network performance monitoring) international collaboration, only using version 2, which required EGEE to develop a version 2 to version 1 translator. In February 2006 EGEE NPM have access to GÉANT2, Abilene, and ESNet network monitoring data, and the list of partners is growing.

EGEE team have developed a prototype - the Mediator, which is a discoverer and a broker of NPM information. Also two clients for it has been produced, i.e., the Diagnostic Tool (DT) and the Publisher. The DT was developed as GUI intended for use by NOCs and GOCs. The DT was the world's first demonstration of single access to heterogeneous NPM data from heterogeneous resources. For example, e2e data gathered with e2emonit were accessible on the EGEE test bed. The DT is available for download and access[12]. The Publisher is a client software to be used by software, rather than people, developed mostly according to the requirements of EGEE JRA1[13]. The Publisher is also available for download (https://edms.cern.ch/document/682653/).

Any network monitoring data published using NM-WG interface can be made available for EGEE.

The BalticGrid project's monitoring infrastructure and tools to be developed should use NM-WG interface in order to achieve better integration with EGEE. Therefore the mentioned e2emonit tool (http://marianne.in2p3.fr/egee/network/download.shtml) might be the best starting point for the BalticGrid network monitoring infrastructure.

3.10. OTHER MONITORING SERVICES

Many other monitoring services are developed in the European academic community and beyond. Several organisations are looking into possibilities to measure one way delay, packet loss, and similar network parameters. GÉANT2 delay measurement activity is currently under investigation, and several types of tools are currently deployed.

The RIPE NCC (www.ripe.net) has been active in the measurement area and one of the services they offer is Test Traffic Measurements (TTM). The goal of TTM is to collect data describing the performance of the network between different service providers such as network delays, packet losses or routing information. In order to participate in the TTM service, a measurement probes will have to be installed at the site interested in this service. One RIPE TTM is installed in the GÉANT2 Geneva PoP. It is possible to access the measurement results to more than 70 other ASs (Autonomous Systems) through the RIPE TTM website (http://www.ripe.net/ttm/).

Also DFN (German NREN, www.dfn.de) has developed devices for collecting performance metrics. Their IPPM devices were installed on several GÉANT PoPs (Frankfurt PoP - DE, Tel Aviv PoP - IL) and within a few NRENs (PSNC Poznan - PL, GARR PoP Milan - IT, DFN PoP Frankfurt - DE) in order to measure one-way delay, jitter and packet loss between those points. The visualization of results is provided by the University of Erlangen (Germany).

3.11. CURRENT LOAD CHARACTERISTICS

The current load of the national links to GÉANT is available from the GÉANT weathermap (stats.geant.net). To access historical data about the usage of the links, an access to the private area is needed. Alternatively local network monitoring systems of the NRENs could be used. For example, in LATNET historical data about the load of the GÉANT link as well as about other links are available only internally. Those data can be made available to BalticGrid SA2 participants.

We have used data provided by the Taksometro tool [10] in order to see trends in the load of GÉANT and GÉANT2 links to the Baltic countries.

3.11.1. Trends in Estonia

The average aggregated load of the GÉANT link to EENet, Estonia is shown in Fig. 12. The average load for the whole period is about 100Mbps, slowly growing. In the middle of February 2006 monitoring of the Estonian link has been moved to GÉANT2, but also there the load is about 100-140Mbps.

