Body of European Regulators
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BEREC

Annex of

Monitoring quality of Internet access services in the context of net neutrality

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Annex: Quality measurement tools and platforms

Measurement tools

In this annex a selection of basic measurement tools for assessing quality aspects of the Internet access service are described briefly.

Network Diagnostic Tool

The Network Diagnostic Tool (NDT) is a client/server measurement tool that provides network configuration and performance testing of end user equipment (computer) and local network environment. The system is composed of a client program (command line or java applet) and a pair of server programs (a webserver and a testing/analysis engine). Both command line and java applet clients communicate with the server to perform these diagnostic functions. Multi-level results allow novice and expert users to view and understand the test results.

The majority of network performance problems occur in or near the users' computer. These problems include, but are not limited to, duplex mismatch conditions on Ethernet links, incorrectly set TCP buffers in the user's computer, or problems with the local network infrastructure. The NDT is designed to quickly and easily identify a specific set of conditions that are known to impact network performance. A multi-level series of plain language messages, suitable for novice users, and detailed test results, suitable for a network engineer, are generated and available to the user. Finally, the test results may be easily emailed to the appropriate administrator to assist in the problem resolution phase.

Glasnost

Glasnost is a measurement tool for detecting traffic differentiation that is triggered by transport protocol headers (e.g. ports) or packet payload. Glasnost is designed to be an on-demand system. Each time a user uses Glasnost, traffic differentiation between flows of the user and a reference flow are checked at the time of the test. While Glasnost has not been designed to detect traffic shaping that affects all flows of a user, e.g., based on time of day or network load or user behaviour, it is possible to infer such shaping policies by aggregating and comparing the results of Glasnost tests conducted at different times of the day by different users on different networks.

Instead of inferring differentiation based on a particular manipulation mechanism, Glasnost detects the presence of differentiation based on its impact on application performance. Glasnost is based on client/server architecture. Clients connect to a Glasnost server to run various tests. Each test measures the path between the client and the server by generating flows that carry data specific to the application under investigation. The transmission performance of this flow is compared with the performance of a reference flow containing no application specific data.

A client first contacts a central webpage that redirects to a Glasnost measurement server. This dynamic redirection enables load balancing across measurement servers and makes it easy to incorporate new servers by adding them to the redirection list. After the client is

redirected, the measurement server presents a simple user interface. The user selects the application traffic she would like to test and starts the test by just clicking a "Start" button. The client's browser downloads a java applet that starts exchanging packets with the server.

The Glasnost test can be implemented on any client server infrastructure (e.g. see QoS Study Germany[1],[2]). The Glasnost test was developed by researchers at the Max Planck Institute for Software Systems. A publicly accessible Glasnost test implementation is provided by the Max Planck Institute by making use of the Measurement Lab (M-Lab) research platform.

ShaperProbe

Shaperprobe is an active-probing tool which detects whether an ISP uses a token bucket method to apply traffic shaping. A token bucket allows a maximum burst of traffic to be serviced at the peak capacity of the link, while any remaining traffic is serviced at a lower shaping rate. With such a method, the access rate typically drops after a user has downloaded or uploaded a certain number of bytes.

In the case that such traffic shaping is performed, Shaperprobe reports the shaping rate and the maximum burst size before shaping begins. Initial experiments showed that ShaperProbe has false positive and false negative detection rates of less than 5%.[3]

The tool is available for testing at the M-Lab platform.[4]

Neubot

Neubot[5] is a free-software Internet bot, developed and maintained by the Nexa Center for Internet and Society, which is installed on a user's computer and gathers network performance data useful to investigate network neutrality. Once installed, it runs in the background and periodically performs active transmission tests with M-Lab servers. Three tests are currently implemented: `speedtest', that emulates HTTP; `bittorrent', that emulates BitTorrent; and `raw`, that performs a raw TCP test.

All tests measure the goodput (application-level throughput) and Round Trip Time (RTT) both in the upload and download directions. A typical test lasts for 10-15 sec, whereas the rest of the time the program is asleep, having a minimum impact on system and network load. Test results are saved both locally and on the test servers, and are published on the web under Creative Commons Zero allowing anyone to re-use it freely for the same purpose.

