FINAL REPORT ON THE BALTIC GRID NETWORK PROVISIONING AND MONITORING DATA ANALYSIS

Document Filename:	**BG-DSA2-5-v1-1-IMCSUL-FinalReport**
Activity:	SA2
Partner(s):	KTH, EENet, VU, ITPA
Lead Partner:	IMCS UL
Document classification:	**PUBLIC**

Abstract: during the Baltic Grid project Network provisioning activity studied network requirements put forward by various applications, developed Service Level Specifications and Service Level Agreements that have been signed between BalticGrid and National Research and Education networks in Estonia, Latvia and Lithuania. In order to supervise the implementation of Service Level Agreements, monitoring system has been designed, different network performance tests performed and analysed. Collected monitoring data are used to analyse network performance and identify existing and possible bottlenecks.

Document review and moderation

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Released for moderation to	Lauri Anton	EENet	23/04/2008	
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Document Log

Version	Date	Summary of changes	Author
0.1	21/2/2008	Plan and structure of the deliverable	Katrina Sataki
0.2	17/3/2008	Draft version of section 4.1.3	Baiba Kaskina
0.3	20/3/2008	Draft version of sections 2 and 3, updated section 3.1.3	Katrina Sataki
0.4	27/3/2008	Draft version of section 5.1.3	Karlis Podins, Janis Dzerins
0.5	31/3/2008	Draft version of sections 5.1.2, 5.1.4, 7	Guntis Barzdins
0.6	1/4/2008	Draft version of section 4.1.2	Martins Libins, Solvita Rovite
0.7	1/4/2008	Draft version of section 6	Katrina Sataki
1.0	2/4/2008	Draft version finalised	Katrina Sataki, Baiba Kaskina
1.1	4/4/2008	Draft version	Guntis Barzdins
1.4	29/4/2008	Revisions	Lauri Anton
1.5	30/4/2008	Final version	Katrina Sataki

Contents

1. INTRODUCTION

1.1. PURPOSE

The purpose of this document is to give an overview on the network provisioning for the Baltic Grid performed by SA2 activity during the whole project.

1.2. APPLICATION AREA

The progress of the Baltic Grid network provisioning during the whole project period is described and summarised here details to give an overview of the development and explain the main networking principles tested. Results of the project are applicable in other projects, including the extension of the BalticGrid project – BalticGrid II.

This document is intended for network support and monitoring specialists.

1.3. REFERENCES

[1] BalticGrid	Deliverable DAS2.1 : Overview of requirements for BalticGrid and interconnection to other Grids
[2] BalticGrid	Deliverable DSA2.2 Report on network Service Level Specifications for BalticGrid and draft Service Level agreement
[3] BalticGrid	Deliverable DSA2.3 Progress report on current Service Level agreements and their implementation in the Baltic region
[4] BalticGrid	Deliverable DSA2.4 Design and implementation of monitoring system
[5] Porta Optica study	Deliverable D3.3: Fiber Network Development Plan

1.4. TERMINOLOGY

ACRONYMS	EXPLANATION
BAR	Bandwidth Allocation and Reservation
CERN	European Organisation for Nuclear Research
CMS	Compact Muon Solenoid
diffserv	Differentiated services
EENet	Estonian Educational and Research Network
EGEE	Enabling Grids for E-sciencE
GÉANT	European Academic Network
HEP	High Energy Physics
JRA	Joint Research Activity
LATNET	National Research and Education Network of Latvia, renamed to SigmaNet in

	2007
LITNET	National Research and Education Network of Lithuania
NREN	National Research and Education Network
PoP	Point of Presence
QoS	Quality Of Services
SA	Specific Service Activity
SigmaNet	National Research and Education Network of Latvia, former LATNET
SLA	Service Level Agreement
SLS	Service Level Specification
VO	Virtual Organization

2. BASIC PRINCIPLES OF THE BALTICGRID NETWORK PROVISIONING

The goal of the BalticGrid project is to establish a production-quality Grid in the Baltic region. The main task brought forward by the SA2 activity is to manage and ensure:

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

The technical challenges 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 addressed 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 basis of the said SLS;
3) conclusion of SLAs with the respective NRENs;
4) monitoring of the concluded SLAs.

The first challenge of SA2 was to capture network requirements put forward by various users of the BalticGrid and model BalticGrid network according to the Service Level Specifications formalising these network requirements. To enact the model, Service Level Agreements (SLAs) were signed with NRENs in Estonia, Latvia, and Lithuania.

For BalticGird purposes two main strategies outlined in SLAs were proposed:

I – over-provisioning of network resources;

II – support for Quality of Service (QoS) classes.

Since over-provisioning is easier to implement and it requires less administrative efforts, it was defined as a prior strategy, leaving QoS as an optional strategy in cases when over-provisioning is not possible due to limited bandwidth availability.

In both cases SLAs determine the set of network parameters NRENs undertake to provide to the BalticGrid users. BalticGrid network monitoring system was set up in order to monitor available network bandwidth and other network parameters stated in the SLAs, as well as to identify and solve network bottlenecks in due time, monitoring system has been elaborated.

3. OVERVIEW OF THE BALTICGRID NETWORK AND ITS DEVELOPMENT

3.1. NETWORK OF THE BALTIC STATES BEFORE THE BALTICGRID PROJECT

BalticGrid network is built upon the GÉANT2 network. At the beginning of the project, GÉANT2 international connectivity for Estonia and Lithuania was 622 Mbps, but for Latvia – 155 Mbps. Those links were not used at full capacity leaving enough room for the needs of entire academic community.

A capacity problem, which was not identified by other GÉANT2 users, was clearly seen by Grid users requiring regular transmission of large data files. It was noticed when considering the GÉANT2 Premium IP (PIP) service specification, which by design is limited to only 10% of upstream bandwidth and shall be shared among all potential requestors. That meant that if high network demand applications[1] were to be executed in the BalticGrid clusters, only few CPUs could be fully used for that purpose due to the limited GÉANT2 link capacity.

3.1.1. Estonia

Estonian Educational and Research Network (EENet) is a governmental non-profit organisation 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.

At the beginning of the BalticGrid project the international connection of the Estonian academic data communication network via GÉANT2 was 622 Mbps (link Tallinn–Copenhagen). The internal backbone connected most counties of Estonia.

The average aggregated load of the GÉANT2 link to EENet was about 100Mbps, slowly growing. Few traffic (January, March 2005) peaks up to 700-900Mbps were observed, but their origin was unknown and likely was related to some network disturbances. Less than Best Effort traffic (LBE) in Estonia had 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. However, Premium IP traffic had not been used on the GÉANT2 link to Estonia.

At the end of 2006 the load of the GÉANT2 link to Estonia was approximately 15 %.

3.1.2. Latvia

The Latvian Academic Network LATNET was founded in 1992 (in 2007 renamed to SigmaNet) as a separate unit of the Institute of Mathematics and Computer Science in order to provide Internet services to the academic community of Latvia.

International connectivity of LATNET was via GÉANT2 network connection with 155Mbps capacity. The general trend was that traffic on the GÉANT2 link was doubling every year. Aggregated traffic statistics showed that since November 2004 incoming and outgoing traffic was between 10 and 20 Mbps. LBE traffic had been used in February 2006, but in very small amounts just for testing purposes. Premium IP service had not been used.

3.1.3. Lithuania

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.

[1] For example, CERN Atlas application that demands 12 Mbps upstream per CPU

A 622 Mbps link connected LITNET to GÉANT2. A backup link of 25 Mbps provided LITNET connection to Bite as a second high capacity link if urgently required.

The average load of the GÉANT2 link to Lithuania was about 300-400 Mbps. Since the total link capacity was 622Mbps, it was estimated that there would be enough bandwidth for first Grid users and Premium IP service.

Usage of LBE traffic on the LITNET link has been very minor, about 1-2Mbps.