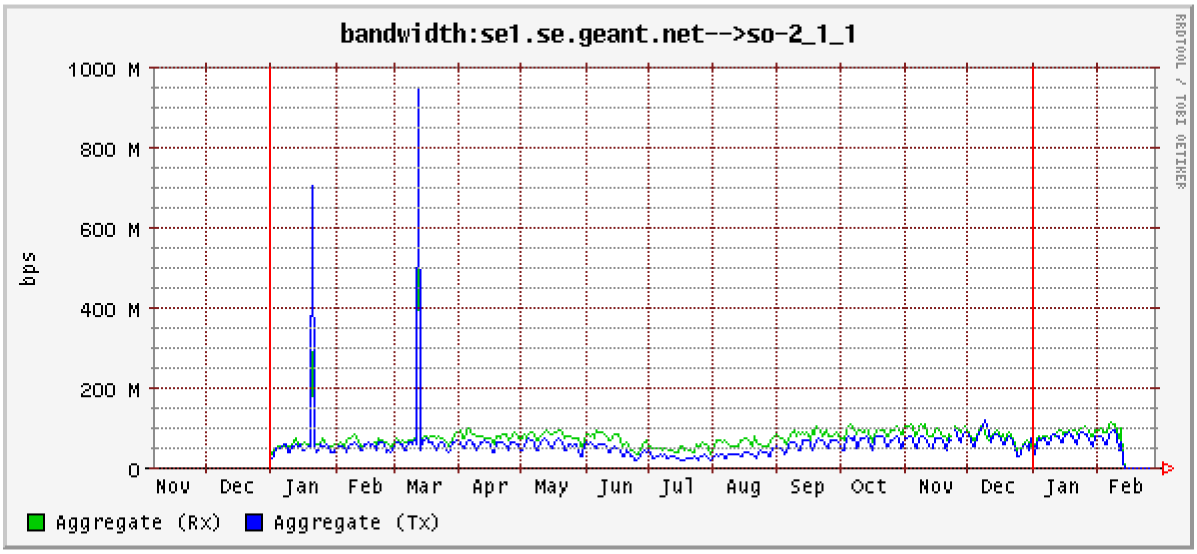

Fig. 12 Monthly traffic statistics on the GEANT link to EEnet

Few traffic (January, March 2005) peaks can be observed up to 700-900Mbps, but their origin is unknown and likely is related to some network disturbances.

LBE traffic in Estonia has been used since beginning of the year 2005, but in relatively small amounts (up to 10Mbps) with one peak up to 400Mbps in January 2005.

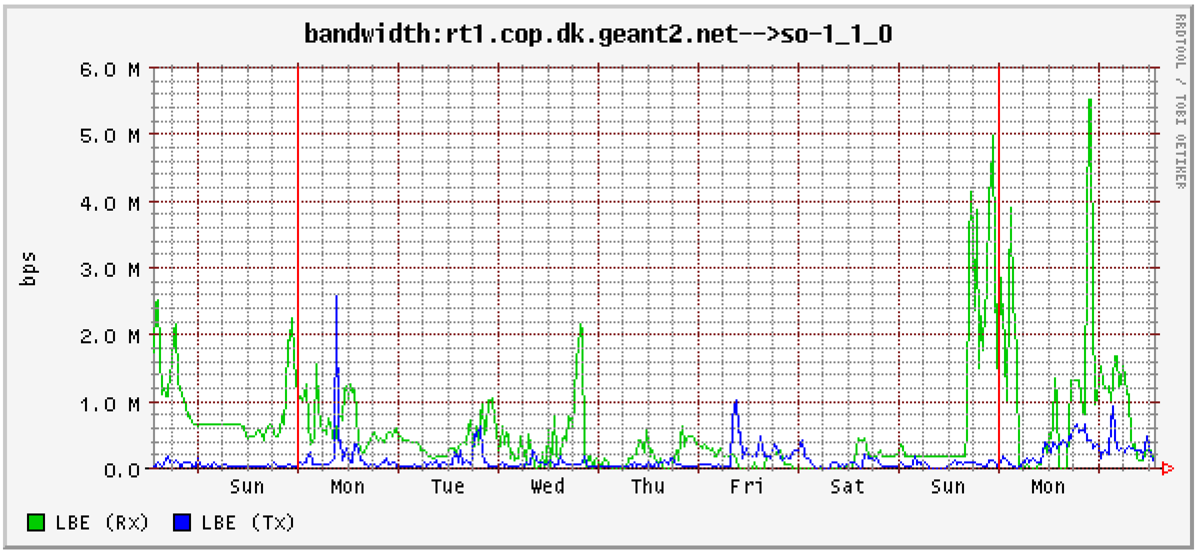

Fig. 13 Daily LBE traffic on the GEANT link to Estonia

Fig. 13 shows that lately LBE traffic in small amounts is used daily.

However, Premium IP traffic according to the Taksometro statistics has not been used on the GÉANT link to Estonia.

Currently the load of the GÉANT link to Estonia is approximately 15 % which leaves enough space for the Grid services and Premium IP usage.

3.11.2. Trends in Latvia

Seeing statistics from the Taksometro as well as from the local network monitoring system, the general trend is that traffic on the GÉANT link is doubling approximately every year. Fig. 14 is showing aggregated traffic statistics since November 2004, when incoming and outgoing traffic was between 10 and 20 Mbps. The end is the graph is February 2006, when average incoming traffic was 50Mbps, but outgoing around 30Mbps. The end of the graph is zero because the statistics of this link have been moved to the GÉANT2 system.

