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Deliverable D5.1 - Proof of Concept Testbed

Addendum

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Abstract:

During the course of the project a model for QoS provisioning in GÉANT network has been defined and implemented as the IP-Premium service. Several test scenarios have been performed in multiple-domain environment including five European NRENs and GÉANT network. H.323 traffic patterns have been identified and used in traffic simulators for metric measurements. This deliverable describes the results of test-case setup, which involved real users of H.323 video

Keywords: QoS, GÉANT, IP Premium

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EXECUTIVE SUMMARY

This addendum describes the efforts made to check the feasibility of the proposed IP-Premium implementation in production networks, with the strong emphasis on end-to-end QoS delivery.

It is organized as follows: the background for the testing process is contained in the Introduction. The test-case topology is described in Section 3. Section 4 presents a test scenario, then Section 5 describes the measurement techniques and monitoring infrastructure used for experiments. Section 6 lists end-point equipment configuration. Finally, the sample representative results and their evaluation are presented in Sections 7 and 8 respectively.

1 INTRODUCTION

The initial work of the SEQUIN project (Service QUality across INdependently managed Networks) focused on the definition of the IP-Premium service and its implementation architecture [1][2]. The implementation model was validated with a number of proof of concept tests, but only tests using production networks provide fundamental feedback on the feasibility of the proposed architecture. Four of the NRENs (GARR B from Italy, GRNET from Greece, GWiN from Germany and SWITCH from Switzerland) together with the GÉANT network, have conducted test-cases on production networks involving external users. It was important to select a group of users with good understanding of QoS requirements and implementation, therefore users from the TERENA TF-STREAM community [3] were selected as this Task Force performs research on and tests of real usage and scalability of audio/video streaming and conferencing tools and techniques.

2 TESTBED TOPOLOGY

The implementation of the Premium IP services on an end-to-end scale in the European environment means that traffic crosses multiple domains [4][5]. The test-case involving end-users was designed in such way to reflect the complexity of a multi-domain heterogeneous pan-European network.

The test-case is composed of four high and lower speed national networks connected via the GÉANT backbone, connecting six testing locations. Such a composition reflects the real world, where the coexistence of different types of networks and QoS techniques is very common .

The core network (GÉANT) is built with the use of 10Gbit/s and 2.5 Gbit/s POS technology and Juniper routers. Access networks connect to the GÉANT with 2.5 Gbit/s POS links, except for GRNET, which connects with 2x155Mbit/s ATM links.

The detailed H.323 network topology has been depicted in Figure 1, page 5.

The locations in Germany [6] are connected by the G-WiN network to GÉANT. The local sub-network at the campus of the University of Stuttgart (RUS) is connected using the G-WiN core network to the other local network - FOKUS in Berlin. This connection is made with an STM-1 SDH point-to-point circuit. Both networks connect through Cisco 7200 routers to the G-WiN IP network, which carries the traffic to the GÉANT.

GRNET [7] is connected to the GEANT core in London with two ATM 155Mbit/s links. The border router, a Cisco 7507, is connected with Gigabit Ethernet interfaces with the main backbone router, a Cisco 7513. The latter is connected with 2Mbit/s PCM link with a Cisco 1750 router, which is directly connected with the videoconference equipment through an ethernet LAN.