3.1.4. GÉANT2 topology of the Region

The GÉANT2 project is aiming at the development of the GÉANT2 network - a multi-gigabit pan-European data communications network, reserved specifically for research and educational use.

GÉANT2 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 GÉANT2 backbone.

During the initial GÉANT2 project the following connectivity (see Fig. 1) had been set up in the Baltic region:

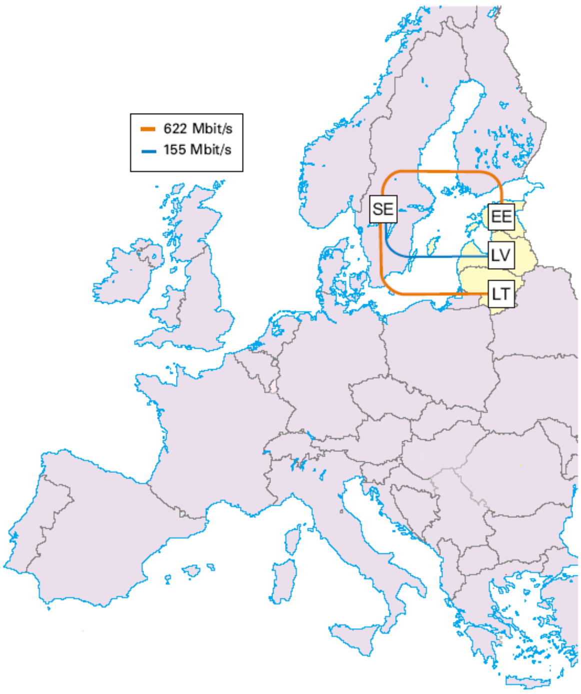

Fig. 1 – GÉANT2 topology in the Baltic region in 2006

In the follow up framework of GÉANT2 during 2006 2.5Gbit fiber optic lines are installed from Copenhagen to Tallinn, then to Riga, to Vilnius and to Poland (see Fig. 2). All NRENs, i.e., EENet, LATNET and LITNET, found a possibility to upgrade their international connectivity to 1 Gbps.

This is the state of network infrastructure also at the moment of writing this document, meaning the maximal possible GÉANT2 connectivity in the region being 2.5 Gbps:

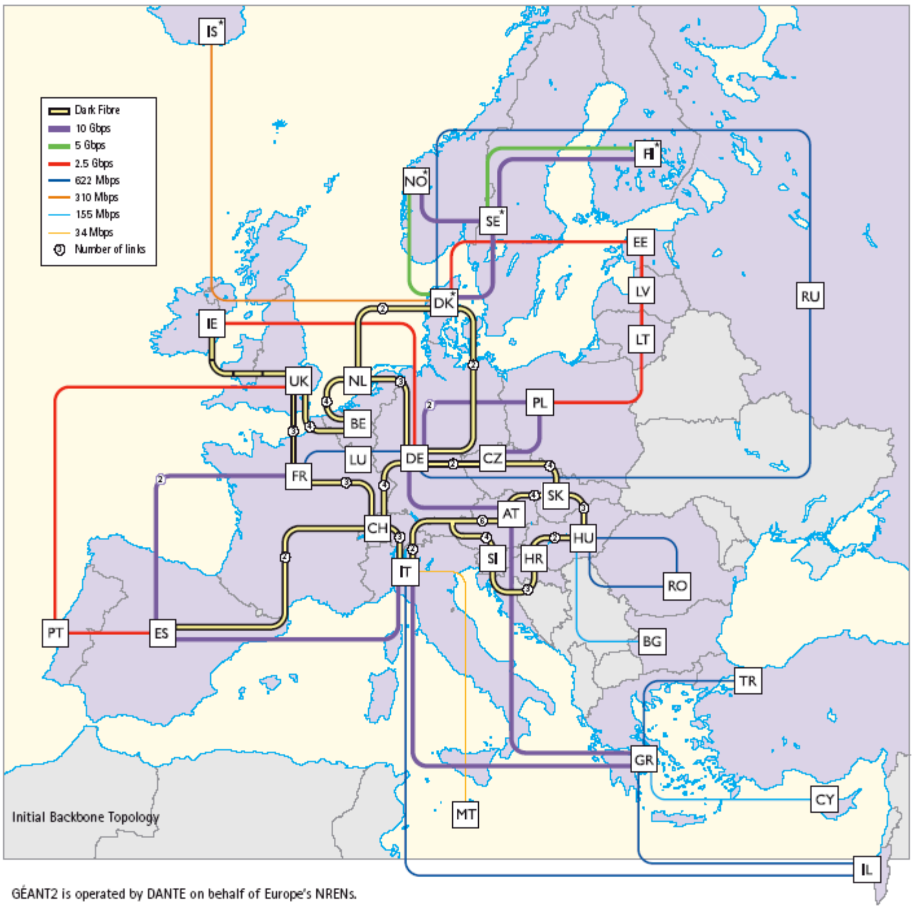

Fig. 2 – GÉANT2 connectivity since summer 2006

3.2. NETWORK REQUIREMENTS ANALYSIS

Grid applications from the network requirements perspective could be roughly divided into two major groups, namely, applications that process pre-collected data and applications working on data acquired in real time.

Applications that process pre-collected data 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.

The second class of applications work on data delivered in real time. In this scenario an application consumes and/or produces a stream of data over network.

To specify network requirements the need for more detailed application analysis was recognised and closer study of applications was conducted and summarised by the NA3 activity. One of the conclusions drawn from the potential BalticGrid applications survey was that network bandwidth requirements of identified applications were negligible compared to the available network bandwidth.

However, this analysis did not take into consideration applications, which other EGEE members would be running on the EGEE certified BalticGrid computing clusters, e.g., HEP experiments originating from CERN and others. Tests with HEP CMS application in the BalticGrid network showed that it had a major influence on the network traffic and generated between 400Mbps – 1Gbps traffic for the duration of several weeks – more than the rest of academic community in the region in total (!). This showed that also EGEE application requirements need to be taken into account for the future development of the BalticGrid network.

In the light of these considerations, for the initial planning purposes the best estimate was that the EGEE certified resource centres of the BalticGrid had to have at least 1Gbps capacity available between each other and towards the GÉANT2 pan-European network.

3.3. CONCLUSION OF SERVICE LEVEL AGREEMENTS

Within the SA2 of BalticGrid SLAs with the involved NRENs were developed and concluded. The said SLAs consist of two parts:

1) General provisions – this part sets out the substantive clauses setting out the legal basis for the cooperation between NREN and the BalticGrid project. These provisions also serve as guidelines to the interpretation of the specific provisions of the Agreement;
2) Specific provisions - technical service parameters which are offered and/or can be ordered.

General provisions of the SLA contain Administrative Level Objects (ALO) that include general information related to parties and the agreement itself:

- requisites of the Parties;
- purpose of the Agreement (includes the clause about the chosen SLA type);
- responsibilities of the parties: who is responsible for what, who are the contact persons, what are the expected reaction times of helpdesks etc.
- modification and termination of the Agreement

Specific provisions of the SLA contain Service Level Objects (SLO), i.e., regarding of the SLA type chosen Specific provisions list the actual technical service parameters which are offered and/or can be ordered.

In the case of over-provisioning of network resources it is necessary to define the very notion of over-provisioning and to state clearly what conditions of the network could be considered as over-provided.

In the case of QoS this part of the SLA contains definitions of parameters that could be ordered by the BalticGrid users.

EENet and LITNET agreed to provide enough resources for both Grid users and other GÉANT2 users, i.e., they signed agreement with over-provisioning option in the Specific provisions part.

The first SLA No SA2-2006/10-01 was signed with LITNET 16 October, 2006. The terms of agreement were discussed during the meeting between LITNET and BalticGrid representatives in Riga, Latvia. Both parties agreed that collaboration is mutually beneficial for the further development of networking in Lithuania.

