Regulatory Framework and Technical Aspects of Broadband Access to the Internet in Europe

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Abstract—**This paper deals with the regulatory framework and technical aspects of broadband access to the Internet in Europe. It begins with a concise presentation of the most important conditions of the European Parlament and European Council regulatory framework. It goes on to describe briefly how the package directives 2009/140/WE and 2009/136/WE are being implemented in Poland and Germany. Following that, there is a discussion of the main network parameters involved in the evaluation of quality of network access according to the European Telecommunications Standards Institute (ETSI). Next, the tool "Measurement Lab" is described briefly, and measurements of QoS that have been conducted with the tool are presented graphically, and interpreted. The paper concludes with a summary and outlook on further work.**

Keywords - communications networks, communications services, multimedia applications, internet access, quality of service, QoS measurement techniques and tools

I. INTRODUCTION

The demand for larger and larger bandwidths in the modern information and telecommunications technology age is growing rapidly. There are already numerous applications throughout the Web, e.g. video telephony, video on demand, video streaming IPTV, which would be unthinkable without generously sized bandwidths. Modern, IP-based data networks, that constitute the backbone, have been comprehensively extended and can offer users a wide choice of broadband channels. The last mile, however, still represents a considerable hurdle; in many countries of the world it still hampers rapid access to the Internet. In Europe broadband access has yet to be defined; the European Commission has so far left it up to the individual member states. Consequently, in Poland, for instance, the lower limit was set following a recommendation by the Ministry for Infrastructure [1] at 2 Mbps for download and 1 Mbps for upload whereas in Germany the Federal Ministry for Economic Affairs and Technology, after discussing the issue with branch associations, has stated in its Broadband Atlas and its Broadband Portal [2] that 1024 kbps is the absolute minimum access rate for both upload and download.

In May 2010 the European Commission published "A Digital Agenda for Europe" [3] containing the EC's goals for broadband access throughout Europe. They envisage all Europeans having broadband access (however that may be defined in the individual member states) by the year 2013. The Agenda foresees all Europeans having a connection with a data rate of at least 30 Mbps by 2010, with half of all households having a connection with a data rate of more than 100 Mbps.

There are already several ways to access the Internet. Fig. 1 shows broadband solutions.

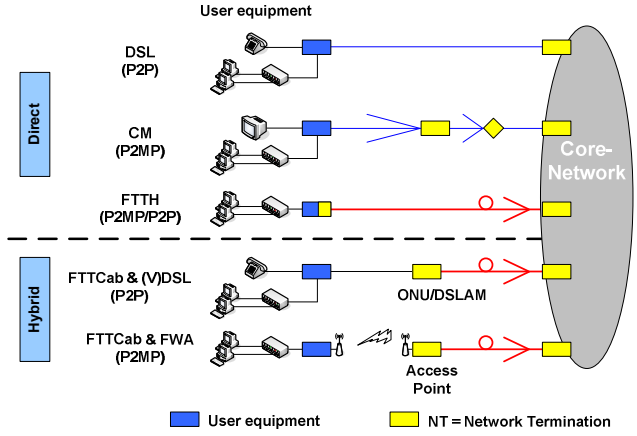

Figure 1. Internet access solutions

Hybrid direct access via copper cable using xDSL technology is extremely widespread. Most of the broadband connections throughout the world are of this type. A second possibility are TV cable networks over a cable modem. Download rates of 25 Mbps can be achieved using optimum access techniques. Fibre optics technology ensures even better access. Ethernet Passive Optical Networks technology (EPON; Standard IEEE 802.3ah) is particularly worth mentioning here.

It enables transmissions of up to 10 Gbps over distances of up to 20 km [4]. Fig. 1 also shows that the technologies mentioned above can be combined, for instance to achieve a compromise between Capex and Opex.

There are now various ways of accessing the core network over the air interface as well. Second-generation mobile telephone networks (GSM) are not capable of providing data transmission rates of 1, let alone 2 Mbps. Third-generation networks (UMTS) are a different matter; they are laid out for transmission rates in excess of 2 Mbps. And the new fourth-generation mobile telephone networks (LTE: Long-Term-Evolution) should offer an even more impressive performance. According to the Specification Doc. 3GPP Release 8 transmission rates of over 300 Mbps for download and more than 80 Mbps for upload will be possible. WiMAX technology (Worldwide Interoperability for Microwave Access; IEEE 802.16) must also be mentioned at this juncture. It enables broadband transmissions over several kilometres. Satellite transmissions provide broadband channels for download as well, but the shear length of time that the signals are underway usually precludes the use of this technology for modern Internet applications, that are often time-critical. As Fig. 1 shows, a combination of landline and air interface systems, in which the Capex-Opex relationship plays a decisive role, is also possible.