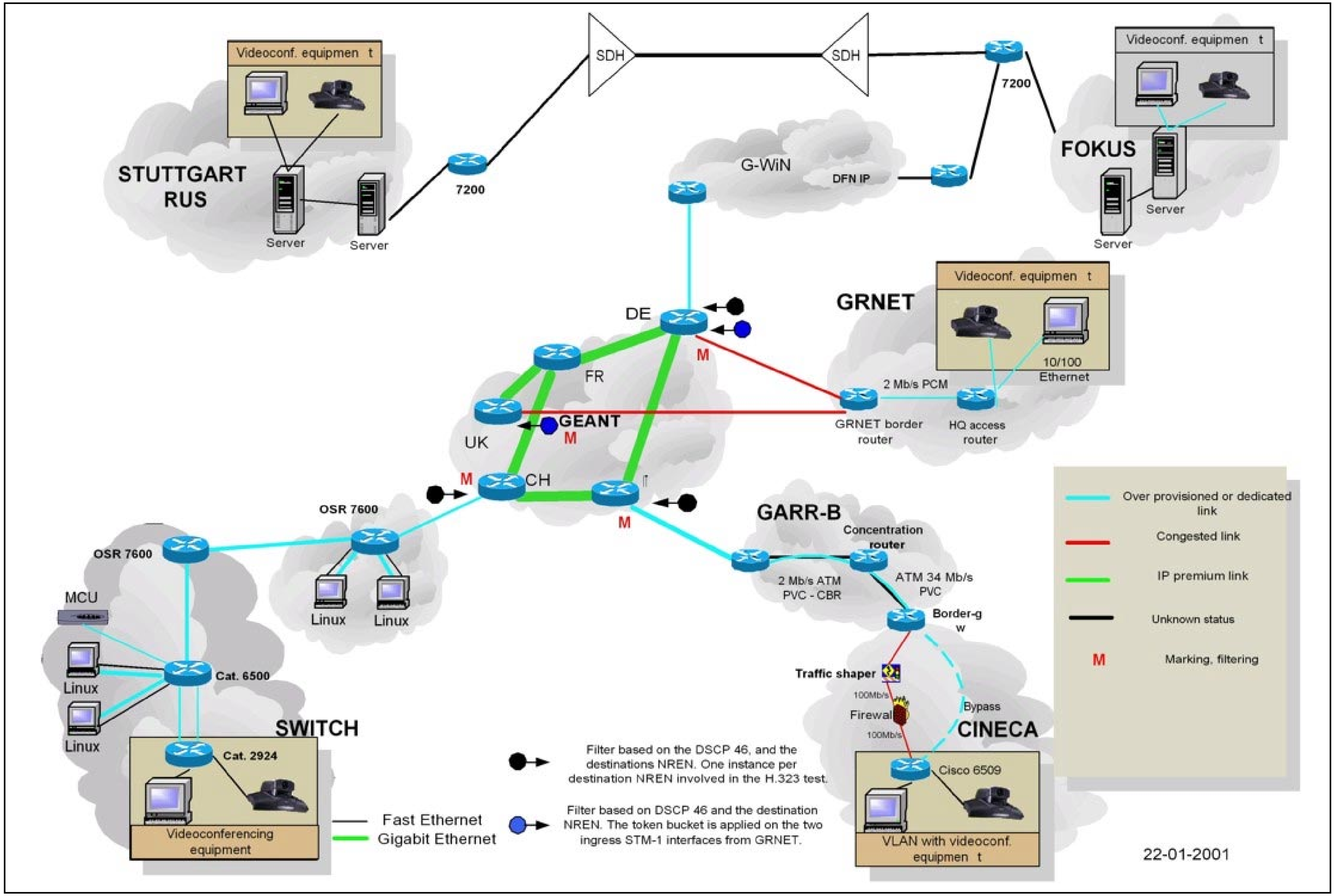
[7] Greek Research & Technology Network (GRNET) http://www.grnet.gr/technical_en.html

The Italian GARR-B network provides connectivity for H.323 users in CINECA. GARR-B [8] is built with an ATM technology and uses a Cisco 12000 router with POS 2.5Gb/s interface to connect to the GÉANT network. An ATM 2Mbit/s PVC-CBR channel has been set up to ensure the connectivity between CINECA and the GARR-B border router to GÉANT. At the CINECA side the videoconferencing equipment is connected to Cisco 6590. On a path between this device and a border router to GARR-B, there is a firewall and traffic shaper that can guarantee and enforce capacity limitations per source or application. There is also an extra connection installed to bypass the LAN devices and connect directly to the GARR-B router.