Neubot does not explicitly detect net neutrality violations. Its merit lies in that it is a lightweight, open-source program, and has a distributed architecture, that allows to collect results from multiple clients and to continuously monitor their performance. The architecture

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[1] "Bundesnetzagentur – Quality of Service of Broadband Access Lines", last modified July 10th, 2013, accessed January 27th 2014, http://www.bundesnetzagentur.de/cln_1932/EN/Areas/Telecommunications/Companies/MarketRegulation/QualityStudy/QualityStudy_node.html
[2] "Initiative Netzqualität: Netzneutralitäts-Test", Bundesnetzagentur, accessed January 27th, 2014, http://www.initiative-netzqualitaet.de/netzneutralitaetstest/ (in German only)
[3] P. Kanuparthy and C. Dovrolis. "ShaperProbe: end-to-end detection of ISP traffic shaping using active methods." In Proceedings of the 2011 ACM SIGCOMM Internet Measurement Conference (IMC '11), ACM, New York, NY, USA, 473-482.
[4] "Tests – M-Lab", M-Lab, accessed January 27th, 2014, http://www.measurementlab.net/tools/shaperprobe .
[5] "Neubot – The network neutrality bot", Nexa Center for Internet and Society, accessed January 27th, 2014, http://www.neubot.org/

is highly configurable, allowing a central administrator to decide for what tests should be performed, at what time, and for how long.[6]

Network Access Neutrality Observatory

Network Access Neutrality Observatory (NANO)[7] identifies performance degradations that result from net neutrality violation by an Internet service provider (ISP), such as, differential treatment of specific applications, users, or destinations by the ISP. Existing systems for detecting differential treatment are typically specific to an application or to a particular differentiation mechanism.

To distinguish differentiation from other causes of degradation (e.g. overload, misconfiguration or failure), NANO uses a statistical method to establish causal relationship between an ISP and observed service performance. NANO agents deployed at participating clients across the Internet collect performance data for selected services and report this information to centralized servers, which analyse the measurements to establish causal relationships between an ISP's policy and performance degradations.

The NANO agent monitors the number of packets transferred for each active flow per unit time, as well as tracks for unexpected events like packet loss, and TCP reset packets. The NANO agent correlates each flow with the application that owns the flow. NANO agent also monitors the load on the client computer.

In relation to privacy, NANO monitors the users' Internet traffic that has the NANO agent installed, and sends limited statistics, but does not collect data on the content being sent. For instance, trying to visit a web page, it will record the source IP address, the IP address of the site that is accessed and the number of packets transmitted, but it will not record the requests that the browser sends to the website or the web page that is returned and displayed in the user's browser.

The user may also decide to exclude a set of websites or monitoring applications, for instance, user could exclude hotmail.com or gmail.com if he does not want email services to be supervised. To achieve this, NANO agent examines DNS resolutions that the client generates to determine the IP addresses that mail websites maps to. This allows the NANO agent to ignore packets with these IP addresses. Moreover, user can also temporarily disable all monitoring by NANO agent.

Measurement platforms

In this section different examples of existing controlled measurement platform concepts are described. The basic idea of a controlled measurement platform is to provide an infrastructure and architecture that allows for active measurements (client/server architecture). Such platforms may provide a pre-defined set of measurement tools or even offer an open infrastructure where any measurement tool may be implemented.

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[6] J. C. De Martin, and A. Glorioso, "The Neubot project: A collaborative approach to measuring internet neutrality". In Proceedings of the IEEE International Symposium on Technology and Society, 2008 (ISTAS 2008), 1-4.
[7] http://www.cc.gatech.edu/~feamster/papers/nano-hotnets2008.pdf

The clients used can be either hardware or software based. Since these measurement platforms are designed to allow for precise measurements under controlled conditions and following detailed measurement scenarios, hardware based probes are used.

RIPE Atlas

RIPE Atlas is a global network of hardware-based measurement probes that measure Internet connectivity and reachability, providing an unprecedented understanding of the state of the Internet in real time. With RIPE Atlas, the RIPE NCC has the ambition to create the world's largest Internet measurement system. In order to achieve this aim, they use a form of crowd-sourced solution relying on the Internet community, both in the RIPE NCC's service region and around the world, to host probes.

The overarching goals of RIPE Atlas are:

- To provide users with an active measurement tool for baseline and on-demand individual measurements from thousands of vantage points around the Internet.
- To produce Internet "traffic maps" and other data that can be used by the technical community.
- To act as a trusted source of data regarding real-life, active measurements.

The probes are connected to Internet accesses of participating entities. They are small hardware devices, powered by USB, attached to an Ethernet port on residential gateways via a network cable. They conduct different built-in measurements (ping, traceroute, DNS and SSLcert) and relay this data to the RIPE NCC, where it is aggregated with data from the rest of the RIPE Atlas network.

Besides these simple hardware probes there are so-called "anchor" probes. These are enhanced probes used as powerful regional measurement targets and will allow more measurements to be directed towards them, while running the same software, thus ensuring consistency of the methodology and results syntax. The RIPE Atlas anchors are configured to be both probes and targets.