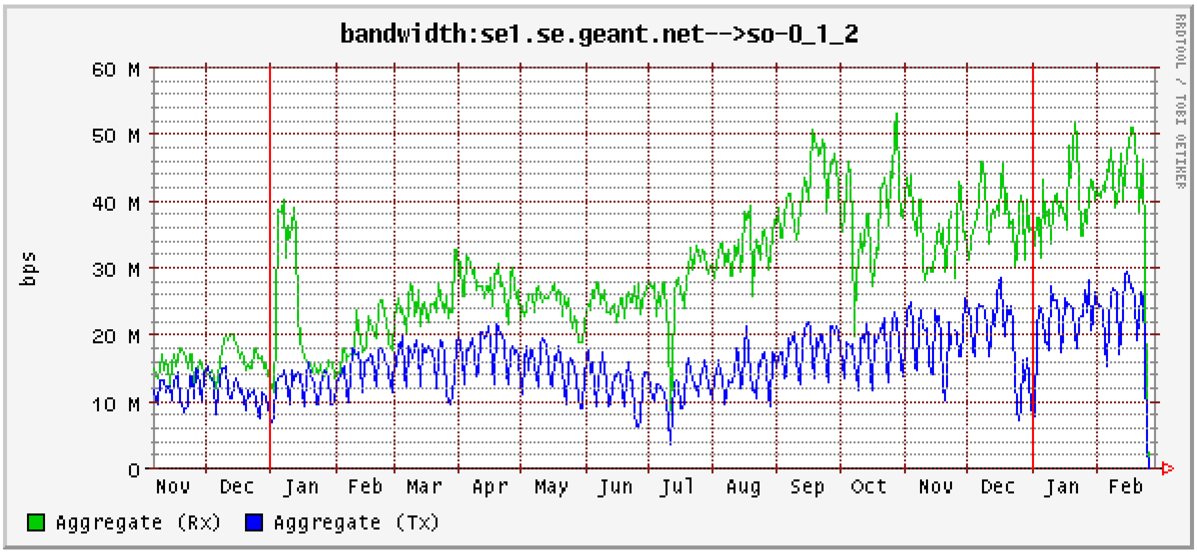

Fig. 14 Monthly traffic statistics on the GÉANT link to LATNET

Statistics of the LBE traffic (Fig. 15) shows that it has been used in February 2006, but in very small amounts, which is probably just for testing purposes.

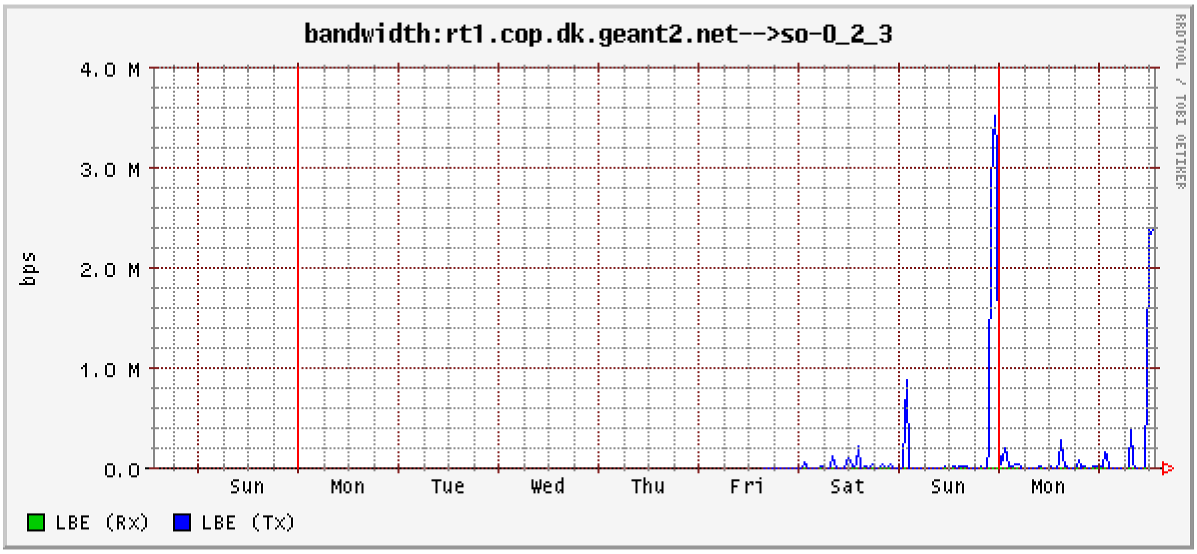

Fig. 15 Weekly statistics of LBE traffic on the GÉANT link to LATNET

Premium IP service has not been used in Latvia so far.

Currently the GÉANT link load is approximately 50-55 % which leaves some space for starting the Grid services and using Premium IP. The link will be upgraded to 622Mbps with implementation of GÉANT2 (spring 2006).

3.11.3. Trends in Lithuania

The average load of the GÉANT link to Lithuania is about 300-400Mbps. The total link capacity is 622Mbps, so there is still some space for first Grid users and Premium IP service. LITNET is planning to upgrade their links in the year 2006 to double the capacity. Fig. 16 shows the load of the GÉANT link to Lithuania before switching to GÉANT2.