The SWITCH network consists of two parts: the first in CERN, Geneva [9] and the second in Swiss Federal Institute of Technology (ETHZ) in Zurich [10]. The network's part in CERN provides connectivity to GÉANT using a 2.5 Gb/s link. CERN hosts SWITCH's Cisco 7600OSR router, which is connected to the same type of router on ETHZ side with Gigabit Ethernet link.

The H.323 equipment is located on the ETHZ premises and uses Cisco 6500 to connect to the ETHZ Cisco7600 border router with Gigabit Ethernet link.

Figure 1 Detailed H323 Test Topology



3 PERFORMED TEST SCENARIOS

All of the tests were performed in end-to-end set up, between each pair of the participants. This meant that the complete set of tests required 20 separate measurement sessions. The measurements in each of sessions were organized as follows:

1. First, at a given time the videoconference was initiated – users on both sides had to assess the audio and video quality
2. Simultaneously the ICMP Ping tool was used to gather information about end-to-end RTT.
3. After finishing RTT measurements and assessing audio/video quality (on both ends) the videoconference session was terminated.
4. The server part of RUDE/CRUDE tool was being run on both end stations, and the traffic pattern imitating videoconference stream was being sent through the network in both directions, subsequently. This measurements allowed to record jitter and packet loss.
5. Finally NETPERF throughput test was used to assess the bandwidth available for Premium IP service.

This scenario is a result of multiple trials, where different test scenarios have been evaluated, and finally, the best one reflecting the real situation has been used.

4 MEASUREMENT TECHNIQUES

Premium IP can be sufficiently described by four packet stream performance parameters: available bandwidth, one way delay (or, alternatively, round trip time - RTT), packet loss and jitter (IP delay variation - IPDV). These parameters can be measured in the network and are necessary for network configuration – they are called “metric measurements”. For the metric measurements a sample traffic pattern has been prepared, based on the H.323 traffic analysis from a SunForum 3.2 videoconferencing unit. On the other hand, the end-user satisfaction may be expressed by the subjective measurement – i.e. for the videoconference transmission the user may assess the picture and sound quality. Due to these assumptions the following measurement techniques have been adopted [11][12]:

- For the subjective measurements the user should assess the quality of the long distance videoconferencing by comparing it with the local videoconference results. The assessment is given in the form of the number ranging from 1 to 6 – (unacceptable, very poor, poor, acceptable, good, very good). Obviously for that kind of tests the real H.323 devices are used.
- Jitter [13] is measured with the use of active measurement techniques. For the metric measurements of jitter the artificial traffic is generated with the RUDE/CRUDE tool set [14]. The default traffic pattern is intended to simulate H.323 traffic by sending variable-sized packets irregularly spaced, based on a sample of actual H.323 traffic. Additionally, equal packet size traffic can be used. There is also an option for DSCP marking for those sites that do not support DSCP marking on the router.
- IP packet loss [15]. This parameter is measured with active measurement techniques using ICMP Ping. The measurement is done with 1 second Ping run in the background of the test stream for the transmission time being. Additionally RUDE/CRUDE output trace file allows for estimation of packet loss.
- Round Trip Time – due to limitations of the measurement infrastructure (requirements for fine GPS time synchronization on both endpoints) [16] the use of ICMP Ping has been accepted for the RTT tests. Similarly as for packet loss, this measurement is done with 1 second ping for the transmission time being

- The bandwidth available for the stream [17] is measured as the maximum IP-level throughput between endpoints. For this test, the Netperf UDP stream has been used.

There is also a tool called Taksometro, which has been developed by DANTE for the support of the SEQUIN tests.