LATNET, as one of the laboratories of IMCS UL – the partner within the BalticGrid project, saw an obvious need for collaboration. But it was not possible to offer bandwidth of more than 155 Mbps for international capacity due to the lack of network funding. Therefore the only option was to provide QoS management to ensure that all GÉANT2 users experience trouble-free bandwidth utilisation. Final version of the agreement No SA2-2006/10-01 was signed 27 October 2006. However, the BalticGrid project in Latvia was the major driving force for a historic upgrade of the GÉANT2 connection from 155 Mbps to 1 Gbps and the Ministry of Education and Science of Latvia covering the GÉANT2 costs. Thus, LATNET got an opportunity to improve its services and switch to over-provisioning. The procedure was initiated and modifications signed by both parties (19 April 2007).

Although EENet was the first to upgrade GÉANT2 connection from 622Mbps to 1Gbps, discussions between EENet and the BalticGrid project were the most extensive. One of the project partners, NICPB, from Estonia, wished to upgrade the connection between NICPB to GÉANT PoP from 1 Gbps to 2 Gbps. The investigation of the situation and possible solutions took more time than anticipated. Unfortunately for the time being it proved to be impossible to upgrade the connection. The agreement No SA2-2006/10-03 between EENet and the BalticGrid project was signed on 16 February 2007.

SLAs in all three Baltic states were established and the work on monitoring the adherence of agreement provisions was initiated.

4. NETWORK MONITORING SYSTEM OF THE BALTICGRID NETWORK

4.1.1. Principles of the Network Monitoring System

In order to ensure SLAs the system for monitoring network availability for BalticGrid resource centres was implemented and is publicly accessible at http://gridimon.balticgrid.org. This portal provides a convenient centralised view on the essential historic and real-time BalticGrid network parameters, thus serving as an excellent troubleshooting and SLA adherence monitoring portal. The monitoring system also helps to spot potential problems and take countermeasure in due time.

The measurements collected by the monitoring system are analysed in order to identify trends and carry out measures necessary for the improvement of network services. Establishing of the international monitoring system covering resources located within several independent NRENs serving BalticGrid resource centres itself was one of the main technical challenges as each of NRENs is using their own and generally incompatible system to monitor network traffic. BalticGrid network monitoring had to be overlaid on these heterogeneous network monitoring systems, as the intention was to integrate, rather than duplicate network monitoring systems of the involved NRENs

The primary goal is to monitor the network status, whether the Grid clusters are accessible, international links are up and the Grid resource centres at the user institutions are on-line. This information is typically collected by the NRENs from the network devices via SNMP protocol. The data is typically collected regularly, at least every 5 minutes. BalticGrid network monitoring portal is further retrieving this information in real-time from the monitoring systems of the involved NRENs, which have willingly cooperated with BalticGrid SA2 activity to make this information accessible to the BalticGrid.

The adherence monitoring has to focus on the relevant network performance data depending on which type of the Specific provisioning in the SLA is concluded.

If the NREN has agreed to provide over-provisioning, then the following network performance parameters should be collected and analysed on the monthly basis: packet loss, one-way delay, MTU, jitter, traffic load and available bandwidth.

Several of these parameters can be collected with SNMP data, including traffic load, available bandwidth, error counters.

To get results for other types of data, such as packet loss, one-way delay, jitter, an active monitoring process is used. Active measurements can provide information also about other network performance parameters which are not specified in the SLA, but can be useful to determine the cause of problems with data transmission speed and quality.

Soliciting of the proper network monitoring data for this portal was not a trivial task, because it turned out, that not all Baltic NRENs are monitoring all the essential performance parameters included in the signed BalticGrid SLAs. It was easy to obtain the actual traffic graphs for most links of interest for the BalticGrid, as this is the most popular parameter monitored by NRENs. But obtaining of more SLA-oriented graphs for packet-loss and packet-delay initially was not possible, as these parameters were not monitored. Meanwhile, these are the most essential parameters for actual data transfer performance measurement in the Grid environment, and therefore are essential to BalticGrid.

SA2 activity evaluated two options for obtaining packet-loss and packet-delay graphs – the EGEE developed E2Emonit and Cisco SNMP rping. Finally, SA2 sided with Cisco SNMP rping option due to its easier implementation in the NREN networks, already largely based on Cisco equipment.

Rping between devices has been implemented via specifically defined template within Cacti. This template is used to activate perl script rping.pl to execute commands on Cisco devices. Results are gathered and graphs showed in the template. The perl script was written by Omer Ansari in 2000, but it was not widely used by the Baltic NRENs. Some changes in the script were implemented by BalticGrid SA2 (e.g., to show SLA in a unified 100% scale) which allowed wide-spread introduction of this monitoring technique in the network serving the BalticGrid.

4.1.2. Operation of the Network Monitoring System

The network monitoring system http://gridimon.balticgrid.org is used by site administrators of the BalticGrid project to monitor all the necessary parameters of network links. This information is useful for providing stable network performance and for timely identification of possible problems.

Portal consists of 3 levels:

1. first level shows geographical apportionment of the monitored participants and the relevant international GEANT2 network topology (see Fig. 3);
2. second level is the technical diagram of the selected country network topology (see Fig. 4);
3. third level contains graphs of the monitored parameters (see Fig. 6 and Fig. 7).

At the moment of writing the portal contained data from 3 monitored countries: Estonia, Latvia and Lithuania (see Fig. 3).

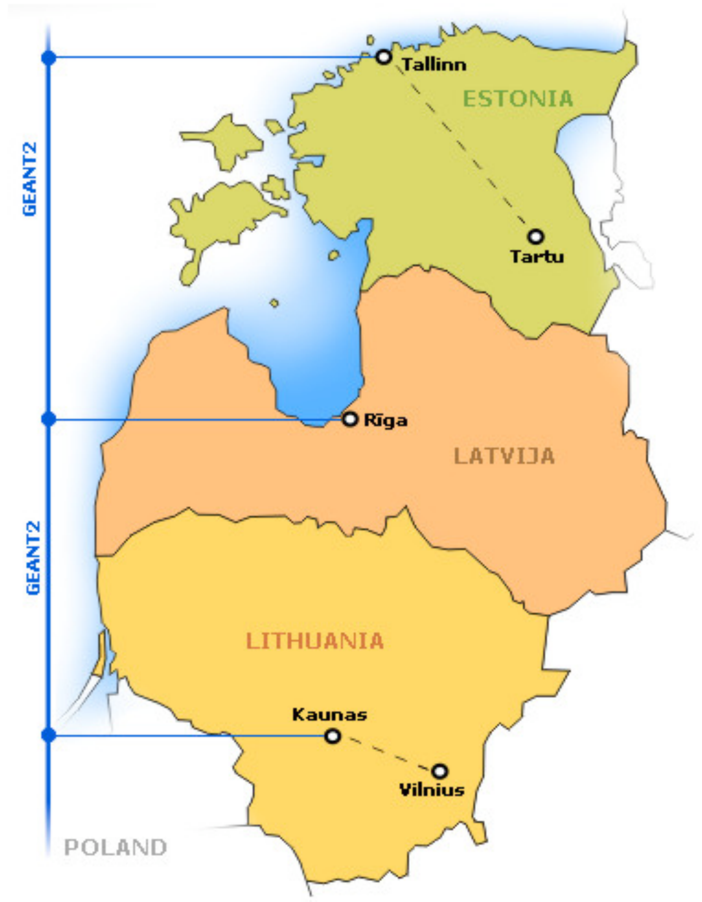

Fig. 3 – the first level of the monitoring portal

By clicking on the country map monitoring system goes in to the second level – network diagram of the country. See Fig. 4 as an example of the second level.