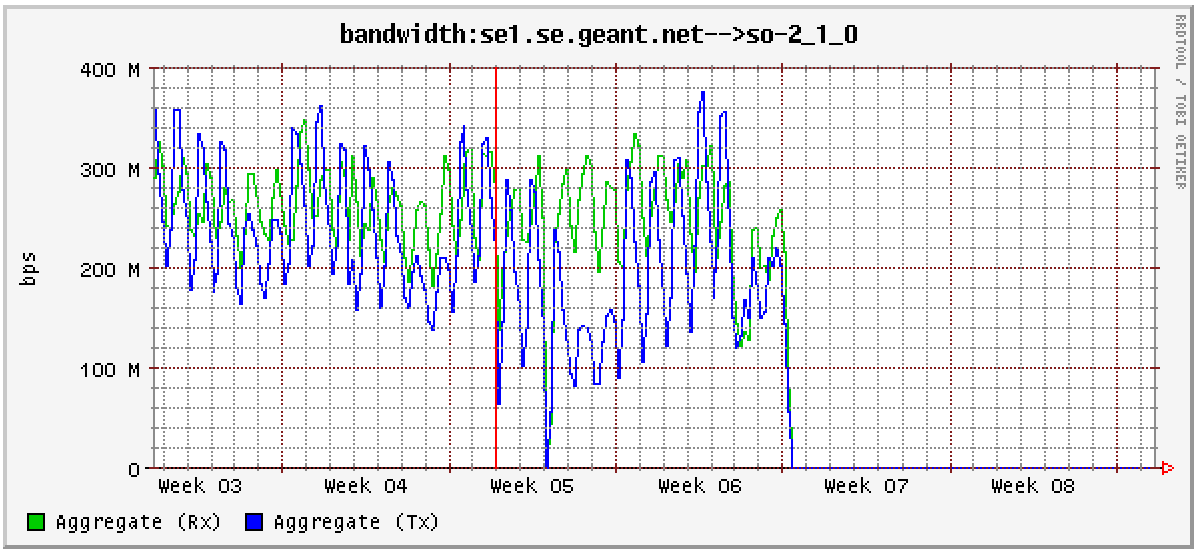

Fig. 16 Weekly traffic statistics on the GÉANT link to Lithuania

Usage of LBE traffic on the LITNET link has been very minor, about 1-2Mbps. Fig. 17 shows the weekly LBE traffic statistics before switching to the GÉANT2 monitoring system.

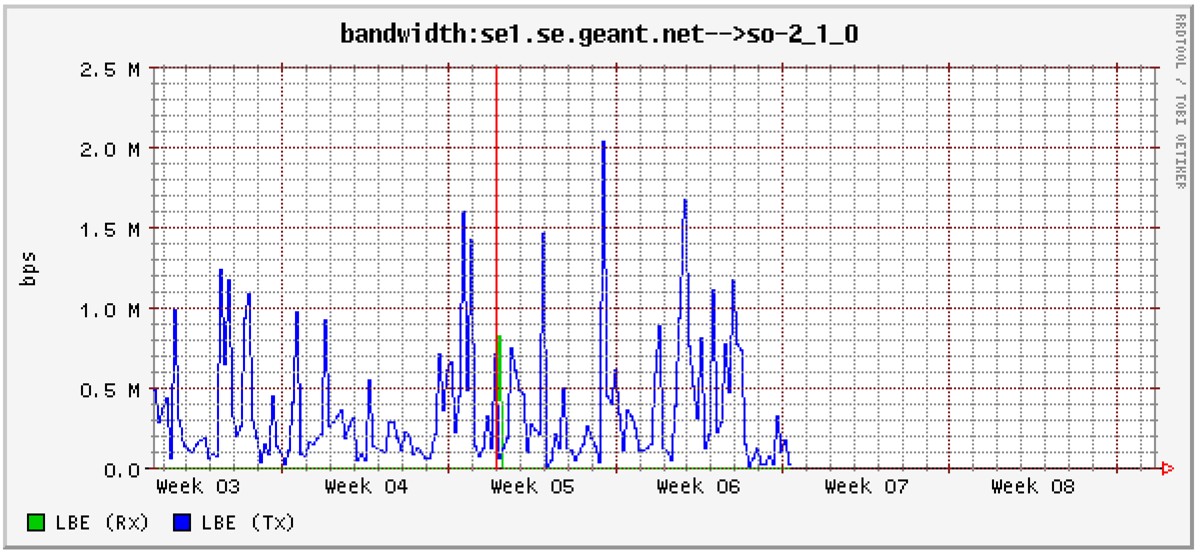

Fig. 17 Weekly LBE traffic statistics on the GÉANT link to Lithuania

Premium IP service graphs show very minor usage (few bps), which could be only for testing purposes.

3.12. AVAILABILITY OF NETWORK SERVICES IN PARTICIPATING COUNTRIES

3.12.1. Situation in Latvia

In Latvia, LATNET (Latvian NREN) the QoS is fully supported and requested service levels can be guaranteed for the customers. The exact amount of guaranteed traffic for each customer may depend on the local connection and should be specified in the SLA. This level can also vary depending on time (period of high message activity between modules and periods of high local calculation time in modules) and from application (more calculation intensive vs. more message intensive) that is running on the GRID.

