


Release V3	Deliverable 5.1.2 “Connectivity and performance tests report for local and pan-European (across GEANT) testbed design for the Trial”	
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Abstract:

The network integration of the EuQoS system is done incrementally during the whole project life. This document is the first brick of this integration for trials and consists in the evaluation of the partner network connectivity to GEANT. This is the third version of the document (release 1 has been delivered at the end of February 2005 and release 2 in august 2005) and it includes end to end tests as well as the remaining missing site-to-site tests and also a new round of nocturnal tests and also for the first time diurnal tests.


Keywords:

Netmeter, IxChariot, Active measurement tools, EuQoS testbed characterization


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Document history

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V1	01/03/05	Official intermediate release of D5.1.2 sent to EC
V1.1	12/04/05	Add document history Update for PTIN connectivity, FTRD MP, Soluziona connectivity in subchapter 3.3 Add contacts in table "Partner IP configuration summary" in subchapter 3.3 Modification of UoB testbed in subchapter 3.2.2.2
V1.2	22/04/05	Update of table "Partner IP configuration summary" in subchapter 3.3 TID's local tests results added Modification of flows generated (subchapters 3.4 , 4.2 , 5.2 & 6.2)
V1.3	12/05/2005	Update of table "Partner IP configuration summary" in subchapter 3.3 Results of second phase on site-to-site tests with Chariot added
V1.4	24/05/2005	Update on list of contributors and abstract (page 1) Update on UoB local tests (subchapter 5.3.2) Add LAAS's local tests (subchapter 5.3.4) Add site-to-site tests results realized by UPC with Netmeter (subchapter 4.4.1) Update of table "Partner IP configuration summary" in subchapter 3.3 Modification on Chariot results for UPC due to new tests with Chariot only (subchapter 4.4.2) Add PTC's local tests Add results of E2E tests for the two first couples of partners
V1.5	26/05/2005	Update on PTC's Site-To-Site results in subchapter 4.4.2 Add PTC's testbed description Modification on Netmeter results for UPC due to new tests with Netmeter only (subchapter 4.4.1) Add testbed description, local tests results and E2E tests from PTIN Add testbed description, local tests results and E2E tests from UoPisa
V1.6	27/05/2005	Add E2E tests results UoC-PTRD (Subchapter 6.3.5) Editorial changes (every chapter)

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<i>Release</i>	<i>Date</i>	<i>Changes</i>
V2	31/05/2005	Update on PTIN's local tests results Update on PTRD-UoC E2E tests results Update on LAAS's local tests results
V2.1	27/10/2005	New round of tests (3 rd) results, template done.
V2.2	28/10/2005	PTC Netmeter results and UDP1 nocturnal FTRD Chariot results integration
V2.3	02/11/2005	PTC Netmeter updated results (28 th of October) and nocturnal UDP2, VoIP, TCP FTRD Chariot results integration
V2.4	08/11/2005	UPC Netmeter results, UoPisa Netmeter results and diurnal UDP2, VoIP, TCP FTRD Chariot results integration
V2.5	17/11/2005	Upgrade of Chariot tests with UoPisa after an update on the testbed.
V2.6	23/11/2005	UPC Netmeter updated results and update of FTRD results following an update on GEANT connection
V2.7	07/12/2005	Update of UoC's contacts Integrate diurnal Netserver TCP tests, Update on GRE endpoint for UoB and LAAS Integration of PTRD contribution Updated Chariot results after UoB's connection upgrade Updated Chariot results after LAAS's connection upgrade Updated Netmeter Soluziona's results from 7 th of December
V2.8	05/01/2006	Updated Netmeter results from Soluziona Updated Netmeter results from WUT Updated Netmeter results from UoPisa Updated Netmeter results from LAAS Updated Netmeter results from PTRD Updated Netmeter results from UoB Updated Netmeter results from UPC fro all partners
V2.9	02/02/2006	Updated Netmeter results from UPC for all partners Add subchapters on changes on GEANT connections from all partners Add subchapters on changes on GEANT connections for UoC Update of UoB's local tests Update of executive summary, introduction, intermediate S2S tests conclusions and final conclusion
V3	06/02/2006	Document sent to the EC

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1 Executive Summary

The network integration of the EuQoS system is done incrementally during the whole project life. This document describes the first stage of this integration for trials and consists in the evaluation of the partner network connectivity to GEANT. More precisely, it deals with inter-partners network characterization for the full meshed EuQoS network setup. For this 131 Point To Point links between the partners have been established through GRE tunnels through NREN's and GEANT and based on Best Effort Quality. This characterisation has been conducted with 4 different data flows (VoIP, UDP1, UDP2 and TCP) and analyze the different parameters that are of interest for future EuQoS implementation

The network architecture set-up for these tests follows the chapter "Virtual Core Network" in the deliverable D5.1.1. This is the third version of the document D 5.1.2, it includes the local tests, the end to end tests between 6 couples of partners and the results of two complete new rounds of Site To Site tests performed on one hand during diurnal working hours and on another hand during nocturnal hours. The tests are based on Netmeter and IxChariot active measurement tools.

After two rounds of tests performed beginning and mid 2005, due to poor results, many changes have occurred on many partner's GEANT connections and testbeds. So this third official release deals with all the testbeds connected and optimized as deeper as possible at the time the tests have been performed.

With this third and fourth round of tests, the characterization of the PAN-European EuQoS network is very complete and let appear that even with tunnels established in Best Effort Quality between all the partners, the links are of good quality during the day and also during the night. At this step the only remaining black points are :

1. connection issue of UoB's testbed : the reason has been identified and the solving is in progress
2. important losses for links with Soluziona and all other partners

As a next step, in a near future, these two issues will be solved and a new characterization will be conducted on these particular cases.

In parallel with the solving of the mentioned issues, complementary tunnels with PIP Quality will be established between the partners already associated in couples for End-To-End tests and a complementary characterization of these new Point-To-Point connections will be conducted.

So now with the characterization conducted and the significant improvements brought on the different testbeds and GEANT connections, even if some improvements will to be done, the EuQoS network infrastructure is ready, characterized and qualified to setup the prototype implementation and experiments at a PAN-European level.


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2 Introduction

As a first step in the building of the EuQoS system for Work package 5, this document describes the connectivity between partners through the Pan-European network GEANT. The description is based on tests that do not involve any EuQoS piece or any GEANT/NREN feature but the initial network infrastructure set-up by partners for the project as defined in WP5.1.1. This document is a starting point to validate the partner connectivity, to evaluate the initial network characteristics between partner pairs, as EuQoS phase 1 focuses on point to point applications, and if required to upgrade network equipments or contract with NRENS. The goal here is to find the way to a stable and performing network for the next WP5 phases.

The document begins by a short description of the active measurements tools discussed for these tests. Then, following test definitions results are presented and commented for :

- Local tests : characterization of every testbeds locally between measurement points NX-1 and NX-2.
- Site To Site tests : characterization of every Point To Point connections between all the partners (131), so between every measurement points NX-1 and NY-1 and every Ex.
- End To End tests : characterization of 6 End-To-End connections between 6 couples of partners, so between measurement points NX-2 and NY-2.

The network architecture set-up for these tests follows the chapter "Virtual Core Network" in the deliverable D5.1.1. This is the third version of the document D 5.1.2, it includes the local tests, the end to end tests between 6 couples of partners and the results of two complete new rounds of Site To Site tests performed on one hand during diurnal working hours and on another hand during nocturnal hours. The tests are based on Netmeter and IxChariot active measurement tools.

With this third and fourth round of tests, the characterization of the PAN-European EuQoS network is very complete and let appear that even with tunnels established in Best Effort Quality between all the partners, the links are of good quality during the day and also during the night.

So now with the characterization conducted and the significant improvements brought on the different testbeds and GEANT connections, even if some improvements will to be done, the EuQoS network infrastructure is ready, characterized and qualified to setup the prototype implementation and experiments at a PAN-European level.

3 Tests principles and configurations

3.1 Setup of measurement tools

3.1.1 Basic setup configuration

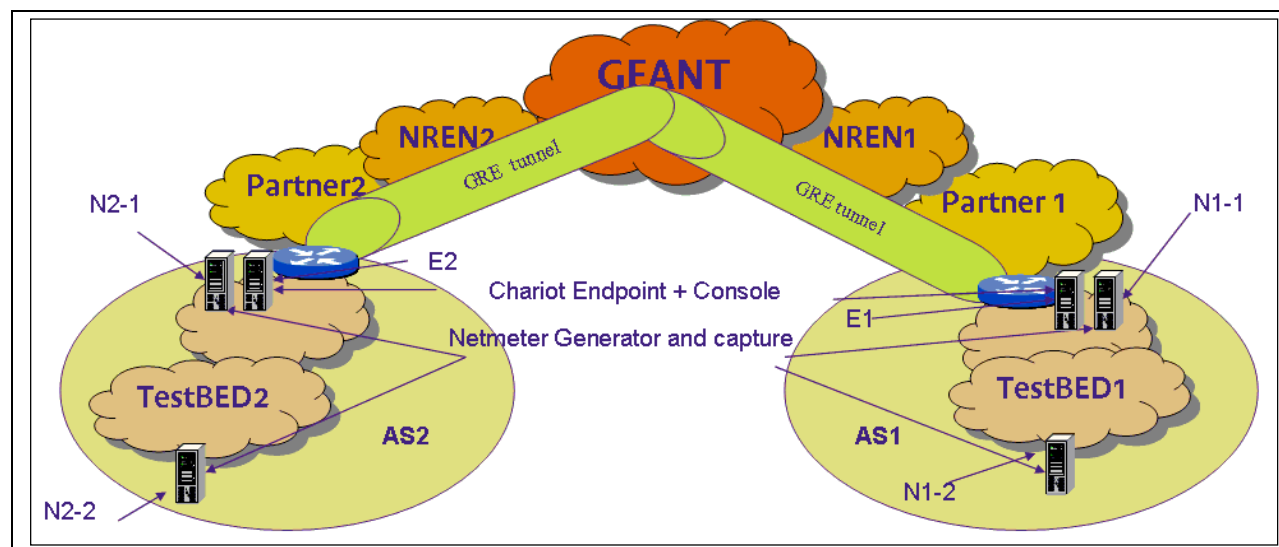



Figure 3.1-1 : Basic setup configuration

Three machines are set-up on each partner site:

- Two PCs (N2-1, N2-2) running Netmeter generator. One PC (N2-1 or N1-1) is configured depending on the test either in generator or in monitoring mode. Thus, the network equipment on which the generator (N2-1) is connected needs to be in the other generator (N2-2) flow path to GEANT. Also, support for monitoring features is required on this equipment.
- One PC running Chariot Endpoint and Chariot if needed (E1). Chariot is setup to validate the results provided by Netmeter in one type of measurement.

3.1.2 Testbed specific configurations

This chapter aims at describing the network details relevant for the tests. This includes naturally the Netmeter and IxChariot generators but also any network difference with the testbed description found in the deliverable D5.1.1., for more details see D5..1.2 V2.1 annex


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3.2 Partner IP configuration summary

FTRD	UoB	TID
BGP AS : 65501, 65502	BGP AS : 65503	BGP AS : 65508
End of GRE Tunnel : 161.106.229.0	End of GRE Tunnel : 130.92.70.226	End of GRE Tunnel : 130.206.206.146
Private addresses : 10.194.0.0/16	Private addresses : 10.195.0.0/16	Private addresses : 10.200.0.0/16
BGP router session address : 10.194.110.96	BGP router session address : 10.195.0.1	BGP router session address : 10.200.0.1
Chariot Endpoint address:10.194.110.106	Chariot Endpoint address: 10.195.0.8	Chariot Endpoint address: 10.200.1.4; 10.200.1.2
Netmeter1 address:10.194.110.107	Netmeter1 address: 10.195.0.3	Netmeter1 address:10.200.1.2
Netmeter2 address : 10.194.126.208	Netmeter2 address:10.195.0.7	Netmeter2 address: 10.200.2.2
NTP Server : 10.193.68.201 (FTRD Strat.1 Server)	NTP Servers : public one + 10.198.0.2 (UPC)	NTP Servers : 10.198.0.2 (UPC)
Contact : Pascal Le Guern Phone +33 2 96 05 02 40 email : pascal.leguern@francetelecom.com	Contacts : Marc Brogle , Phone : +41 31 631 86 68 brogle@iam.unibe.ch Dragan Milic , Phone :, +41 31 631 53 09 milic@iam.unibe.ch	Contact : Pedro Aranda Phone +34913374702 email : paag@tid.es
CNRS-LAAS	UoPisa	PTIN
BGP AS : 65504	BGP AS : 65505	BGP AS : 65509
End of GRE Tunnel : 193.49.97.4	End of GRE Tunnel : 193.206.136.2	End of GRE Tunnel : 193.137.95.90
Private addresses : 10.196.0.0/16	Private addresses : 10.197.0.0/16	Private addresses : 10.201.0.0/16
BGP router session address : 10.196.0.1	BGP router session address : 10.197.0.1	BGP router session address : 10.201.0.1
Chariot Endpoint address: 10.196.1.100	Chariot Endpoint address: 10.197.1.50	Chariot Endpoint address: 10.201.10.1
Netmeter1 address:10.196.0.2	Netmeter1 address: 10.197.1.20	Netmeter1 address: 10.201.10.1
Netmeter2 address: 10.196.0.4	Netmeter2 address: 10.197.1.30	Netmeter2 address:
NTP Server : 10.198.0.2 + 10.194.110.96	NTP Server : 10.203.2.2	NTP Servers : 10.204.1.10 +10.203.2.2 + 10.198.0.2
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UPC	Soluziona	UoC
BGP AS : 65506	BGP AS : 65513	BGP AS : 65510
End of GRE Tunnel : 84.88.40.1	End of GRE Tunnel : 130.206.207.18	End of GRE Tunnel : 193.136.203.143
Private addresses : 10.198.0.0/16	Private addresses : 10.199.0.0/16	Private addresses : 10.202.0.0/16
BGP router session address : 10.198.0.1	BGP router session address : 10.199.0.1	BGP router session address : 10.202.0.1
Chariot Endpoint address:10.198.0.4	Chariot Endpoint address: 10.199.0.102	Chariot Endpoint address: 10.202.0.100
Netmeter1 address:10.198.0.10	Netmeter1 address: 10.199.0.100	Netmeter1 address: 10.202.0.100
Netmeter2 address:10.198.0.2	Netmeter2 address: 10.199.0.101	Netmeter2 address: 10.202.0.101
NTP Server : 10.198.0.2	NTP Servers : 10.204.1.10 + 10.198.0.2	NTP Servers : 10.203.2.2 + 10.198.0.2
Contacts : Jordi Domingo-Pascual email: jordi.domingo@ac.upc.edu René Serral-Gracià Phone : +34 934 054 061 email: rserral@ac.upc.edu	Contacts : Rubén Romero San Martín , Phone : +34 91 21 020 00 ext. 42068 email : rrsanmartin@soluziona.com Jose Pablo Caballero Moreno Phone : +34 91 210 20 00 ext. 49571 Email : jpcaballero.ig@soluziona.com	Contacts : Bruno Carvalho email : becarv@student.dei.uc.pt Paulo Simões email : psimoes@dei.uc.pt Luís Cordeiro , Phone : +351 239 790 017 email : cordeiro@dei.uc.pt
WUT	PTRD	PTC/ERA)
BGP AS : 65511	BGP AS : 65512	BGP AS : 65513
End of GRE Tunnel : 212.191.224.142	End of GRE Tunnel : 150.254.213.45	End of GRE Tunnel : 212.191.227.30
Private addresses : 10.203.0.0/16	Private addresses : 10.204.0.0/16	Private addresses : 10.205.0.0/16
BGP router session address : 10.203.0.1	BGP router session address : 10.204.0.1	BGP router session address : 10.205.0.1
Chariot Endpoint address: 10.203.2.2	Chariot Endpoint address: 10.204.1.12	Chariot Endpoint address:10.205.1.3
Netmeter1 address: 10.203.2.2	Netmeter1 address: 10.204.1.10	Netmeter1 address:10.205.1.3
Netmeter2 (+Chariot) address: 10.203.1.10	Netmeter2 (and Endpoint2) address: 10.204.3.3	Netmeter2 address:
NTP Server : 10.203.2.2	NTP Server : 10.204.1.10 + 10.203.2.2	NTP Server : 10.203.2.2
Contact : Marek Dabrowski , Phone : +48 22 660 7836 email : mdabrow5@tele.pw.edu.pl Jaroslaw Sliwinski , Phone : +48 22 660 7836 email : jsliwins@tele.pw.edu.pl	Contacts : Jaroslaw Kowalczyk , Phone : +48 22 699 52 34 email: jaroslaw.kowalczyk2@telekomunikacja.pl Zbigniew Kopertowski , Phone : +48 22 699 53 email : Zbigniew.Kopertowski@telekomunikacja.pl	Contact : Krzysztof Bronarski , Phone : +48606759356 email : KBronarski@eranet.pl Sławomir Tkacz , phone: +48 602201803 email: STkacz@era.pl ,

Table 3.2-1 : Partner IP configuration summary

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3.3 Simulated Flows

There are four kinds of flows simulated by IxChariot and Netmeter. The same flow definitions are used for every type of tests (local, Site-To-Site and End-To-End) and also for both tools in order to compare and validate Netmeter figures.

- **VoIP** : (type G.729) UDP – 60 Byte packets – 8 kbps – two flows per tests
Endpoint A-> Endpoint B and Endpoint B-> Endpoint A. One test.
- **UDP1** : payload 1420B packets (total packet size = 1462 bytes)–unidirectional flow – 1 Mbps. One flow per test. Two tests Endpoint A-> Endpoint B then Endpoint B-> Endpoint A.
- **UDP2** : payload 160B packets (total packet size = 202 bytes) –unidirectional flow – 1 Mbps. One flow per test. Two tests Endpoint A-> Endpoint B then Endpoint B-> Endpoint A.
- **TCP** : payload 1420B packets –unidirectional elastic flows. One flow per test. Two tests Endpoint A-> Endpoint B then Endpoint B-> Endpoint A.

Each elementary test lasts 10 minutes.

3.4 Partner Availability

At this stage, for the first time all the partners are connected to GEANT and in addition, thanks to the limitations found through the two first rounds of tests, many of the partners have upgraded their connection to GEANT in their domain of responsibility and also on the connection with their NREN.

3.5 Configuration archive

All the results gathered during these tests are worthless if configurations involved during the tests are not known and saved in a dedicated location. Apart from the description in the section "Testbed specific configuration", configuration files regarding EuQoS project are stored in a private document store by each Partner for its part of the network involved. Also, all the files generated by Chariot are stored by FTRD.

4 Site to site tests (GRE tunnel only)

4.1 Architecture

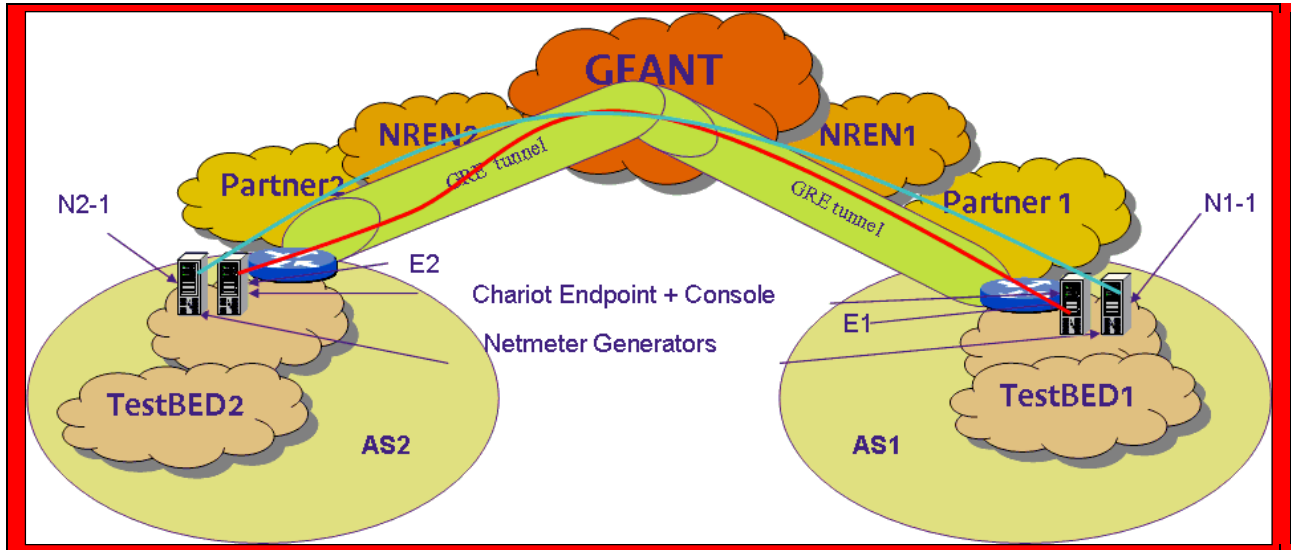


Figure 4.1-1 : Site-to-Site tests architecture

4.2 Changes occurred on the EuQoS Pan-European network between the second round and the 3rd and 4th rounds of tests

4.2.1 FTRD

Initially the connection to GEANT was setup only for a while through the regional Network RERIF and with a "a priori" limited bandwidth. A big change has occurred just before the start of the third and fourth phases and our testbed is now connected directly from FTR&D premises to RENATER with a dedicated Ethernet link at 100 Mbit/s and without transiting anymore through RERIF and with a guaranteed bandwidth for EuQoS project of 8 Mbit/s on this new dedicated link.

4.2.2 PTRD


Since second round of tests in PTRD's testbed there were some minor changes which don't affect the local and site to site network performance.

Main changes concern hardware and configuration upgrades. Two new PC machines were added to the edge of our testbed, first with MMS tools installation and second one for WP3 modules purpose. In order to improve overall synchronization between all partner's machines we have updated a list of ntp servers with new UPC one.

We are preparing now for deployment the QoS provisioning in our ADSL access network. It requires a replacement current xDSL home gateway with new equipment we are now researching for.

According to that in the close future our ADSL network may be unstable.

From GEANT connectivity point of view we have updated tunnel configuration regarding changes performed in partner's networks. The third round of test showed that there are some small packet losses between PTRD and other partners but our investigation indicate that an issue is out of our network.

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4.2.3 TID

TID's testbed has experienced very few changes since the previous round of tests. The most relevant one was the update of the connectivity to RedIris (Spanish NREN) from an ATM PVC to a VLAN in a Gigabit Ethernet link, due to changes in RedIris' infrastructure.

4.2.4 UoC

A lot has changed since the last round of tests. All the three machines in our testbed were replaced by newer ones and two new machines were added (all P4 3GHz, 1GB RAM). Fedora Core 2 and 3 was replaced with Debian 3.1 r0a (Sarge) as our main Operative System. Our connection to the CIUC was upgraded from a 100Mbps laser link to a 1Gbps optic fiber connection, as was the CIUC connection to the FCCN (also to 1Gbps). NTP time synchronization is now kept with both UPC (10.198.0.2) and WUT (10.203.2.2), by an automated daily task. The last two machines added to the testbed have now been replaced with two new identical, bearing DAG cards.

4.2.5 UoB


UoB's test bed has been prepared for Gigabit Ethernet from the beginning but was connected to the Internet through a 100 MBit/s Fast Ethernet link. This connection was redundant with a load balancer between the University's two links to the Internet via SWITCH, the Swiss NREN. This allowed to have an even traffic distribution and a higher reliability of the connection. Unfortunately this resulted in some problems with out-of-order (OoO) packets in the performed tests with different partners. In order to improve the bandwidth of the Internet connection, the test bed's link has been upgraded to 1Gbit/s Ethernet with an almost direct connection to one of the University's border router bypassing the load balancer. The connection to the Internet now passes through three switches and the border router in contrast to the past where multiple switches, firewalls and the load balancer were involved.

Inside the test bed minor updates have been performed. All machines except the chariot end-point (which runs on Windows 2000 Professional) have been updated to Fedora Core 4 Linux. The IP address of the tunnel end-point has been moved to a new sub-net which resulted in a change of all the tunnel configurations on all partner's tunnel end-points.

Recent tests have shown, that the out-of-order problem has been solved by upgrading the connection and changing the path. On the other hand some new problems arose with a quite high outbound loss of short UDP packets during the UDP2-Tests. We have been investigating on this issue and located the source of the problem. At the moment we are taking actions to solve this issue as soon as possible.

4.2.6 UPC

UPC's testbed has suffered very small changes from the initial proposal, the main upgrades were concerning the hardware used for the tests, where Pentium II and Pentium III were upgraded to Pentium IV machines.