5 END POINT EQUIPMENT

Only selected videoconferencing devices have been used for testing, and the selection was due to particular version of Multipoint Conference Unit (MCU) used. Only some of the initially selected stations were fully compatible with MCU and they have been selected for use in further tests. A wide range of H.323 video-conferencing equipment is used allowing users to check the behavior of Premium IP service under different end-system conditions. The list of the equipment includes the following units:

- VCON Falcon and Polycom ViewStation 128 located in CRIHAN, France;
- SunVideo Plus 1.3 card and SUN Solaris 2.6 with Sunforum 3.2 in FOKUS, Germany;
- VCON Escort 25 in RUS, Germany;
- Polyspan ViewStation 128 in CINECA, Italy;
- VCON ViGO located in GRNET, Greece;
- VCON ViGO, Polyspan ViaVideo, Tandberg 1000 and Polycom ViewStation SP, RADVision NGK-100 MCU and a gatekeeper located in SWITCH, Switzerland.

Additionally a dedicated computer for active measurements has been installed in each localization. End-point equipment is always connected via dedicated LAN to the nearest router.

6 TEST RESULTS

The set of tables below shows the results gathered during multiple international measurement sessions for Premium IP. The perceived audio/video quality, bandwidth, packet loss and RTT values have been shown for all cases, while a representative results have been drawn for measured jitter values.

IP Premium	FROM				
Audio	SWITCH	FOKUS	RUS	GRNET	CINECA
SWITCH	x	3(MCU)	4-5	6	6
FOKUS	3.6	x	6	3	6
RUS	3.6	6	x	6	6
GRNET	5.4	3(MCU)	5	x	6
CINECA	6	6	5	6	x

(MCU) - tests performed with the use of MCU unit, due to interoperability problems in videoconference equipment.
Low results for audio transmission mainly caused by low audio volume (sound clear but quiet).

Fig. 1. Perceived audio quality for videoconference transmission using Premium IP

IP Premium	FROM				
Video	SWITCH	FOKUS	RUS	GRNET	CINECA
SWITCH	x	6(MCU)	5	6	6
FOKUS	4.8	x	6	5	6
RUS	4.8	6	x	4	6
GRNET	5.4	5(MCU)	5	x	5
CINECA	5.4	6	5	5	x

(MCU) – tests performed with the use of MCU unit, due to interoperability problems in videoconference equipment

Fig. 2. Perceived video quality of videoconference transmission using Premium IP.

IP Premium	FROM				
Bandwidth [10^3 bit/s]	SWITCH	FOKUS	RUS	GRNET	CINECA
SWITCH	x	3307.87	1909.83	870.00	1816.73
FOKUS	1910.00	x	8725.30	910.00	1825.09
RUS	1910.00	8895.45	x	830.00	1835.18
GRNET	1910.00	853.41*	1909.02	x	1839.94
CINECA	1751.46	1944.39	1844.84	910.00	x

(*) – DoS attack occurred during test
Guaranteed Premium IP capacity configured at 2000kbit/s

Fig. 3. Available bandwidth for Premium IP service.

IP Premium	FROM				
Loss[%]	SWITCH	FOKUS	RUS	GRNET	CINECA
SWITCH	x	0.00	0.00	0.02	0.00
FOKUS	0.00	x	0.00	0.01	0.00
RUS	0.00	0.00	x	0.02	0.00
GRNET	0.00	0.00	0.00	x	0.00
CINECA	0.00	3.07	2.70	0.25	x

Fig. 4. Packet loss for Premium IP service.

IP Premium	FROM														
RTT[ms]	SWITCH			FOKUS			RUS			GRNET			CINECA		
	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX
SWITCH				37.00	37.00	41.00	50.68	51.31	55.43	112.22	114.29	124.14	17.04	19.91	19.97
FOKUS	30.0	38.00	60.00				14.66	17.30	414.66	109.67	110.49	167.59	17.80	20.50	40.00
RUS	50.0	50.00	61.00	10.00	13.00	480.00				186.94	229.82	313.69	29.95	39.62	49.96
GRNET	110.0	114.00	190.00	117.00	119.00	141.00	186.90	230.20	254.80				119.80	120.04	127.82
CINECA	25.1	27.67	48.41	27.00	30.00	82.00	39.93	42.01	81.85	119.82	120.05	127.82			

Fig. 5. RTT for Premium IP service.

The following charts present sample jitter measurements for traffic from RUS to GRNET.