According to the GÉANT agreement, only 10% of the total bandwidth can be used for the Premium IP traffic. In Latvian case it is 10% of 155Mbps, which means 15.5Mbps. It is obvious that this is very limiting and possibilities to enlarge the percentage of available Premium IP service should be investigated.

All used equipment in LATNET is DiffServ aware and can mark traffic according to the DiffServ specification, so it can be forwarded taking into account existing QoS specification.

The IMCS UL Grid cluster is connected to the Latvian GÉANT PoP with 100Mbps Ethernet connection, which is under an average load of 55%. QoS and traffic prioritisation on this link is available, but not used. If speeds more than 100 Mbps are required, then Latvian customers have to wait until GÉANT2 implementation which are predicted to be in May 2006. Then GÉANT2 PoP will be located near the Grid cluster, therefore implementation of higher speeds will be greatly simplified.

Connection of the RTU cluster to GÉANT2 is up to 100Mbps.

All institutions connected to LATNET can ask for guaranteed bandwidth service and NREN will implement it according to possibilities of physical connection.

3.12.2. Situation in Estonia

Currently EENet is connected to GÉANT by 622 Mbps connection to PoP in Copenhagen. In the future, there will be additional link to GÉANT PoP in Warsaw through Riga and Vilnius.

At the moment EENet does not offer Premium IP service and EENet does not have plans to provide it in the near future. EENet has 1Gbps links to main customers and also it has 1Gbps fibre-optic link between Tallinn and Tartu with possibility to upgrade to 2Gbps whenever it is needed. That capacity should be sufficient for EENet's clients for at least two years.

3.12.3. Situation in Lithuania

The academic network of Lithuania LITNET is not a partner of BalticGrid project, but as Vilnius University is a member of LITNET and a partner of BalticGrid project at the same time, there are no foreseen difficulties to conclude the SLA with LITNET.

A 622 Mbps link connects LITNET to GÉANT. All nodes of the BalticGrid project are located in two cities: Vilnius and Kaunas that are interconnected by 1 Gbps fibre optic. A new fibre optic cable was laid down between the two cities and the new 10 Gbps equipment will be launched during 2006. Very fast 10Gbps line connecting Vilnius University and LITNET will be launched at the same time. Other Lithuanian BalticGrid nodes are interconnected with 1Gbps fibre optics (except company BGM).

LITNET does not use IP Premium services yet, but plans to introduce such services in 2006. The tender for necessary equipment was announced recently.

3.13. NETWORK SERVICES RELEVANCE TO THE BALTICGRID

After exploring the available QoS classes most likely BalticGrid will be using all types of service classes. Premium IP will be used for Grid application-application messaging, also inter process and inter site rapid data transfer. Less than Best Effort IP traffic will be used for initial large volume data transfer between the Grids. Best Effort class IP can be used for routine Grid operations traffic and for service and control messaging between Grid managing nodes as well as in cases when Premium IP cannot be enabled. Also all monitoring functions related traffic can be forwarded as the Best Efforts class traffic.

4. NETWORK REQUIREMENTS FROM BALTICGRID APPLICATIONS

When looking at grid applications from the network requirements perspective, they can be roughly divided into two major groups, namely, applications that process pre-collected data and applications working on data acquired in real time. In the following subsections these groups are described in more details.

4.1. APPLICATIONS THAT PROCESS PRE-COLLECTED DATA

Applications of this kind are "usual" grid applications. They are usual in a sense that their input data is prepared ahead of the time and stored in a file and made available to a job when it executes. Of course the data files can be large and their delivery may be demanding on network resources, but these problems are mostly solvable by scheduling systems and BAR.

		Application name	Dataset size (GB)	Min. number of nodes	CEs communicate
HEP	1	CMS	10-300	1	✓
	2	ABINIT	10-300	1	
	3	MCIsing	10-300	4	✓
Material Sciences	4	GAMESS/GAUSSIAN	10-300	1	✓
	5	VPSM	10-300	1	
	6	ATOM	10-300	4	✓
	7	SFSEARCH	<10	4	
	8	SYMLECTIC1	<10	1	
	9.1	TestGen	<10	1	
	9.2	ASTRO	<10	1	
	9.3	Optimal Design	<10	1	
	9.4	FrontMove	10-300	1	
	9.5	DEMPARALLEL	<10	16	✓
	9.6	Scatter Solver	<10	4	✓
	9.7	Shgsolve	<10	1	
	9.8	NSMGT	<10	4	✓
	9.9	LOAD	<10	1	✓
Bioinformatics	10	AlignACE	<10	1	
	11	MEME	<10	1	
	12	Pratt	<10	1	
	13	SPEXS	<10	1	
	14	Trie*agrep	<10	1	
	15	CCP4	<10	1	
	16	CNS	<10	1	
	17	BiomedMining	<10	1	

Table 4-1 Application key requirements

Judging from the application descriptions considered by NA3 activity they all fall into this category. From the Table 4-1 we see that about 2/3 of applications need work on less than 10GB data sets. Data transfers of this scale should be easily satisfiable by the current GEANT network infrastructure.