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Other important changes concern the synchronization, where a PPS (Pulse Per Second) generators were installed from the GPS source with the goal of improve the synchronization precision on the local testbed (since all machines are receiving the signal).

On the connectivity point of view, the connection towards RedIris continues to be 1Gbps. The only internal change has been on the configuration, where on the first and second rounds, some packet losses were detected on the testbed due to a misconfiguration of the duplex option on the interfaces. Further analysis of the out of order packets was issued, and the final conclusion was that the problem relies somewhere inside the core network.

Finally, in short time is planned to migrate the 10Mbps backbone of the testbed to 100Mbps for better testing experience.

4.2.7 WUT

No changes on testbed or GEANT connection which should have an impact on S2S measurements.

4.2.8 UoPisa

A Linux-based router inserted instead of the previous Cisco 2621 allows for installing and testing the LLMT and TAT tools. The BGP session to all testbeds are setup on the Linux router.

4.2.9 LAAS

Compared to the second round of experiments, there was a major evolution of LAAS testbed. The way it is interconnected with RENATER - the French NRN - has changed. Until one month ago, our testbed was part of the LAAS operational network, interconnected by a 100 Mbps Ethernet link to the Toulouse MAN for education and Research (called REMIP), this later being a level 2 switched network (GigE ring), interconnected to RENATER thanks to a 1 Gbps Ethernet link. Now, the LAAS testbed used for EuQoS is separated from the LAAS operational network, and directly connected to RENATER thanks to a GigE fibre link.

The new LAAS testbed is built on 3 Juniper M7i routers, and 18 PC (pentium 4).

The end point address of the tunnels has then been changed... But except that, we kept the same private EuQoS addressing plan as before.

But this change should have major implications on the communication performance.


As well, it will make easier the performance analysis tasks.

4.2.10 PTIN

- Upgrade of the connection to our NREN to FastEthernet directly to the backbone in Fiber.
- -Upgrade to Fedora 4 in the End-to-End test endpoint.

4.2.11 PTC

After many tests the network element responsible for the extremely high packet loss ratio has been identified. We have established that the losses were caused by a damaged network card on the link to Polish NREN Pionier. The card has been changed and since that moment the quality has significantly improved. The losses hardly ever occur, and if so, they are on the acceptable level.


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Furthermore the ATM contract in our backbone network has been changed. UBR service was replaced by CBR on the PVC to NREN with PCR=6000.

Netmeter was also upgraded to version 2.0.7. All machines are now synchronized with three NTP servers provided by the partners and the synchronization is constantly monitored.

4.2.12 Soluziona

Finalization of the connection to their NREN and GEANT, yet with a limited bandwidth of 256 kbit/s.

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4.3 Results of diurnal tests in the third phase (October 2005 to January 2006)

Based on the recommendations proposed and adopted at EUQoS meeting in September in Vilanova, a third phase of tests is done during diurnal working hours, in order to locate and understand the causes of the numerous losses seen during the tests in phases 1 and 2 and also to evaluate the impacts of load onn the CORE network..

4.3.1 Netmeter

NetMeter results are presented in tables. The sender of a flow is in the first row of the table and the receiver is the first column. For example, figures in the second row and second column were generated with a flow from PTRD to FTRD.

Test scripts were run once, except with some partners with synchronization issues where the test ran twice. The test round lasted 10 minutes, the synchronization is accomplished through the NTP servers configured across the EuQoS network, some of these NTP servers are directly connected to a GPS source, and others in addition have the PPSKit kernel patch for higher level of accuracy.

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD												
PTRD	4 3.33 E-4		0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	3 2.55 E-4
TID	0 < 8.33 E-5	0 < 8.33 E-5		0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	38 3.17 E-3
UoC	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5		0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	22 1.83 E-3
UoB	1 8.33 E-5	0 < 8.33 E-5	1 8.33 E-5	0 < 8.33 E-5		2 1.67 E-4	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	NC	0 < 8.33 E-5	23 1.92 E-3
UPC	1 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5		0 < 8.33 E-5	2 1.67 E-4	1 8.33 E-5	0 < 8.33 E-5	5 4.17 E-4	35 2.92 E-3
WUT	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	1 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5		0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	38 3.17 E-3
UoPisa	0 < 8.33 E-5	0 < 8.33 E-5	95 7.9 E-4	5 4.17 E-4	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5		0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	23 1.92 E-3
LAAS	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5		0 < 8.33 E-5	0 < 8.33 E-5	11 9.17 E-4
PTIN	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	6 5.00 E-4	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5		0 < 8.33 E-5	26 2.17 E-3
PTC	1 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5		63 5.25 E-3
Soluziona	3 2.50 E-4	2 1.67 E-4	88 7.33 E-3	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	1 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	12 1.00 E-3	

Table Legend : Green : Ratio R ≤ 5.00 E-5
Orange : 5.00 E-5 < R ≤ 5.00 E-4
Red : R > 5.00 E-4
NC : no connection

Table 4.3-2 : diurnal VoIP Loss Ratio/Lost Packets (Netmeter)

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD												
PTRD	0 < 1.73 E-5		0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	20 2.12 E-3
TID	0 < 1.73 E-5	0 < 1.73 E-5		0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	57 5.99 E-3
UoC	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5		0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	3 5.21 E-5	0 < 1.73 E-5	44634 7.75 E-1
UoB	0 < 1.73 E-5	0 < 1.73 E-5	71 1.23 E-3	52 9.02 E-4		0 < 1.73 E-5	2 3.47 E-5	0 < 1.73 E-5	0 < 1.73 E-5	NC	0 < 1.73 E-5	30122 5.22 E-1
UPC	17 2.95 E-4	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5		0 < 1.73 E-5	25 4.34 E-4	1 1.73 E-5	0 < 1.73 E-5	40 6.94 E-4	92 1.60 E-3
WUT	128 2.22 E-3	0 < 1.73 E-5	0 < 1.73 E-5	2 3.47 E-5	0 < 1.73 E-5	0 < 1.73 E-5		0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	43 4.52 E-3
UoPisa	1 1.73 E-5	0 < 1.73 E-5	8 1.39 E-4	24 4.17 E-4	4 6.94 E-5	0 < 1.73 E-5	0 < 1.73 E-5		0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	NC
LAAS	1666 2.89 E-2	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5		0 < 1.73 E-5	0 < 1.73 E-5	31492 5.47 E-1
PTIN	4 6.94 E-5	0 < 1.73 E-5	0 < 1.73 E-5	8 1.39 E-4	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5		0 < 1.73 E-5	44668 7.75 E-1
PTC	1 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	2 3.47 E-5	0 < 1.73 E-5	2 3.47 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5		897 1.56 E-2
Soluziona	8 8.41 E-4	109 1.15 E-2	13 1.37 E-3	35 3.68 E-3	1 1.05 E-4	292 3.07 E-2	2 2.10 E-4	1 1.05 E-4	10 1.05 E-3	5 5.26 E-4	290 3.05 E-2	

Table Legend :
Green : Ratio R ≤ 5.00 E-5
Orange : 5.00 E-5 < R ≤ 5.00 E-4
Red : R > 5.00 E-4
NC : no connection

Table 4.3-4 : diurnal UDP1 Lost Ratio/Lost Packets (Netmeter)

- The total amount of sent packets is 57.600 except for Soluziona

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD												
PTRD	0 < 1.73 E-5		0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5
TID												
UoC												
UoB	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5		NC	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	NC	0 < 1.73 E-5	0 < 1.73 E-5
UPC	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5		0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	117 2.03 E-3
WUT	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5		0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	307 5.32 E-3
UoPisa	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5		0 < 1.73 E-5	NC	0 < 1.73 E-5	NC
LAAS	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5		0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5
PTIN												
PTC												
Soluziona	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	

Table Legend :
 Green : Ratio $R \leq 5.00 \text{ E-5}$
 Orange : $5.00 \text{ E-5} < R \leq 5.00 \text{ E-4}$
 Red : $R > 5.00 \text{ E-4}$
 NC : no connection

Table 4.3-5 : diurnal UDP1 Out-of-Order (OoO) Ratio / Packets (Netmeter)

4.3.1.3 UDP2

The graphs corresponding to these figures are available on demand.

	FTRD			PTRD			TID			UoC			UoB			UPC			WUT			UoPisa			LAAS			PTIN			PTC			Soluziona		
FTRD																																				
PTRD	28	26	87				34	33	49	46	44	49	20	19	23	42	41	44	8	7	104	25	25	28	32	30	34	50	47	104	14	10	26	52	45	179
TID	17	16	41	34	33	49				12	11	35	18	18	24	9	8	32	32	32	55	15	15	18	17	17	18	13	12	76	36	36	41	29	11	861
UoC	23	22	32				6	5	32				22	21	31	15	15	24				21	21	25	23	21	103				236	37	300			
UoB	31	30	314	19	18	122	17	16	160	22	20	140				389	279	1486	19	17	456	9	8	129	31	31	147				24	21	140	556	532	652
UPC	24	22	71	42	41	103	9	8	29	5	3	19	27	23	38				41	40	45	24	23	27	25	24	27	48	47	108	31	29	45	492	18	617
WUT	28	26	1416	7	7	22	32	32	67	40	39	71	23	22	30	40	40	47				24	24	25	27	27	29	40	39	102	9	9	16	58	40	600
UoPisa	30	30	39	25	25	38	76	16	714	26	25	59	12	11	18	23	23	24	29	24	125										27	27	32	589	565	999
LAAS	19	10	3022	28	28	46	16	16	207	23	23	29	12	12	18	24	24	25	50	50	89	30	30	44				25	25	88	30	30	42	527	509	860
PTIN	28	25	82	43	35	45	24	9	1571	5	1	79	30	27	85	23	19	1013	54	44	1199	27	24	83	30	27	84				53	47	111	556	22	754
PTC	28	27	49	9	9	27	35	34	77	47	46	61	22	22	27	43	42	56	5	5	46	27	26	40	28	28	42	47	47	110				63	43	897
Soluziona	595	103	1086	501	55	958	511	12	936	455	8	938	476	32	930	468	17	941	504	51	1729	473	25	921	466	19	928	472	21	942	502	54	950			

Table 4.3-6 : diurnal UDP2 One-Way Delay (Avg-Min-Max) in ms (Netmeter).

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD												
PTRD	13 2.41 E-5		0 < 1.86 E-6	0 < 1.86 E-6	127 2.40 E-4	3 5.57 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	19 3.53 E-5	0 < 1.86 E-6	115 2.14 E-3
TID	0 < 1.86 E-6	0 < 1.86 E-6		15 2.79 E-5	0 < 1.86 E-6	0 < 1.86 E-6	62 1.15 E-4	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	124 2.31 E-3
UoC	7 1.30 E-5	6106 1.13 E-2	0 < 1.86 E-6		0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	3925 7.29 E-3	451523 8.39 E-1
UoB	789 1.47 E-3	565 1.05 E-3	445 8.27 E-4	672 1.25 E-3		563 1.05 E-3	709 1.32 E-3	623 1.16 E-3	572 1.06 E-2	NC	810 1.51 E-3	162942 3.03 E-1
UPC	3104 1.08 E-2	0 < 1.86 E-6	0 < 1.86 E-6	3 5.57 E-6	4 7.43 E-6		1 1.86 E-6	5869 1.09 E-2	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	4310 8.01 E-3
WUT	5834 1.08 E-2	0 < 1.86 E-6	0 < 1.86 E-6	18 3.34 E-5	1 1.86 E-6	0 < 1.86 E-6		0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	306 5.69 E-4
UoPisa	10 1.85 E-05	0 < 1.86 E-6	155640 2.89 E-1	45 8.36 E-5	10 1.85 E-5	0 < 1.86 E-6	0 < 1.86 E-6		0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	657 1.2 E-3
LAAS	33166 6.16 E-2	0 < 1.86 E-6	45 8.36 E-5	0 < 1.86 E-6	15 2.79 E-5	0 < 1.86 E-6	1 1.86 E-6	0 < 1.86 E-6		0 < 1.86 E-6	0 < 1.86 E-6	383929 7.13 E-1
PTIN	2 3.72 E-6	289 5.37 E-4	26670 4.96 E-2	85 1.58 E-4	0 < 1.86 E-6	0 < 1.86 E-6	524 9.74 E-4	0 < 1.86 E-6	0 < 1.86 E-6		0 < 1.86 E-6	450924 8.38 E-1
PTC	8 1.49 E-5	4 7.43 E-6	1 1.86 E-6	11 2.04 E-5	0 < 1.86 E-6	2 3.72 E-6	25 4.65 E-5	3 5.57 E-6	2 3.72 E-5	0 < 1.86 E-6		529 4.75 E-3
Soluziona	25406 2.29 E-1	25902 2.33 E-1	35584 3.21 E-1	24128 2.17 E-1	26014 2.34 E-1	24105 2.17 E-1	24132 2.17 E-1	24549 2.21 E-1	24131 2.17 E-1	24126 2.17 E-1	36803 3.32 E-1	

Table Legend :
Green : Ratio $R \leq 5.00 \text{ E-5}$
Orange : $5.00 \text{ E-5} < R \leq 5.00 \text{ E-4}$
Red : $R > 5.00 \text{ E-4}$
NC : no connection

Table 4.3-7 : diurnal UDP2 Lost Ratio/ Lost Packets (Netmeter)

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD												
PTRD	0 < 1.86 E-6		0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6
TID	0 < 1.86 E-6	0 < 1.86 E-6		16 2.97 E-5	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	17 3.16 E-5	10 1.86 E-5	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6
UoC	7 1.30 E-5	3 5.57 E-6	0 < 1.86 E-6		0 < 1.86 E-6	0 < 1.86 E-6	1 1.86 E-6	2 3.72 E-5	0 < 1.86 E-6	0 < 1.86 E-6	5 9.29 E-6	237 4.40 E-4
UoB	11 2.04 E-5	2 3.72 E-6	1 1.86 E-6	3 5.57 E-6		2 3.72 E-6	5 9.29 E-6	4 7.43 E-6	9 1.67E-5	NC	2 3.72 E-6	0 < 1.86 E-6
UPC	5981 1.11 E-2	9001 1.67 E-2	0 < 1.86 E-6	1143 2.12 E-2	8829 1.64 E-2		10726 1.99 E-2	4787 8.99 E-3	6183 1.15 E-2	17762 3.30 E-2	10964 2.04 E-2	0 < 1.86 E-6
WUT	56 1.04 E-04	0 < 1.86 E-6	132 2.45 E-4	112 2.08 E-4	0 < 1.86 E-6	116 2.16 E-4		85 1.58 E-4	85 1.58 E-4	124 2.30 E-4	0 < 1.86 E-6	0 < 1.86 E-6
UoPisa	3 5.57 E-6	7 1.30 E-5	19 3.53 E-5	4 7.43 E-6	1 1.86 E-6	1 1.86 E-6	3 5.57 E-6		5 9.29 E-6	NC	2 3.72 E-5	0 < 1.86 E-6
LAAS	0 < 1.86 E-6	712 1.32 E-3	506 9.40 E-4	419 7.79 E-4	2191 4.07 E-3	3610 6.71 E-3	526 9.77 E-4	606 1.13 E-3		608 1.13 E-3	572 1.06 E-3	8 1.49 E-5
PTIN	0 < 1.86 E-6	3 5.57 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6		0 < 1.86 E-6	0 < 1.86 E-6
PTC	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6		0 < 1.86 E-6
Soluziona	253 2.27 E-3	254 2.28 E-3	319 2.87 E-3	385 3.46 E-3	253 2.27 E-3	259 2.33 E-3	382 3.43 E-3	381 3.42 E-3	256 2.30 E-3	319 2.87 E-3	212 1.90 E-3	

Table Legend :
Green : Ratio $R \leq 5.00 \text{ E-5}$
Orange : $5.00 \text{ E-5} < R \leq 5.00 \text{ E-4}$
Red : $R > 5.00 \text{ E-4}$
NC : no connection

Table 4.3-8 : diurnal UDP2 Out-of-Order (OoO) Ratio / Packets (Netmeter)


4.3.1.4 TCP

The last tests of this phase include the TCP tests, where packets with a payload of 1420bytes are sent.

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD		1.25	0.55	NC	1.43	0.66	0.80	1.14	NC	0.85	2.07	0.2
PTRD	3.16		5.57	NC	6.01	2.42	8.23	0.69	NC	4.22	3.91	0.24
TID	2.92	5.60		NC	5.64	7.60	5.89	6.80	NC	5.37	5.93	0.16
UoC	NC	NC	NC		NC	NC	NC	NC	NC	NC	NC	NC
UoB	1.62	5.83	2.40	NC		3.85	4.94	16.94	NC	1.96	5.43	0.24
UPC	2.53	4.72	6.42	NC	9.16		5.38	9.35	NC	4.08	5.42	0.21
WUT	2.85	8.38	3.92	NC	6.48	2.62		6.10	NC	2.72	38.97	0.14
UoPisa	4.35	6.73	5.48	NC	20.29	5.24	7.14		NC	3.91	7.44	0.14
LAAS	NC	NC	NC	NC	NC	NC	NC	NC		NC	NC	NC
PTIN	5.15	4.72	5.98	NC	2.41	6.10	4.70	6.03	NC		3.74	0.15
PTC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC		
Soluziona	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.23	

Table Legend :
 Green : Average Throughput $T \geq 1$ Mbps
 Orange : $0.9 \leq T < 1$
 Red : $T < 0.9$ Mbps
 NC : no connection

Table 4.3-9 : diurnal TCP Throughput in Mbps (Netserver)

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4.3.1.5 Conclusion on diurnal tests performed with Netmeter

The results of tests show :

- Bad results for UoB in transmit side for all the flows tested. The reason has been identified (corrupted fibre) and the solving is in progress.
- Bad results for VoIP flows with all other partners when Soluziona is receiver. The reason is not yet identified, yet this issue is to be solved.
- Bad results for UDP1 and UDP2 flows with all other partners when Soluziona is receiver and also when transmitter. The reason is not yet identified, yet this issue is to be solved.
- No Connection, on measurement points aspects, between UoB and PTIN
- Bad results for all the flows between UoPisa and TID
- Bad results for all the flows between UoPisa and UoC
- Bad results for all the flows between PTIN and UoC
- Bad results for UDP1 and UDP2 flows from UPC to UoPisa
- Bad results for UDP1 flows from UPC to PTC
- Bad results for UDP1 and UDP2 flows from WUT to FTR&D
- Bad results for UDP1 and UDP2 flows from LAAS to FTR&D
- Bad results for UDP1 flows from UPC to PTC
- Bad results for UDP2 flows from PTIN to PTRD
- Bad results for UDP2 flows from PTIN to TID
- Bad results for UDP2 flows from PTIN to UoC
- Bad results for UDP2 flows from PTIN to WUT
- Numerous OoO packets in all cases when UPC is transmitter
- Numerous OoO packets in all cases when LAAS is transmitter
- TCP issues for UoC and LAAS in both directions

4.3.2 Chariot.

Chariot results are presented in tables. The sender of a flow is in the first row of the table and the receiver is the first column. For example, figures in the second row and second column were generated with a flow from PTRD to FTRD. Test scripts were all run during the working hours of the day and each test lasted 10 minutes.

4.3.2.1 VoIP

The graphs corresponding to these figures are available on demand.

	FTRD			PTRD			TID			UoC			UoB			UPC			WUT			UoPisa			LAAS			PTIN			PTC			Soluziona		
FTRD				42	41	43	16	15	20	24	23	25	11	9	12	23	22	24	40	39	41	30	30	30	9	6	11	34	23	25	42	41	44	21	19	27
PTRD	41	39	42				42	40	45	50	49	52	19	18	19	54	51	59	6	5	16	31	33	37	28	27	30	49	47	51	6	5	12	51	28	119
TID	15	15	17	42	41	43				11	8	37	16	15	18	10	8	14	42	41	44	15	15	17	16	15	16	9	8	10	41	41	42	10	3	22
UoC	24	23	25	50	49	53	11	8	28				24	23	25	18	16	21	50	49	59	28	26	33	23	21	28	4	3	5	49	48	51	15	13	17
UoB	10	8	14	18	16	22	16	15	20	25	24	45				24	24	28	18	17	22	29	27	33	9	6	17	29	28	32	21	20	31	53	0	546
UPC	22	22	24	50	49	51	9	6	10	16	15	17	25	22	25				54	53	56	23	22	24	24	22	24	17	15	19	49	48	50	17	1	27
WUT	41	40	42	6	4	9	42	42	43	49	49	50	18	16	19	56	54	58				34	33	35	26	24	27	49	47	50	5	5	7	49	47	50
UoPisa	30	29	30	35	34	35	15	14	16	26	23	27	30	27	32	24	23	25	34	33	36				30	29	31	26	25	27	36	35	37	21	18	24
LAAS	10	9	11	28	27	30	16	15	17	17	5	24	11	11	12	23	22	25	27	26	28	30	30	31				24	23	25	30	29	30	23	20	26
PTIN	24	24	25	50	49	51	9	8	11	3	2	4	30	28	32	18	16	22	49	47	51	27	25	29	24	23	25				49	48	50	14	11	16
PTC	43	43	45	6	6	6	40	38	43	48	47	50	21	20	31	48	45	50	5	5	7	37	36	38	29	27	30	48	47	50				60	0	144
Soluziona	22	21	24	82	58	147	16	2	75	16	14	19	592	588	596	18	15	28	50	47	60	24	20	28	23	21	26	17	15	20	50	49	98			

Table 4.3-10: diurnal VoIP One way Delay (average-min-max) in ms (Chariot)

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD		1 3.33 E-5	1 3.33 E-5	1 3.33 E-5	1 3.33 E-5	1 3.33 E-5	1 3.33 E-5	1 3.33 E-5	0 < 3.33 E-5	1 3.33 E-5	1 3.33 E-5	14 4.67 E-4
PTRD	5 1.66 E-4		0 < 3.33 E-5	48 1.60 E-3	0 < 3.33 E-5	0 < 3.33 E-5	48 1.60 E-3	1 3.33 E-5	47 1.57 E-3	0 < 3.33 E-5	0 < 3.33 E-5	913 3.04 E-2
TID	0 < 3.33 E-5	0 < 3.33 E-5		0 < 3.33 E-5	2 6.67 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	1 3.33 E-5	51 1.70 E-3
UoC	5 1.66 E-5	45 1.00 E-3	1 3.33 E-5		2 6.67 E-5	1 3.33 E-5	2 6.67 E-5	1 3.33 E-5	1 3.33 E-5	0 < 3.33 E-5	81 2.70 E-3	14 4.67 E-4
UoB	68 2.27 E-3	66 2.20 E-3	55 1.83 E-3	4 1.33 E-4		0 < 3.33 E-5	55 1.83 E-3	57 1.90 E-3	163 5.43 E-3	47 1.57 E-4	55 1.83 E-3	88 2.93 E-3
UPC	2 6.67 E-5	1 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	4 1.33 E-4		4 1.33 E-4	1 3.33 E-5	1 3.33 E-5	1 3.33 E-5	1 3.33 E-5	0 < 3.33 E-5
WUT	3 1.00 E-4	46 1.53 E-3	1 3.33 E-5	1 3.33 E-5	0 < 3.33 E-5	1 3.33 E-5		1 3.33 E-5	0 < 3.33 E-5	1 3.33 E-5	0 < 3.33 E-5	9 3.00 E-4
UoPisa	2 6.67 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5		0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	13 4.33 E-4
LAAS	0 < 3.33 E-5	46 1.53 E-3	1 3.33 E-5	1 3.33 E-5	554 1.85 E-2	1 3.33 E-5	1 3.33 E-5	1 3.33 E-5		1 3.33 E-5	1 3.33 E-5	49 1.63 E-3
PTIN	1 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	2195 7.32 E-2	0 < 3.33 E-5	3 1.00 E-4	0 < 3.33 E-5	0 < 3.33 E-5		0 < 3.33 E-5	0 < 3.33 E-5
PTC	3 1.00 E-4	0 < 3.33 E-5	0 < 3.33 E-5	82 2.73 E-3	0 < 3.33 E-5	0 < 3.33 E-5	2 6.67 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5		1 3.33 E-5
Soluziona	1 3.33 E-5	0 < 3.33 E-5	506 1.69 E-2	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	

Table Legend : Green : Ratio $R \leq 5.00 \text{ E-5}$
Orange : $5.00 \text{ E-5} < R \leq 5.00 \text{ E-4}$
Red : $R > 5.00 \text{ E-4}$

Table 4.3-11 : diurnal VoIP Lost packets number & Lost packets ratio (Chariot)

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD	0 < 3.33 E-5	4 1.33 E-4	2 6.67 E-5	2 6.67 E-5	2 6.67 E-5	1 3.33 E-5	1 3.33 E-5	1 3.33 E-5	0 < 3.33 E-5	1 3.33 E-5	1 3.33 E-5	0 < 3.33 E-5
PTRD	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5
TID	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	1 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	1 3.33 E-5	0 < 3.33 E-5
UoC	14 4.66 E-4	20 6.67 E-4	25 8.33 E-4	0 < 3.33 E-5	7 5.33 E-4	16 5.33 E-4	13 4.33 E-4	14 4.67 E-4	14 4.67 E-4	0 < 3.33 E-5	11 3.67 E-4	8 2.66 E-4
UoB	0 < 3.33 E-5	0 < 3.33 E-5	1 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	16 5.33 E-4	0 < 3.33 E-5	0 < 3.33 E-5	3 1.00 E-4
UPC	0 < 3.33 E-5	1 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	8 2.67 E-4	4 1.33 E-4	4 1.33 E-4	2 6.67 E-5	2 6.67 E-5	0 < 3.33 E-5
WUT	5 1.67 E-4	0 < 3.33 E-5	8 2.66 E-4	6 2.00 E-4	0 < 3.33 E-5	7 2.33 E-4	0 < 3.33 E-5	3 1.00 E-4	0 < 3.33 E-5	1 3.33 E-5	0 < 3.33 E-5	10 3.33 E-4
UoPisa	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5
LAAS	0 < 3.33 E-5	36 1.20 E-3	19 6.33 E-4	19 6.33 E-4	16 5.33 E-4	25 8.33 E-4	29 9.67 E-3	32 1.07 E-3	0 < 3.33 E-5	24 8.00 E-4	29 9.67 E-3	13 4.33 E-4
PTIN	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	3 1.00 E-4	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5
PTC	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	1 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5
Soluziona	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5

Table Legend : Green : Ratio $R \leq 5.00 \text{ E-5}$
Orange : $5.00 \text{ E-5} < R \leq 5.00 \text{ E-4}$
Red : $R > 5.00 \text{ E-4}$


Table 4.3-12 : diurnal Out-of-Order (OoO) VoIP packets number & ratio (Chariot)

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD		16	88	11	3	26	75	6	3	48	5	10
PTRD	42		42	118	2	11	123	2	126	39	31	9328
TID	64	16		77	31	10	81	2	3	45	17	84
UoC	50	105	59		5	10	107	8	42	45	74	34
UoB	60	67	76	64		73	78	67	158	63	74	141
UPC	51	6	18	11	2		46	2	2	46	6	77
WUT	45	107	10	11	2	9		4	2	46	65	26
UoPisa	21	8	8	14	1	11	101		2	45	5	30
LAAS	46	107	20	60	2	10	30	2		48	5	37
PTIN	48	47	48	48	44	47	48	45	48		48	46
PTC	49	7	12	11	3	10	87	68	3	66		399
Soluziona	44	90	271	11	10	11	94	10	10	41	80	

Table 4.3-13 : diurnal VoIP Maximum delay variation in ms (Chariot)

Based on the results for VoIP diurnal tests, the following cases are to be refined :

- Quite high LPR from FTRD to Soluziona
- High LPR in both directions between PTRD and UoC
- High LPR in both directions between PTRD and WUT
- High LPR in both directions between PTRD and LAAS

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- High LPR from PTRD to Soluziona
 - High LPR in both directions between TID and Soluziona
 - High LPR in both directions between UoC and PTC
 - High LPR with all other partners when UoB is transmitter
 - High LPR from LAAS to Soluziona
 - High OoOPR from UoC to PTRD
 - High OoOPR from UoC to TID
 - High OoOPR from UoC to UPC
 - High OoOPR from UoB to LAAS
 - High OoOPR from LAAS to all other partners except FTR&D.