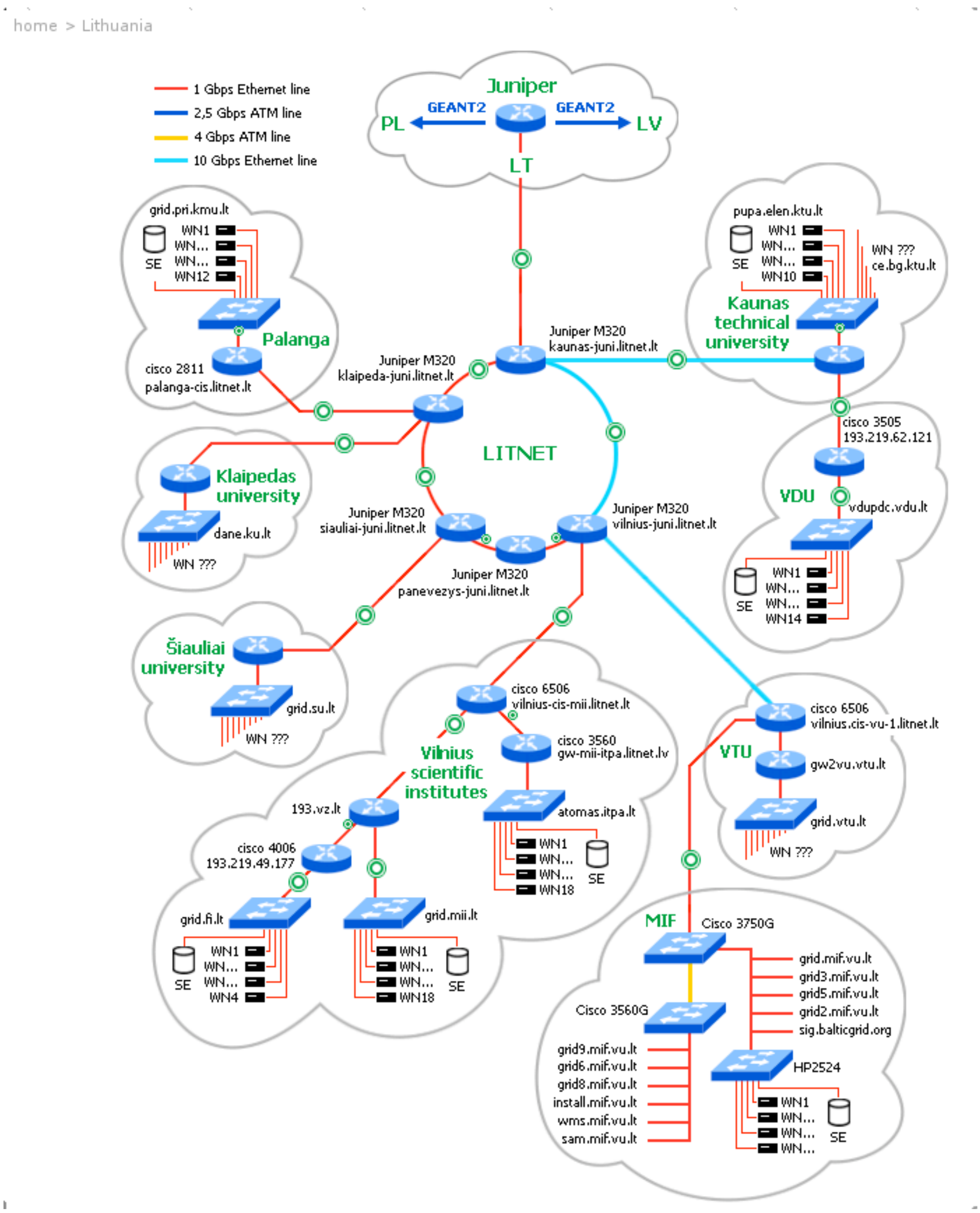

Fig. 4 – network flow chart of Lithuania

By clicking on the green points located in the middle of the links as shown in Fig. 5, a menu of the third level becomes available. In the menu there are shown all available monitoring parameters of the selected link.

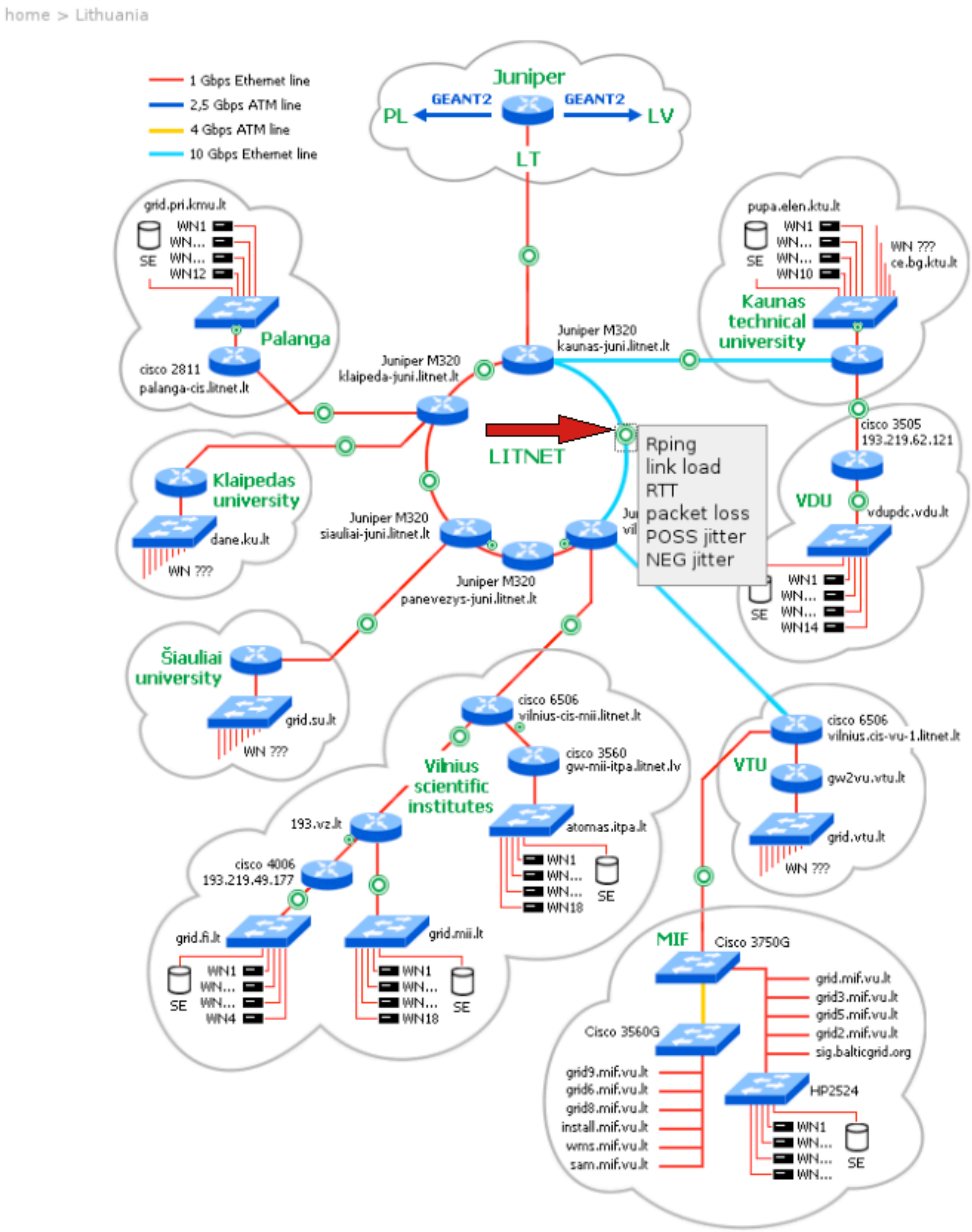

Fig. 5 – access to graphical monitoring information

By choosing one of the parameters (e.g., rping and link load) a graph is provided.