The rest of applications (1, 2, 3, 4, 5, 6, 9.4) work on datasets from 10GB to 300GB. If this is to be an amount of data that needs to be transferred then this task might be challenging.

There is yet another aspect of networking worth mentioning in this category. A considerable part of applications collected by NA3 activity up to this moment use MPI. MPI works best if the communication is done using low latency interconnects such as *InfiniBand* and *Myrinet* between Computing Elements. These networks are short-range and thus are usually limited to a single cluster. But it is also possible to run these applications using ordinary networks keeping in mind that network latency may (and usually will) impact application performance dramatically depending on the use of MPI. This is a case where Premium IP (see section 3.2 on page 24) would have a great impact on the operation of BalticGrid.

4.2. APPLICATIONS WORKING ON DATA ACQUIRED IN REAL-TIME

The second class of applications work on data delivered in [soft] real time. In this scenario an application consumes and/or produces a stream of data over network. This communication usually happens between an applications that produces data (usually a sensor or some other data acquirement equipment) and a grid job, but may also be between two or more jobs or even between a job and an appliance.

As mentioned above, none of applications collected by NA3 activity need data delivery between clusters while the applications are running. But there might be applications of this kind in the future.

5. OVERVIEW OF NETWORK REQUIREMENTS FROM EGEE PROJECT

Apart from network requirements identified within the BalticGrid project (previous chapter), we consider it necessary to briefly review here also essential network requirements identified in the EGEE project [6], of which BalticGrid is a part of. The purpose of such review is to ensure that no essential and realistic (possible to implement) requirements have gone unnoticed in this BalticGrid requirements document.

5.1. NETWORK SCHEDULED RESERVATION

Ability to request for a scheduled reservation of network resources, i.e., with both the beginning and termination of the resources' reservation and thus availability to be in a future timescale.

It is common for Grid applications to know in advance of a future need for transmission of a certain amount of data. In those cases where it is crucial that network resources are available at the time when the data is ready for transmission, it is essential to have reserved the network resources from beforehand so as to ensure timely delivery of the data at the destination.

This requirement is addressed by the BAR (Bandwidth Advance Reservation) service developed within EGEE.

5.2. GUARANTEED DELIVERY TIME

It must be possible to reserve the resources required to ensure that a file is delivered by a certain date and time (respecting any policy restrictions, and so on).

Some Grid applications require that the output of a computation must be transferred to some target position on a relatively short timescale. This requirement should allow many separate jobs to work to a common deadline for applications like data reprocessing.

This requirement is addressed by the BAR (Bandwidth Advance Reservation) service developed within EGEE.

5.3. SCHEDULED CONNECTIVITY TEST

In order to collect data on the status of connectivity, regular ping tests should be performed. Those tests shall be run every 10 minutes for general information purpose. The scheduled test results on delay and packet loss- should be displayed in matrix format with the capability to display a sub-matrix corresponding to the choice of a sub-set of sites. Historical information should be available. Historical information provides a reference to evaluate current performances or the behaviour over the time. This test should be performed for the different type of services available.

The topology of the test to be run is unspecified ((a)full mesh between all the sites, (b) full mesh between all the sites of a region, (c) b + full mesh between regions, (d) c + e2e to major sites for a given application, etc)

This test is addressed by the EGEE NPM (Network Performance Monitoring) and specifically by the e2emonit toolset.

5.4. SCHEDULED THROUGHPUT TEST

Evaluation of the TCP throughput performance over the network (memory to memory tests). These scheduled tests are run every hour or every day to get an overview of the overall performances of the networks. SA1 would like to access historical plots. The data would be accessed regularly by the ROC several times a day.

Test accuracy: Rough accuracy (±100Mbps or ±10Mbps according to the application). The location of the tests boxes is very important to provide information as close as possible from the operational information (firewall, capacity, etc).Those tests should be performed for the different type of network services provided. It has been reckoned that those tests are quite network resource hungry and a well studied network measurement test topology should be set-up.

This test is addressed by the EGEE NPM (Network Performance Monitoring) and specifically by the e2emonit toolset.

5.5. USE STANDARD APIS

Network Services should use standard APIs and methodologies whenever possible. Possible examples might include: Workload Management Service interfaces, Billing, Information Services, Logging and Book-keeping Services. The WMS is designed to take into account the possible existence of Network Services. The use of standardised interfaces reduces the work required by each activity to design those interfaces, as well as reducing the work required to make use of implementations.

This requirement is addressed by EGEE NPM.

5.6. CONNECTIVITY TROUBLESHOOTING

In case of network problem, Grid NOC/ROC shall be able to perform following tests for troubleshooting.