4.3.2.2 UDPI (packets of payload 1420 bytes, rate 1 Mbps)

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD		0.999	0.999	0.996	0.996	0.998	0.996	0.997	0.996	0.996	0.999	0.176
PTRD	1		0.998	0.998	0.999	0.998	0.998	1	0.998	0.997	0.998	0.176
TID	0.998	0.997		0.997	0.998	0.999	0.998	1	0.992	0.998	0.998	0.176
UoC	0.997	TO	0.986		0.999	0.994	0.996	0.999	0.999	0.997	0.993	0.176
UoB	0.993	0.993	0.993	0.993		0.993	0.993	0.993	0.993	0.992	0.992	0.175
UPC	0.999	0.997	0.998	0.996	0.998		0.998	0.999	0.998	0.998	0.998	0.176
WUT	0.997	0.998	0.998	0.997	1	0.999		0.998	0.998	0.998	0.998	0.176
UoPisa	0.996	0.999	0.999	0.996	0.997	0.997	0.996		0.997	0.996	0.996	0.176
LAAS	0.998	TO	0.992	0.998	0.996	0.999	0.998	1		0.998	1	0.176
PTIN	0.991	0.990	0.990	0.992	0.991	0.991	0.990	0.993	0.990		0.990	0.175
PTC	0.998	0.997	0.998	0.994	0.998	0.999	0.996	0.997	1	0.998		0.176
Soluziona	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	

Table Legend : Green : Bandwidth B ≥ 0.990
 Orange : 0.950 ≤ B < 0.990
 Red : B < 0.950
 TO: Time Out after a while

Table 4.3-14 : diurnal UDP1 Throughput (average-min-max) in Mbps (Chariot)

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD		2 3.71 E-5	1 1.86 E-5	0 < 1.86 E-5	1 1.86 E-5	1 1.86 E-5	2 3.71 E-5	2 3.71 E-5	0 < 1.86 E-5	0 < 1.86 E-5	1 1.86 E-5	1 1.05 E-4
PTRD	5 9.28 E-5		0 < 1.86 E-5	84 8.67 E-3	0 < 1.86 E-5	0 < 1.86 E-5	2 3.71 E-5	0 < 1.86 E-5	0 < 1.86 E-5	85 1.56 E-3	0 < 1.86 E-5	5 5.26 E-4
TID	7 1.31 E-4	5 9.28 E-5		1 1.86 E-5	1 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	262 4.87 E-3	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.05 E-4
UoC	10 1.86 E-4	TO	558 1.04 E-2		0 < 1.86 E-5	198 3.67 E-3	46 8.54 E-4	0 < 1.86 E-5	0 < 1.86 E-5	3 5.58 E-5	184 3.41 E-3	9 9.46 E-4
UoB	91 1.69 E-3	127 2.36 E-3	91 1.69 E-3	85 1.58 E-3		86 1.60 E-3	78 1.45 E-3	127 2.36 E-3	107 1.99 E-3	297 5.52 E-3	138 2.57 E-3	19 2.00 E-3
UPC	13 2.41 E-4	3 5.58 E-5	0 < 1.86 E-5	133 2.47 E-3	5 8.67 E-5		10 1.86 E-4	1 1.86 E-5	1 1.86 E-5	0 < 1.86 E-5	1 1.86 E-5	0 < 1.05 E-4
WUT	13 2.41 E-4	4 7.42 E-5	0 < 1.86 E-5	2 3.71 E-5	0 < 1.86 E-5	0 < 1.86 E-5		0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.05 E-4
UoPisa	9 1.67 E-4	1 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	4 7.44 E-5	0 < 1.86 E-5	2 3.71 E-5		0 < 1.86 E-5	0 < 1.86 E-5	4 7.42 E-5	15 1.58 E-3
LAAS	0 < 1.86 E-5	TO	203 3.52 E-3	0 < 1.86 E-5	92 1.71 E-3	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5		0 < 1.86 E-5	0 < 1.86 E-5	1 1.05 E-4
PTIN	24 4.45 E-4	84 1.56 E-3	20 3.71 E-4	0 < 1.86 E-5	387 7.38 E-3	22 4.08 E-4	20 3.71 E-4	0 < 1.86 E-5	28 5.21 E-4		26 4.84 E-4	1 1.05 E-4
PTC	25 4.64 E-4	1 1.86 E-5	0 < 1.86 E-5	133 2.47 E-3	3 5.58 E-5	0 < 1.86 E-5	4 7.44 E-5	16 2.97 E-4	0 < 1.86 E-5	0 < 1.86 E-5		8 8.41 E-4
Soluziona	0 < 1.05 E-4	1 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	8 8.41 E-4	

Table Legend : Green : Ratio $R \leq 5.00 \text{ E-5}$
Orange : $5.00 \text{ E-5} < R \leq 5.00 \text{ E-4}$
Red : $R > 5.00 \text{ E-4}$
TO: Time Out after a while

Table 4.3-15 : diurnal UDP1 Lost packets number and ratio (Chariot)

Tests involving UoB after November upgrade show a high LPR around 2 E-3 with every partners in transmit direction


	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD		0 < 1.86 E-5	0 < 1.86 E-5	2 3.71 E-5	2 3.71 E-5	0 < 1.86 E-5	0 < 1.86 E-5	1 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.05 E-4
PTRD	0 < 1.86 E-5		0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.05 E-4
TID	0 < 1.86 E-5	0 < 1.86 E-5		0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	1 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.05 E-4
UoC	0 < 1.86 E-5	TO	0 < 1.86 E-5		0 < 1.86 E-5	0 < 1.86 E-5	1 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	2 3.71 E-5	0 < 1.05 E-4
UoB	0 < 1.86 E-5	0 < 1.86 E-5	3 5.58 E-5	2 3.71 E-5		1 1.86 E-5	3 5.58 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.05 E-4
UPC	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5		0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.05 E-4
WUT	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5		2 3.71 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.05 E-4
UoPisa	1 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5		0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.05 E-4
LAAS	0 < 1.86 E-5	TO	0 < 1.86 E-5	0 < 1.86 E-5	2 3.71 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5		0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5
PTIN	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	1 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5		0 < 1.86 E-5	0 < 1.05 E-4
PTC	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5		0 < 1.05 E-4
Soluziona	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.86 E-5	0 < 1.05 E-4	0 < 1.05 E-4	

Table Legend : Green : Ratio $R \leq 5.00 \text{ E-}50.987$
Orange : $5.00 \text{ E-}5 < R \leq 5.00 \text{ E-}4$
Red : $R > 5.00 \text{ E-}4$
TO: Time Out after a while

Table 4.3-16 : diurnal Out-of-Order UDP1 packets number & ratio (Chariot)

Based on the results for UDP1 diurnal tests, the following cases are to be refined :

- Very limited bandwidth for Soluziona connection
- Slight LPR from FTRD to all other partners except LAAS and Soluziona
- High LPR & OoOPR in both directions between PTRD and UoC

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- High LPR in both directions between PTRD and PTIN
 - Quite High LPR in both directions between PTRD and Soluziona
 - High LPR in both directions between TID and LAAS
 - High LPR in both directions between TID and Soluziona
 - High LPR in both directions between UoC and UPC
 - High LPR from UoC to WUT
 - High LPR in both directions between UoC and PTC
 - High LPR from UoC to Soluziona
 - High LPR with all other partners when UoB is transmitter
 - High LPR from UoPisa to Soluziona
 - High LPR in both directions between PTC and Soluziona
 - High OoOPR from PTRD to LAAS

4.3.2.3 UDP2 (packets of payload 160 bytes)

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD		0.999	0.999	1	0.998	1	0.999	1	0.998	0.772	0.999	0.174
PTRD	1		0.992	0.998	0.998	0.997	0.998	0.998	0.998	0.954	0.998	0.174
TID	1	0.995		0.995	0.996	0.996	0.995	0.998	0.995	0.947	0.997	0.173
UoC	0.985	TO	0.987		0.979	0.989	0.980	0.975	0.977	0.947	0.980	0.173
UoB	0.993	0.992	0.991	0.992		0.993	0.992	0.993	0.992	0.843	0.992	0.173
UPC	1	0.997	0.998	0.998	0.998		0.998	0.998	0.995	0.953	0.997	0.174
WUT	0.976	0.995	0.984	0.987	0.995	0.983		0.978	0.984	0.939	0.993	0.173
UoPisa	0.999	0.998	0.998	0.997	0.998	0.998	0.998		0.998	0.853	0.999	0.173
LAAS	0.997	TO	0.997	0.866	0.856	0.852	0.871	0.859		0.830	0.885	0.174
PTIN	0.606	0.781	0.806	0.808	0.756	0.784	0.821	0.749	0.815		0.815	0.163
PTC	0.997	0.995	0.994	0.996	0.997	0.995	0.996	0.997	0.997	0.945		0.174
Soluziona	0.173	0.172	0.173	0.173	0.173	0.173	0.172	0.172	0.173	0.173	0.173	

Table Legend : Green : Bandwidth B ≥ 0.990
Orange : 0.950 ≤ B < 0.990
Red : B < 0.950
TO: Time Out after a while

Table 4.3-17 : diurnal UDP2 Throughput (average-min-max) in Mbps (Chariot)

UoB slight bandwidth limitations in transmit direction have disappeared after upgrade of November 2005

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD		0 < 2.13 E-6	19 3.83 E-5	2 4.26 E-6	0 < 2.13 E-6	3 6.05 E-6	3 6.05 E-6	0 < 2.13 E-6	0 < 2.13 E-6	113440 2.29 E-1	0 < 2.13 E-6	1263 1.47 E-2
PTRD	2 4.26 E-6		0 < 2.13 E-6	0 < 2.13 E-6	0 < 2.13 E-6	735 1.48 E-3	24 4.84 E-5	4 8.53 E-6	1 2.13 E-6	21761 4.39 E-2	0 < 2.13 E-6	1157 1.32 E-2
TID	0 < 2.13 E-6	0 < 2.13 E-6		1 2.13 E-6	1 2.13 E-6	0 < 2.13 E-6	0 < 2.13 E-6	0 < 2.13 E-6	0 < 2.13 E-6	24009 4.84 E-2	230 4.64 E-4	1256 1.43 E-2
UoC	5 1.01 E-5	TO	41 8.27 E-5		32 6.45 E-5	86 1.74 E-4	49 9.89 E-5	33 7.03 E-5	21 4.23 E-5	24092 4.86 E-2	45 9.08 E-5	1277 1.46 E-2
UoB	1945 3.92 E-3	2109 4.25 E-3	1424 2.87 E-3	2002 4.04 E-3		1619 3.26 E-3	1947 3.92 E-3	1827 3.68 E-3	2073 4.18 E-3	75978 1.53 E-1	1939 3.91 E-3	1562 1.78 E-2
UPC	0 < 2.13 E-6	771 1.5 E-3	0 < 2.13 E-6	1 2.13 E-6	1 2.13 E-6		22 5.12 E-5	0 < 2.13 E-6	5 1.01 E-5	22076 4.71 E-2	58 1.24 E-4	1157 1.32 E-2
WUT	27 5.44 E-5	0 < 2.13 E-6	9 1.82 E-5	10 2.02 E-5	110 2.22 E-4	5 1.07 E-5		15 3.02 E-5	6 1.21 E-5	23272 4.71 E-2	83 1.68 E-4	1494 1.71 E-2
UoPisa	614 1.24 E-3	1 2.13 E-6	116 2.34 E-4	2 4.26 E-6	7 1.41 E-5	0 < 2.13 E-6	41 8.26 E-5		0 < 2.13 E-6	71932 1.45 E-1	0 < 2.13 E-6	1208 1.38 E-2
LAAS	0 < 2.13 E-6	TO	161 3.25 E-5	134 2.70 E-4	4037 8.14 E-3	125 2.52 E-4	235 4.74 E-4	140 2.82 E-4		24081 4.85 E-2	46 9.27 E-5	1018 1.16 E-2
PTIN	195457 3.90 E-1	104777 2.12 E-1	91698 1.86 E-1	90759 1.84 E-1	116979 2.36 E-1	102850 2.08 E-1	84276 1.71 E-1	120567 2.43 E-1	87920 1.77 E-1		87315 1.77 E-1	6066 6.93 E-2
PTC	5 1.07 E-5	0 < 2.13 E-6	262 5.28 E-4	6 1.28 E-5	0 < 2.13 E-6	0 < 2.13 E-6	0 < 2.13 E-6	9 1.81 E-5	4 8.06 E-6	24420 4.93 E-2		1079 1.23 E-2
Soluziona	1437 1.67 E-2	1623 1.85 E-2	1437 1.64 E-2	1481 1.69 E-2	1488 1.70 E-2	1442 1.65 E-2	1495 1.71 E-2	1442 1.65 E-2	1425 1.63 E-2	1531 1.75 E-2	1488 1.70 E-2	

Table Legend : Green : Ratio $R \leq 5.00 \text{ E-}5$
Orange : $5.00 \text{ E-}5 < R \leq 5.00 \text{ E-}4$
Red : $R > 5.00 \text{ E-}4$
TO: Time Out after a while

Table 4.3-18 : diurnal UDP2 Lost Packets number and ratio (Chariot)

UoB High LPR (around $3.5 \text{ E-}3$) with every partners in transmit direction have appeared after upgrade of November 2005

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD		313 6.31 E-4	83 1.67 E-4	106 2.14 E-4	70 1.41 E-4	128 2.58 E-4	296 5.97 E-4	161 3.25 E-4	0 < 2.13 E-6	58 1.17 E-4	208 4.19 E-4	0 < 1.14 E-5
PTRD	1 2.13 E-6		0 < 2.13 E-6	0 < 2.13 E-6	0 < 2.13 E-6	0 < 2.13 E-6	0 < 2.13 E-6	0 < 2.13 E-6	0 < 2.13 E-6	0 < 2.13 E-6	0 < 2.13 E-6	0 < 1.14 E-5
TID	0 < 2.13 E-6	5 1.07 E-5		2 4.26 E-6	1 2.13 E-6	7 1.49 E-5	22 4.44 E-5	0 < 2.13 E-6	45 9.08 E-5	2 4.26 E-6	1 2.13 E-6	0 < 1.14 E-5
UoC	5756 1.16 E-2	TO	3867 7.80 E-3		8207 1.65 E-2	3145 6.70 E-3	7550 1.52 E-2	10506 2.24 E-2	9256 1.87 E-2	0 < 2.13 E-6	7262 1.47 E-2	1 1.14 E-5
UoB	0 < 2.13 E-6	1 2.13 E-6	5 1.07 E-5	2 4.26 E-6		5 1.07 E-5	1 2.13 E-6	2 4.26 E-6	3 6.40 E-6	2 4.26 E-6	0 < 2.13 E-6	86 9.82 E-4
UPC	5 1.07 E-5	26 5.24 E-5	0 < 2.13 E-6	6 1.28 E-5	15 3.02 E-5		11 2.34 E-5	25 5.04 E-5	1420 2.86 E-3	6 1.28 E-5	113 2.41 E-4	0 < 1.14 E-5
WUT	10742 2.17 E-2	3 6.06 E-6	5077 1.03 E-2	3873 7.82 E-3	16 3.23 E-5	5951 1.20 E-2		8145 1.64 E-2	5282 1.06 E-2	3923 7.93 E-3	0 < 2.13 E-6	0 < 1.14 E-5
UoPisa	7 1.41 E-5	4 8.53 E-6	1 2.13 E-6	8 1.71 E-5	75 1.51 E-4	4 8.53 E-6	4 8.53 E-6		81 1.63 E-4	4 8.53 E-6	14 2.82 E-5	0 < 1.14 E-5
LAAS	0 < 2.13 E-6	TO	22162 4.48 E-2	64080 1.29 E-1	65332 1.32 E-1	71272 1.44 E-1	61603 1.24 E-1	67626 1.36 E-1		58133 1.17 E-1	55919 1.48 E-1	3 3.43 E-5
PTIN	1 2.02 E-6	0 < 2.13 E-6	0 < 2.13 E-6	1 2.02 E-6	0 < 2.13 E-6	0 < 2.13 E-6	0 < 2.13 E-6	0 < 2.13 E-6	3 6.40 E-6		0 < 2.13 E-6	0 < 1.14 E-5
PTC	0 < 2.13 E-6	5 1.07 E-5	0 < 2.13 E-6	209 4.22 E-4	0 < 2.13 E-6	241 4.86 E-4	0 < 2.13 E-6	0 < 2.13 E-6	0 < 2.13 E-6	285 5.75 E-4		0 < 1.14 E-5
Soluziona	0 < 1.14 E-5	0 < 1.14 E-5	0 < 1.14 E-5	0 < 1.14 E-5	86 9.82 E-4	0 < 1.14 E-5	0 < 1.14 E-5	0 < 1.14 E-5	0 < 1.14 E-5	0 < 1.14 E-5	0 < 1.14 E-5	


Table Legend : Green : Ratio R ≤ 5.00 E-5
Orange : 5.00 E-5 < R ≤ 5.00 E-4
Red : R > 5.00 E-4
TO: Time Out after a while

Table 4.3-19 : diurnal UDP2 Out-of-order Packets number and ratio (Chariot)

UoB OoO packets in transmit direction have disappeared after upgrade of November 2005

Based on the results for UDP2 diurnal tests, the following cases are to be refined:

- Very limited bandwidth for Soluziona connection
- limited bandwidth in both directions for PTIN

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- limited bandwidth for LAAS when transmitter
- limited bandwidth for UoC when transmitter
- Time Out issue from UoC to PTRD
- Time Out issue from LAAS to PTRD
- High LPR in both directions between PTRD and UoC
- High LPR in both directions between TID and PTC
- Slight LPR when UoC is transmitter
- High LPR with all other partners when UoB is transmitter
- High LPR in both directions with all other partners for PTIN
- High LPR in both directions with all other partners for Soluziona
- Quite high OoOPR with most of other partners (except LAAS) when FTR&D is transmitter
- High OoOPR with most of other partners (except PTIN) when UoC is transmitter
- High OoOPR with most of other partners (except PTRD, UOB and PTC) when WUT is transmitter
- High OoOPR with most of other partners (except FTRD) when LAAS is transmitter
- High OoOPR in both directions between LAAS and Soluziona


4.3.2.4 TCP

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD		0,96-0,63-1,03	2,56-2,03-3,83	1,77-0,72-3,29	2,02-1,29-4,73	2,29-1,37-3,82	3,46-2,36-3,65	2,46-1,91-3,90	2,71-2,36-4,29	1,37-0,65-3,19	2,20-1,74-2,23	0,17-0,11-0,23
PTRD	2,52-1,26-4,01		2,87-1,84-2,95 (TO)	TO	3,05-1,48-3,10	2,55-0,62-2,83 (TO)	6,91-5,94-7,23	3,76-1,02-3,84	2,25-1,90-2,26	1,24-0,97-2,37 (TO)	2,49-0,44-4,10	0,18-0,16-0,22 (TO)
TID	2,92-1,69-4,03	0,68-0,61-0,69		3,32-1,64-5,07	2,01-1,30-3,42	3,60-3,07-4,75	2,12-1,58-2,28	3,50-2,66-4,14	3,94-1,65-5,02	1,42-0,88-2,50	2,04-1,05-2,29	0,20-0,17-0,23
UoC	1,84-0,78-4,09	0,72-0,60-0,73	2,03-1,10-4,24		1,60-0,99-2,56	1,94-0,84-5,44	1,17-0,66-3,39	2,80-0,73-5,43	1,86-1,09-4,44	1,73-1,04-6,14	1,46-0,59-3,48	0,17-0,06-0,24
UoB	4,47-0,58-5,51	1,36-0,47-1,47	3,44-0,60-4,39	2,64-0,55-3,42		4,49-0,51-4,86	4,87-0,60-5,20	4,15-0,46-5,88	7,62-0,66-8,45	2,38-0,54-3,59	1,71-0,47-1,85	0,09-0,05-0,11
UPC	2,64-1,20-3,68	0,57-0,46-0,58	3,44-2,23-4,09	2,86-1,18-3,84	1,80-1,24-2,26		1,88-1,53-1,93	3,99-0,94-5,09	3,67-2,86-3,88	1,33-0,73-2,86	1,87-1,53-1,93	0,15-0,08-0,23
WUT	1,11-0,61-1,99	2,13-1,65-2,55	1,20-1,09-1,88	0,97-0,59-1,59	2,03-1,15-2,69	1,10-1,02-1,84		1,16-0,88-2,40	2,29-1,80-5,43	0,71-0,46-1,47	13,97-5,37-24	0,15-0,14-0,17
UoPisa	2,66-1,10-3,67	0,70-0,64-0,83	2,79-2,31-3,44	1,86-0,86-2,89	1,76-0,71-1,88	4,04-0,94-5,14	2,87-1,44-2,89		3,27-2,61-3,29	0,93-0,56-1,66	2,66-2,12-2,67	0,21-0,17-0,23
LAAS	4,07-2,74-4,79	0,69-0,60-0,71	1,99-1,37-3,47	2,27-1,25-3,09	2,72-1,69-4,36	2,23-1,95-5,63	2,57-2,13-7,10	1,70-1,40-4,80		1,06-0,78-1,44	1,17-0,56-1,74	0,11-0,07-0,16
PTIN	2,61-0,81-4,10	0,61-0,47-0,62	3,92-1,92-5,24	4,02-1,26-6,00	1,67-0,89-2,21	3,62-1,33-5,47	2,20-0,77-3,25	3,93-1,76-5,26	3,15-2,01-4,45		2,13-0,68-3,27	NC
PTC	0,83-0,51-1,61	3,23-1,49-3,87	1,23-0,77-2,72	1,27-0,66-1,95	1,02-0,75-1,92	1,20-1,03-3,31	17,35-3,80-29,63	1,27-0,86-5,10	1,55-1,29-1,82	0,81-0,46-2,15		0,10-0,08-0,15
Soluziona	0,19-0,09-0,23	0,21-0,12-0,23 (TO)	0,14-0,12-0,20	0,18-0,12-0,24	0,21-0,20-0,23	0,18-0,15-0,24	0,18-0,17-0,22	0,17-0,15-0,19	0,21-0,17-0,23	NC	0,12-0,10-0,19	

Table Legend : Green : Average Throughput $T \geq 1$ Mbps
Orange : $0.9 \leq T < 1$
Red : $T < 0.9$ Mbps
TO: Time Out after a while

Table 4.3-20: diurnal TCP Throughput (average-min-max) in Mbps (Chariot)


- PTRD tests show a limited TCP throughput of around 0.60 Mbit/s with all other partners when PTRD is receiver, except with WUT and PTC (GEANT and other NRENs not used)
- From PTRD to TID, the TCP flows are cut after around 1 minute (tests performed two times with similar results).
- From PTRD to UoC, the TCP flows are cut permanently (tests performed two times with similar results).