The software on the Atlas probe is developed by the RIPE NCC, also based on input from the Internet community, and is available as open software. Whether or not the NRAs would be able to influence future developments and add measurement functionality suited to meet their needs, will require further investigation.

There are currently several thousand active probes in the RIPE Atlas network, concentrated in the RIPE NCC service region of Europe, the Middle East and parts of Central Asia, and the network is constantly growing. The RIPE NCC collects the data from this network and provides maps and graphs based on the aggregated results. RIPE Atlas users who host a probe can also use the entire RIPE Atlas network to conduct customised measurements that provide valuable data about their own network(s).

M-Lab

Measurement Lab (M-Lab) is an open, distributed server platform provided to researchers to deploy Internet measurement tools developed by different parties, mostly research organisations and universities[8]. M-Lab is not a complete measurement platform by itself; but

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[8] As defined by M-lab webpage: http://www.measurementlab.net/about

it provides the infrastructure to set-up a measurement platform by deploying respective measurement tools on top of it. The data collected by those tools is released in the public domain.

Various measurement tools are running on M-Lab in order to measure the performance of end-users' Internet connections and to perform diagnostics. The tools only collect data related to the specifically orchestrated communication flows between the client machine and the M-Lab server. All data collected by the tools is made publicly available. All tools are created by researchers, not by M-Lab itself.

M-Lab assists scientific research by providing widely-distributed servers and ample connectivity for researchers' use. Each tool is allocated dedicated resources on the M-Lab platform to facilitate accurate measurements. Server-side tools are openly licensed and operated to allow third-parties to develop their own client-side measurement software. These servers are located around the world of which currently 18 are located in Europe .

The existing M-Lab tools allow end users to test their Internet access connection and to detect net neutrality breaches in fixed and mobile environments. The most interesting M-Lab tools for BEREC's purposes are Network Diagnostic Tool (NDT), Glasnost, Shaperprobe, and Neubot.

An important aspect of the M-Lab software is that it is licensed as open-source. Thus users and organizations

• 	Have the possibility to verify the security of the platform from their perspective,
• 	Can modify the existing software for their special needs and
• 	Can develop new software with the option of becoming an M-Lab tool.

The potential issue related to the existing software is that the support from the developers of the measurement applications could be limited since there is no contractual relationship.

Another important point is that all the collected and stored measurement results in M-Lab servers is publicly available to the community (principle of open data). The advantage of this solution is that everyone can use the data and historical data can be easily collected and processed. It is then up to NRAs or third parties to process and present the data in a coordinated way.

At present three European NRAs are cooperating on the basis of a Memo of Understanding with M-Lab. EETT uses the NDT and Glasnost tools for its HYPERION[9]. OCECPR in Cyprus has also adopted the M-Lab tools, using the same interface as EETT.[10] RTR has integrated the NDT into its RTR-NetTest[11].

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[9] http://hyperiontest.gr/

[10] http://2b2t.ocecpr.org.cy/

[11] https://www.nettest.at/

National initiatives

Austria

Title	RTR-NetTest
Country/NRA	Austria - RTR
Application and scope	• QoS measurement of Broadband Internet access offered via fixed and mobile networks addressed especially to an interested specialist public such as end users/consumers, network operators and interest group representatives
Project period	• Permanent platform (since May 2013)
Measurement concept	• Measurement of test connections based on a client server architecture • Web based speed test (https://www.netztest.at) and software based test (https://www.rtr.at/en/tk/netztest) • end users asked to measure download and upload speed

Parameters measured	• Measurement of Internet network layer performance
	  ◦ troughput (download and upload)
	  ◦ packet delay (ping)
	  ◦ signal strength

Measurement implementation	• Measurement probes
	  ◦ end user equipment (PC/smartphone/tablet app for Android and iOS)
	  ◦ any end user may take part, i.e. all operating systems and types of browsers
	• Measurement software
	  ◦ RTR Multithreaded Broadband Test (RMBT)
	  ◦ java based software available by download (app)
	  ◦ browser-based version of the software
	  ◦ optional Network Diagnostic Tool (NDT-Test)
	  ◦ Open Source solution
	• Measurement server
	• Collection of data

	◦ measurements initiated by end user, no measurement schedule ◦ results published as open data
Statistical aspects	Statistics based on quantils of measurement results on individual operators, devices, technologies
Standards considered	
Publication	• Both in the app and the browser version of the RTR-NetTest you have the option of viewing all previous tests distributed geographically on a map • browse individual tests and view statistics of tests with various filters