- Ping for testing the reachability from one site to another one. Indeed it should be expected that they may want to trigger some ping test with some specific parameters to check the stability of the minimum, average and maximum delay values.
- Traceroute to show all the intermediary hosts. They may also want to know how long it takes for packets to get from their host to each hop as well as if packets get lost along the way, which can be useful in tracking network problems. Because of the asymmetric routing, it is usually a good idea to do traceroutes in both directions if possible when trying to debug network slowness. In doing so, crucial information that can help them to fix the network problem should be provided with.
- Evaluation of the TCP throughput performance as a typical measure of the effective rate between specific end points (i.e. Destination Address/Source Address/Port) across the network so that they can isolate the problem and eventually change the network configuration. To do so, they may require a TCP bandwidth estimator used to estimate the rate of a given flow.
- Port discovery to verify that TCP and UDP ports of a machine are accessible. They may want to have a multithreaded system, so that on fast machines they could scan ports in very a few seconds. They may require it has descriptions for the common ports and can perform scan on predefined port ranges.

On demand or in case of security incident ROC or NOC must be able to test TCP and UDP ports open of the RCs resources.

6. REQUIREMENTS FOR INTERCONNECTION TO OTHER GRIDS

Already the initial assessment of the existing Grid activities within the Baltic region shows that BalticGrid is likely to be a heterogeneous Grid network, where different applications and various international collaborations will need to be accommodated. These can be split in two major groups – collaboration with other EGEE grid community members, and collaboration with other grids worldwide. Both options are explored in the following sub-chapters.

6.1. INTERCONNECTION WITH EGEE GRID COMMUNITY MEMBERS

By design, BalticGrid is envisioned as an integral part of the EGEE Grid community, and thus close ties with other EGEE-related Grids are expected, such as sharing of VO and computational resources, application migration and intensive know-how exchange within EGEE community meetings and otherwise.

The members of the seminal EGEE project and the follow-up EGEE-II project form the core of the EGEE community. Along with CERN, it includes most of Western, Central, South-East and South-West European countries, Ireland, United Kingdom, Nordic countries, and Russia.

Based on the success of the SEE-GRID project (EGEE extension to South-East Europe: Albania, Bosnia-Herzegovina, Bulgaria, Croatia, FYR of Macedonia, Greece, Hungary, Serbia – Montenegro, Romania, Turkey), lately EU has funded several new regional projects aimed at extending the EGEE grid community worldwide. Along with BalticGrid being one of them, other projects extend the EGEE grid community beyond European continent to China (EUChinaGRID project), Mediterranean region (EUMedGRID project, includes Malta, Algeria, Morocco, Egypt, Syria, Tunisia, Turkey) and Latin America (EELA project, includes Brazil, Chile, Cuba, Mexico, Argentina).

Although no specific projects are under way currently, it is likely that Ukraine and Belarus will join the EGEE Grid community in the near future as well. Due to their physical and historic proximity to the Baltic region and Poland, BalticGrid might contribute to “gridification” of these countries.

The technical interconnection with EGEE Grid community members is likely to be achieved through the EGEE centralized interoperation mechanisms and GEANT network, having been put in place by the EGEE and EGEE-II projects. Close adherence to the EGEE and GEANT guidelines in the BalticGrid should ensure that BalticGrid becomes a fully integrated part of the EGEE, and thus has all necessary means to efficiently interoperate with other EGEE Grid community members. CERN participation in the BalticGrid project is enabling such an integration both on the technical and organizational level.

6.2. INTERCONNECTION WITH OTHER GRIDS

Due to EGEE the success and expansion beyond the European continent, the necessity to interconnect with other Grids worldwide is not foreseen as a priority for the BalticGrid project. Nevertheless, BalticGrid shall be open to such possibilities, if specific applications or international collaborations would require such interconnections. Here we list some of the possible interconnections of interest.

Nordugrid is an initiative of the Scandinavian countries in the Grid middleware development in parallel to EGEE. Although Nordugrid is likely to be superseded by EGEE middleware in the long term, for historic reasons it is still widely used in Nordic countries, along with some pilot installations in Estonia and Lithuania. Network interconnection with these Grids shall not pose any specific network requirements, as they all are part of GEANT network.

DEISA project is developing Grid solutions for a supercomputer-based infrastructure in Europe, applicable to a complementary set of scientific problems. Should there be any need to interconnect with DEISA, this could pose more networking challenges, as DEISA by default uses dedicated optical lambda (light-path) connections over fibre. At present international fibre connections in the Baltic countries are out of reach for scientific networking needs. Meanwhile the Porta Optica study is addressing this need for the future.

Finally, there are other large scientific Grids, like OSG (OpenScienceGrid, USA) and NAREGI (Japan). At present there is no active regional collaboration with any of these. If necessary, these interconnections shall be considered on the case-by-case basis along the guidelines set forth by GGF.