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- From PTRD to UPC, the TCP flows are cut after around 15 seconds (tests performed two times with similar results).
 - From PTRD to PTIN, the TCP flows are cut after around 20 seconds (tests performed two times with similar results).

4.3.2.5 *Conclusion on diurnal tests performed with Chariot*

- Some cases with bad results need to be more investigated with DAG cards on site-to-site level (for more details see the subsections above for each type of testing flow).
- There is an important limitation on the transmit Side of UoB whom solving is in progress
- There is an important limitation in terms of bandwidth in both directions for Soluziona. Yet taking into account this limitation when adapting the rate of test flows, there is still a high Loss Packet Ratio and more particularly with small packets and even with worse results in the receive direction.

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4.4 Results of nocturnal tests in the fourth phase (October 2005 to January 2006)

Based on the recommendations proposed and adopted at EUQoS meeting in September in Vilanova, a third phase of tests is done, in order to locate and understand the causes of the numerous losses seen during the tests in phase 1 and 2.

4.4.1 Netmeter

NetMeter results are presented in tables. The sender of a flow is in the first row of the table and the receiver is the first column. For example, figures in the second row and second column were generated with a flow from PTRD to FTRD.

Test scripts were run once, except with some partners with synchronization issues where the test ran twice. The test round lasted 10 minutes, the synchronization is accomplished through the NTP servers configured across the EuQoS network, some of these NTP servers are directly connected to a GPS source, and others in addition have the PPSKit kernel patch for higher level of accuracy.

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5
PTRD	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	13 1.10 E-3
TID	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	16 1.33 E-3
UoC	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	4 3.33 E-4
UoB	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	1 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	16 1.33 E-3
UPC	1 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	94 7.83 E-3	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	24 2.00 E-3
WUT	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	31 1.92 E-3
UoPisa	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	23 1.92 E-3
LAAS	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	6 5.00 E-4
PTIN	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	2 1.67 E-4	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	18 1.50 E-3
PTC	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	2 1.67 E-4	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	NC	0 < 8.33 E-5	28 2.33 E-3
Soluziona	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	1 8.33 E-5	1 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	1 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	1 8.33 E-5	0 < 8.33 E-5

Table Legend :
 Green : Ratio $R \leq 5.00 \text{ E-5}$
 Orange : $5.00 \text{ E-5} < R \leq 5.00 \text{ E-4}$
 Red : $R > 5.00 \text{ E-4}$
 NC : no connection

Table 4.4-2 : nocturnal VoIP Loss Ratio/Lost Packets (Netmeter)

4.4.1.2 UDPI

The graphs corresponding to these figures are available on demand.

	FTRD			PTRD			TID			UoC			UoB			UPC			WUT			UoPisa			LAAS			PTIN			PTC			Soluziona		
FTRD																																				
PTRD	30	30	45				36	36	57	47	47	57	21	20	23	45	45	48	9	9	59	27	27	28	30	30	32	66	63	113	16	16	22	89	88	139
TID	17	17	38	35	25	54				14	13	43	18	18	37	13	13	50	36	36	49	17	17	17	17	17	70	16	16	64	41	41	44	56	54	399
UoC	28	28	33	46	46	158	14	13	69				28	28	31	25	23	1012				27	27	33	27	27	30	10	9	58	52	51	60	3327	65	6234
UoB	11	11	92	19	19	11	16	16	116	25	24	111				25	24	1012	17	17	103	29	29	125	10	9	10				26	25	95	3321	3122	3518
UPC	27	26	34	45	45	48	12	12	27	24	23	29	30	30	31				43	43	43	26	26	26	26	26	27	23	23	70	51	51	56	69	62	502
WUT	41	28	1685	9	9	16	34	34	53	42	42	97	19	19	20	44	44	45				25	25	27	27	27	28	45	44	92	15	15	17	84	83	415
UoPisa	32	32	36	27	26	33	17	17	18				13	13	14	27	27	255	25	25	60				31	31	31				33	33	36	325	306	345
LAAS	19	12	1925	29	29	37	17	27	58	25	25	31	11	11	23	30	29	30	51	50	109	30	30	30				26	25	73	35	35	40	3339	3170	3536
PTIN	38	37	84	52	51	100	20	19	68	12	10	73	38	38	86	30	28	1019	60	48	1264	0	0	1	33	32	80				56	56	104	3346	3222	3432
PTC	36	36	54	16	16	22	42	42	62	53	53	74	26	26	32	52	51	1041	15	15	21	33	32	38	35	35	40	57	56	103				93	91	433
Soluziona	92	67	410	97	79	436	55	51	362	67	61	398	74	59	388	69	63	1028	118	83	451	69	63	358	73	67	389	62	61	106	108	89	583			

Table 4.4-3 : nocturnal UDP1 One-Way Delay (Avg-Min-Max) in ms (Netmeter).

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD												
PTRD	0 < 1.73 E-5		0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	19 2.02 E-3
TID	0 < 1.73 E-5	0 < 1.73 E-5		0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	6 1.04 E-4	0 < 1.73 E-5	0 < 1.73 E-5	78 8.20 E-3
UoC	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5		0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	44606 7.74 E-1
UoB	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5		0 < 1.73 E-5	2 3.47 E-5	0 < 1.73 E-5	0 < 1.73 E-5	NC	0 < 1.73 E-5	42642 7.40 E-1
UPC	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	116 2.01 E-3	0 < 1.73 E-5		3 5.21 E-5	1751 3.04 E-2	0 < 1.73 E-5	NC	1 1.73 E-5	3150 5.46 E-2
WUT	138 2.39 E-3	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5		0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	31 3.26 E-3
UoPisa	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	1 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5		0 < 1.73 E-5	NC	0 < 1.73 E-5	NC
LAAS	87 1.51 E-3	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5		0 < 1.73 E-5	0 < 1.73 E-5	31492 1.20 E-1
PTIN	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	1 1.73 E-5	1 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5		0 < 1.73 E-5	6916 1.20 E-1
PTC	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	9 1.56 E-4	42 7.29 E-4	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5		45 7.81 E-4
Soluziona	2 1.59 E-4	1 7.93 E-5	1 7.93 E-5	10 7.93 E-4	0 < 7.93 E-5	1 7.93 E-5	0 < 7.93 E-5	0 < 7.93 E-5	0 < 7.93 E-5	2 1.59 E-4	1 7.93 E-5	

Table Legend :
 Green : Ratio $R \leq 5.00 \text{ E-5}$
 Orange : $5.00 \text{ E-5} < R \leq 5.00 \text{ E-4}$
 Red : $R > 5.00 \text{ E-4}$
 NC : no connection

Table 4.4-4 : nocturnal UDP1 Lost Ratio/Lost Packets (Netmeter)

- The total amount of sent packets is: 57.600

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD												
PTRD	0 < 1.73 E-5		0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5
TID												
UoC												
UoB	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5		0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	NC	0 < 1.73 E-5	0 < 1.73 E-5
UPC	0 < 1.73 E-5	11743 2.04 E-1	8420 1.46 E-1	8292 1.44 E-1	8370 1.45 E-1		0 < 1.73 E-5	7997 1.39 E-1	0 < 1.73 E-5	NC	6852 1.19 E-1	780 1.35 E-2
WUT	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5		0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	246 4.27 E-3
UoPisa	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5	NC	0 < 1.73 E-5	0 < 1.73 E-5	0 < 1.73 E-5		0 < 1.73 E-5	NC	0 < 1.73 E-5	NC
LAAS												
PTIN												
PTC												
Soluziona	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	0 < 8.33 E-5	

Table Legend :
 Green : Ratio $R \leq 5.00 \text{ E-5}$
 Orange : $5.00 \text{ E-5} < R \leq 5.00 \text{ E-4}$
 Red : $R > 5.00 \text{ E-4}$
 NC : no connection

Table 4.4-5 : nocturnal UDP1 Out-of-Order (OoO) Ratio / Packets (Netmeter)

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD												
PTRD	0 < 1.86 E-6		4 7.43 E-6	0 < 1.86 E-6	4 7.43 E-6	3 5.57 E-6	0 < 1.86 E-6	2 3.72 E-6	0 < 1.86 E-6	0 < 1.86 E-6	1 1.86 E-6	93 1.11 E-3
TID	0 < 1.86 E-6	0 < 1.86 E-6		0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	373 6.93 E-4
UoC	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6		0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	451087 8.38 E-1
UoB	348 7.01 E-4	209 4.21 E-4	226 4.56 E-4	365 7.36 E-4		388 7.82 E-4	482 9.72 E-4	339 6.83 E-4	192 3.87 E-4	NC	302 6.09 E-4	295753 5.96 E-1
UPC	148 2.75 E-4	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	1 1.86 E-6		428 7.95 E-4	9 1.67 E-5	0 < 1.86 E-6	687 1.28 E-3	0 < 1.86 E-6	442894 8.23 E-1
WUT	7752 1.44 E-2	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6		0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	145 1.30 E-3
UoPisa	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6		0 < 1.86 E-6	NC	0 < 1.86 E-6	NC
LAAS	12945 2.41 E-2	371 6.89 E-4	0 < 1.86 E-6	0 < 1.86 E-6	2 3.72 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6		0 < 1.86 E-6	0 < 1.86 E-6	68482 1.27 E-1
PTIN	3 5.57 E-6	0 < 1.86 E-6	0 < 1.86 E-6	49 9.10 E-5	30 5.57 E-5	0 < 1.86 E-6	1029 1.91 E-3	0 < 1.86 E-6	0 < 1.86 E-6		6 1.11 E-5	416240 7.73 E-1
PTC	1 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	3 5.57 E-6	405 7.53 E-4	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6		193 1.73 E-3
Soluziona	24552 2.21 E-1	24641 2.21 E-1	24087 2.17 E-1	24168 2.18 E-1	24333 2.19 E-1	24659 2.22 E-1	24694 2.22 E-1	24314 2.19 E-1	24596 2.28 E-1	24119 2.17 E-1	24659 2.22 E-1	

Table Legend :
Green : Ratio $R \leq 5.00 \text{ E-5}$
Orange : $5.00 \text{ E-5} < R \leq 5.00 \text{ E-4}$
Red : $R > 5.00 \text{ E-4}$
NC : no connection

Table 4.4-7 : nocturnal UDP2 Lost Ratio/ Lost Packets (Netmeter)

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD												
PTRD	0 < 1.86 E-6		0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 8.98 E-6
TID	39 7.25 E-5	0 < 1.86 E-6		39 7.25 E-5	0 < 1.86 E-6	17 3.16 E-5	20 3.72 E-5	0 < 1.86 E-6	0 < 1.86 E-6	55 1.02 E-4	0 < 1.86 E-6	0 < 8.98 E-6
UoC	9 1.67 E-5	3785 7.03 E-3	2 3.72 E-6		1 1.86 E-6	0 < 1.86 E-6	7 1.30 E-5	2 3.72 E-6	14540 2.70 E-2	0 < 1.86 E-6	6456 1.20 E-2	237 2.13 E-3
UoB		4 8.06 E-6	14 2.82 E-5	2 3.72 E-6		1 2.02 E-6	1 2.02 E-6	0 < 2.02 E-6	1 2.02 E-6	NC	0 < 2.02 E-6	0 < 8.98 E-6
UPC	0 < 1.86 E-6	1889 3.53 E-3	0 < 1.86 E-6	258956 4.81 E-1	13006 2.42 E-2		0 < 1.86 E-6	11385 2.12 E-2	6479 1.20 E-2	129 2.40 E-4	1843 3.42 E-3	342 3.07 E-3
WUT	84 1.56 E-4	0 < 1.86 E-6	216 4.01 E-4	198 3.68 E-4	0 < 1.86 E-6	153 2.84 E-4		159 2.95 E-4	88 1.64 E-4	184 3.42 E-4	0 < 1.86 E-6	0 < 8.98 E-6
UoPisa	4 7.43 E-6	5 9.29 E-6	4 7.43 E-6	6 1.11 E-5	6 1.11 E-5	5 9.29 E-6	5 9.29 E-6		6 1.11 E-5	NC	8 1.49 E-5	0 < 8.98 E-6
LAAS	0 < 1.86 E-6	892 1.66 E-3	650 1.21 E-3	583 1.08 E-3	804 1.49 E-3	800 1.49 E-3	707 1.31 E-3	768 1.43 E-3		880 1.64 E-3	737 1.37 E-3	83 7.46 E-4
PTIN	0 < 1.86 E-6	0 < 1.86 E-6	13 2.42 E-5	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6		0 < 1.86 E-6	45 4.04 E-4
PTC	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6	0 < 1.86 E-6		0 < 8.98 E-6
Soluziona	251 2.26 E-3	191 1.72 E-3	259 2.33 E-3	386 3.47 E-3	256 2.30 E-3	259 2.33 E-3	387 3.48 E-3	381 3.42 E-3	380 3.41 E-3	258 2.32 E-3	127 1.14 E-3	

Table Legend : Green : Ratio R ≤ 5.00 E-5
Orange : 5.00 E-5 < R ≤ 5.00 E-4
Red : R > 5.00 E-4
NC : no connection

Table 4.4-8 : nocturnal UDP2 Out-of-Order (OoO) Ratio / Packets (Netmeter)


4.4.1.4 TCP

The last tests of this phase include the TCP tests, where packets with a payload of 1420bytes are sent.

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD		1.95	0.77	NC	3.30	2.34	2.18	2.58	NC	1.03	NC	NC
PTRD	3.29		5.57	NC	6.04	2.52	8.26	0.72	NC	4.19	NC	NC
TID	5.55	5.59		NC	6.74	7.63	5.93	6.02	NC	5.22	NC	NC
UoC	NC	NC	NC		NC	NC	NC	NC	NC	NC	NC	NC
UoB	5.44	4.14	3.86	NC		4.62	2.98	4.55	NC	2.28	NC	NC
UPC	4.81	5.00	6.56	NC	9.16		5.38	8.41	NC	4.14	NC	NC
WUT	3.63	8.36	4.00	NC	6.40	2.62		2.27	NC	2.72	NC	NC
UoPisa	4.76	6.79	5.51	NC	18.70	5.26	7.45		NC	3.87	NC	NC
LAAS	NC	NC	NC	NC	NC	NC	NC	NC		NC	NC	NC
PTIN	4.81	4.72	6.09	NC	3.06	6.36	4.89	3.67	NC		NC	NC
PTC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC		NC
Soluziona	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	

Table Legend :
 Green : Bandwidth $B < 0.9$
 Orange : $0.90 \leq B < 1$
 Red : $B \geq 1$
 NC : no connection


Table 4.4-9 : nocturnal TCP Throughput in Mbps (Netserver)

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4.4.1.5 Conclusion on nocturnal tests performed with Netmeter


The results of tests show :

- Bad results for UoB in transmit side for all the flows tested. The reason has been identified (corrupted fibre) and the solving is in progress.
- High LPR for VoIP flows with all other partners when Soluziona is receiver.
- High LPR for VoIP flows from UPC to UoPisa
- No Connection for VoIP flows from PTC to PTIN
- High LPR for UDP1 flows with all other partners when Soluziona is receiver.
- High LPR for UDP1 flows from WUT to FTRD
- High LPR for UDP1 flows from LAAS to FTRD
- High LPR for UDP1 flows from UPC to UoC
- High LPR for UDP1 flows from UPC to UoPisa
- No Connection for UDP1 flows from UPC to PTIN
- No Connection for UDP1 flows from UoPisa to PTIN
- High LPR for UDP2 flows with all other partners in both direction with Soluziona
- Slight LPR for UDP2 flows from UPC to FTRD
- High LPR for UDP2 flows from WUT to FTRD
- High LPR for UDP2 flows from LAAS to FTRD
- High LPR for UDP2 flows from LAAS to PTRD
- High LPR for UDP2 flows from UPC to WUT
- High LPR for UDP2 flows from UPC to PTIN
- High LPR for UDP2 flows from PTIN to WUT
- No Connection for UDP2 flows from UoPisa to PTIN

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- Slight OoOPR for UDP2 flows with many partners when TID is transmitter
- High OoOPR for UDP2 flows with many partners when UoC is transmitter
- High OoOPR for UDP2 flows with many partners when UPC is transmitter
- Slight OoOPR for UDP2 flows with many partners when WUT is transmitter
- High OoOPR for UDP2 flows with many partners when LAAS is transmitter
- No Connection for TCP flows for UoC in both directions
- No Connection for TCP flows for LAAS in both directions
- No Connection for TCP flows for PTC in both directions
- No Connection for TCP flows for Soluziona in receiving direction

The issues found seem to be very important, yet they concerned a very large number of tests and if we extract the particular issues on the GEANT connection from UoB and Soluziona, there remain only a few cases that need to be further studied. So there are still some effort and investigation to do, yet the global quality has extremely increased from the first and second phases of tests and at present the so called EuQoS trial network has become of relatively good quality and much more stable than in the past.

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4.4.2 Chariot.

Chariot results are presented in tables. The sender of a flow is in the first row of the table and the receiver is the first column. For example, figures in the second row and second column were generated with a flow from PTRD to FTRD.

Test scripts were all run during the night and each test lasted 10 minutes.

4.4.2.1 VoIP

The graphs corresponding to these figures are available on demand.

	FTRD			PTRD			TID			UoC			UoB			UPC			WUT			UoPisa			LAAS			PTIN			PTC			Soluziona		
FTRD				42	41	42	15	14	16	24	23	26	9	8	9	24	23	27	40	38	42	19	18	21	9	7	11	25	24	27	43	43	44	22	19	22
PTRD	43	41	46				43	42	44	50	48	51	20	19	24	52	51	55	6	5	12	35	35	37	25	22	29	49	47	51	8	6	9	168	62	262
TID	15	14	16	43	42	43				9	8	10	16	15	16	8	7	9	42	41	42	16	15	19	15	15	16	9	8	11	41	41	42	14	0	57
UoC	24	24	25	50	49	51	9	8	9				23	23	24	18	16	21	49	48	50	27	26	30	23	22	25	3	1	4	50	49	52	39	12	64
UoB	10	9	13	19	19	23	15	13	20	20	20	24				24	23	30	17	15	64	11	9	12	11	8	15	23	21	27	21	21	25	26	24	26
UPC	22	21	25	51	49	52	8	7	9	18	13	20	23	21	24				59	47	367	23	22	24	23	21	24	16	15	17	50	50	53	14	2	25
WUT	41	41	42	6	5	7	42	42	43	50	49	50	18	16	18	49	48	53				33	32	35	27	26	31	49	49	50	8	7	9	47	43	48
UoPisa	15	14	16	35	34	36	16	14	16	26	25	27	12	10	12	23	22	24	34	33	35				21	19	22	25	23	27	36	36	37	21	19	22
LAAS	12	12	13	28	27	30	17	16	17	23	22	24	13	10	15	24	23	25	27	26	27	20	19	20				24	23	25	40	39	42	21	20	22
PTIN	26	25	27	50	50	51	8	6	10	3	2	4	23	21	24	18	16	19	49	47	54	27	26	30	23	21	25				49	48	54	14	12	16
PTC	43	43	44	9	8	9	34	32	36	49	48	49	20	19	25	48	47	49	5	4	8	35	33	37	41	40	43	49	48	50				47	44	48
Soluziona	23	21	26	75	66	164	227	179	246	19	0	36	25	25	27	21	14	41	49	46	52	21	20	25	22	21	25	16	15	19	48	47	49			

Table 4.4-10: nocturnal VoIP One way Delay (average-min-max) in ms (Chariot)

- The delays are smaller after LAAS upgrade

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD		1 3.33 E-5	1 3.33 E-5	1 3.33 E-5	0 < 3.33 E-5	1 3.33 E-5	1 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	1 3.33 E-5	1 3.33 E-5
PTRD	0 < 3.33 E-5		0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	4 1.33 E-4	0 < 3.33 E-5	0 < 3.33 E-5	26 8.67 E-4
TID	0 < 3.33 E-5	0 < 3.33 E-5		0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5
UoC	2 6.67 E-5	3 1.00 E-4	2 6.67 E-5		1 3.33 E-5	2 6.67 E-5	5 1.67 E-4	1 3.33 E-5	1 3.33 E-5	0 < 3.33 E-5	1 3.33 E-5	3 1.00 E-4
UoB	71 2.37 E-3	33 1.10 E-3	55 1.83 E-3	49 1.63 E-3		44 1.47 E-3	71 2.37 E-3	0 < 3.33 E-5	60 2.00 E-3	52 1.73 E-3	37 1.23 E-3	1 3.33 E-5
UPC	1 3.33 E-5	1 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5		1 3.33 E-5	0 < 3.33 E-5	1 3.33 E-5	1 3.33 E-5	1 3.33 E-5	1 3.33 E-5
WUT	2 6.67 E-5	0 < 3.33 E-5	1 3.33 E-5	1 3.33 E-5	0 < 3.33 E-5	2 6.67 E-5		1 3.33 E-5	1 3.33 E-5	1 3.33 E-5	0 < 3.33 E-5	1 3.33 E-5
UoPisa	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	1 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	1 3.33 E-5		0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5
LAAS	0 < 3.33 E-5	1 3.33 E-5	1 3.33 E-5	1 3.33 E-5	1 3.33 E-5	1 3.33 E-5	2 6.67 E-5	1 3.33 E-5		1 3.33 E-5	1 3.33 E-5	1 3.33 E-5
PTIN	0 < 3.33 E-5	1 3.33 E-5	1 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	2 6.67 E-5	2 6.67 E-5	0 < 3.33 E-5	0 < 3.33 E-5		2 6.67 E-5	1 3.33 E-5
PTC	1 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	3 1.00 E-4	0 < 3.33 E-5	0 < 3.33 E-5	1 3.33 E-5		1 3.33 E-5
Soluziona	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	1 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	1 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	

Table Legend : Green : Ratio $R \leq 5.00 \text{ E-5}$
Orange : $5.00 \text{ E-5} < R \leq 5.00 \text{ E-4}$
Red : $R > 5.00 \text{ E-4}$

Table 4.4-11 : nocturnal VoIP Lost packets number & Lost packets ratio (Chariot)

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD		3 1.00 E-4	2 6.67 E-5	5 1.67 E-4	0 < 3.33 E-5	2 6.67 E-5	7 2.33 E-4	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	1 3.33 E-5	1 3.33 E-5
PTRD	0 < 3.33 E-5		0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5
TID	0 < 3.33 E-5	0 < 3.33 E-5		0 < 3.33 E-5	1 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5
UoC	10 3.33 E-4	12 4.00 E-4	8 2.67 E-4		11 3.67 E-4	14 4.67 E-4	16 5.33 E-4	17 5.66 E-4	11 3.67 E-4	0 < 3.33 E-5	11 3.67 E-4	11 3.67 E-4
UoB	1 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5		0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	1 3.33 E-5
UPC	2 6.67 E-5	1 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5		4 1.33 E-4	0 < 3.33 E-5	3 1.00 E-4	1 3.33 E-5	1 3.33 E-5	0 < 3.33 E-5
WUT	10 3.33 E-4	0 < 3.33 E-5	4 1.33 E-4	8 2.67 E-4	0 < 3.33 E-5	10 3.33 E-4		9 3.00 E-4	1 3.33 E-5	3 1.00 E-4	0 < 3.33 E-5	7 2.33 E-4
UoPisa	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5		0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5
LAAS	0 < 3.33 E-5	26 8.67 E-4	14 4.67 E-4	21 7.00 E-4	17 5.67 E-4	18 6.00 E-4	24 8.00 E-4	20 6.67 E-4		15 5.00 E-4	5 1.67 E-4	3 1.00 E-4
PTIN	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5		0 < 3.33 E-5	0 < 3.33 E-5
PTC	1 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	1 3.33 E-5		1 3.33 E-5
Soluziona	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	0 < 3.33 E-5	

Table Legend : Green : Ratio $R \leq 5.00 \text{ E-5}$
Orange : $5.00 \text{ E-5} < R \leq 5.00 \text{ E-4}$
Red : $R > 5.00 \text{ E-4}$

Table 4.4-12 : nocturnal Out-of-Order (OoO) VoIP packets number & ratio (Chariot)


- Tests involving UoC show slight OoO packets ratios with all other partners, except PTIN, when UoC is transmitter.
- Tests involving WUT show slight OoO packets ratios with all other partners, except PTRD, PTC and LAAS, when WUT is transmitter.
- Tests involving LAAS show slight OoO packets ratios with all other partners, except FTRD, when LAAS is transmitter.