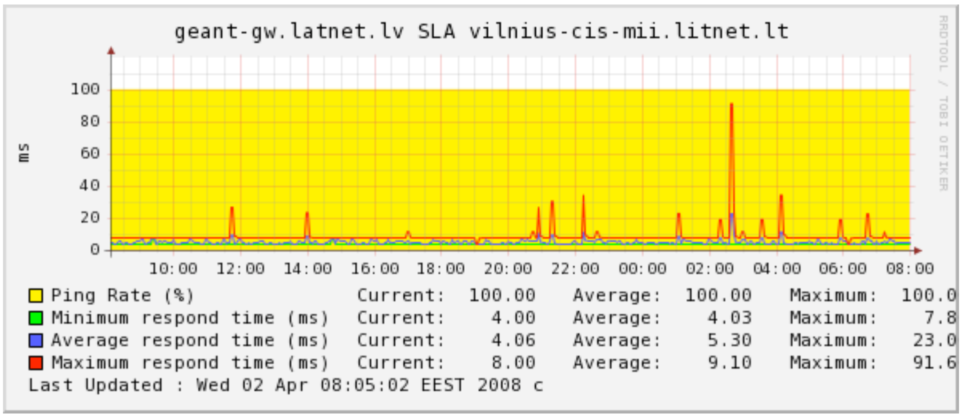

Fig. 6 – rping graph

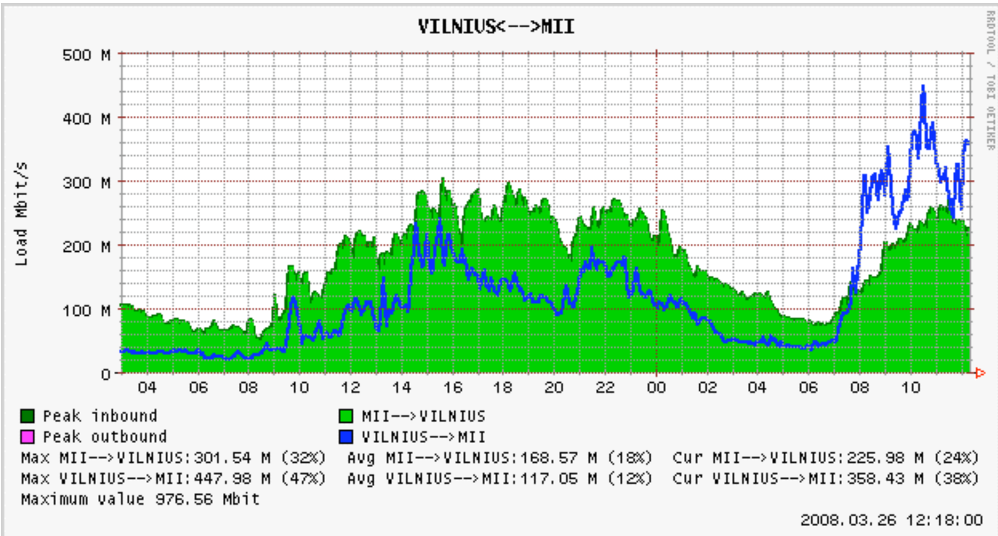

Fig. 7 – link load graph

Access to the Lithuanian graphs is restricted by LITNET to specified remote IP addresses which means users of the monitoring portal cannot directly access to the monitoring resources on the LITNET servers. To ensure the graphs are available to everyone in the BalticGrid they are fetched every 15 minutes by the BalticGrid monitoring portal and served further from there.

The structure of the monitoring portal allows accessing all the necessary information in one place and can be used for statistical purposes as well.

4.1.3. Integration of the Network Monitoring System with other services of the Baltic Grid

To facilitate the needs of the BalticGrid cluster administrators, during the last BalticGrid AHM meeting in Stockholm (December, 2007), it was decided to consolidate all monitoring data about the BalticGrid resources from different sources in one place. This consolidated information page would provide the administrators with compact overview of not only network-related monitoring data, but also monitoring data collected through other systems about the CPU load, job queues and cluster utilization and other parameters of their clusters.

The construction of such consolidated information page was not envisioned by the BalticGrid project, therefore timeframe for complete implementation of this will likely extend beyond the end of BalticGrid project.

The following monitoring information is available about the BalticGrid resources:

1. Network utilisation information, which is provided by each respective NREN in a different format and layout. In spite of the differences, however, this information is always based on SNMP data, later processed by Ganglia, Cacti, MRTG, Cricket or similar tools. This information is collected by the BalticGrid Gridimon portal (http://gridimon.balticgrid.org/) and displayed in a unified manner for the each monitored link. See Fig. 8, Fig. 9, Fig. 10 as examples of the data utilisation information available about the BalticGrid network resources.