Fig. 1 also shows just how many various possibilities there are today of realising broadband access to the Internet. Once an access method has been chosen, it still remains to be decided how the transmission rate over the last mile can be measured objectively. Multiple use of certain resources in core networks often means that the ISP cannot deliver the transmission rates that were agreed upon in the contract. Now, the directives of the European Parliament and European Council [5-6] stipulate that this parameter must be measured. This is a considerable challenge to companies that manufacture and purvey measuring systems to this end. There are a number of test programmes available in the Internet that can do this, but their credibility is to be viewed with caution. For broadband access to the Internet is afflicted by a number of problems as this study will reveal.

To begin with, the directives of the European Commission regarding broadband access to the Internet will be described briefly. The paper will then go on to show how these directives are being put into practice in Poland and Germany. Following that, the parameters that have the greatest influence on data transmission within the Internet will be defined in line with ETSI Recommendations. The measuring system "MeasurementLab" [7] will be described briefly in the section after that. It provides an open, scientifically proven platform with which it is possible to conduct several tests aimed at assessing the quality of broadband access to the Internet. In the course of this study, the tool was used to conduct a series of practical measurements. The results will be presented graphically, and interpreted. Thus, the paper will reveal where the strengths and weaknesses of the tool lie. The paper concludes with a summary and an outlook on future work.

II. Regulatory Framework in Europe

A. *The regulations of the European Parliament and of the European Council with regard to transparency and the level of quality of telecommunications services*

Convergence of telecommunications, media and information technology require that all the networks and services related to the transfer of information be bundled in a single regulatory framework.

In adopting the regulatory framework for electronic communications networks and services the European Parliament and the European Council have been guided by, among other things, the desire to establish full competition between businesses operating on the telecommunications market while at the same time giving customers the free choice of provider by giving them unlimited access to information about the quality of services that the providers offer.

25th November 2009 the European Parliament and the European Council adopted the so-called communications package that includes:

1) Directive 2009/140/EC of the European Parliament and the European Council of 25th November 2009 amending Directives 2002/21/EC on a common regulatory framework for electronic communications networks and services, 2002/19/EC on access to and interconnection of electronic communications networks and associated facilities, and 2002/20/EC on the authorisation of electronic communications networks and services (Official Journal L 337/37) [5].

2) Directive 2009/136/EC of the European Parliament and the European Council of 25th November 2009 amending Directive 2002/22/EC on universal service and users' rights relating to electronic communications networks and services, Directive 2002/58/EC concerning the processing of personal data and the protection of privacy in the electronic communications sector, and Regulation (EC) No 2006/2004 on cooperation between national regulatory authorities (NRAs) responsible for the enforcement of consumer protection laws (Official Journal L 337/11) [6].

Following publication of these documents, all EU member states were obliged to publish and adopt the laws, regulations and administrative provisions necessary to comply with these directives on or by 25th May 2011.

In its Preamble (31) Directive 2009/136/EC drew attention to issues of regarding end-users' access to information, including information about the quality of services: *"End-users should have access to publicly available information on communications services. Member states should be able to monitor the quality of services which are offered in their territories. National regulatory authorities should be able systematically to collect information on the quality of services offered in their territories on the basis of criteria which allow comparability between service providers and between member states. Undertakings providing communications services, operating in a competitive environment, are likely to make*

adequate and up-to-date information on their services publicly available for reasons of commercial advantage. National regulatory authorities should nonetheless be able to require publication of such information where it is demonstrated that such information is not effectively available to the public."

Article 22 of Directive 2009/136/EC, "Service Quality" emphasizes the obligations of companies that provide publicly available communications networks and services with regard to the transparency of electronic services to end-users. Put simply: they are to make information about their offers, services and level of service quality easy to understand and compare with other offers. To provide end-users access to comprehensive, comparable, reliable and user-friendly information, NRAs may, among other things, specify quantifiable indicators of quality of services and content, and what administrative information is to be published, and how it is to be formulated.

B. Initiatives of the European Commission with regard to Quality of Services for Network Neutrality in 2010 and 2011

With the project "*Digital Agenda for Europe*" of 30th June 2010 the European Commission launched a programme of public consultation on Network Neutrality and the Open Internet, including issues of quality of services (QoS) [3].

The public consultation was attended by 318 interested parties representing all levels of the value chain, that it to say: Body of European Regulators for Electronic Communications (BEREC), member state authorities, Internet service providers, content providers, consumer organisations and the general public, i.e. end-users. In a press release 9th November 2010, the European Commission published the results of the consultations carried out during the period from 30th June to 30th October 2010. The most important decisions of the consultation can be found on the Web at [8].

19th April 2011 the European Commission sent a communiqué to the European Parliament and the European Council detailing the principles of *"Open Internet and Network Neutrality"* [9].