Finland

Title	Large scale QoS measurements
Country/NRA	Finland - FICORA
Application and scope	• Provides comparable data between operators • Allows monitoring of QoS evolution over time, in a stable environment • Allows users to measure the QoS of their own broadband subscription
Project period	Pilot 2013-2014

Measurement concept	• Measurement services have not yet been agreed on and all comparable measurements can be included.
	• .However it is very likely that we will use at least a crowd sourcing SW based clients (Netradar) will be used.
	  ◦ active measurements
	  ◦ currently only mobile/WLAN
	  ◦ user initialized or periodical, server controlled
	  ◦ national IPX and cloud service

Parameters measured	• Full set has not been decided yet, however e.g. these parameters will be available from Netradar
	  ◦ Location from GPS, network or WLAN
	  ◦ Download and upload speeds
	  ◦ Latency
	  ◦ Manufacturer, model, operating system and version
	  ◦ Network and subscriber operator
	  ◦ Signal strength
	  ◦ Base station
	  ◦ Mobile technology, such as UMTS, HSPA

Measurement implementation	• Measurement software ◦ software client • Measurement server

	◦ national IPX and cloud service • Collection of data 　◦ FICORA will collect data from one or more sources
Statistical aspects	• Crowd sourcing
Standards considered	
Publication	•

France

Title	Primary system (centralised)
Country/NRA	France - ARCEP
Application and scope	• Provides comparable data between operators • Allows monitoring of QoS evolution over time, in a stable environment
Project period	• Permanent platform
Measurement concept	• Type of measurement concept, i.e. active or passive measurement • Measurement architecture (e.g. client server, active/passive measurement) • independent external (black box) versus internal network provider measurements • Measurement reference points (e.g. end user network termination point and server at IXP)

Parameters measured	• Network layer
	  ◦ Throughput
	  ◦ Packet delay
	• Application layer
	  ◦ web browsing
	  ◦ streaming
	  ◦ file sharing

Measurement implementation	• Measurement probes
	  ◦ dedicated hardware
	  ◦ controlled environment
	• Measurement software
	• Collection of data

Statistical aspects	
Standards considered	
Publication	

France (Continued)

Title	Secondary system (distributed)
Country/NRA	France - ARCEP
Application and scope	• Delivers individual results to the end user (representative data) • Allows consistency checks with primary system results
Project period	• Permanent platform
Measurement concept	• Measurement of test connections based on a client server architecture • Web based speed test
Parameters measured	• Throughput (upload and download)
Measurement implementation	• Measurement probes 　◦ end user equipment, i.e. probes not controlled 　◦ any end user may take part, i.e. all operating systems and types of browsers • Measurement software • Measurement server 　◦ central server platform • Collection of data 　◦ measurements initiated by end user, no measurement schedule
Statistical aspects	
Standards considered	
Publication	

Germany

Title	Quality study on broadband Internet accesses - Part 1
Country/NRA	Germany – Bundesnetzagentur (BNetzA)
Application and scope	- Broadband Internet access offers offered via fixed and mobile networks - Aim is to measure the status quo and to provide basis for further decisions on an informed basis
Project period	June – December 2012 and July- December 2013
Measurement concept	- National measurement platform - Measurement of test connections based on a client server architecture - Measurement
Parameters measured	- Measurement of Internet network layer performance and one application performance (web browsing) - Parameters for fixed and mobile Internet accesses - throughput (download and upload) - http and ftp - packet delay - ICMP (ping) - web browsing - DNS lookup time - http download - net neutrality - ssh, P2P, email, flash video - Parameters for fixed Internet accesses only - Interdependency of bundled services (IPTV and VoIP) - net neutrality (March – June 2013) - Glasnost - BitTorrent - eMule - Email (POP) - Email (IMAP4) - HTTP Transfer

	◦ SSH Transfer ◦ Video-on-Demand ◦ Flash video

Measurement implementation	• Measurement probes
	  ◦ dedicated hardware with PC architecture
	  ◦ Windows XP Embedded
	  ◦ controlled environment with regular checks
	  ◦ connected to regular end user interfaces according to specifications of access provider
	• Measurement software
	  ◦ pre-installed software using TCP/IP stack and setting of OS
	  ◦ proprietary software developed by company performing measurement
	• Net neutrality measurement
	  ◦ Implementation of Glasnost software on clients
	  ◦ Implementation of Glasnost server on platform
	• Collection of data
	  ◦ Distribution of probes
	    ▪ at 26 locations
	    ▪ access lines of 13 providers available at locations
	    ▪ DSL and cable access offers, best in class, i.e. the best offer available
	  ◦ 24/7 measurements

Statistical aspects	• National and regional providers are covered based on a market analysis of Q3/2011 • no specific validation since within a controlled measurement environment • no post-processing
Standards considered	• ETSI EG 201 057-4 • Internet network performance based on IETF RFCs