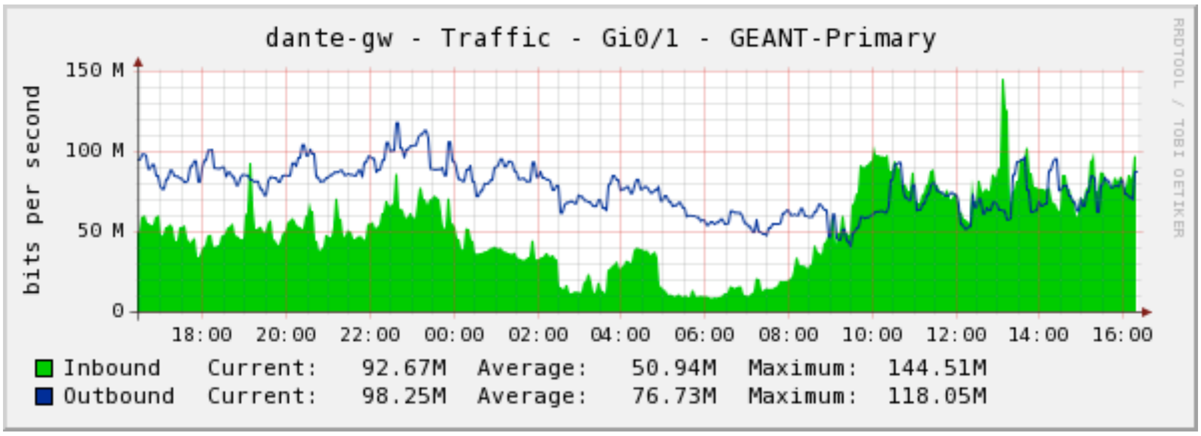

Fig. 8 – Example of network utilisation data from Latvia

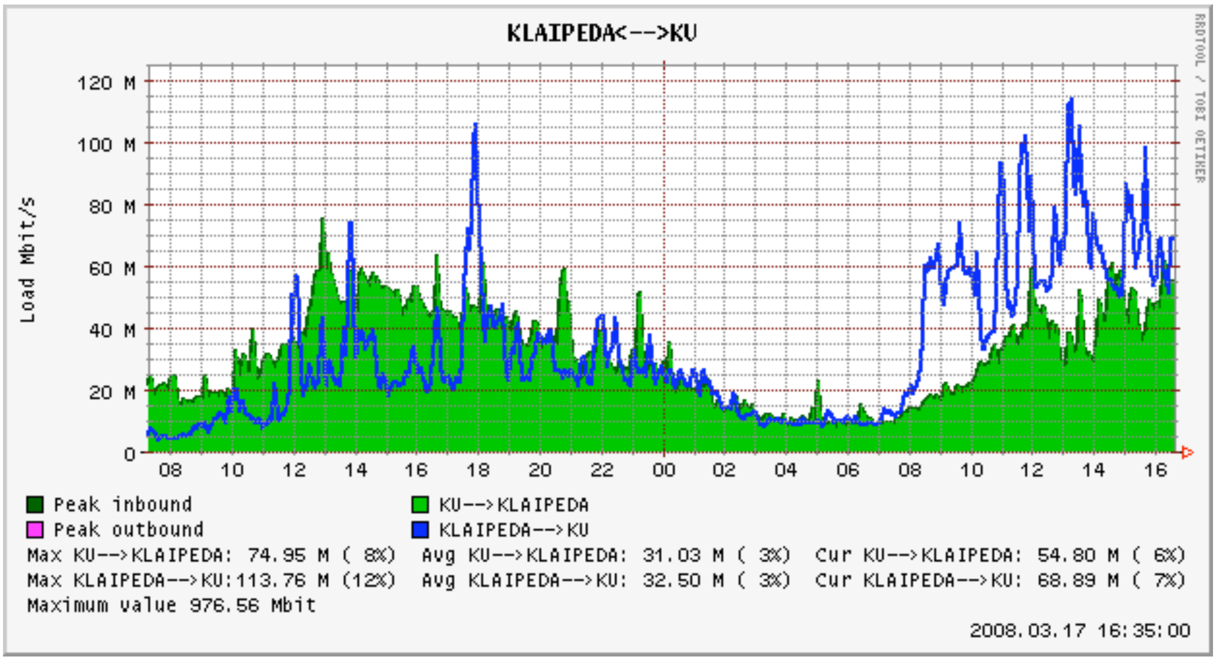

Fig. 9 – Example of network utilisation data from Lithuania

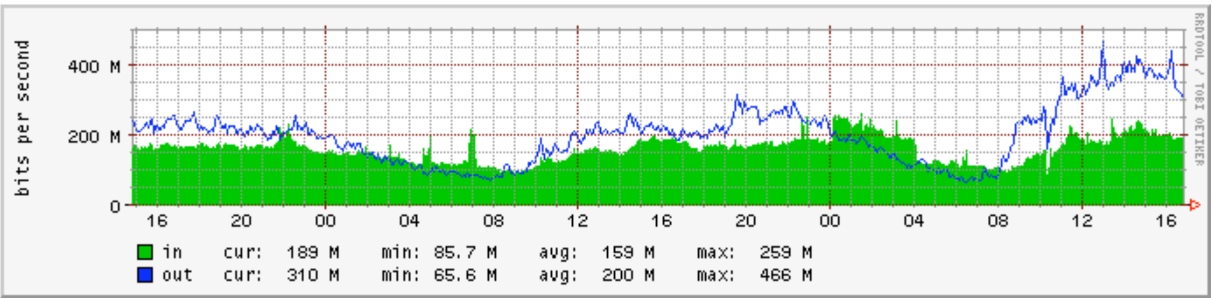

Fig. 10 – Example of network utilisation data from Estonia

These data are collected by Gridimon, but in the case of the consolidated information page they would be taken from the source points, i.e. monitoring portals of EENet, LITNET and SigmaNet (former LATNET). Monitoring data from Poland and Sweden, where some BalticGrid clusters are located, is not included in the Gridimon portal currently, but could be included in the consolidated information page.

2. Rping data show the connectivity monitoring information for the particular link and particular cluster. These data provide possibility to evaluate the quality of the connection and to see how the quality of the connection corresponds with SLA (Service Level Agreement) in long term. See Fig. 11 – as example of the available rping data about one of the Grid clusters in Lithuania. Rping data about all Grid clusters is available from the Gridimon (http://gridimon.balticgrid.org) portal.

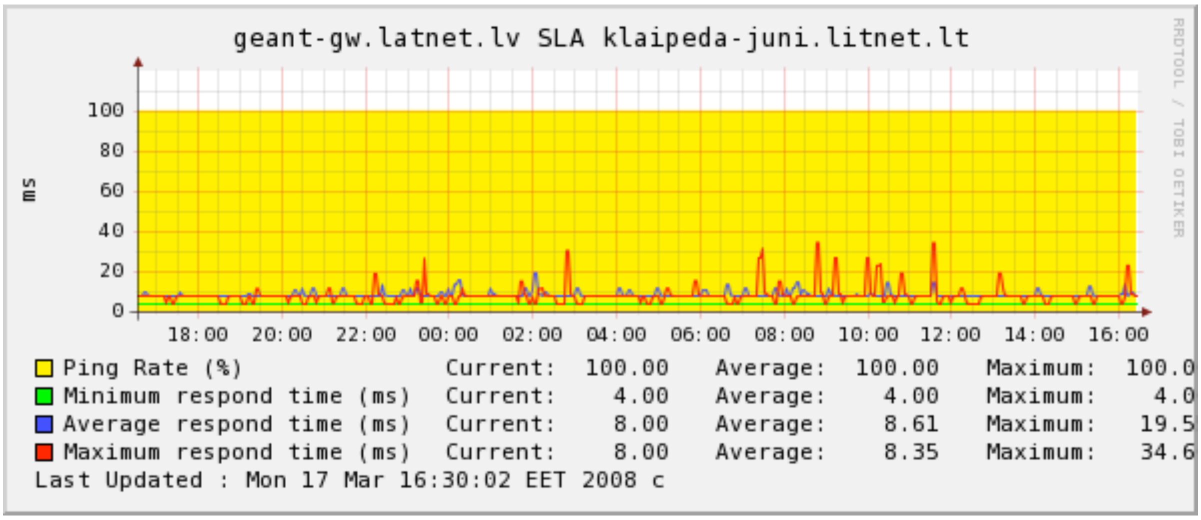

Fig. 11 – example Rping data

Direct link to the graphs for each cluster would be provided from the consolidated information page.

3. Job statistics provide data from the BAT client about each particular Grid cluster – how many jobs are in queue, how many are in the progress and how many have been executed. These statistics are generated separately for each cluster and each virtual organisation. See Fig. 12 – an example of job statistics in the RTU cluster. Job statistics are provided by the http://grid.cyfronet.pl/bat/ portal. The consolidated information page would include direct links to the graphs about the particular clusters.

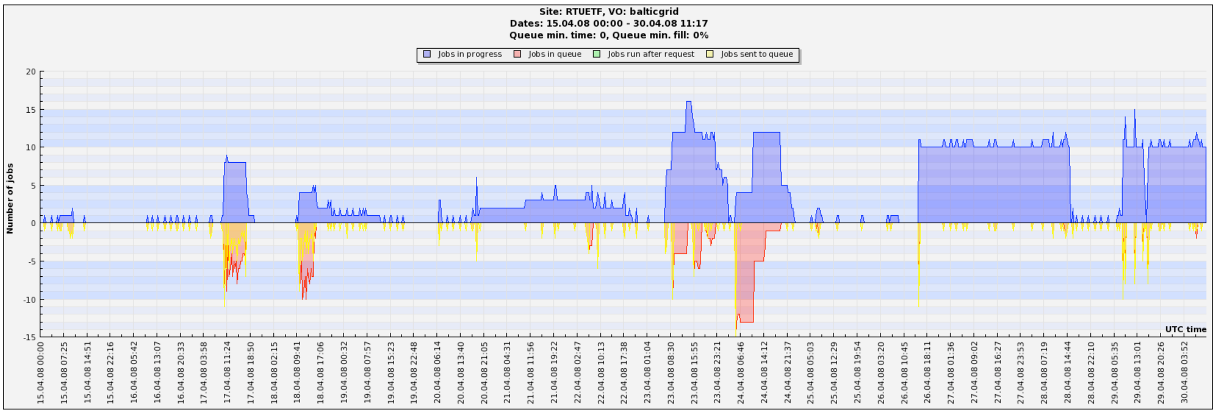

Fig. 12 – example of the job statistics data

4. Summary of the information about the status of the particular cluster is available from http://infosite.balticgrd.org/. For example, see EENet Grid cluster statistics on Fig. 13.