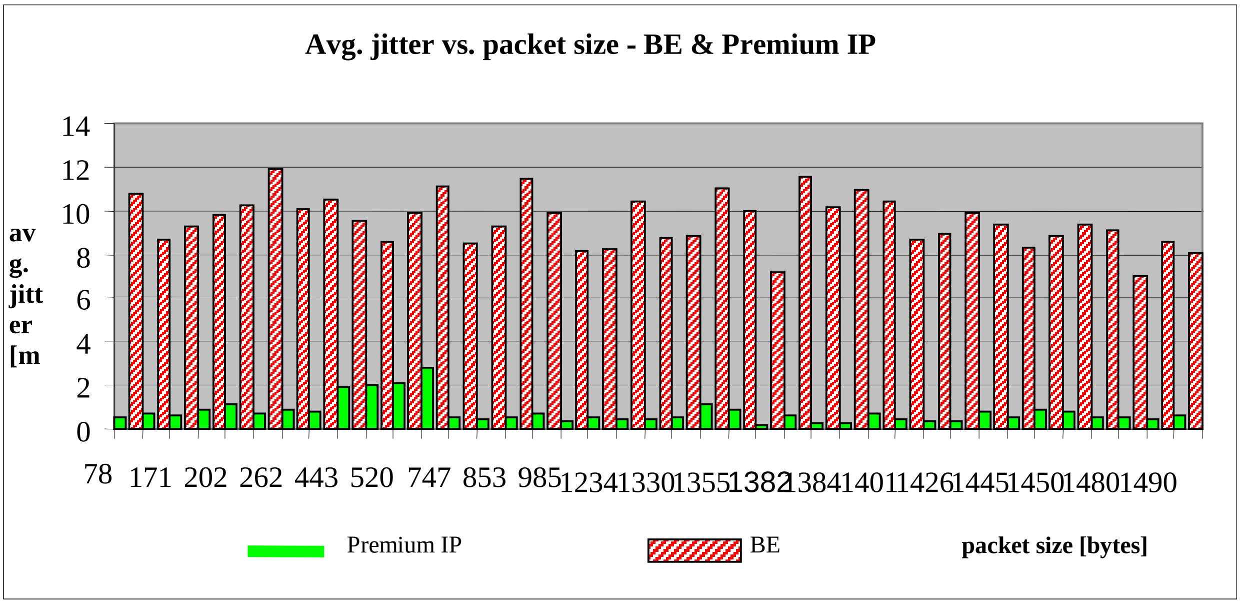
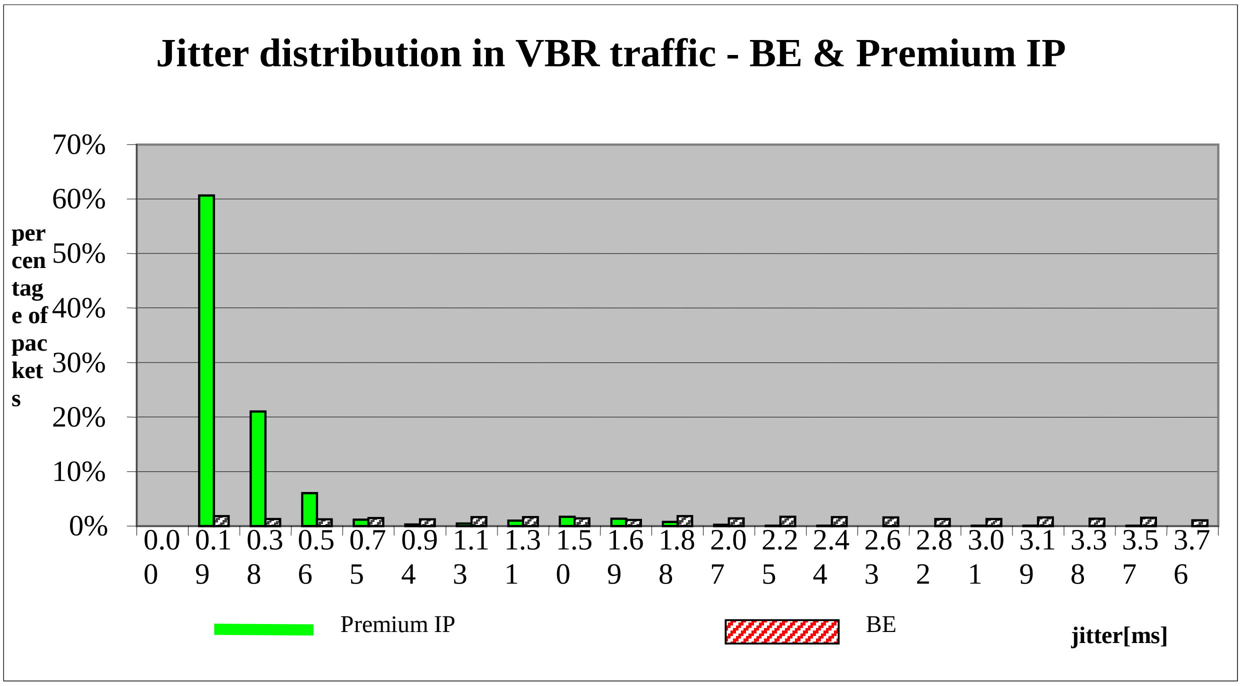