Publication	• [Download link](#)
	• Aggregated figures based on access technology
	  ◦ delay measurement results
	  ◦ interdependency of bundled services
	• no benchmarking of ISPs
	• net neutrality measurement still ongoing

Germany (Continued)

Title	Quality study on broadband Internet accesses - Part 2
Country/NRA	Germany – Bundesnetzagentur (BNetzA)
Application and scope	• Broadband Internet access offers offered via fixed networks • Aim is to measure the status quo and to provide basis for further decisions on an informed basis
Project period	• June – December 2012 and July- December 2013 • 2014 Development and implementation of a permanent web based measurement tool for end users (fixed and mobile)
Measurement concept	• Measurement of test connections based on a client server architecture • Web based speed test (http://www.initiative-netzqualitaet.de) • end users asked to measure download and upload speed

Parameters measured	• Measurement of Internet network layer performance
	• Parameters
	  ◦ throughput (download and upload)
	    ▪ http only
	• net neutrality (March – June 2013)
	  ◦ bittorrent

Measurement implementation	• Measurement probes
	  ◦ end user equipment, i.e. probes not controlled
	  ◦ any end user may take part, i.e. all operating systems and types of browsers
	• Measurement software
	  ◦ software downloaded via browser
	  ◦ software executed within flash environment
	  ◦ proprietary software developed by company performing measurement
	  ◦ Glasnost software for net neutrality measurement
	• Measurement server
	  ◦ central server platform (load balanced)

	◦ good interconnection to IPX
	• Collection of data
	◦ measurements initiated by end user, no measurement schedule
Statistical aspects	• performance and reliability of measurement server cross-checked with measurement platform
	• substantial validation and post-processing of raw data
	◦ plausibility check of end user data input
	◦ only one measurement per access line
	▪ cross-check via IP address and router ID
	▪ combination of OS and browser type
Standards considered	• ETSI EG 201 057-4
	• Internet network performance based on IETF RFCs
Publication	• Download link
	• Aggregated figures based on access technology, on bandwidth classes, rural, urban, suburban
	• anonymised benchmarking of ISPs
	• net neutrality measurement still ongoing

Greece

Title	System for Performance Evaluation of Broadband connections HYPERION (www.hyperiontest.gr)
Country/NRA	Greece - EETT
Application and scope	• Monitoring and Evaluation framework for fixed broadband connections • Allows monitoring of QoS evolution over time, in a user-initiated environment
Project period	• Permanent platform
Measurement concept	• Measurements are user-initiated and based on crowd-sourcing techniques • The Measurement platform used is M-Lab, and a geomapping graphical front-end dashboard has been implemented. • Software based measurements • Measurement reference point is the end- user network termination point and the relevant measurement server is based at the IXP • Open-source software
Parameters measured	• Parameters of Network Diagnostic Tool and Glasnost tool

Measurement implementation	• Measurement probes
	  ◦ There is no user hardware used, only a web-based service
	  ◦ Measurement server
	    ▪ M-Lab platform -Two servers are installed in the GRIX –major exchange node in Athens, Greece
	• Measurement software
	  ◦ Network Diagnostic Tool
	  ◦ Glasnost tool
	• Collection of data
	  ◦ Only registered users may view a history of their connection statistics. Registered users contribute to the

	aggregated broadband statistics for the Greek region. The HYPERION registered users are about 11.000 at the end of December 2013
Statistical aspects	The statistical data provided relies on the measurements performed by the HYPERION registered users, and mainly reflects urban areas in Greece, so far.
Standards considered	
Publication	- Connection statistics per user and aggregate statistics per postal area/municipality/county/region - Results can be geomapped and also managed with graphs and lists. - Geomapped information provides a really good overview of the fixed broadband access packages in Greece - Registered users have the ability to manage their HYPERION account.

Ireland

Title	**Broadband Test and See (in progress)**
Country/NRA	Ireland - ComReg
Application and scope	• Measurement of Broadband speed offered via fixed, mobile and wireless connections • Allows users to measure the speed of their own broadband connection
Project period	• Pilot 2014
Measurement concept	• National measurement platform • Software based measurements • Measurements are user initiated and based on crowd sourcing techniques
Parameters measured	• Upload • Download • Ping • Latency • Jitter
Measurement implementation	• Development of a Software Measurement solution (in progress) • Collection of data
Statistical aspects	
Standards considered	
Publication	