7. SUMMARY OF CHALLENGES

The Grid, by being a distributed, parallel, and networked processing of applications and services, could be viewed as a network of various elements, such as servers, computing nodes, storage devices. Their mutual collaboration is managed by Grid middleware, and it is highly desirable to make use of wide varieties of network services, as well as be able to perform network-aware Grid functions, e.g., storage management, scheduling. Thus the most essential tool to ensure effective operation and performance of Grid resources is the network itself.

The technical challenges that have to be faced during the implementation of BalticGrid project could be categorised into three groups:

1) software and hardware related;
2) network services related;
3) monitoring activities.

SA2 activity is addressing all those issues by implementing the following tasks:

1) development of Service Level Specification (SLS) taking into account specific needs of BalticGrid users;
2) development of Service Level Agreement (SLA) on the base of the said SLS;
3) conclusion of SLAs with the respective NRENs;
4) monitoring of the concluded SLAs.

All current Grid applications are developed for existent hardware platforms and often for specific set of software, which causes a lot of problems for interoperability between different clusters and managed network services of different NRENs.

7.1. HARMONISED IMPLEMENTATION OF NETWORK SERVICES

One of the main technical issues is related to the technical implementation of Premium IP. As no partner (EENet, LANET, LITNET) has experience in providing and requesting the service, a common system of the Premium IP request procedure should be implemented. Since LITNET is not a partner in the BalticGrid project, situation in Lithuania might be more challenging.

Currently in the GÉANT network there is no Service Level Agreement (SLA) for Premium IP. As stated in 3.12.1: “According to the GÉANT agreement, only 10% of the total bandwidth can be used for the Premium IP traffic. In Latvian case it is 10% of 155Mbps, which means 15.5Mbps. It is obvious that this is very limiting and possibilities to enlarge the percentage of available Premium IP service should be investigated.” To get best possible performance from Grid applications BalticGrid must make SLA enforcing Premium IP class service with all the involved NRENs which will be the next step taken by the SA2 activity.

Technical limitations of the Premium IP as identified in 3.2.1 are: “The maximum length of time a reservation can be made for is 3 months. A reservation can be made up to 3 months in advance. A request for more than 250Mbps Premium IP will require additional approval, and therefore more time in advance will be required.” This means that later in the project repeated study of BalticGrid applications should be performed in order to identify the need for advance network resources request procedure and more thorough scheduling and planning.

7.2. TECHNICAL CHALLENGES OF NETWORK MONITORING ACTIVITIES

As pointed out in 3.2.4: „Currently in the GÉANT network, no Service Level Agreement (SLA) is offered for Premium IP as the monitoring infrastructure allowing the SLA metric verification is still under study.” This brings forward a question of how to ensure that the requested bandwidth stated in the SLA has been delivered? In order to ensure SLAs the system for monitoring is to be implemented.

The monitoring system would also help to spot potential problems and take countermeasure in due time by local means or in cooperation with GEANT PERT.

Monitoring system should observe LBE traffic as well. Packet drop levels for LBE traffic should be monitored and problems addressed.

The current and historic load data for the GÉANT links is accessible for the NRENs (in the password protected area), and we should investigate if this can be used for the BalticGrid project. Additionally local monitoring systems of the NRENs could be used to create a separate system for the BalticGrid project needs. Because many Grid-based applications are exchanging messages between the Grid-involved sites, delay and packet loss are vital parameters to the whole operation of Grid and to the Grid-based application performance.

The measurements collected by the monitoring system should be analysed in order to identify trends and carry out measures necessary for the improvement of network services in due time. The monitoring system itself is one of the main technical challenges as any of NRENs are using their own system to monitor network traffic. Also the ways of monitoring the network performance should be agreed upon and implemented. Thus, the set of measured elements is to be identified and implemented in the BalticGrid monitoring system.

One of the options how to get the QoS and reliability and availability needed for BalticGrid applications is to use a technology like MPLS. Most of the Grids utilise an IP network. Another thing closely related to the use of MPLS is the possibility to set up high bandwidth, low latency high QoS connections between two distinct points. Considering MPLS and Grid, there are three basic estimations:

1) Grid assumes high performance IP network. Most of the service providers have elected to implement their high performance networks on top of MPLS.
2) Grid requires extremely low latency, extremely high QoS, extremely high bandwidth links - MPLS is optimized to deliver that.
3) Grid can be expected to generate any-to-any traffic, and MPLS is designed to deliver that.

Using MPLS within the BalticGrid is an opportunity. If Baltic NRENs make direct interconnects and bypass GÉANT, then there is no reason to use other QoS techniques than MPLS to achieve the goals essential for BalticGrid. This could be a step towards the ultimate goal of PortaOptica vision for cross-border direct optical connections between NRENs and setting up lambdas or paths for special projects, like BalticGrid.