Computing Element(s)

CE	OS	CPU type	CPUs	Memory	Other inf

kriit.eenet.ee	Scientific Linux 3.0.6	AMD Athlon 2100 MHz	6	512	SAM | GStat

Storage Element(s)

SE	Total space	Free space	gsiftp endpoint	gsiftp port
kriit.eenet.ee	2002579 Mb	367205 Mb	gsiftp://kriit.eenet.ee	2811

Fig. 13 – example of the cluster statistics.

Data from these four sources would be gathered together under the general information portal http://infosite.balticgrid.org/ for the BalticGrid cluster administrators. There will be a separate section for the cluster administrators, where by choosing their cluster they would be provided with information extracted from other sources about their clusters. By clicking on each particular graph it would be possible to get easily redirected to the original source of data where more data and statistics are available.

It was decided to show only 1 day graphs in the consolidated page, so that the newest information is available for the cluster administrators. If they need older information or comparison with the same day of the week a week ago, they are able to access this information in the source portals, where it comes from.

The developers of this consolidated page faced difficulties because the BAT client provided graphs for two days, but other sources – only for one day. It was investigated that changing the size of the utilization and rping graphs to two days would require significant programming effort, therefore it was decided to stick to the original format provided by each portal without alternations.

The consolidated monitoring information page for the cluster administrators is under construction and will be available soon.

5. MONITORING DATA ANALYSIS

5.1.1. SLA adherence monitoring

SLA adherence monitoring in BalticGrid was conducted manually through regular review of collected monitoring data. The observed performance degradations were communicated to the respective NREN representatives for further investigation.

The collected monitoring data shows that generally Baltic NREN networks provide adequate service adhering or exceeding the requirements of the SLA agreements concluded with the BalticGrid project. The few observed network performance degradation cases were thoroughly investigated.

Following are examples of the problematic cases identified and investigated:

- BalticGrid cluster in IMCS UL has been temporarily connected by local NRENs to the GÉANT2 network via 100Mbps Ethernet Switch port, instead of 1Gbps Ethernet Switchport normally used,
- BalticGrid cluster traffic has been temporarily misrouted via commercial Internet provider during reorganisation process at Latvian NREN,
- BalticGrid clusters in Estonia from February 2008 are suffering from periodically overloaded 1Gbps EENET connection to GÉANT2 network. Capacity upgrade there is still pending,
- Initial traffic bottlenecks in Lithuania on the path to some BalticGrid clusters, especially ITPA.

This list of some identified and investigated problems illustrate the usefulness of the implemented SLA adherence monitoring system at http://gridimon.balticgrid.org as well as the usefulness of the concluded SLA agreements with NRENs – they have ensured the close and willing cooperation of the BalticGrid project and Baltic NRENs in investigation and resolving of the identified problems.

On the technical side, we would like to stress the exceptional value of rping monitoring included in the BalticGrid network monitoring portal. This kind of monitoring is the least intrusive, allows efficient QoS monitoring of all network links, even those, for which local NREN has no specific monitoring available. It also correlates closely with the actual QoS experienced by the Grid users.

5.1.2. Identification of the existing and future bottlenecks in the network

Tests performed in order to identify available network capacity (stress tests) show that when using UDP, available bandwidth is close to its maximum possible value, but, since GridFTP is TCP-based, in everyday grid usage scenario, when users are moving large files, the importance of TCP performance is much higher.

SA2 team tested bandwidth between birzs.latnet.lv cluster and other BalticGrid clusters and varied number of parallel TCP connections. The tests show unexpected variation in transfer speed per one TCP connection. Some clusters, namely g03n02.pdc.kth.se and dangus.itpa.lt are more than 10 times faster than all other BalticGrid clusters, despite all measured clusters having gigabit (or faster) links to the BalticGrid infrastructure (see 14). In order to get optimal data transfer speed on slower clusters, multiple TCP connections should be used in parallel. This should be taken into consideration when using grid and also clearly indicates room for improving cluster network performance.

Number of TCP connections needed to reach maximum possible bandwidth depends greatly on the selected end-point clusters and their network load. Extensive performance measurements were spread over longer period of time to minimise network stress-testing influencing the production environment of the BalticGrid as little as possible.

Network testing has been carried out using *iperf* bandwidth measurement tool.

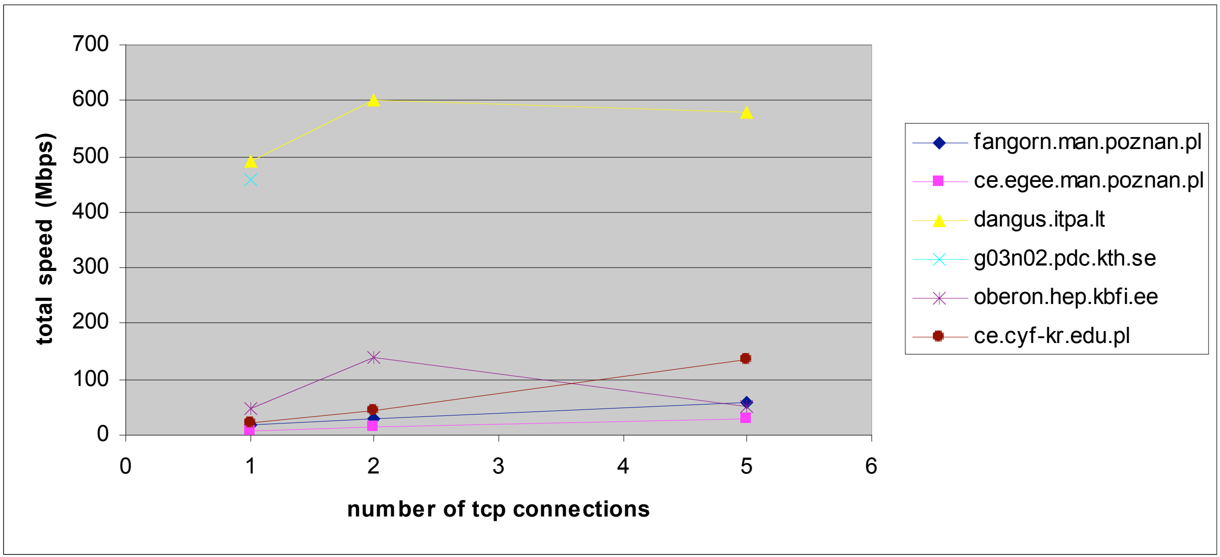

Fig. 14 - available bandwidth for clusters with gigabit (or faster) link to BG infrastructure

Measurements with 1, 2 and 5 parallel connections were made. As seen in Fig. 14, bandwidth for dangus.itpa.lt and g03n02.pdc.kth.se clusters clearly exceeds that of other clusters.

Measurements with 1, 2 and 5 parallel connections also showed a remarkable difference in bandwidth per one connection between clusters, e.g., spektras.itpa.lt and grid9.mif.vu.lt reach speeds close to the maximum possible (see **Fig. 15**).