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD		8	10	13	3	10	32	11	4	47	5	6
PTRD	16		10	11	17	8	127	2	14	45	3	397
TID	17	8		21	1	12	16	18	7	47	4	361
UoC	9	10	11		20	10	50	3	5	45	75	48
UoB	55	65	90	84		62	519	1	53	81	83	44
UPC	17	8	20	10	2		45	2	2	48	75	67
WUT	7	4	14	12	2	8		2	2	43	20	49
UoPisa	50	13	11	13	1	8	8		2	47	6	33
LAAS	48	16	8	13	2	10	20	15		47	75	33
PTIN	49	47	48	46	46	45	180	45	48		46	63
PTC	36	14	6	11	2	7	84	3	4	46		41
Soluziona	30	10	93	90	10	11	16	10	11	48	13	

Table 4.4-13 : nocturnal VoIP Jitter, Maximum Delay Variation in ms (Chariot)

Based on the results for VoIP nocturnal tests, the following cases are to be refined :

- Tests involving UoC show small Lost Packets Ratios with many partners, when UoC is transmitter.
- Tests involving WUT show small Lost Packets Ratios with many partners, when WUT is receiver.
- Tests with UoB after connection update (dec. 2005) show a high LPR in transmit direction and an interrupted test due to a Time Out in the opposite way with PTIN.
- High LPR from PTRD to Soluziona

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- Tests involving FTRD show slight OoO packets ratios with many partners.
 - Tests involving UoC show slight OoO packets ratios with all other partners, except PTIN, when UoC is transmitter.
 - Tests involving WUT show slight OoO packets ratios with all other partners, except PTRD, PTC, UoB and LAAS, when WUT is transmitter.
 - Tests involving LAAS show high OoO packets ratios with all other partners, except FTRD, when LAAS is transmitter.

4.4.2.2 UDPI (packets of payload 1420 bytes, rate 1 Mbps)

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD		0.999	0.999	0.996	0.997	0.998	0.996	0.997	0.996	0.996	0.999	0.176
PTRD	1		0.998	0.998	0.999	0.999	0.998	0.999	0.998	0.998	0.998	0.174
TID	1	0.997		0.998	0.999	0.999	0.996	0.999	0.999	0.996	0.998	0.176
UoC	0.998	0.998	0.996		0.999	0.997	0.996	0.999	0.999	0.996	0.998	0.176
UoB	0.993	0.994	0.993	0.993		0.993	0.993	0.993	0.993	0.993	0.993	0.176
UPC	0.999	0.998	0.998	0.998	0.999		0.998	0.998	0.998	0.998	0.998	0.176
WUT	0.998	0.998	0.998	0.998	1	1		0.999	0.998	0.998	0.998	0.176
UoPisa	0.997	0.997	0.996	0.996	0.997	0.997	0.996		0.997	0.996	0.996	0.176
LAAS	0.999	0.998	0.998	0.996	1	0.999	0.997	1		0.998	0.998	0.176
PTIN	0.991	0.991	0.990	0.989	0.993	0.990	0.990	0.993	0.992		0.992	0.176
PTC	1	0.997	0.998	0.998	0.999	0.999	0.996	0.999	0.997	0.998		0.176
Soluziona	0.176	0.176	0.176	0.176	0.176	0.176	0.164	0.176	0.176	0.176	0.176	

Table Legend : Green : Bandwidth B ≥ 0.990
Orange : 0.950 ≤ B < 0.990
Red : B < 0.950

Table 4.4-14 : nocturnal UDP1 Throughput (average) in Mbps (Chariot)

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD		1 1.86 E-5	1 1.86 E-5	1 1.86 E-5	4 7.44 E-5	0 < 1.86 E-5	0 < 1.86 E-5	1 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.05 E-4
PTRD	1 1.86 E-5		1 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	2 3.72 E-5	2 3.72 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	1 1.05 E-4
TID	0 < 1.86 E-5	3 5.57 E-5		0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	3 5.57 E-5	0 < 1.86 E-5	0 < 1.86 E-5	1 1.86 E-5	0 < 1.86 E-5	0 < 1.05 E-4
UoC	1 1.86 E-5	34 6.31 E-4	6 1.11 E-4		0 < 1.86 E-5	37 6.87 E-4	22 4.08 E-4	0 < 1.86 E-5	0 < 1.86 E-5	41 7.63 E-4	29 5.38 E-4	3 3.15 E-4
UoB	104 1.93 E-3	67 1.25 E-3	92 1.71 E-3	66 1.23 E-3		85 1.58 E-5	97 1.80 E-3	95 1.77 E-3	77 1.43 E-3	85 1.58 E-5	86 1.60 E-5	0 < 1.05 E-4
UPC	1 1.86 E-5	3 5.57 E-5	0 < 1.86 E-5	0 < 1.86 E-5	1 1.86 E-5		1 1.86 E-5	1 1.86 E-5	1 1.86 E-5	0 < 1.86 E-5	1 1.86 E-5	0 < 1.05 E-4
WUT	2 3.72 E-5	4 7.44 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5		0 < 1.86 E-5	0 < 1.86 E-5	1 1.86 E-5	0 < 1.86 E-5	0 < 1.05 E-4
UoPisa	1 1.86 E-5	4 7.44 E-5	0 < 1.86 E-5	1 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	5 9.28 E-5		0 < 1.86 E-5	1 1.86 E-5	1 1.86 E-5	2 2.10 E-4
LAAS	0 < 1.86 E-5	TO	0 < 1.86 E-5	12 2.23 E-4	0 < 1.86 E-5	0 < 1.86 E-5	6 1.12 E-4	0 < 1.86 E-5		0 < 1.86 E-5	0 < 1.86 E-5	3 3.15 E-4
PTIN	2 3.72 E-5	2 3.72 E-5	34 6.34 E-4	98 1.83 E-3	0 < 1.86 E-5	35 6.53 E-4	30 5.60 E-4	0 < 1.86 E-5	0 < 1.86 E-5		0 < 1.86 E-5	0 < 1.05 E-4
PTC	0 < 1.86 E-5	2 3.72 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	2 3.72 E-5	0 < 1.86 E-5	1 1.86 E-5	0 < 1.86 E-5		0 < 1.05 E-4
Soluziona	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	621 6.53 E-2	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	

Table Legend : Green : Ratio $R \leq 5.00 \text{ E-5}$
Orange : $5.00 \text{ E-5} < R \leq 5.00 \text{ E-4}$
Red : $R > 5.00 \text{ E-4}$
TO : Time Out after a while there is no answer from the machine and the Chariot test is then interrupted.

Table 4.4-15 : nocturnal UDP1 Lost packets number and ratio (Chariot)


- UoC tests show a relatively high LPR with all other partners in transmitting direction (tests performed two times at different nights with similar results)
- PTIN tests show a high LPR with all other partners in transmit direction (tests performed two times at different nights with similar results)

- Tests with UoB after connection's upgrade show a high LPR, around 1.8 E-3, in transmit direction with every partners whereas the previously bad results seen before the upgrade in receive direction are solved.
- Test from UoB to WUT show a high LPR (tests performed two times at different nights with similar results)
- Tests from UoB to TID show a high LPR (tests performed two times at different nights with similar results)

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	1 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.05 E-4
PTRD	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.05 E-4
TID	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.05 E-4
UoC	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.05 E-4
UoB	0 < 1.86 E-5	1 1.86 E-5	1 1.86 E-5	4 7.44 E-5	0 < 1.86 E-5	1 1.86 E-5	0 < 1.86 E-5	4 7.44 E-5	0 < 1.86 E-5	2 3.72 E-5	2 3.72 E-5	0 < 1.05 E-4
UPC	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.05 E-4
WUT	2 3.72 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.05 E-4
UoPisa	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.05 E-4
LAAS	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.05 E-4
PTIN	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.05 E-4
PTC	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.86 E-5	0 < 1.05 E-4
Soluziona	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4	0 < 1.05 E-4

Table Legend : Green : Ratio $R \leq 5.00 \text{ E-5}$
Orange : $5.00 \text{ E-5} < R \leq 5.00 \text{ E-4}$
Red : $R > 5.00 \text{ E-4}$

Table 4.4-16 : nocturnal Out-of-order UDP1 packets number & ratio (Chariot)

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Based on the results for UDP1 diurnal tests, the following cases are to be refined :

- Very limited bandwidth for Soluziona connection
- High LPR from UoC to PTRD
- High LPR from UoC and UPC
- High LPR from UoC and PTIN
- High LPR from UoC and PTC
- High LPR with all other partners for UoB when transmitter
- Time Out from LAAS to PTRD
- High LPR from PTIN to TID
- High LPR from PTIN to UoC
- High LPR from PTIN to UPC
- High LPR from PTIN to WUT
- High LPR from Soluziona to WUT

4.4.2.3 UDP2 (packets of payload 160 bytes)

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD		0.998	0.997	0.997	0.998	1	0.997	0.998	0.998	0.840	0.997	0.174
PTRD	0.998		0.992	0.998	0.998	0.999	0.998	0.998	0.998	0.954	0.997	0.174
TID	0.996	0.995		0.995	0.996	0.998	0.995	0.997	0.995	0.948	0.995	0.172
UoC	0.980	NC	0.991		0.982	0.991	0.981	0.970	0.981	0.946	0.977	0.173
UoB	0.993	0.992	0.990	0.992		0.992	0.992	0.993	0.993	0.844	0.992	0.173
UPC	0.999	0.998	0.997	0.998	0.998		0.998	0.998	0.998	0.954	0.998	0.103
WUT	0.979	0.995	0.984	0.985	0.996	0.985		0.981	0.985	0.939	0.995	0.174
UoPisa	0.998	0.998	0.998	0.997	0.998	0.998	0.998		0.998	0.854	0.998	0.174
LAAS	0.997	TO	0.906	0.904	0.872	0.970	0.880	0.872		0.846	0.916	0.174
PTIN	0.751	0.780	0.808	0.808	0.809	0.784	0.816	0.729	0.815		0.815	0.163
PTC	0.995	0.996	0.994	0.994	0.996	0.995	0.996	0.995	0.994	0.946		0.173
Soluziona	0.173	0.173	0.130	0.173	0.173	0.173	0.173	0.166	0.173	0.173	0.173	

Table Legend : Green : Bandwidth $B \geq 0.990$

Orange : $0.950 \leq B < 0.990$

Red : $B < 0.950$

TO : Time Out after a while there is no answer from the machine and the Chariot test is then interrupted.

Table 4.4-17 : nocturnal UDP2 Throughput (average-min-max) in Mbps (Chariot)

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD		0 < 2.02 E-6	0 < 2.02 E-6	3 6.05 E-6	1 2.02 E-6	0 < 2.02 E-6	1 2.02 E-6	3 6.05 E-6	3 6.05 E-6	78462 1.58 E-1	0 < 2.02 E-6	1058 1.21 E-2
PTRD	37 7.89 E-5		0 < 2.02 E-6	3 6.04 E-6	0 < 2.02 E-6	0 < 2.02 E-6	0 < 2.02 E-6	5 1.01 E-5	0 < 2.02 E-6	21732 4.38 E-2	0 < 2.02 E-6	1099 1.24 E-2
TID	52 1.05 E-4	0 < 2.02 E-6		1 2.02 E-6	0 < 2.02 E-6	0 < 2.02 E-6	66 1.33 E-4	0 < 2.02 E-6	0 < 2.02 E-6	23585 4.76 E-2	0 < 2.02 E-6	1990 2.27 E-2
UoC	15 1.11 E-5	NC	11 2.22 E-5		18 3.63E-5	21 4.24 E-5	20 4.04 E-5	15 3.02 E-5	13 2.62 E-5	24540 4.95 E-2	15 3.02 E-5	1145 1.34 E-2
UoB	1854 3.74 E-3	2094 4.22 E-3	1465 2.95 E-3	1934 3.90 E-3		2061 4.15 E-3	1883 3.80 E-3	1505 3.03 E-3	1673 3.37 E-3	75559 1.52 E-1	1886 3.80 E-3	1232 1.41 E-2
UPC	62 1.25 E-4	2 4.03 E-6	0 < 2.02 E-6	0 < 2.02 E-6	2 4.03 E-6		0 < 2.02 E-6	2 4.03 E-6	11 2.22 E-5	21807 4.40 E-2	1 2.02 E-6	36346 4.15 E-1
WUT	31 6.61 E-5	1 2.02 E-6	8 1.62 E-5	8 1.62 E-5	76 1.53 E-4	6 1.28 E-5		17 3.62 E-5	13 2.63 E-5	24836 4.88 E-2	0 < 2.02 E-6	1099 1.25 E-2
UoPisa	139 2.80 E-4	0 < 2.02 E-6	0 < 2.02 E-6	1 2.02 E-6	5 1.01 E-5	0 < 2.02 E-6	0 < 2.02 E-6		0 < 2.02 E-6	71157 1.43 E-1	0 < 2.02 E-6	1022 1.17 E-2
LAAS	0 < 2.02 E-6	TO	74 1.49 E-4	71 1.43 E-4	2090 4.21 E-3	106 2.14 E-4	110 2.22 E-4	93 1.87 E-4		24247 4.89 E-2	61 1.30 E-4	986 1.12 E-2
PTIN	119319 2.54 E-1	105345 2.14 E-1	90703 1.84 E-1	90237 1.82 E-1	116973 2.36 E-1	102947 2.09 E-1	86864 1.76 E-1	130589 2.65 E-1	87134 1.76 E-1		87394 1.77 E-1	6017 6.87 E-2
PTC	31 6.61 E-5	1 2.02 E-6	0 < 2.02 E-6	69 1.39 E-4	4 8.06 E-6	2 4.03 E-6	0 < 2.02 E-6	0 < 2.02 E-6	2 4.03 E-6	24025 4.85 E-2		1201 1.37 E-2
Soluziona	1444 1.65 E-2	1486 1.70 E-2	22471 2.57 E-1	1538 1.75 E-2	1539 1.76 E-2	2873 3.28 E-2	1484 1.69 E-2	1488 1.70 E-2	1484 1.69 E-2	1480 1.69 E-2	1477 1.69 E-2	

Table Legend : Green : Ratio $R \leq 5.00 \text{ E-5}$
Orange : $5.00 \text{ E-5} < R \leq 5.00 \text{ E-4}$
Red : $R > 5.00 \text{ E-4}$
TO : Time Out after a while there is no answer from the machine and the Chariot test is then interrupted.

Table 4.4-18 : nocturnal UDP2 Lost Packets number and ratio (Chariot)


	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD		168 3.58 E-4	58 1.17 E-4	32 6.45 E-5	97 1.96 E-4	76 1.53 E-4	151 3.22 E-4	145 3.09 E-4	0 < 2.02 E-6	18 3.84 E-5	122 2.60 E-4	1 1.14 E-5
PTRD	0 < 2.02 E-6		0 < 2.02 E-6	NC	0 < 2.02 E-6	0 < 2.02 E-6	0 < 2.02 E-6	0 < 2.02 E-6	0 < 2.02 E-6	0 < 2.02 E-6	0 < 2.02 E-6	0 < 1.14 E-5
TID	0 < 2.02 E-6	12 2.42 E-5		0 < 2.02 E-6	19 3.83 E-5	0 < 2.02 E-6	0 < 2.02 E-6	0 < 2.02 E-6	7 1.41 E-5	0 < 2.02 E-6	2 4.03 E-6	114 1.30 E-3
UoC	7924 1.60 E-2	NC	2139 4.32 E-3		7083 1.43 E-2	2269 4.58 E-3	6772 1.37 E-2	12919 2.60 E-2	7262 1.46 E-2	0 < 2.02 E-6	8812 1.78 E-2	0 < 1.14 E-5
UoB	1 2.02 E-6	1 2.02 E-6	10 2.02 E-5	2 4.03 E-6		1 2.02 E-6	1 2.02 E-6	3 3.05 E-6	2 4.03 E-6	0 < 2.02 E-6	2 4.03 E-6	6 6.85 E-5
UPC	20 4.26 E-5	13 2.77 E-5	0 < 2.02 E-6	10 2.02 E-5	14 2.82 E-5		7 1.41 E-5	8 1.71 E-5	17 3.43 E-5	4 8.08 E-6	13 2.62 E-5	0 < 1.14 E-5
WUT	15452 3.11 E-2	5 1.01 E-5	4825 9.75 E-3	4433 8.95 E-3	10 2.02 E-5	4516 9.13 E-3		7116 1.52 E-2	4756 1.01 E-2	3671 9.59 E-3	0 < 2.02 E-6	0 < 1.14 E-5
UoPisa	6 1.28 E-5	8 1.71 E-5	2 4.03 E-6	2 4.03 E-6	3 3.05 E-6	3 6.04 E-6	3 6.04 E-6		5 1.01 E-5	1 2.02 E-6	0 < 2.02 E-6	0 < 1.14 E-5
LAAS	0 < 2.02 E-6	TO	45072 9.09 E-2	45193 9.11 E-2	59379 1.20 E-1	60836 1.23 E-1	57328 1.16 E-1	61288 1.24 E-1		49676 1.00 E-1	38923 7.85 E-2	2 2.28 E-5
PTIN	0 < 2.02 E-6	0 < 2.02 E-6	0 < 2.02 E-6	0 < 2.02 E-6	0 < 2.02 E-6	0 < 2.02 E-6	0 < 2.02 E-6	0 < 2.02 E-6	0 < 2.02 E-6		0 < 2.02 E-6	0 < 1.14 E-5
PTC	612 1.23 E-3	4 8.08 E-6	210 4.24 E-4	0 < 2.02 E-6	0 < 2.02 E-6	219 4.42 E-4	0 < 2.02 E-6	72 1.53 E-4	94 2.00 E-4	148 2.99 E-4		0 < 1.14 E-5
Soluziona	0 < 1.14 E-5	0 < 1.14 E-5	103 1.18 E-3	0 < 1.14 E-5	0 < 1.14 E-5	0 < 1.14 E-5	0 < 1.14 E-5	0 < 1.14 E-5	0 < 1.14 E-5	0 < 1.14 E-5	0 < 1.14 E-5	

Table Legend : Green : Ratio $R \leq 5.00 \text{ E-5}$
Orange : $5.00 \text{ E-5} < R \leq 5.00 \text{ E-4}$
Red : $R > 5.00 \text{ E-4}$
NC : No Connection

Table 4.4-19 : nocturnal UDP2 Out-of-order Packets number and ratio (Chariot)

Based on the results for UDP2 nocturnal tests, the following cases are to be refined:

- Very limited bandwidth for Soluziona connection

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- limited bandwidth in both directions for PTIN
- limited bandwidth for LAAS when transmitter
- limited bandwidth for UoC when transmitter
- limited bandwidth for WUT when transmitter
- Slight LPR for UDP2 flows with many partners when FTRD is transmitter
- No Connection for UDP2 flows from UoC to PTRD
- Slight LPR for UDP2 flows TID to WUT
- High LPR with all other partners when UoB is transmitter
- Slight LPR for UDP2 flows WUT to UoB
- High LPR for UDP2 flows LAAS to UoB
- Quite high LPR with many partners for LAAS in transmit direction
- High LPR in both directions with all other partners for PTIN
- High LPR in both directions with all other partners for Soluziona
- Quite high OoOPR with many partners when FTR&D is transmitter
- High OoOPR with most of other partners (except PTIN) when UoC is transmitter
- High OoOPR with most of other partners (except PTRD and PTC) when WUT is transmitter
- High OoOPR with most of other partners (except FTRD) when LAAS is transmitter
- High OoOPR from Soluziona to TID


4.4.2.4 TCP

	FTRD	PTRD	TID	UoC	UoB	UPC	WUT	UoPisa	LAAS	PTIN	PTC	Soluziona
FTRD		1,00-0,86-1,05	2,54-2,33-3,51	2,42-1,55-3,22	1,96-1,19-4,80	2,32-1,97-4,51	2,28-1,83-2,37	2,59-2,19-2,97	2,70-2,32-3,26	1,10-0,73-1,96	2,20-1,74-2,24	0,18-0,15-0,23
PTRD	2,41-1,30-3,86		NC	TO	3,02-1,49-3,10	TO	6,43-4,20-7,04	NC	NC	NC	1,86-1,55-1,94	0,22-0,14-0,23
TID	2,85-2,33-3,51	NC		3,06-1,61-4,24	1,98-1,20-3,42	3,63-2,95-4,36	2,97-1,18-3,59	NC	3,92-2,82-4,78	1,46-0,94-2,54	0,94-0,82-1,44	NC
UoC	1,50-0,82-3,76	0,71-0,58-0,73	2,74-1,84-5,28		1,50-1,11-2,30	1,51-0,76-4,23	0,99-0,58-3,44	1,96-1,03-4,82	3,06-1,81-5,45	1,64-1,05-4,45	1,13-0,49-3,50	0,08-0,06-0,15
UoB	4,54-0,59-5,78	1,32-0,48-1,48	3,48-0,61-4,29	2,78-0,54-3,56		4,48-0,51-4,90	4,95-0,58-5,18	NC	7,74-0,67-8,48	2,37-0,51-3,36	1,69-0,48-1,87	0,08-0,06-0,10
UPC	3,40-1,29-3,87	0,71-0,55-0,74	2,85-2,36-3,57	3,43-2,48-4,35	1,79-1,04-2,26		1,88-1,43-1,93	4,14-2,33-5,07	3,67-2,90-3,88	1,49-0,76-3,39	1,90-1,54-1,94	0,16-0,09-0,22
WUT	1,24-1,12-1,87	2,00-1,71-2,79	1,54-1,31-2,34	1,29-1,07-1,71	2,19-1,45-2,50	1,10-0,92-1,85		1,45-1,08-2,44	2,43-1,79-4,88	0,72-0,49-1,43	14,62-4,63-25	0,08-0,06-0,11
UoPisa	3,90-2,25-4,48	NC	NC	2,53-1,38-3,13	NC	4,14-2,52-5,08	2,88-1,39-2,89		4,59-3,68-4,71	0,95-0,61-1,74	2,65-2,11-2,66	0,21-0,15-0,23
LAAS	4,09-2,95-4,84	1,00-0,82-1,09	2,00-1,54-3,93	1,97-0,70-3,09	2,81-1,49-4,38	2,24-1,69-5,38	2,55-1,64-4,37	2,22-1,47-3,66		1,06-0,78-1,51	NC	0,15-0,14-0,16
PTIN	2,89-1,45-4,05	0,71-0,56-0,75	3,94-2,16-5,03	4,12-2,09-5,43	1,71-1,07-2,20	3,91-1,32-5,76	2,15-0,78-3,26	3,89-1,74-5,32	3,13-1,95-4,46		2,18-0,78-3,24	0,14-0,06-0,20
PTC	0,91-0,61-1,78	0,83-0,52-1,08	1,38-0,66-0,82	1,16-0,69-1,85	1,04-0,78-1,92	1,06-0,70-2,46	18,64-3,34-29,63	0,98-0,68-2,60	NC	0,75-0,48-1,75		0,15-0,12-0,20
Soluziona	0,16-0,15-0,23	0,07-0,05-0,18	NC	0,12-0,11-0,22	0,17-0,08-0,21	0,10-0,07-0,21	0,15-0,10-0,21	0,17-0,14-0,19	0,19-0,17-0,22	0,14-0,07-0,20	0,18-0,14-0,21	


Table Legend : Green : Average Throughput $T \geq 1$ Mbps
Orange : $0.9 \leq T < 1$
Red : $T < 0.9$ Mbps
NC : no connection; TO : Time Out after a while (# 45s.)