Italy

Title	MisuraInternet.it
	Quality monitoring for Fixed Broadband Internet Access
Country/NRA	Italy - AGCOM
Application and scope	• Monitoring of ISP performance (nation-wide in all regions)
Project period	• Permanent platform
Measurement concept	• National measurement platform based on both ISP measurements, and end-user measurements. Both measurement methods employ the same Network Measurement System, based on a software agent running on a standard Personal Computer. • Client server based architecture
Parameters measured	– Data transmission speed – Packet Delay (one way transmission time) – Packet loss ratio – Unsuccessful data transmission ratio

Measurement implementation	A. ISP Measurements based on dedicated "probes" located in geographical area main urban areas.
	• Measurement probes
	  ◦ dedicated hardware
	  ◦ Operating system
	  ◦ Management of probes
	
	B. End-user measurements allow users to measure their own fixed line performances. The endpoint is located in the user's house.
	• Measurement software
	  ◦ Software agent Ne.Me.Sys
	
	C. Collection of data
	  ◦ Distribution of probes
	    ▪ Three clusters of servers are located into the three most important Italian IXPs (Internet Xchange Point): MiX, NaMeX and ToPIX respectively in Milan, Rome and Turin
	    ▪ 20 Clients (hardware probes) are located into specific

	government buildings (i.e. Ispettorati Territoriali or probe rooms) that constitute the QoS monitoring infrastructure Independent measuring organisation (FUB) operates a "Monitoring and Setting system" that allows to remotely control all probes, schedule activities and collect results
Statistical aspects	• The following four values relevant to data transmission speed are computed for both download and upload direction: - 95 th percentile in kbit/s - 5 th percentile in kbit/s - The mean value in kbit/s - The standard deviation in kbit/s • The following two values relevant to delay (one way transmission time) are computed: - The mean values in milliseconds - The standard deviation
Standards considered	ETSI Guide EG 202 057 057-4
Publication	Results of statistical measurements periodically certified and published on AGCOM WEB site

Title	MisuraIntenetMobile.it Quality monitoring for Mobile Internet Access
Country/NRA	Italy - AGCOM
Application and scope	• Monitoring of mobile network performance and quality of internet access services provided from the four Italian mobile operators • Nation-wide: 20 big cities selected for the first measurement campaign, covering all geographic regions of the Country
Project period	• Biannual measurement campaigns planned over a multi-year period (Agcom deliberation 154/12/CONS)
Measurement concept	• On-field active measurement: drive tests are performed through 1000 test suites per campaign, based on nomadic approach (that is, tests are operated in static and outdoor conditions). In addition, dynamic tests are carried out but the correspondent results are for internal use only. • The test terminal devices currently selected are USB dongles for laptops.

	• The test network architecture makes use of test servers located in a IXP
Parameters measured	• Data transmission throughput; Data transmission unsuccesful rate; Packet delay; Packet loss; Jitter • During every test suite, a test cycle is performed, through atomic tests measuring the following key parameters: FTP upload data transmission and fault rate HTTP download data transmission and fault rate HTTP download WEB page browsing time and fault rate HTTPS download WEB page browsing time and fault rate Data transmission delay (round trip time) Packet loss rate Jitter
Measurement implementation	Test tool: SwissQual Diversity Benchmarker. Test terminal device presently selected: USB connect card for PC (evolution to smartphone foreseen in the near future). USB key hardware type presently selected: Huawey K4605 / E372.
Statistical aspects	Individual statistics for each network will be published.
Standards considered	ETSI TS-102-250 & TS-202- 057
Publication	Periodic publication of comparative results at the end of each measurement campaign. Final reports are published on Agcom's website http://www.agcom.it/Default.aspx?message=contenuto&DCId=701

Latvia

Title	Internet Access Service Quality Measurement Tool (ITEST)
Country/NRA	Latvia - SPRK
Application and scope	• Web based tool (speed meter) for IAS end users
Project period	• Permanent platform
Measurement concept	• Measurement of test connections based on a client server architecture • Web based speed test (http://itestn.sprk.gov.lv)
Parameters measured	• Measurement of Internet network layer performance 　◦ Throughput Download/Upload 　◦ Packet loss ratio 　◦ Latency 　◦ Jitter
Measurement implementation	• Measurement probes 　◦ end user equipment 　◦ any end user may take part, i.e. all operating systems and types of browsers • Measurement software 　◦ based on Visualware measurement platform • Measurement server 　◦ two servers and switch connected to two Latvian Internet exchange points – LIX and SMILE • Collection of data 　◦ Access to measurement tool may have any customer and any Internet Access Service provider (IAS) with Latvian IP address, Windows (Windows 2000, Windows XP, Windows Vista or Windows 7) and JAVA installed. 　◦ measurements initiated by end user, no measurement schedule
Statistical aspects	
Standards	

considered	
Publication	• SPRK has the access to all measurement results; IAS has the access to its own measurements and IAS customers to their last measurement