Fig. 6. Comparison of average jitter for different packet sizes of Premium IP and BE traffic.



(*) Up to 95th percentile of Premium IP jitter distribution

Fig. 7. Distribution of jitter values for Premium IP and BE traffic.

7 CONCLUSIONS

The results shown in the previous section confirm the usability of an accepted Premium IP service model. There is a description below of the test results for each measured parameter.

7.1 Perceived Quality of Premium IP videoconference stream

This test revealed that enabling Premium IP allows for undisturbed transfer of audio/video stream. There were some low quality voice transmissions, but this happened due to unsatisfactory interoperability of different videoconferencing stations (audio was clear, but very low volume). The lowest mark for videoconference transmitted with Premium IP service was 4 (acceptable), with most assessments at very good and good level.

Generally this result should already confirm the usefulness of Premium IP service for end-to-end delivery, but for better understanding of the QoS mechanisms, the following conclusions were drawn for metric measurements results:

7.2 Bandwidth available for Premium IP service

The bandwidth guarantee was fulfilled for almost all test sessions.

The only exception here were the tests from GRNET, where the results showed only about 800 kbits/s. This issue has been investigated and a few possible reasons have been taken into account: incorrect Premium IP service configuration, DoS attack while tests were done, incorrect test procedure. But at the end none of those reasons has been proved. Probably the lowered value was due to misconfiguration on border router in Greece.

7.3 Packet loss

Recorded packet loss was equal to zero or very low (<0.02%) for all destinations except CINECA, where for some transmissions the recorded packet loss reached 3%. It is believed that this happened due to CBR ATM PVC configuration where shaping was applied. High results for perceived audio/video quality on the same link confirm that even 3% packet loss was acceptable for videoconference tools.

7.4 RTT

Measured end-to-end RTT was related to the link speed and was acceptable in all cases.

7.5 Jitter

The results of the jitter measurements show that the use of Premium IP strongly reduces end-to-end stream jitter. In general the average jitter measured for all sessions for Premium IP was much lower than for BE traffic. And the distribution of jitter values for Premium IP traffic was much tighter than that for BE traffic.

The international testing process allowed also gaining an experience in a number of important aspects:

- operational service provisioning in multi-domain, multi-technology environment; another immediate result of the testing process was the Premium IP service offered to another research projects, such as Aquila and Moicane
- development of procedures for service ordering and implementation in multi-domain environment,
- estimating a metric values for end-to-end SLA

Even with small discrepancies, shown by some of the measurement, the accepted model of Premium IP has been validated and recognized as suitable for wider implementation.

8 ACKNOWLEDGEMENTS

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