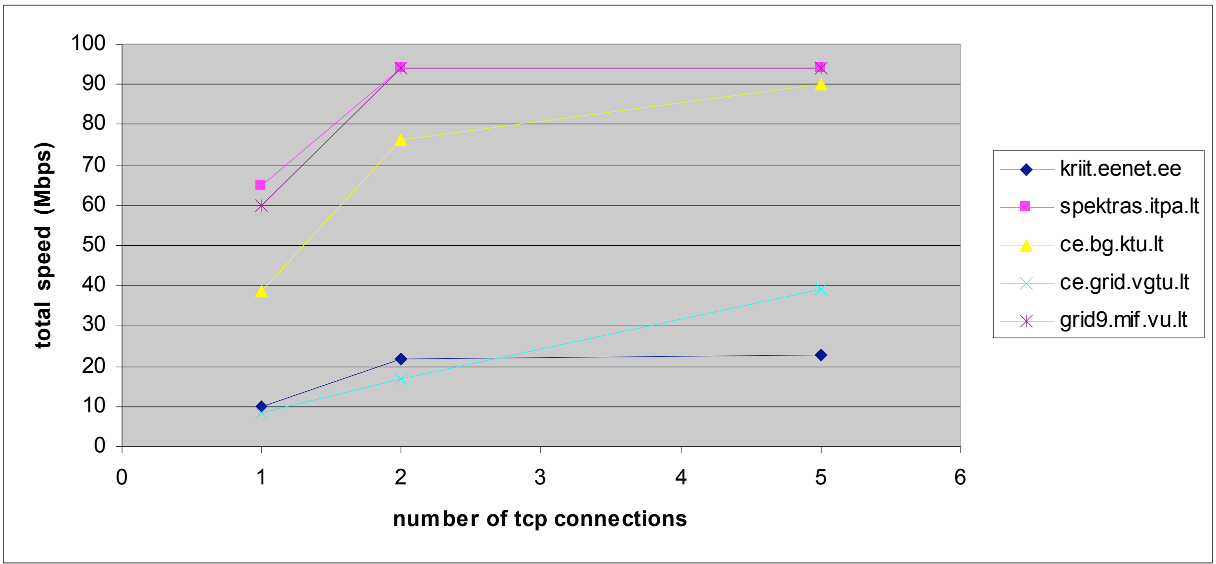

Fig. 15 - total bandwidth for clusters with 100Mbit link to BG infrastructure

Measurements with 1, 5, 10, 20, 40, 60 and 80 parallel connections were also performed. Steady growth in total speed can be observed from 1 to 20 parallel connections. The growth of speed per one connection starts to decrease when having 20 parallel connections. Total speed decreases after the maximum total speed of about 700 Mbps is reached at 40 connections (see Fig.16).

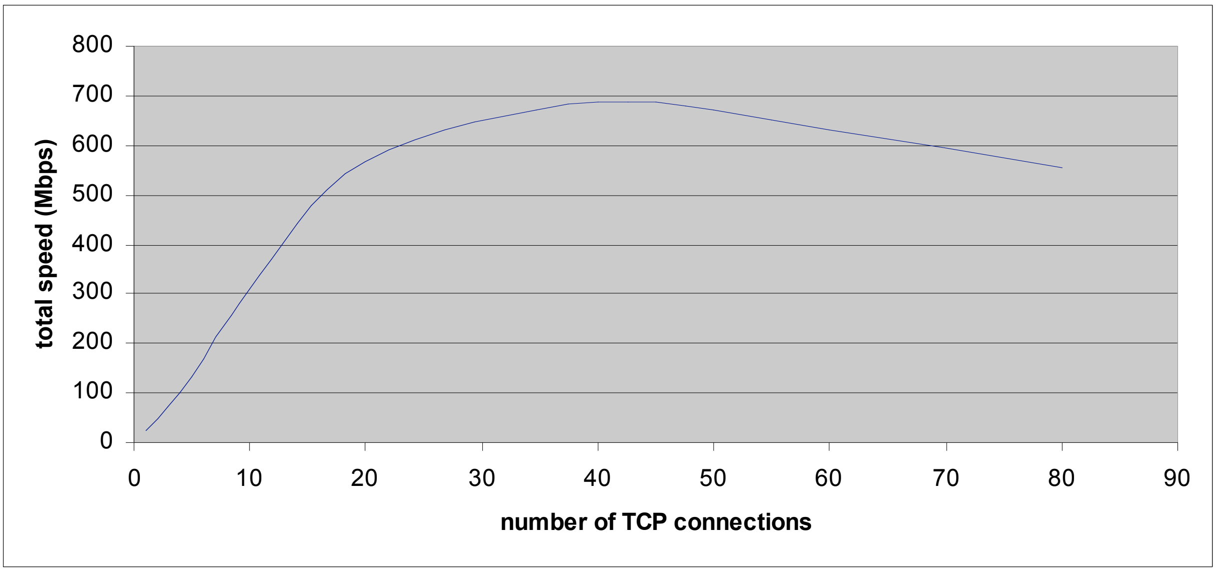

Fig. 16 - total bandwidth for ce.cyf-kr.edu.pl cluster

Cluster	max connection speed	number of tcp connections		
		1	2	5
fangorn.man.poznan.pl	1000	19	31	57
kriit.eenet.ee	100	10	22	23
ce.egee.man.poznan.pl:	1000	8	15	28
spektras.itpa.lt	100	65	94	94
dangus.itpa.lt	1000	490	600	580
ce.bg.ktu.lt	100	39	76	90
ce.grid.vgtu.lt	100	8,3	17	39
grid9.mif.vu.lt	100	60	94	94
g03n02.pdc.kth.se	1000	458		
oberon.hep.kbfi.ee	1000	47	140	53
ce.cyf-kr.edu.pl	1000	22	45	134

Tab. 1 - Achieved speed - overview of test results

5.1.3. Summary of the Network data analysis

To summarise, the network performance monitoring approach selected by the BalticGrid project has turned out to be highly successful. It has fully met the needs of the project and its users, as well as has been communicated to other EGEE member networks through several occasions.

The key novelties introduced in the network monitoring by BalticGrid project are concluded SLA agreements with involved NRENs and implementation of the overlay network performance monitoring portal, which collects monitoring data from involved NRENs, as well as performs independent rping QoS monitoring for SLA adherence measurements.

6. FUTURE DEVELOPMENT OF THE NETWORKING IN THE BALTIC STATES

The future development of the networking in Estonia, Latvia and Lithuania is outlined by the Porta Optica Study Project funded by the European Commission under the FP6 contract no. 026617 [5].

Development plans for Estonia include connecting 13 cities to the high speed fiber network backbone with speed 1-10 Gbps. The most important research centres in Estonia are in Tallinn and in Tartu, in addition there are higher education institutions situated in 7 other towns: Narva, Rakvere, Viljandi, Pärnu, Haapsalu, Türi (all assigned with higher priority) and Kuressaare (slightly lower priority). Over 1100 km of intercity dark fibre is needed to connect all these cities. In the first phase one cross border connection with Latvia is planned – between Valka nad Valga.

Development plans for Latvia include connecting 20 cities to the high speed fiber network backbone with speed 1-10 Gbps. Over 1035 km of intercity dark fibre is needed to achieve this goal. In the first phase two cross border connections are planned – one with Estonia and one with Lithuania.

Development plans for Lithuania include connecting 14 cities to the high speed fiber network backbone with speed 1-10 Gbps. Over 580 km of intercity dark fibre is needed to achieve this goal. In the first phase two cross border connections are planned – one with Latvia and one with Poland.

Of course, the actual network development will highly depend on the financial resources available and political will of the governments.

7. CONCLUSIONS

All three NRENs from Estonia, Latvia and Lithuania agreed on collaboration with the BalticGrid project and expressed their readiness to provide high quality service by signing the Service Level Agreements. During the course of the BalticGrid project, all three NRENs have also upgraded their GÉANT connections to 1Gbps, largely due to the needs of BalticGrid project. Meanwhile these upgrades in turn have benefited the academic communities of the respective countries.

The network performance monitoring approach selected by the BalticGrid project has turned out to be highly successful. It has fully met the needs of the BalticGrid project. Concluded SLA agreements with involved NRENs and implementation of the overlay network performance monitoring portal, which collects monitoring data from involved NRENs, as well as performs independent rping QoS monitoring for SLA adherence measurements ensure the overall network resource provisioning to all interested users.

The initial set of network stress-tests showing wide variety of TCP file transfer performance between different BalticGrid clusters have helped to identify a vital bottleneck in the current Grid infrastructure in the Baltic countries, that will be addressed in the follow-up project of BalticGrid.