Table 4.4-20: nocturnal TCP Throughput (average-min-max) in Mbps (Chariot)

- No Connection in both direction between PTRD and TID
- Time Out from PTRD to UoC and Very limited bandwidth from UoC to PTRD
- Time Out from PTRD to UPC and Very limited bandwidth from UPC to PTRD

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- No Connection in both direction between PTRD and UoPisa
 - No Connection from PTRD to LAAS
 - No Connection from PTRD to PTIN and Very limited bandwidth from PTIN to PTRD
 - Very limited bandwidth from PTC to PTRD
 - No Connection in both direction between TID and UoPisa
 - No Connection in both direction between TID and Soluziona
 - No Connection in both direction between UoB and UoPisa
 - Very limited bandwidth from WUT to PTIN
 - No Connection in both direction between LAAS and PTC
 - Very limited bandwidth from PTC to PTIN
 - No Connection from PTRD to LAAS and High LPR from UPC to PTRD
 - Very limited bandwidth with all other partners in both directions for Soluziona

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4.4.2.5 Conclusion on nocturnal tests performed with Chariot

- Some cases with bad results need to be more investigated with DAG cards on site-to-site level (for more details see the subsections above for each type of testing flow).
- There is an important limitation on the transmit Side of UoB whom solving is in progress
- There is an important limitation in terms of bandwidth in both directions for Soluziona. Yet taking into account this limitation when adapting the rate of test flows, there is still a high Loss Packet Ratio and more particularly with small packets and even worse in the receive direction.

4.5 Conclusion on Site-To-Site tests

An extremely hard work of characterization of the 131 Point-To-Point links between partners has been performed many times with 4 different types of flows and with two different measurement tools. Thanks to this very complete iterative process (testing-improving-testing-improving ...) the quality of the EuQoS trial has extremely increased and now we know what quality we can expect from this Pan-European EuQoS network based on GRE tunnels between partners established on Best Effort Quality. So with more fine tuning on the remaining issues, this EuQoS network will become of good quality and will allow the implementation and testing of the different EuQoS prototypes on the different testbeds.

However the EuQoS partners working in WP5 have to continue the work to ever increase the quality of the established network.

5 Local tests (access network only)

5.1 Architecture

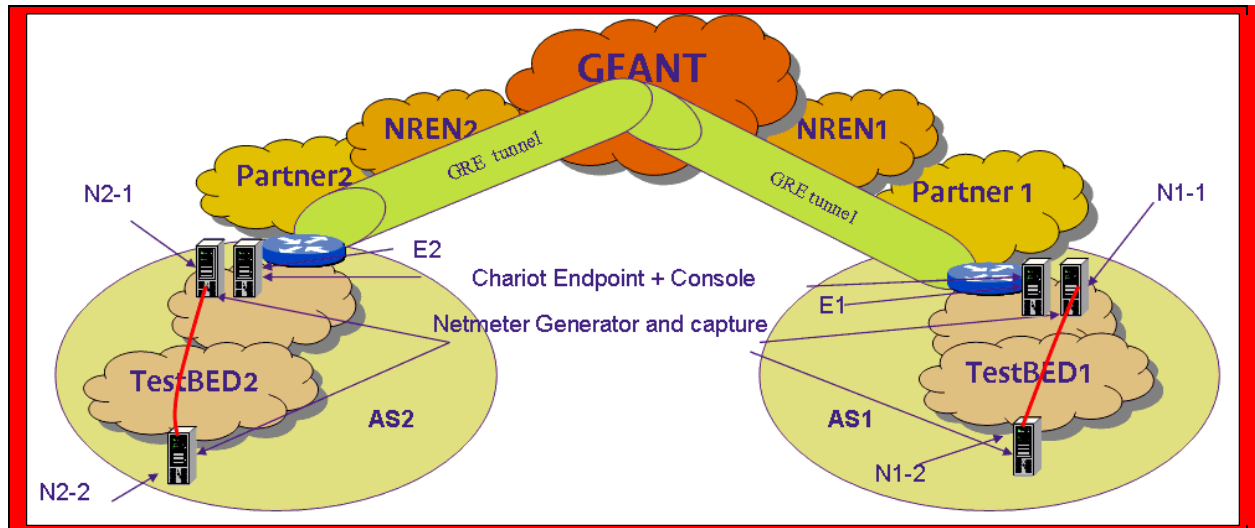



Figure 5.1-1 : local tests architecture

Both Netmeter PCs are used in active mode (i.e.: no monitoring feature is required). Flows are set-up between the two local Netmeter generators.

5.2 Flows generated

- **VoIP** : (type G.729) UDP – 60 Byte packets – 8 kbps – two flows per tests
Endpoint A-> Endpoint B and Endpoint B-> Endpoint A. One test.
- **UDP1** : payload 1420B packets (total packet size = 1462 bytes)–unidirectional flow – 1 Mbps. One flow per test. Two tests Endpoint A-> Endpoint B then Endpoint B-> Endpoint A.
- **UDP2** : payload 160B packets (total packet size = 202 bytes) –unidirectional flow – 1 Mbps. One flow per test. Two tests Endpoint A-> Endpoint B then Endpoint B-> Endpoint A.
- **TCP** : payload 1420B packets –unidirectional flows . One flow per test. Two tests Endpoint A-> Endpoint B then Endpoint B-> Endpoint A.

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5.3 Results

5.3.1 WUT’s Netmeter Local Tests

The tests were performed using the Netmeter tool. The testbed configuration for the connectivity test was presented in chapter 3.2.2.1.

A single test traffic stream was generated between two Netmeter end-points in WUT testbed. In **traffic scenario #1**, the test stream was generated with rate 50 packets/sec, with packet length (payload) 48B. The resulting bit rate was 19,2kbps (36kbps on the Ethernet layer).

In **traffic scenario #2**, the test stream was generated with rate 88.33 packets/sec, with packet length (payload) 1500B. The resulting bit rate was 1Mbps (1.027mbps on the Ethernet layer). In all cases, the test duration was 5 minutes.

The following tests cases were considered:

5.3.1.1 “Uplink” direction.

The WMP₁ (Wireless Measurement Point) was used as artificial traffic generator, while the MP₁ (Measurement Point) was used as traffic receiver.

Traffic scenario #1:

One-way delay (OWD) [ms] (min/max/average): 0.394/0.573/10.58

Packet loss ratio: 0

The plots of OWD (one-way delay) and IPDV (IP delay variation) are presented in D5.1.2 annex on Figure 5.3 1, and Figure 5.3 2, respectively.

Traffic scenario #2:

One-way delay (OWD) [ms] (min/max/average): 2.384/2.652/14.95

Packet loss ratio: 0

The plots of OWD (one-way delay) and IPDV (IP delay variation) are presented on D5.1.2 annex on Figure 5.3 1, and Figure 5.3 2, respectively.

5.3.1.2 “Downlink” direction.

In this test case, the MP₁ was used as artificial traffic generator, while the WMP₁ was used as traffic receiver.

Traffic scenario #1:


One-way delay (OWD) [ms] (min/max/average): 0.664/0.707/8.936

Packet loss ratio: 0

Traffic scenario #2:


One-way delay (OWD) [ms] (min/max/average): 2.722/2.770/8.1441

Packet loss ratio: 0

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5.3.1.3 Conclusions

The simple local connectivity tests confirm, that the testbed (router, WLAN equipment, and measurement tools) is configured properly, and the packet transfer quality (in under-loaded WLAN access network) is, as it was expected, satisfactory.

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5.3.2 UoB’s Netmeter Local Tests

In this section we present the local tests performed at the UoB Ethernet test-bed. Netmeter was used for each test to generate a single traffic stream between two local nodes, interconnected by a gigabit-ethernet switch. The following two tests have been performed:

5.3.2.1 1Mbps UDP tests


The results obtained are the following:

- Flow Relative Start (msec): 0
- Flow Relative Stop (msec): 600000

Pattern PERIODIC

- Send Rate (packets/sec): 85
- UDP Packet Size (bytes): 1450
- IP Packet Size (bytes): 1478
- Nr. of MODs 0
- Flow Source 10.195.0.3:32842
- Flow Destination 10.195.0.8:5000
- Received packets: 51001
- Join delay (sec): 53050.597656
- Recv rate (packets/sec): 85.000
- Recv data rate (kbps): 986.019
- Packets dropped: 0
- Average delay(sec): 0.000164
- Max delay (sec): 0.000476
- Min delay (sec): 0.000153
- Delay variation (sec): 0.000323

5.3.2.2 VoIP Tests

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The results obtained are the following:

- Flow Relative Start (msec): 0
- Flow Relative Stop (msec): 600000

Pattern PERIODIC

- Send Rate (packets/sec): 20
- UDP Packet Size (bytes): 60
- IP Packet Size (bytes): 88
- Nr. of MODs 0
- Flow Source 10.195.0.3:32871
- Flow Destination 10.195.0.8:5000
- Received packets: 12000
- Join delay (sec): 58003.207031
- Recv rate (packets/sec): 20.000
- Recv data rate (kbps): 9.601
- Packets dropped: 0
- Average delay(sec): 0.000150
- Max delay (sec): 0.000276
- Min delay (sec): 0.000110
- Delay variation (sec): 0.000166

5.3.2.3 Conclusion

The results obtained on these two tests show that the UoB Ethernet test-bed works without any problems with very low impact on the quality of the transmitted flows. There are no packet losses, the receiving rate is equal to the sending rate, the delays are very short and the delay variation is very limited. With these tests we validated the UoB Ethernet test-bed for the future EuQoS experiments.

5.3.3 FTRD’s Local Tests

The tests have been performed using both Netmeter and Chariot tools. The testbed configuration is described in deliverable D5.1.1.

The characteristics of the ADSL link used to perform the tests on the testbed are the following :

- Rate Down : 8128 kbit/s (ATM)
- Rate Up : 320 kbit/s (ATM)
- Interleaving Mode : Medium

As defined initially, three types of traffic stream were generated between two Netmeter endpoints, or two chariot endpoints, in FTRD testbed All the tests last 10 minutes.

In **traffic VoIP**, the test stream was generated with rate 20 packets/sec, with packet length (payload) 60 bytes. The resulting bit rate was 9,6kbps.

In **traffic UDP**, the test streams were different according to the way of transmitting:

- Downstream : Flow generated with rate 84 packets/sec, with packet length (payload) 1450 Bytes. The resulting bit rate was 1Mbps (1.027mbps on the Ethernet layer). In all cases, the test duration was 5 minutes.
- Upstream : Due to the bandwidth limitation on ADSL link in Upstream, the flow to be generated can not be 1 Mbit/s, it is necessary to reduce it. So the flow was generated with packet length (payload) 1435 Bytes at a resulting bit rate of 235 kbit/s (payload).

In **traffic TCP**, the test streams are based on packets of 1450 Bytes (payload) :

5.3.3.1 Upstream results.

The Netmeter2 is the traffic generator, while the Netmeter1 is used as traffic receiver.

5.3.3.1.1 VoIP Results :

	Delay min (ms)	Delay average (ms)	Delay MAX (ms)	Rate (kbit/s)	Lost Packets	Missing packets
Chariot	22	24	30	8	0	0
Netmeter	21.36	23.95	35.59	9.6	0	0

Table 5.3-1 : FT VoIP results Upstream

5.3.3.1.2 UDP Results :

	Delay min (ms)	Delay average (ms)	Delay MAX (ms)	Rate (kbit/s)	Lost Packets	Missing packets
Chariot	NA	NA	NA	240	7	0
Netmeter	85	88	105	235	0	0

Table 5.3-2 : FT UDP results Upstream

5.3.3.1.3 TCP Results :

	Rate (kbit/s)	Expected results
Chariot	259	260
Netmeter	265	260

Table 5.3-3 : FT TCP results Upstream

5.3.3.2 *Downstream results*

The Netmeter1 is the traffic generator, while the Netmeter2 is used as traffic receiver.

5.3.3.2.1 VoIP Results :

	Delay min (ms)	Delay average (ms)	Delay MAX (ms)	Rate (kbit/s)	Lost Packets	Missing packets
Chariot	24	25	27	8	4	0
Netmeter	26.4	26.9	44.4	9.6	0	16

Table 5.3-4 : FT VoIP results Downstream

5.3.3.2.2 UDP Results :

	Delay min (ms)	Delay average (ms)	Delay MAX (ms)	Rate (kbit/s)	Lost Packets	Missing packets
Chariot	NA	NA	NA	1024	31	0
Netmeter	28.6	29	46.6	985.98	2	94

Table 5.3-5 : FT UDP results Downstream

5.3.3.2.3 TCP Results :


	Rate (kbit/s)	Expected results
Chariot	3759	6500
Netmeter	3816	6500

Table 5.3-6 : FT TCP results Downstream

5.3.3.3 *Conclusions*

The local tests point out several interesting things.

- With Netmeter tool, when comparing the number of received packets with the number of sent packets, some packets are missing, they are not in the identified dropped packets. These packets are called in the table "missing packets". This issue could come from a too late start of the distant endpoint which leads it to lose the first sent packets. This point needs to be clarified
- On ADSL Link, if the link is very asymmetrical in terms of rate, due to the ACK traffic generated on Upstream, the Downstream rate measured is limited by the rate limitation of the Downstream.
- With UDP flows, it is necessary to let a free small rate to allow ppp to exchange "keepalive" messages. Otherwise, the ppp session breaks down before the end of the test.
- The results generated through Chariot and Netmeter are comparable.

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5.3.4 LAAS's Netmeter Local Tests

This Section presents the local tests conducted in the LAAS Ethernet Testbed. In each scenario Netmeter was used to generate a single traffic stream between two local nodes, which were interconnected by a fast-ethernet switch. Conducted tests correspond to three different scenarios.

5.3.4.1 Scenario 1

In the first scenario the test stream was generated with a 50 pkts/sec rate, with a packet length (payload) of 48 Byte. The resulting bit rate was 36 kbps at the Ethernet layer and the test duration was 5 minutes.

The results obtained are the following:


Flow IPv4 ID 1

- -Flow Relative Start (msec): 0
- -Flow Relative Stop (msec): 600000

Pattern PERIODIC

- -Sending Rate (packets/sec): 50
- -UDP Packet Size (bytes): 48
- -IP Packet Size (bytes): 76
- Nr. of MODs 0
- Flow Source 140.93.2.52:32843
- Flow Destination 140.93.192.71:5000
- -Received packets: 30000
- -Join delay (sec): 45732.175781
- -Recv rate (packets/sec): 50.000
- -Recv data rate (kbps): 19.201
- -Packets dropped: 0
- -Average delay(sec): 0.011216
- -Max delay (sec): 0.278465
- -Min delay (sec): 0.009106
- -Delay variation (sec): 0.269359

The Figures show the plots of OWD (one-way delay) and IPDV (IP delay variation) for this scenario can be seen in Deliverable D5.1.2 V2.1 annex.

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5.3.4.2 Scenario 2

In Scenario 2 the test stream was generated with a 50 pkts/sec rate, with a packet length (payload) of 1500 Byte. The resulting bit rate at the Ethernet layer was 603 Kbps. The test duration was 10 minutes.

The results obtained are the following:

- Flow Relative Start (msec): 0
- Flow Relative Stop (msec): 600000

Pattern PERIODIC


- Send Rate (packets/sec): 50
- UDP Packet Size (bytes): 1500
- IP Packet Size (bytes): 1528
- Nr. of MODs 0
- Flow Source 140.93.2.52:32843
- Flow Destination 140.93.192.71:5000
- Received packets: 29998
- Join delay (sec): 46934.152344
- Recv rate (packets/sec): 49.996
- Recv data rate (kbps): 599.968
- Packets dropped: 2
- Average delay(sec): 0.011559
- Max delay (sec): 0.169684
- Min delay (sec): 0.009236
- Delay variation (sec): 0.160448

The plots of OWD and IPVD are presented in the Figures which can be seen in Deliverable D5.1.2 V2.1 annex.

5.3.4.3 Scenario3 (VoIP)

In this last scenario the generated test stream had a 20 pkts/sec rate, with a packet length of 60 Byte. The resulting bit rate on the Ethernet layer was 16 Kbps. The test duration was 10 minutes.

The results obtained are the following:

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Flow IPv4 ID 1

- Flow Relative Start (msec): 0
- Flow Relative Stop (msec): 600000

Pattern PERIODIC

- Send Rate (packets/sec): 20
- UDP Packet Size (bytes): 60
- IP Packet Size (bytes): 88
- Nr. of MODs 0
- Flow Source 140.93.2.52:32844
- Flow Destination 140.93.192.71:5000
- Received packets: 12000
- Join delay (sec): 48958.222656
- Recv rate (packets/sec): 20.000
- Recv data rate (kbps): 9.601
- Packets dropped: 0
- Average delay(sec): 0.009549
- Max delay (sec): 0.096151
- Min delay (sec): 0.008740
- Delay variation (sec): 0.087411

The plots of OWD and IPVD are presented in Figures can be seen in Deliverable D5.1.2 V2.1 annex.

5.3.4.4 Conclusion

The results obtained on these 3 scenarios shows that LAAS’s Ethernet local platform works perfectly. It has low impact on the quality of transmitted flows. The 3 tests demonstrate that there are no loss, the receiving rate is the same as the sending rate, the delays are very short and quite constant (delay variation is very limited). These tests then validate the LAAS’s platform for the future EuQoS experiments.

5.3.5 TID's Netmeter Local Tests

The set of local tests has been performed over a PDP context of Background class. Although contexts of this class, in theory, have no guaranteed bandwidth (it depends on the load in the cell), the tests were performed in conditions where the assigned bandwidths were 128 Kbps downlink and 64 Kbps uplink.

According to 5.2, these tests were performed between both local endpoints:

- **Throughput tests with TCP traffic** to get a precise measurement of available bandwidth per context in that conditions of load and propagation. In order to avoid fragmentation, a packet size of 1420 bytes was used.
- **Delay measurement tests with UDP traffic**, to estimate the delay between both endpoints. In order to avoid overloading the UMTS link (which would lead to an excessive queuing delay), generation rates were adapted to the values obtained in the throughput tests:
 - Downstream: 11 packets/sec with packet size of 1448 bytes (1420 B payload), which results in a rate of 127.42 Kbps.
 - Upstream: 5 packets/sec with packet size of 1328 bytes (1300 B payload), which results in a rate of 53.12 Kbps.
- **VoIP test**, where a bidirectional test stream of 20 packets/sec with packet size of 80 bytes (60 B payload) was used, which results in a rate of 12,80 Kbps.

5.3.5.1 TCP Results

	Throughput (Mbps)
Downlink	0.13
Uplink	0.05

Table 5.3-7 : TCP results

According to expected, throughput measurements are close to the theoretical values.


5.3.5.2 UDP results

5.3.5.2.1 Downlink (127 Kbps)

Min. delay (sec)	Average delay (sec)	Max. delay (sec)	Delay variation (sec)	Rate (Kbps)	Lost packets
0.168997	0.307469	1.791920	1.622923	124.929	3

Table 5.3-8 : UDP Downlink results

5.3.5.2.2 Uplink (53 Kbps)

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Min. delay (sec)	Average delay (sec)	Max. delay (sec)	Delay variation (sec)	Rate (Kbps)	Lost packets
0.278998	0.326825	0.679620	0.400622	52.023	0

Table 5.3-9 : UDP Uplink results

5.3.5.3 *VoIP results*

5.3.5.3.1 Downlink

Min. delay (sec)	Average delay (sec)	Max. delay (sec)	Delay variation (sec)	Rate (Kbps)	Lost packets
0.070510	0.081424	0.514325	0.443815	9.601	0

Table 5.3-10 : VoIP Downlink results


5.3.5.3.2 Uplink

Min. delay (sec)	Average delay (sec)	Max. delay (sec)	Delay variation (sec)	Rate (Kbps)	Lost packets
0.278998	0.326825	0.679620	0.400622	52.023	0

Table -5.3-11 : VoIP Uplink results

5.3.5.4 *Conclusions*

- Throughput measurements are near to the theoretical values for the RAB.
- In order to avoid fragmentation, IP packets should not be larger than 1450 bytes (1422 bytes of payload). Otherwise, performance degrades significantly.
- One-way delays are generally higher in uplink than downlink. The main reason is that medium access is more complicated in uplink direction.

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5.3.6 UoC’s Netmeter Local Tests

This Section presents the local tests conducted in the UoC Ethernet Testbed. In each scenario Netmeter was used to generate a single traffic stream between two local nodes, which were interconnected by a fast-ethernet switch. Traffic was generated from node MP1 to node MP2. Conducted tests correspond to three different scenarios.

5.3.6.1 Scenario 1

In the first scenario the test stream was generated with a 50 packets/sec rate, with a packet length (payload) of 48 Byte. The resulting bit rate was 19.2 kbps (36 kbps on the Ethernet layer) and the test duration was 5 minutes. The following Figures show the plots of OWD (one-way delay) and IPDV (IP delay variation) for this scenario.

5.3.6.2 Scenario 2

In Scenario 2 the test stream was generated with a 50 packets/sec rate, with a packet length (payload) of 1500 Byte. The resulting bit rate on the Ethernet layer was 603 Kbps. The test duration was 5 minutes. The plots of OWD and IPVD are presented in the following Figures.

5.3.6.3 Scenario 3

In this last scenario the generated test stream had a 20 packets/sec rate, with a packet length of 60 Byte. The resulting bit rate on the Ethernet layer was 16 Kbps. The test duration was 10 minutes (see the following Figures).

5.3.6.4 Conclusions

The local testbed was ran with success and showed that equipments are right configured and results were expected for the straightforward fast-ethernet connection used the tests.

5.3.7 PTRD’s Netmeter Local Tests

For the local test Netmeter tool was used. Tests with different traffic patterns were performed in ADSL testbed configuration (see figure below).

Polish Telecom R&D lab

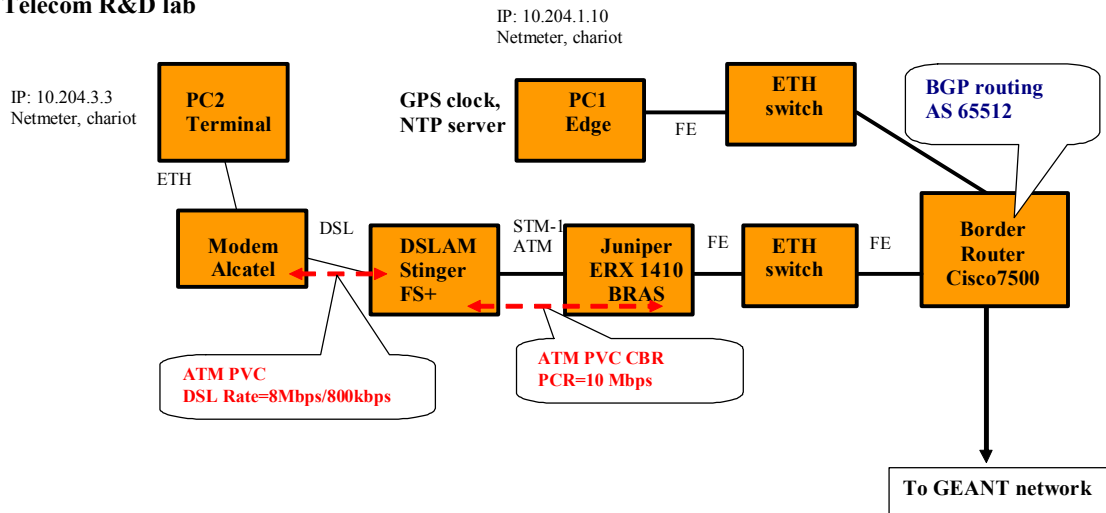


Figure 5.3-1. Polish Telecom R&D (PTRD) testbed for ADSL.

In testbed the PC1 (Edge) and PC2 (ADSL terminal) were used for Netmeter end points. The following traffic patterns were generated:

1. Data stream – 1450 bytes UDP packets, 85 packets/s, ~ 1Mbps at IP layer
2. Data stream – 1450 bytes UDP packets, 44 packets/s, ~ 512 kbps at IP layer
3. VoIP stream – 60 bytes UDP packets, 20 packets/s, 9.6 kbps
4. TCP stream, send message size 1450 bytes

Tests were performed for both transmission directions i.e. uplink (from PC2 to PC1 – from terminal to BRAS) and downlink (from PC1 to PC2 – from BRAS to terminal).