Lithuania

Title	
Country/NRA	Lithunia - RRT
Application and scope	• Web based tool (speed meter) for IAS end users to evaluate IAS QoS basic technical parameters (http://www.matuok.lt)
Project period	• Permanent platform
Measurement concept	• Measurement of test connections based on a client server architecture • Web based speed test
Parameters measured	• Average Throughput (upload and download)
Measurement implementation	• Measurement probes ◦ end user equipment, i.e. probes not controlled ◦ any end user may take part, i.e. all operating systems and types of browsers • Measurement software ◦ provided by RRT • Measurement server ◦ FTP server directly connected to the main Lithuanian IXP from/to which • Collection of data ◦ measurements initiated by end user, no measurement schedule ◦ FTP data files are sent for several times to evaluate average values of transmission speeds ◦ Data file length used for test is self-adjustable regarding to the width of IAS transmission band available
Statistical aspects	
Standards considered	
Publication	

Lithuania (Continued)

Title	
Country/NRA	Lithunia - RRT
Application and scope	• Measurement platform to evaluate mobile/wireless IAS
Project period	• Permanent platform
Measurement concept	• Measurement of test connections based on a client server architecture • Web based speed test

Parameters measured	• basic wireless/mobile network layer parameters
	  ◦ average download transmission speed (FTP/HTTP,)
	  ◦ upload speed for FTP
	  ◦ network unavailability
	  ◦ percentage of unsuccessful registrations to IAS
	  ◦ percentage of unsuccessfully completed downloads/uploads

Measurement implementation	• Measurement probes
	  ◦ Consists of few FTP/HTTP servers (placed in IXP or in cloud of one major content provider) for download/upload FTP/HTTP data files, database SQL server for data containing end subsequent statistical evaluation
	  ◦ 3 pieces of portable equipment (HW/SW based) each consisting of 4 wireless/mobile terminal equipment (USB radio modems) and capable to test semi simultaneously IAS QoS of 4 operators.(GSM/EDGE/UMTS/LTE/WiMAX).
	• Measurement software
	  ◦ provided by RRT
	• Measurement server
	  ◦ FTP server directly connected to the main Lithuanian IXP from/to which
	• Collection of data

	◦ FTP and HTTP data files are constructed corresponding to relevant standards and are self-adjustable regarding to the width of IAS transmission band available.(ex. For GSM shortest data file – for LTE longest.
Statistical aspects	
Standards considered	
Publication	• RRT annually issues a report on wireless/mobile IAS QoS evaluation providing statistical values of QoS parameters based on data obtained using above described system. (2011 annual report: http://www.rrt.lt/lt/apzvalgos-ir-ataskaitos/belaides-Interneto-prieigos-m4ms.html) • Anyone has an opportunity to access the database of IAS system to obtain real time data and statistical data of QoS tests as well as to use tools of this database such as filtering based on operator, technology, time period, place, graphical representing of data , etc.

Norway

Title	
Country/NRA	Norway - NPT
Application and scope	• Broadband Internet access offers offered via fixed and mobile networks
Project period	• Permanent platform
Measurement concept	• Measurement of test connections based on a client server architecture • Web based speed test (http://www.nettfart.no) • end users asked to measure download and upload speed

Parameters measured	• Measurement of transport layer performance
	  ◦ troughput (download and upload)
	    ▪ TCP, with HTTP fallback
	  ◦ data latency

Measurement implementation	• Measurement probes
	  ◦ end user equipment
	  ◦ any end user may take part, i.e. all operating systems and types of browsers
	• Measurement software
	  ◦ software downloaded via browser
	  ◦ measurement engine from Ookla
	• Measurement server
	  ◦ cluster of servers at the Norwegian Internet Exchange (NIX)
	• Collection of data
	  ◦ measurements initiated by end user, no measurement schedule

Statistical aspects	
Standards considered	• ETSI EG 201 057-4 • Internet network performance based on IETF RFCs
Publication	• Web access to data base • presentation of measurements per ISP, county and/or month