As the results the following parameters were measured: One-way delay (OWD) (min/max/average and distribution), Packet loss ratio, IPDV (IP packet delay variation) and its distribution, data rate, throughput for TCP stream.

5.3.7.1 Data stream – UDP 1Mbps and 512 kbps stream

5.3.7.1.1 Downlink direction - 1Mbps

The results for downlink direction are following:


Received data rate: 982.032 kbps

Packet dropped: 0

Average delay: 4.073 ms

Max delay: 26.685 ms

Min delay: 3.359 ms

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Delay variation: 23.322 ms

On the figures below the OWD, OWD distribution and IPDV, IPDV distributions are shown.

5.3.7.1.2 Uplink direction – 1Mbps

The results for uplink direction are following:

Received data rate: 705.999 kbps

Packet dropped: 14 412 packets

Received packets: 36589 packets

Average delay: 1.031s

Max delay: 1.2 s

Min delay: 0.0218 s

Delay variation: 1.185 s

On the figures below the OWD, OWD distribution and IPDV, IPDV distributions are shown.

5.3.7.1.3 Uplink direction – 512kbps

The results for uplink direction are following:

Received data rate: 510.418 kbps

Packet dropped: 0

Average delay: 16.56ms

Max delay: 33.25ms

Min delay: 15.67ms

Delay variation: 17.57ms

On the figures below the OWD, OWD distribution and IPDV, IPDV distributions are shown.

5.3.7.2 VoIP stream – UDP 9.6 kbps unidirectional stream

5.3.7.2.1 Downlink direction - VoIP

The results for uplink direction are following:

Received data rate: 9.6 kbps

Packet dropped: 0


Average delay: 0.852ms

Max delay: 84.57 ms

Min delay: 0.254 ms

Delay variation: 84.32 ms

On the figures below the OWD, OWD distribution and IPDV, IPDV distributions are shown.

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5.3.7.2.2 Uplink direction - VoIP

The results for uplink direction are following:

Received data rate: 9.6 kbps

Packet dropped: 0


Average delay: 5.576ms

Max delay: 21.89 ms

Min delay: 4.969ms

Delay variation: 16.92ms

On the figures below the OWD, OWD distribution and IPDV, IPDV distributions are shown.

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5.3.7.3 TCP stream

5.3.7.3.1 Downlink

The results for Downlink direction are following:

Throughput: 6.83 Mbps

Send Socket Size: 16384

Receive Socket Size: 87380

5.3.7.3.2 Uplink

The results for Uplink direction are following:

Throughput: 680 kbps

Send Socket Size: 16384

Receive Socket Size: 87380

5.3.7.4 Conclusions

The local tests confirm the proper configuration of the ADSL testbed. The UDP test show that the better results for delay characteristics were achieved for downlink than for uplink direction (average delay from 1 to 5 ms comparing to 5-15 ms depends on packet size). As it was expected for ADSL technology the throughput for downlink is about 10 times bigger than for uplink (6.8 Mbps comparing to 680 kbps). For 1 Mbps UDP stream for uplink direction the congestion were observed (the maximum throughput for UDP is about 700 kbps since the ADSL uplink capacity was 800 kbps). Therefore, for measuring delay characteristics of uplink direction 512kbps UDP stream were used.

5.3.8 UPC’s Netmeter Local Tests

This section describes the local tests done at the UPC’s internal network.

The tests were done from Malvasia to Pampol on a first stage, and then on the opposite direction for comparing the performance of both sending and reception, the detailed description of the testbed can be found in deliverable D5.1.1.

As stated on the testbed’s description the Netmeter endpoints are synchronized via a GPS NTP server, for guaranteeing that the synchronization is accurate enough just before the tests and once finished the instruction `ntpdate` has been executed on both machines giving an estimate error shown in Table 5.3-12(units in microseconds).

<i>Endpoint</i>	<i>Before</i>	<i>After</i>
Malvasia	182	185
Pampol	136	132

Table 5.3-12 .- Clock precision for local tests (μ s)

The set of test is composed by an UDP flow on each direction of the testbed, and a low bandwidth flow, also on each direction, which simulates VoIP traffic and finally a TCP flow for computing the link bulk transfer bandwidth.


5.3.8.1 1Mbps UDP tests

The tests last for 10 minutes each. Table 5.3-13 shows a summary of the obtained results. All the results are expressed in milliseconds.

	<i>Average delay</i>	<i>Maximum delay</i>	<i>Minimum delay</i>	<i>Maximum Delay Variation</i>	<i>Packet losses</i>
Malvasia → Pampol	3.3	338.4	2.7	335.72	0
Pampol → Malvasia	3.2	68.4	3.1	65.2	0

Table 5.3-13.- UDP local results (ms)

The Table 5.3-13 highlights the good behaviour of the Ethernet testbed, giving a very good average delay. Looking at the maximum delay is easy to see the outlier on the test because the average is very close to the minimum.

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5.3.8.2 VoIP Tests

Now the focus will be the VoIP tests. The endpoint status is the same as before, but now the used bandwidth is far smaller.

	<i>Average delay</i>	<i>Maximum delay</i>	<i>Minimum delay</i>	<i>Maximum Delay Variation</i>	<i>Packet losses</i>
Malvasia → Pampol	0.75	336	0.44	335.62	0
Pampol → Malvasia	0.75	7.61	0.67	6.94	0

Table 5.3-14.- VoIP local results (ms)

As can be easily seen on Table 5.3-14, the lower the bandwidth the lower the one way delay of the data is.

As a summary, the results of this section show the good behaviour of the testbed.


5.3.8.3 TCP Tests

The final set of tests consists on running 5 times the same test, with NetPerf, for computing the bulk bandwidth available on the network.

The throughput reported by Netmeter on all the tests is 9.41Mbps without any variation. Here the traffic parameters were:

- Packet size: 1024
- Test duration: 10minutes

The above bandwidth result is coherent with the tight link on the path, being an Ethernet link at 10Mbps.

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5.3.9 UoPisa’s Netmeter Local Tests

The netmeter measurement is based on two linux machines one connected to fastethernet and another to the WiFi as indicated on the test bed document. The traffic types considered for the measurements are **UDP traffic, VOIP traffic**. The tests last 10 minutes and the characteristics of the traffic are specified at the beginning of each traffic type. The measurement is done from the local machine 10.197.1.30 to 10.197.1.20. The NTP synchronization problem has been solved and the results of the local measurements done are as follows:

5.3.9.1 Tests UDP-1Mbps

Flow IPv4 ID 1
-Flow Relative Start (msec): 0
-Flow Relative Stop (msec): 600000
Pattern PERIODIC
-Send Rate (packets/sec): 826
-UDP Packet Size (bytes): 160
-IP Packet Size (bytes): 188
Nr. of MODs 0
Flow Source 10.197.1.30:32856
Flow Destination 10.197.1.20:5000
-Received packets: 495508
-Join delay (sec): 55530.472656
-Recv rate (packets/sec): 825.845
-Recv data rate (kbps): 1057.084
-Packets dropped: 92/495600000
-Average delay(sec): 0.002184
-Max delay (sec): 0.040669
-Min delay (sec): 0.001916
-Delay variation (sec): 0.038753

Table 5.3-15 : UDP tests parameters

5.3.9.2 Tests VoIP

-Flow Relative Start (msec): 0
-Flow Relative Stop (msec): 600000
Pattern PERIODIC
-Send Rate (packets/sec): 50
-UDP Packet Size (bytes): 32
-IP Packet Size (bytes): 60
Nr. of MODs 0
Flow Source 10.197.1.30:32870
Flow Destination 10.197.1.20:5000
-Received packets: 29989
-Join delay (sec): 57955.335938
-Recv rate (packets/sec): 49.982
-Recv data rate (kbps): 12.796
-Packets dropped: 11/30000000
-Average delay(sec): 0.004040
-Max delay (sec): 0.057206
-Min delay (sec): 0.003685
-Delay variation (sec): 0.053521

Table 5.3-16 : VoIP tests parameters

5.3.9.3 Conclusions

After solving problem with ntp synchronization the measurements done are considered satisfactory. We are investigating to solve the problem of the few dropped packets.

5.3.10 PTIN’s NetMeter Local Tests

The tests have been performed using NetMeter tool. The trial configuration is described in deliverable D5.1.1.

The characteristics of the ADSL link used to perform the tests at PTIN premises are the following:

Rate: Upstream → 8000 kbit/s, Maximum attained: 10676 kbit/s
Downstream → 800 kbit/s, Maximum attained: 1251 kbit/s

Noise margin: Upstream → 19 dB
Downstream → 16 dB

Attenuation: Upstream → 3 dB
Downstream → 5 dB

Output power: Upstream → 12 dBm
Downstream → 9 dBm

All the tests were performed during 10 minutes.

In **traffic VoIP**, the test stream was generated with rate 20 packets/sec, with packet length (payload) 60 bytes. The resulting bit rate was 9,6kbps.

In **traffic UDP**, the test streams were different according to the way of transmitting:

Downstream: Flow generated with rate 84 packets/sec, with packet length (payload) 1450B. The resulting bit rate was 972 kbits/s.

Upstream: Due to the bandwidth limitation on ADSL link in Upstream, the flow to be generated can not be 1 Mbit/s, it is necessary to reduce it. So the flow was generated with packet length (payload) 1435 Bytes at a resulting bit rate of 230 kbit/s (payload).

In **traffic TCP**, the test streams are based on packets of 1450 Bytes (payload):

5.3.10.1 Upstream results

The Netmeter2 is the traffic generator, while the Netmeter1 is used as traffic receiver.

5.3.10.1.1 VoIP Results:

	Delay min (ms)	Delay average (s)	Delay MAX (s)	Rate (kbit/s)	Lost Packets	Missing packets
Chariot	NA	NA	NA	NA	NA	NA
Netmeter	13,7	15,2	70,6	9.6	0	0

Table 5.3-17 : PTIN VoIP results Upstream

5.3.10.1.2 UDP Results:

	Delay min (ms)	Delay average (ms)	Delay MAX (ms)	Rate (kbit/s)	Lost Packets	Missing packets
Chariot	NA	NA	NA	NA	NA	NA
Netmeter	31,6	33,3	94,9	229.6	0	0

Table 5.3-18 : PTIN UDP results Upstream

5.3.10.1.3 TCP Results:

This test has failed in both directions, we will repeat it. The TCP tests were performed several times but were unfinished due to an unexpected problem that should be further investigated.

5.3.10.2 *Downstream results*

The Netmeter1 is the traffic generator, while the Netmeter2 is used as traffic receiver.

5.3.10.2.1 VoIP Results:

	Delay min (ms)	Delay average (ms)	Delay MAX (ms)	Rate (kbit/s)	Lost Packets	Missing packets
Chariot	NA	NA	NA	NA	NA	NA
Netmeter	32,9	34,2	197,9	9.6	0	0

Table 5.3-19 : PTIN VoIP results downstream

5.3.10.2.2 UDP Results:

	Delay min (ms)	Delay average (ms)	Delay MAX (ms)	Rate (kbit/s)	Lost Packets	Missing packets
Chariot	NA	NA	NA	NA	NA	NA
Netmeter	35,2	36,3	99.6	971.5	143	0

Table 5.3-20: PTIN UDP results downstream

5.3.11 PTC’s NetMeter Local Tests

The tests were performed with the Netmeter tool. Two measurement points were used: one in the user equipment (UE) and the other in the G_i interface (as specified D2.1.1). A laptop with a PCMCIA card was used as the UE. EuQoS-dedicated access point (APN), configured in GGSN, had the following features:

- *UL bit rate: 64 Kbps*
- *DL bit rate: 384 Kbps*
- *UMTS CoS: Background*

To avoid IP packet fragmentation the MTU configured in the core of UMTS access network was 1476B.

The tests consisted of three simulation scenarios:

- **Throughput test** - measurements focused on actual available bandwidth (TCP traffic)
Packet size: 1420B (payload)
Test duration: 5min
- **VoIP simulation** (UDP traffic)
Packet size: 60B payload (88B IP packet size)
Packet generation rate: 20 packets/s
Test duration: 10min
- **UDP traffic**
 - Downlink
Packet size: 1440B (1468B IP packet size)
Packet generation rate: 27 packets/s
Test duration: 10min
 - Uplink
Packet size: 1440B (1468B IP packet size)
Packet generation rate: 5 packets/s
Test duration: 10min

5.3.11.1 Throughput test

	Throughput (Mbps)
Downlink	0.32
Uplink	0.06

Table 5.3-21 : throughput tests

5.3.11.2 VoIP simulation

Underneath there are numerical as well as graphical representations of the results gathered from VoIP tests scenario as described above.

5.3.11.2.1 Downlink

In this test case, the MP₂ was used as artificial traffic generator, while the MP₁ was used as traffic receiver.

Received packets	11997
Lost packets	3
Received data rate	9.6 Kbps
Average delay	0.181 sec
Maximum delay	0.864 sec
Minimum delay	0.130 sec
Delay variation	0.734 sec

Table 5.3-22 : VoIP results Downlink

5.3.11.2.2 Uplink

In this test case, the MP₁ was used as artificial traffic generator, while the MP₂ was used as traffic receiver.

Received packets	11979
Lost packets	5
Received data rate	9.6 Kbps
Average delay	0.114 sec
Maximum delay	0.479 sec
Minimum delay	0.096 sec
Delay variation	0.383 sec

Table 5.3-23 : VoIP results Uplink

5.3.11.3 UDP traffic

Underneath there are numerical as well as graphical representations of the results gathered from UDP tests scenarios as described above.

5.3.11.3.1 Downlink

In this test case, the MP₂ was used as artificial traffic generator, while the MP₁ was used as traffic receiver.

Received packets	16196
Lost packets	5
Received data rate	310.9 Kbps
Average delay	0.241 sec
Maximum delay	0.612 sec
Minimum delay	0.154 sec
Delay variation	0.458 sec

Table 5.3-24 : Downlink UDP results

5.3.11.3.2 Uplink


In this test case, the MP₁ was used as artificial traffic generator, while the MP₂ was used as traffic receiver.

Received packets	2994
Lost packets	6
Received data rate	57.5 Kbps
Average delay	0.315 sec
Maximum delay	0.655 sec
Minimum delay	0.294 sec
Delay variation	0.361 sec

Table 5.3-25 : Uplink UDP results

5.3.11.4 Conclusions

The results of test scenarios described above show, that the PTC’s UMTS testbed is setup properly and ready for further tests. We have observed small losses in every test (3-6 packets), which was probably caused by the imperfect synchronization between Netmeter endpoints.

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5.3.12 Soluziona’s NetMeter Local Tests

Tests were performed using the NetMeter tool. The Soluziona’s testbed is presented in chapter 3.2.2.12.

Four streams were generated, duration 5 minutes in “live” network (4 Wireless machines in 1 AP, 2 other AP surrounding):

- Stream number 1:Upload VoIP: 20 pkts/sec, 60B payload,Wc1: generator, PC1:rx
- Stream number 2:Download VoIP: 20 pkts/sec, 60B payload, Wc1: rx, PC1:generator
- Stream number 3:Upload 1Mbps: 85 pkts/sec, 1420 B payload,Wc1: generator, PC1:rx
- Stream number 4:Download 1Mbps: 85 pkts/sec, 1420 B payload,Wc1: rx,PC1:generator

* Stream number 1:Upload VoIP: 20 pkts/sec, 60B payload,Wc1: generator, PC1:rx

One-way delay (OWD) [ms] (min/max/average): 0.426/16.0/0.613

Packet loss ratio: 0

* Stream number 2:Download VoIP: 20 pkts/sec, 60B payload, Wc1: rx, PC1:generator

One-way delay (OWD) [ms] (min/max/average): 0.585/4.832/0.918

Packet loss ratio: 0.0006

* Stream number 3:Upload 1Mbps: 85 pkts/sec, 1420 B payload,Wc1: generator, PC1:rx

One-way delay (OWD) [ms] (min/max/average): 0.510/30.212/1.069

Packet loss ratio: 0

* Stream number 4:Download 1Mbps: 85 pkts/sec, 1420 B payload,Wc1: rx,PC1:generator

One-way delay (OWD) [ms] (min/max/average): 0.365/7.890/0.664

Packet loss ratio: 0.0012

Conclusions

Testbed working fine and packet drops almost zero in “live” network.

6 End to End tests

These tests initially planned are postponed due to late connectivity of most of the partners for this phase.

6.1 Architecture

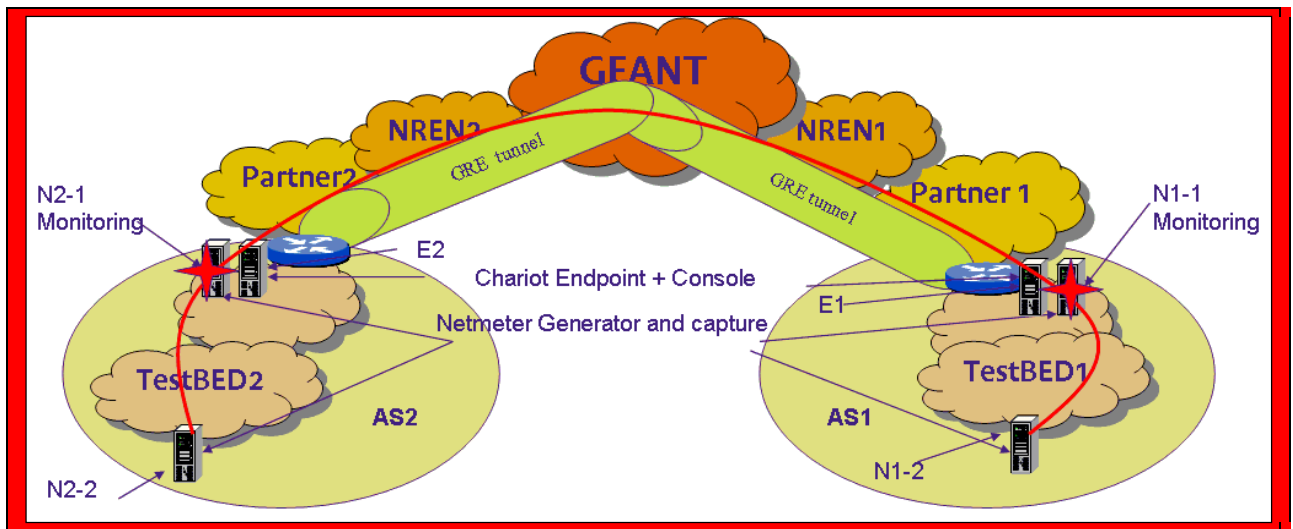


Figure 6.1-1 : End to End Tests architecture

One Netmeter generator (Nx-2) is used by testbed and traffic is setup between two partners (Nx-2). The second Netmeter PC (Nx-1) is setup in monitoring mode.


6.2 Flows generated

- **VoIP** : (type G.729) UDP – 60 Byte packets – 8 kbps – two flows per tests Endpoint A-> Endpoint B and Endpoint B-> Endpoint A. One test.
- **UDP1** : payload 1420B packets (total packet size = 1462 bytes)–unidirectional flow – 1 Mbps. One flow per test. Two tests Endpoint A-> Endpoint B then Endpoint B-> Endpoint A.
- **UDP2** : payload 160B packets (total packet size = 202 bytes) –unidirectional flow – 1 Mbps. One flow per test. Two tests Endpoint A-> Endpoint B then Endpoint B-> Endpoint A.
- **TCP** : payload 1420B packets –unidirectional flows . One flow per test. Two tests Endpoint A-> Endpoint B then Endpoint B-> Endpoint A.

6.3 Results

6.3.1 WUT ⇔ FTRD

The tests are here realized from the endpoint of the WUT's testbed (WiFi testbed) and the endpoint of the FTRD's testbed (xDSL testbed). These two testbeds are described in detail indeliverable D5.1.1.

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6.3.1.1 VoIP results

	Delay min (ms)	Delay average (ms)	Delay MAX (ms)	Lost Packets Number	Lost Packets ratio	OoO Packets Number	OoO Packets ratio	Missing packets	Max Delay variation (ms)
WUT (FTRD	66	64	152	0	< 3.3 E-5	0	< 3.3 E-5	0	88
FTRD (WUT	63	65	88	0	< 3.3 E-5	0	< 3.3 E-5	0	24

Table 6.3-1 : WUT (FTRD End-To-End VoIP tests results

6.3.1.2 UDP1 results

For these tests the generated flows are different from those defined in subchapter 6.2, so the rates of flow are adapted in order to avoid overloading on the upstream xDSL uplink on FTRD's testbed. So the flows are as following :

- send rate in direction WUT->FTRD was 89pkt/s, which corresponds to bitrate 1011.053kbps
- send rate in direction FTRD->WUT was 21pkt/s, which corresponds to bitrate 238.580kbps.


	Delay min (ms)	Delay average (ms)	Delay MAX (ms)	Lost Packets Number	Lost Packets ratio	OoO Packets Number	OoO Packets ratio	Missing packets	Max Delay variation (ms)	Through-put (kbps)
WUT ⇒ FTRD	72	73	102	0	< 1,87 E-5	0	< 1,87 E-5	0	30	1011,053
FTRD ⇒ WUT	107	108	120	0	< 5,94 E-5	0	< 5,94 E-5	0	13	238,85

Table 6.3-2 : WUT ⇔ FTRD End-To-End UDP1 tests results

6.3.1.3 UDP2 results

For these tests the generated flows are different from those defined in subchapter 6.2, so the rates of flows are adapted in order to avoid overloading on the upstream xDSL uplink on FTRD's testbed. So the flows are as following :

- send rate in direction WUT->FTRD was 826 packets/s, which corresponds to bitrate 1011.053kbps
- send rate in direction FTRD->WUT was 140 packets/s, which corresponds to bitrate 179.200 kbps.

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	Delay min (ms)	Delay average (ms)	Delay MAX (ms)	Lost Packets Number	Lost Packets ratio	OoO Packets Number	OoO Packets ratio	Missing packets	Max Delay variation (ms)	Throughput (kbps)
WUT ⇒ FTRD	67	69	78	0	< 2,02 E-6	0	< 2,02 E-6	0	12	1011,053
FTRD ⇒ WUT	64	65	109	1	1,19 E-5	0	< 1,19 E-5	0	45	238,85

Table 6.3-3 : WUT ⇔ FTRD End-To-End UDP2 tests results

6.3.1.4 TCP results

	Rate (Mbps)
WUT ⇒ FTRD	1
FTRD ⇒ WUT	0.260

Table 6.3-4 : WUT ⇔ FTRD End-To-End TCP tests results

6.3.2 TID ⇔ UPC

These local tests have been performed between two access networks of very different characteristics: an UMTS access (TID) and an ethernet LAN.

In ethernet, bandwidth is not a scarce resource and conditions are relatively stable. On the contrary, in UMTS, the radio access (due to its nature) implies more restrictions in bandwidth allocation and makes the environment more unstable.

Thus, the UMTS access will be the most limiting link in the end-to-end path, both from the point of view of bandwidth (it is the bottleneck) and quality. In this set of end-to-end tests, a Background class PDP context was established. Although contexts of this class, in theory, have no guaranteed bandwidth (it depends on the load in the cell), the tests were performed in conditions where the assigned bandwidths were 128 Kbps UPC-TID and 64 Kbps TID-UPC.

6.3.2.1 TCP Results

	Throughput (Mbps)
UPC-TID	0.13
TID-UPC	0.05

Table 6.3-5 : TCP results

According to expected, throughput measurements are close to the theoretical values of the UMTS access, which is the bottleneck.

It must be noted that these values are the same as got in the local tests of Telefónica’s UMTS testbed.

6.3.2.2 UDP1 results

6.3.2.2.1 UPC-TID

Min. delay (ms)	Average delay (ms)	Max. delay (ms)	Delay variation (ms)	Rate (Kbps)	Lost packets	Out of Order
181	258	1579	1398	123.620	2 E-4	0

Table 6.3-6 : UPC ⇒ TID UDP1 results

- Because of the high occupation and the characteristics of medium access in UMTS, average delay is relatively high (but bounded). However, packet losses are very low, due to the mechanisms of recovery and retransmission in lower layers (RCL and LLC).
- As expected, the bandwidth is very close to the maximum of the link.

6.3.2.2.2 TID-UPC

Min. delay (ms)	Average delay (ms)	Max. delay (ms)	Delay variation (ms)	Rate (Kbps)	Lost packets	Out of Order
276	299	778	502	45.042	0	0

Table 6.3-7 : TID ⇒ UPC UDP1 results

- Just as the previous tests, packet losses are efficiently minimized and the impact of high occupation in delay is relevant, but controlled.

6.3.2.3 *UDP2 results*

6.3.2.3.1 UPC-TID

Min. delay (ms)	Average delay (ms)	Max. delay (ms)	Delay variation (ms)	Rate (Kbps)	Lost packets	Out of Order
						0

Table 6.3-8 : UPC ⇒ TID UDP2 results

6.3.2.3.2 TID-UPC


Min. delay (ms)	Average delay (ms)	Max. delay (ms)	Delay variation (ms)	Rate (Kbps)	Lost packets

Table 6.3-9 : TID ⇒ UPC UDP2 results

As you can see in the document, we have had problems in tests with 160 B packets, which have avoided (and are still avoiding) us to complete that section (we have had to leave the section blank).

In summary, we have found severe packet losses even for rates quite lower than nominal bandwidth, which is fairly strange. Even in some scenarios, the PDP context went down, showing that something might be wrong. However, we haven't found any issue for other packet sizes (maybe because VoIP tests consumed much less bandwidth per context), so the problem seems to be related to scheduling capabilities for small packets in the base station.

We are doing some research to confirm it (and get a bound), but we are afraid it will be hard to get sound conclusions soon, as some experts on UMTS UTRAN equipment are not available this week. However, we are committed to find what the cause of this strange behaviour is.

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6.3.2.4 VoIP results

6.3.2.4.1 UPC-TID

Min. delay (ms)	Average delay (ms)	Max. delay (ms)	Delay variation (ms)	Rate (Kbps)	Lost packets	Out of Order
92	103	388	296	9.600	2 E-5	0

Table 6.3-10 : UPC ⇒ TID VoIP results

- Delays are much lower than in UDP tests, as link load is much lower too.
- The same stands for the packet losses and delay variations.

6.3.2.4.2 TID-UPC

Min. delay (ms)	Average delay (ms)	Max. delay (ms)	Delay variation (ms)	Rate (Kbps)	Lost packets	Out of Order
79.122	94.454	1182.070	1102.948	9.601	2 E-5	0

Table 6.3-11 : TID ⇒ UPC VoIP results

- As the UPC-TID link has more bandwidth, the results show a smaller average delay for the VoIP traffic on this direction.
- In general (both directions) the VoIP behaviour is good even in a Background class PDP context (as expected) if load in the cell is under control.

6.3.2.5 Conclusions

- Throughput measurements are near to the theoretical values for the RAB in UMTS, which is the bottleneck of the system.
- There is a relatively large variance in delays due to the mechanisms of retransmission and loss recovery in the UMTS radio interface.

6.3.3 PTIN ↔ LAAS

The tests have been performed using NetMeter tool. The following tables present the results of the tests.

All the tests were performed during 10 minutes.

In **traffic VoIP**, the test stream was generated with rate 20 packets/sec, with packet length (payload) 60 bytes. The resulting bit rate was 9,6kbps.

In **traffic UDP**, the test streams were different according to the way of transmitting:

Downstream: Flow generated with rate 84 packets/sec, with packet length (payload) 1450B. The resulting bit rate was 972 kbits/s.

Upstream: Due to the bandwidth limitation on ADSL link in Upstream, the flow to be generated can not be 1 Mbit/s, it is necessary to reduce it. So the flow was generated with packet length (payload) 1435 Bytes at a resulting bit rate of 230 kbit/s (payload).

In **traffic TCP**, the test streams are based on packets of 1450 Bytes (payload):

6.3.3.1 Upstream results

The PTIN endpoint is the traffic generator, while the LAAS endpoint is used as traffic receiver.

6.3.3.1.1 VoIP Results:

	Delay min (ms)	Delay average (ms)	Delay MAX (ms)	Rate (kbit/s)	Lost Packets	Missing packets
Chariot	NA	NA	NA	NA	NA	NA
Netmeter	14.2	39.9	129.7	9.6	0	0

Table 6.3-12 : PTIN-LAAS VoIP results Upstream

6.3.3.1.2 UDP Results:

	Delay min (ms)	Delay average (s)	Delay MAX (s)	Rate (kbit/s)	Lost Packets	Missing packets
Chariot	NA	NA	NA	NA	NA	NA
Netmeter	0.003	8057.5	86400.0	229.6	1	0

Table 6.3-13 : PTIN-LAAS UDP results Upstream

Analyzing these results and the results from the PTIN local tests, it is easy to conclude that this delay is due to some problem existing at PTIN testbed. This test will be repeated as soon as the problem is detected and corrected.

6.3.3.1.3 TCP results :

PTIN-LAAS TCP tests have the same problem that occurred at PTIN local tests, so they had failed. They will be repeated as soon as the problem is solved.

6.3.3.2 *Downstream results*

The LAAS endpoint is the traffic generator, while the PTIN endpoint is used as traffic receiver.

6.3.3.2.1 VoIP Results:

	Delay min (ms)	Delay average (ms)	Delay MAX (ms)	Rate (kbit/s)	Lost Packets	Missing packets
Chariot	NA	NA	NA	NA	NA	NA
Netmeter	155.1	169.1	241.0	9.6	0	0

Table 6.3-14 : LAAS-PTIN VoIP results downstream


6.3.3.2.2 UDP Results:

	Delay min (ms)	Delay average (ms)	Delay MAX (ms)	Rate (kbit/s)	Lost Packets	Missing packets
Chariot	NA	NA	NA	NA	NA	NA
Netmeter	200.2	224.9	434.0	971.5	247	0

Table 6.3-15 : LAAS-PTIN UDP results downstream

6.3.3.2.3 TCP results :

PTIN-LAAS TCP tests have the same problem that occurred at PTIN local tests, so they had failed. They will be repeated as soon as the problem is solved.

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6.3.4 UoPisa ↔ UoB

This section describes the end to end netmeter measurement test made between UoPisa/CPR and UoB done by UoPisa/CPR. The traffic types considered for the measurements are **UDP traffic**, **VOIP traffic**. All tests last 10 minutes and the characteristics of the traffic are specified at the beginning of each traffic type. The measurement is composed of two parts:

- 1) From UoPisa/CPR machine 10.197.1.20 to UoB machine 10.195.0.3 in both ways
- 2) From UoPisa/CPR machine 10.197.1.20 to UoB machine 10.195.0.7 in both ways


The UoPisa/CPR machine 10.197.1.20 is a wireless netmeter end point.

6.3.4.1 UoPisa/CPR 10.197.1.20 <-> UoB 10.195.0.3

6.3.4.1.1 Tests UDP1-1Mbps

Flow name: UDP1 UoPisa-20 -> UoB-3	Flow name: UDP1 UoB-3 -> UoPisa-20
Flow IPv4 ID 1	Flow IPv4 ID 1
-Flow Relative Start (msec): 0	-Flow Relative Start (msec): 0
-Flow Relative Stop (msec): 600000	-Flow Relative Stop (msec): 600000
Pattern PERIODIC	Pattern PERIODIC
-Send Rate (packets/sec): 89	-Send Rate (packets/sec): 89
-UDP Packet Size (bytes): 1420	-UDP Packet Size (bytes): 1420
-IP Packet Size (bytes): 1448	-IP Packet Size (bytes): 1448
Nr. of MODs 0	Nr. of MODs 0
Flow Source 10.197.1.20:32843	Flow Source 10.195.0.3:32888
Flow Destination 10.195.0.3:5000	Flow Destination 10.197.1.20:5000
-Received packets: 53400	-Received packets: 53377
-Join delay (sec): 35867.789062	-Join delay (sec): 32113.312500
-Recv rate (packets/sec): 89.000	-Recv rate (packets/sec): 88.961
-Recv data rate (kbps): 1011.060	-Recv data rate (kbps): 1010.621
-Packets dropped: 0	-Packets dropped: 23
-Average delay(sec): 0.013986	-Average delay(sec): 0.026800
-Max delay (sec): 0.050340	-Max delay (sec): 0.064835
-Min delay (sec): 0.013325	-Min delay (sec): 0.025477
-Delay variation (sec): 0.037015	-Delay variation (sec): 0.039358


Table 6.3-16 : UDP1 tests parameters

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6.3.4.1.2 Tests UDP2-1Mbps

Flow name: UDP2 UoPisa-20 -> UoB-3	Flow name: UDP2 UOB3 -> UoPisa 20
Flow IPv4 ID 1	Flow IPv4 ID 1
-Flow Relative Start (msec): 0	-Flow Relative Start (msec): 0
-Flow Relative Stop (msec): 600000	-Flow Relative Stop (msec): 600000
Pattern PERIODIC	Pattern PERIODIC
-Send Rate (packets/sec): 826	-Send Rate (packets/sec): 826
-UDP Packet Size (bytes): 160	-UDP Packet Size (bytes): 160
-IP Packet Size (bytes): 188	-IP Packet Size (bytes): 188
Nr. of MODs 0	Nr. of MODs 0
Flow Source 10.197.1.20:32843	Flow Source 10.195.0.3:32901
Flow Destination 10.195.0.3:5000	Flow Destination 10.197.1.20:5000
-Received packets: 495598	-Received packets: 495354
-Join delay (sec): 38228.589844	-Join delay (sec): 53306.250000
-Recv rate (packets/sec): 826.000	-Recv rate (packets/sec): 825.588
-Recv data rate (kbps): 1057.283	-Recv data rate (kbps): 1056.755
-Packets dropped: 2	-Packets dropped: 246
-Average delay(sec): 0.013548	-Average delay(sec): 0.021558
-Max delay (sec): 0.054484	-Max delay (sec): 0.059484
-Min delay (sec): 0.012905	-Min delay (sec): 0.020895
-Delay variation (sec): 0.041579	-Delay variation (sec): 0.038589


Table 6.3-17 : UDP2 tests parameters

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6.3.4.1.3 Tests VOIP

Flow name: VoIP UoPisa-20 -> UoB-3	Flow name: VoIP UoB-3 -> UoPisa-20
Flow IPv4 ID 1	Flow IPv4 ID 1
-Flow Relative Start (msec): 0	-Flow Relative Start (msec): 0
-Flow Relative Stop (msec): 600000	-Flow Relative Stop (msec): 600000
Pattern PERIODIC	Pattern PERIODIC
-Send Rate (packets/sec): 50	-Send Rate (packets/sec): 50
-UDP Packet Size (bytes): 32	-UDP Packet Size (bytes): 32
-IP Packet Size (bytes): 60	-IP Packet Size (bytes): 60
Nr. of MODs 0	Nr. of MODs 0
Flow Source 10.197.1.20:32843	Flow Source 10.195.0.3:32890
Flow Destination 10.195.0.3:5000	Flow Destination 10.197.1.20:5000
-Received packets: 30000	-Received packets: 29959
-Join delay (sec): 39889.531250	-Join delay (sec): 33134.250000
-Recv rate (packets/sec): 50.000	-Recv rate (packets/sec): 49.932
-Recv data rate (kbps): 12.800	-Recv data rate (kbps): 12.783
-Packets dropped: 0	-Packets dropped: 41
-Average delay(sec): 0.013771	-Average delay(sec): 0.012453
-Max delay (sec): 0.049863	-Max delay (sec): 0.039959
-Min delay (sec): 0.013234	-Min delay (sec): 0.011684
-Delay variation (sec): 0.036629	-Delay variation (sec): 0.028275

Table 6.3-18 : VoIP tests parameters


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6.3.4.2 UoPisa/CPR 10.197.1.20 <-> UoB 10.195.0.7

6.3.4.2.1 Tests UDP1-1Mbps

Flow name: UDP1 UoPisa-20 -> UoB-7	Flow name: UDP1 UoB-7 -> UoPisa-20
Flow IPv4 ID 1	Flow IPv4 ID 2
-Flow Relative Start (msec): 0	-Flow Relative Start (msec): 0
-Flow Relative Stop (msec): 600000	-Flow Relative Stop (msec): 600000
Pattern PERIODIC	Pattern PERIODIC
-Send Rate (packets/sec): 89	-Send Rate (packets/sec): 89
-UDP Packet Size (bytes): 1420	-UDP Packet Size (bytes): 1420
-IP Packet Size (bytes): 1448	-IP Packet Size (bytes): 1448
Nr. of MODs 0	Nr. of MODs 0
Flow Source 10.197.1.20:32843	Flow Source 10.195.0.7:32880
Flow Destination 10.195.0.7:5000	Flow Destination 10.197.1.20:5001
-Received packets: 53400	-Received packets: 53393
-Join delay (sec): 36638.187500	-Join delay (sec): 32834.125000
-Recv rate (packets/sec): 89.000	-Recv rate (packets/sec): 88.988
-Recv data rate (kbps): 1011.060	-Recv data rate (kbps): 1010.927
-Packets dropped: 0	-Packets dropped: 7
-Average delay(sec): 0.002872	-Average delay(sec): 0.029078
-Max delay (sec): 0.042849	-Max delay (sec): 0.074538
-Min delay (sec): 0.002240	-Min delay (sec): 0.027898
-Delay variation (sec): 0.040609	-Delay variation (sec): 0.046640

Table 6.3-19 : UDP1 tests parameters (UoB-7)

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6.3.4.2.2 Tests UDP2-1Mbps

Flow name: UDP2 UoPisa-20 -> UoB-7	Flow name: EuQoS - UDP2 UoB-7 -> UoPisa-20
Flow IPv4 ID 1	Flow IPv4 ID 2
-Flow Relative Start (msec): 0	-Flow Relative Start (msec): 0
-Flow Relative Stop (msec): 600000	-Flow Relative Stop (msec): 600000
Pattern PERIODIC	Pattern PERIODIC
-Send Rate (packets/sec): 826	-Send Rate (packets/sec): 826
-UDP Packet Size (bytes): 160	-UDP Packet Size (bytes): 160
-IP Packet Size (bytes): 188	-IP Packet Size (bytes): 188
Nr. of MODs 0	Nr. of MODs 0
Flow Source 10.197.1.20:32843	Flow Source 10.195.0.7:32883
Flow Destination 10.195.0.7:5000	Flow Destination 10.197.1.20:5001
-Received packets: 495597	-Received packets: 495418
-Join delay (sec): 37468.312500	-Join delay (sec): 34859.144531
-Recv rate (packets/sec): 825.999	-Recv rate (packets/sec): 825.706
-Recv data rate (kbps): 1057.280	-Recv data rate (kbps): 1056.905
-Packets dropped: 3	-Packets dropped: 182
-Average delay(sec): 0.001964	-Average delay(sec): 0.026365
-Max delay (sec): 0.039355	-Max delay (sec): 0.071298
-Min delay (sec): 0.001314	-Min delay (sec): 0.024111
-Delay variation (sec): 0.038041	-Delay variation (sec): 0.047187

Table 6.3-20 : UDP2 tests parameters (UoB-7)

6.3.4.2.3 Tests VoIP

Flow name: VoIP UoPisa-20 -> UoB-7	Flow name: VoIP UoB-7 -> UoPisa-20
Flow IPv4 ID 1	Flow IPv4 ID 1
-Flow Relative Start (msec): 0	-Flow Relative Start (msec): 0
-Flow Relative Stop (msec): 600000	-Flow Relative Stop (msec): 600000
Pattern PERIODIC	Pattern PERIODIC
-Send Rate (packets/sec): 50	-Send Rate (packets/sec): 50

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-UDP Packet Size (bytes): 32	-UDP Packet Size (bytes): 32
-IP Packet Size (bytes): 60	-IP Packet Size (bytes): 60
Nr. of MODs 0	Nr. of MODs 0
Flow Source 10.197.1.20:32843	Flow Source 10.195.0.7:32884
Flow Destination 10.195.0.7:5000	Flow Destination 10.197.1.20:5000
-Received packets: 30000	-Received packets: 29962
-Join delay (sec): 39112.042969	-Join delay (sec): 34255.621094
-Recv rate (packets/sec): 50.000	-Recv rate (packets/sec): 49.937
-Recv data rate (kbps): 12.801	-Recv data rate (kbps): 12.784
-Packets dropped: 0	-Packets dropped: 38
-Average delay(sec): 0.002119	-Average delay(sec): 0.023389
-Max delay (sec): 0.037404	-Max delay (sec): 0.050032
-Min delay (sec): 0.001631	-Min delay (sec): 0.022764
-Delay variation (sec): 0.035773	-Delay variation (sec): 0.027268

Table 6.3-21 : VoIP tests parameters (UoB-7)

6.3.4.3 Conclusions

The end to end measurements between UoPisa/CPR and UoB are considered satisfactory. In almost every measurements the traffic from UoPisa/CPR to UoB is better than the opposite direction. There seems a wireless network packet loss on the UoPisa/CPR testbed during reception while there is almost no packet loss during transmission from UoPisa/CPR to UoB. This few dropped packets are also confirmed on the local measurements of the UoPisa/CPR testbed and we are investigating to solve the problem.

The **TCP traffic** measurements are not done due to problem on the Netperf. As soon as the problem is solved we will proceed with the measurements of the TCP measurements.

6.3.5 UoC ↔ PTRD

This section describes the end-to-end measurements between UoC testbed (Ethernet) and the PTRD testbed (ADSL). These two testbeds are described in detail in Deliverable D5.1.1.

6.3.5.1 VoIP Results

	Delay Average (ms)	Delay Min (ms)	Delay Max (ms)	Lost packets number	Lost packets rate	OoO packets	OoO Rate	Max. Delay Variation (ms)
UoC → PTRD	54	56	73	0	0.0	0	0	19
PTRD → UoC	45	43	67	0	0.0	3	1.0 E-4	23

Table 6.3.5-1 : VoIP End-to-End Test Results (UoC/PTRD)

6.3.5.2 UDP1 and UDP2 tests


In order to adjust to DSL limitations, two sets of tests were performed: one using a flow with a bit rate of 1 Mbps in both directions, and another reducing the flow from PTRD to UoC to a bit rate of 512 Kbps.

	Delay Average (ms)	Delay Min (ms)	Delay Max (ms)	Lost packets number	Lost packets rate	OoO packets	OoO rate	Max. Delay Variation (ms)
UoC → PTRD	70	69	88	0	0	0	0	19
PTRD → UoC	1073	61	1262	16811	3,14 E-1	0	0	1201

Table 6.3.5-2: UDP1 tests results (UoC/PTRD, 1 Mbps in both directions)

	Delay Average (ms)	Delay Min (ms)	Delay Max (ms)	Lost packets number	Lost packets rate	OoO packets	OoO rate	Max. Delay Variation (ms)
PTRD → UoC (512kbps)	75	73	204	67	2,49 E-3	0	0	132

Table 6.3.5-3:UDP1 tests results (PTRD → UoC, 512Kbps)

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The UDP1 test results show a high "Lost Packets Ratio (LPR)" in one direction (from PTRD to UoC, 512kbps). The current UoC connection to the NREN is permanently congested, even during the night, and this bottleneck becomes evident in the tests, showing a high LPR.

	Delay Average (ms)	Delay Min (ms)	Delay Max (ms)	Lost packets number	Lost packets rate	OoO packets	OoO rate	Max. Delay Variation (ms)
UoC→PTRD	62	61	89	0	0	106384	1,77 E-1	28
PTRD→UoC	766	46	938	268867	5,42 E-1	1137	5,00 E-3	891

Table 6.3.5-4:UDP2 tests results (UoC/PTRD, 1 Mbps in both directions)

	Delay Average (ms)	Delay Min (ms)	Delay Max (ms)	Lost packets number	Lost packets rate	OoO packets	OoO Rate	Max. Delay Variation (ms)
PTRD→UoC (512kbps)	61	55	126	1	4.8 E-6	756	3.61 E-3	71

Table 6.3.5-5:UDP2 tests results (PTRD → UoC, 512kbps)

The PTRD→UoC test showed an extremely high LPR when using a 1Mbps bit rate, presumably due to the ADSL *uplink* limitations.


In the 512 kbps bit rate, the LPR was lower than in UDP1 tests (packet size of 160 bytes for UDP2, against a packet size of 1420 bytes ofr UDP1).

6.3.5.3 TCP

	Average	Min	Max
UoC→PTRD	1,41	1,40	1,41
PTRD→UoC	0,61	0,61	0,61

Table 6.3-22: Throughput (average-min-max) in Mbps, UoC/PTRD

Achieved results for throughput showed the capacity limitation in PTRD to UoC direction caused by ADSL system, was already expected. In reverse direction the throughput limitation was presumably caused by the already mentioned bottleneck in the UoC connection to NREN – the PTRD ADSL system can transmit traffic up to 8 Mbps, and the polish NREN provides a 10 Mbps ATM connection with guaranteed bandwidth.

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6.3.6 PTRD ↔ Soluziona

This section describes the end-to-end measurements between the PTRD testbed (ADSL) and Soluziona testbed (Wi-Fi). These two testbeds are described in details.

6.3.6.1 VoIP Results

	Delay Average (ms)	Delay Min (ms)	Delay Max (ms)	Lost packets number	Lost packets rate	OoO packets	OoO Rate	Max. Delay Variation (ms)
PTRD→Soluziona	64	63	79	1	1.0 E-4	0	0	16
Soluziona→PTRD	75	74	100	0	0.0	0	0	25

Table 6.3-23 : VoIP End-to-End Test Results (PTRD/Soluziona)

An asymmetry in VoIP results can be observed. Any reasonable conclusions must be preceded with Site-to-Site tests.

6.3.6.2 UDP1 and UDP2 tests


In order to adjust to Soluziona’s bandwidth limitation to GEANT (up to 256kbps at data link layer), two non-standard sets of tests were performed: one using a flow with UDP1 characteristic and reduced bit rate to 224 kbps, and another using a flow with UDP2 characteristic and reduced bit rate to 176 kbps.

	Delay Average (ms)	Delay Min (ms)	Delay Max (ms)	Lost packets number	Lost packets rate	OoO packets	OoO Rate	Max. Delay Variation (ms)
PTRD→Soluziona	124	123	141	10	8.5 E-4	0	0	18
Soluziona→PTRD	125	124	166	2	1.7E-4	0	0	41

Table 6.3-24 : UDP1 End-to-End Test Results (PTRD/Soluziona)

	Delay Average (ms)	Delay Min (ms)	Delay Max (ms)	Lost packets number	Lost packets rate	OoO packets	OoO Rate	Max. Delay Variation (ms)
PTRD→Soluziona	70	64	103	355	4.3 E-3	0	0	39
Soluziona→PTRD	71	67	143	4	4.7E-5	0	0	76

Table 6.3-25 : UDP2 End-to-End Test Results (PTRD/Soluziona)

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The UDP1 and UDP2 test results show lost packet ratio (LPR), especially in one direction from PTRD to Soluziona. It can be reflected by Soluziona’s local test results for similar case (UDP1 stream 4 - download) in which the LPR is at comparable level. In PTRD’s local tests there are no lost packets. Due to lack of site-to-site tests with Soluziona additional measurements are required to confirm this conclusion or identify other issues.

6.3.6.3 TCP

	Average	Min	Max
PTRD→Soluziona	0,24	0,24	0,24
Soluziona→PTRD	0,24	0,24	0,24

Table 6.3-26 : Throughput (average-min-max) in Mbps, PTRD/Soluziona

Obtained throughput shows the link capacity limitation between Soluziona’s and NREN RedIris.

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7 Conclusions


From the results presented in this document, we can conclude that we have now a clear view on the characteristics of local testbeds, full meshed Site-To-Site links and also End-To-End links.

In this document, it's clear that there are still some remaining limitations on some of the tests, yet most of them are known, understood and should be solved in a near future. Yet, an extremely hard work has been done to establish the EuQoS testbed, then to characterize it, then to improve it and then characterize again and so on. This heavy iterative process has brought a very important increase on the EuQoS trial in terms of quality and to be see how important the increase is, there is just to compare the results from the first phase of tests, and those from the second phase with the results obtained in these third and fourth phases of tests, the improvement is impressive. Furthermore due to the fact we have some results of tests on the same infrastructure, yet at very different periods of activity of the days, we can have an idea of the impact of load on our CORE network (based on Best Effort Quality).

There still some improvements to get on EuQoS trials, yet they are like more fine tuning than mass building. These improvements will be accomplished for Best Effort tunnels and also we will establish tunnels between 6 couples of partners with a PIP quality and then characterize these new Point-To-Point connections.

Yet this document is an excellent database on IP links characteristics with an extremely wide range of links possibilities. This range covers from four different types of modern Access Networks to Pan-European links passing through GEANT network, two NRENs and two different access networks. Furthermore the all possibilities of combining site-to-site links through GEANT and from the twelve partners involved have been measured and characterize.

So now, the partners are linked one to the other ones, and this connectivity can be expressed in terms of technical characteristics. The future steps will be to solve the remaining issues, yet, even if it is based on Best effort Quality, we still have a stable and performing network for the next WP5 phases and particularly to implement the first EuQoS prototypes on what we can now called the EuQoS Network.

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8 References

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