	• performance metrics for ISP's products

Poland

Title	**Memorandum** on cooperation for improving the quality of services in the telecommunications market provided to users. (The agreement was signed by the President of UKE with 44 Signatories at present).
Country/NRA	Poland/UKE (*Office of Electronic Communications*)
Application and scope	The idea of signing the Memorandum is consistent with the UKE Regulatory Strategy published in 2012, which lists consumer empowerment and the provision of the required level of quality of telecommunications services as one of its main objectives. The project is also ground-breaking and unique because such extremely sensitive issues have been fixed as a result of co-regulation, or agreement with the market. The objective of the work was to establish a list of quality of service indicators with their precise definitions, to determine methods of making objective measurements as well as the arrangements for publishing the results of measurements and reporting to the President of UKE. The target audience of the final report are not only signatories to the Memorandum. This document is public, and the solutions provided can be also used by other telecommunications companies to develop their own systems of measuring the quality of services. The list, the definitions of the quality of service indicators and methodologies for measuring quality indicators for fixed-line and mobile networks are located at: *http://www.uke.gov.pl/nie-tylko-cena-przejrzyste-wskazniki-jakosci-uslug-13191* There are principles of measurements, data processing and archiving , information about organization of the measurements for mobile networks and the reporting and publication to UKE and to users.
Project period	• Permanent platform
Measurement concept	Report on the work is published on the web at *http://www.uke.gov.pl/nie-tylko-cena-przejrzyste-wskazniki-jakosci-uslug-13191* English version: *http://en.uke.gov.pl/not-only-price-transparent-quality-of-service-indicators-13285*

Parameters measured	- Mobile Services *Coverage Network* **(ETSI TS 102 250-2 p. 5, ECC Report 118 and ECC Report 103)** - Voice Services *Unsuccessful call ratio (***ETSI EG 202 057-2 p.5.1 i ETSI EG 202 057-3 p.6.4.1) – fixed and mobile services** *Speech Quality Ratio* **(ETSI EG 202 057-2 p.5.3) – mobile services** *Dropped Call Ratio* **(ETSI EG 202 057-3 p. 6.4.2) – mobile services** - Internet Access Services (fixed and mobile services) *Data transmission speed* **(ETSI EG 202 057-4 p.5.2)** *Delay* **(ETSI EG 202 057-4 p.5.5)** See Report located on the website at ***http://www.uke.gov.pl/nie-tylko-cena-przejrzyste-wskazniki-jakosci-uslug-13191***
Measurement implementation	See Report on the website at ***http://www.uke.gov.pl/nie-tylko-cena-przejrzyste-wskazniki-jakosci-uslug-13191***
Statistical aspects	
Standards considered	ETSI EG 202 057-2, -3, -4; ETSI TS 102-250
Publication	Publication of the results of the measurements Telecommunications companies will be obliged to publish updated measurements of quality of service on their networks. In contrast, the UKE website will contain summarised benchmarks of quality of service indicators for particular reporting periods submitted by telecommunications undertakings. The first measurement campaign is expected to begin in 2014, and service providers who have joined the Memorandum, will submit to UKE the results of their quality of telecommunications service measurements twice per year.

Portugal

Title	NET.mede (Internet QoS test)
Country/NRA	Portugal
Application and scope	Internet residential access quality of service measurement platform Mobile Fixed
Project period	Partially under development
Measurement concept	Client server topology: • Web based tool • Agent based software available for downloading and installation
Parameters measured	Web based tool (http://www.netmede.pt): • Download/upload speed • Latency Agent based: • Download/upload speed • Latency • Packet loss • Jitter Net neutrality (Traffic Shaping evaluation): • BitTorrent • Flash Video (YouTube)

Measurement implementation	• Measurement probes
	
	  ◦ end user equipment
	
	  ◦ any end user may take part, i.e. all operating systems and types of browsers
	
	• Measurement software

	◦ Java applet
	◦ Agent software
	• Measurement server
	◦ cluster of servers at the Portuguese Internet Exchange (NIX)
Statistical aspects	Under development
Standards considered	• ETSI EG 201 057-4 • Internet network performance based on IETF RFCs
Publication	http://www.anacom.pt/render.jsp?contentId=1183156

Spain

Title	QoS for Internet access service
Country/NRA	Spain - CMT
Application and scope	• Monitoring of ISP performance (nation-wide in all regions)
Project period	• Permanent platform
Measurement concept	• National measurement platform • Client server based architecture Measurement architecture (e.g. client server, active/passive measurement)

Parameters measured	• Network layer
	  ◦ data transmission speed (highest 95% and lowest 5%)
	  ◦ unsuccessful data transmission ratio
	  ◦ successful log-in ratio

Measurement implementation	• Measurement probes
	  ◦ dedicated hardware
	  ◦ Operating system
	  ◦ Management of probes
	• Measurement software
	
	• Collection of data
	  ◦ Distribution of probes
	    ▪ Each service provider installs 1-5 Clients (hardware probes) per region
	  ◦ measurement each 20 minutes

Statistical aspects	
Standards considered	ETSI EG 202 057-4
Publication	Information published quarterly