The communiqué raised, among others, the following issues:

- requirements relating to quality of service;
- ease of changing the provider;
- citizens' and businesses' ease of access to the *open and neutral Internet*;
- The EC will ensure that new legislation in the field of telecommunications on transparency, service quality and the possibility of a change of operator will enter into force on 25th May 2011, and will be implemented in such a way as to safeguard an open and neutral Internet;
- The EC will draw attention to the restrictions on legal services and applications and whether the broadband connections that are used by EU citizens and businesses are as fast as the advertising of the Internet service providers (ISPs) implies;
- The EC has asked BEREC to conduct a detailed study of key issues to ensure an open and neutral, i.e. obstacle-free, Internet.
- change of operator, blocking or restricting of Internet traffic (e.g. voice services), transparency of offers and information about the quality of services provided;
- The EC will publish the information obtained by BEREC, including cases of blocking and limiting legitimate Internet traffic;
- The EC will consider taking more stringent measures should cases of drastic violations of net neutrality rules be identified in terms of transparency, quality of services and freedom to change the provider.

In September 2010 the European Commission announced a tender for testing the quality of broadband services in European Union countries covering the years 2011 to 2013 [10].

The study aims to verify the quality of retail broadband services by examining the differences:

- between the speed quoted by the suppliers and the actual speed achieved by the users;
- between the service providers themselves;
- between rural and urbanized areas;
- between the member states of the European Union.

As part of the project *"Digital Agenda for Europe"* the European Commission, together with SamKnows [11], invited volunteers in the 27 member states of the European Union plus Iceland, Norway and Croatia to measure broadband capacity under the motto "**Measure your broadband accurately**". Information on the types of tests, the conditions under which they are to be made, the methodology and application form, can be found at [12].

Volunteers qualify to receive a specially designed testing device for measuring the broadband Internet connection (SamKnows Whitebox), which can be connected to their modem or router. The SamKnows Whitebox performs the following tests:

- speed of data collection based on the HTTP protocol;
- data upload speed based on the HTTP protocol;
- availability of links;
- delay variation (jitter);
- delay (latency) in both ICMP and UDP;
- loss of both ICMP and UDP packets;
- DNS server response time;
- failure rate of queries to the DNS server;
- response time of Web pages;
- failure rate of loading a Web page.

The study will last 2 years, after which a report will be prepared for the European Commission, which will include statistics (in different sections) on the performance of broadband throughout the EU and in the three participating non-EU countries.

C. BEREC position on Net Neutrality and Quality of Service

In 2010 the European Commission contracted BEREC with the investigation of the key issues influencing an open and neutral Internet. The Expert Working Group EEC BEREC, composed of experts and representatives of various European Union regulators worked on the report **"A Framework for Quality of Service in the scope of Net Neutrality",** which included:

- the definition of the service Internet Access;
- definitions of Network Performance (NP), Quality of Service (QoS), Quality of Experience (QoE), QoS according to Article 22 (3) USD;
- causes and effects of degradation of quality;
- traffic management techniques;
- types of specialized services that require guaranteed end-to-end quality and safety (SLA);
- review of methods and tools for assessing the quality of services;
- new powers of regulators (conditions and procedures for determining the minimum quality requirements);
- conclusions and further action.

As the consultations within the framework of the Expert Working Group BEREC continue, the following issues and challenges to IP network performance evaluation still remain open:

- definition of the responsibilities of suppliers of Internet access services not only in the area of their own resources, but also in the context of interconnection agreements;
- the high susceptibility of the quality parameters of single users' services to the concurrent network load resulting from the sharing of network resources;
- the exploitation of already existing networks of mechanisms and tools to control some of the parameters of the user terminal (e.g. a speedtest application)
- how far the ISP network is responsible for the quality of services;
- what measuring tools should be available to users so that they can correctly formulate a justifiable reason for complaint;
- what parameters of quality and accessibility of services should be specified in ISP agreements for the services they provide for Internet access;
- how service providers should inform their customers about the quality of service so that customers can make a choice going off the basis of their advertisements (actual quality);
- how the provider should inform customers about traffic management and network services, and about the terms of agreements with other entities with whom they exchange IP traffic so that this information be comprehensible to users.

In preparation for future work BEREC prepared a questionnaire in December 2011 addressed separately to network operators and NRAs that manage Internet traffic along with the instructions on filling in the questionnaire. Respondents could seek help in answering the questions by writing to the office of BEREC at *pm@berec.europa.eu*. Respondents' completed questionnaires were to be sent to NRAs by 20th January 2012. All data submitted by operators in the questionnaires will be published by the European Commission and BEREC in such a way as to preserve the anonymity of the participants.

D. State of play of EU Directives in Poland and Germany

In Poland a draft of the Telecommunications Act has been prepared that takes into account the full scope of the regulation package to implement the directives of the European Communities 2009/140/EC [5] and 2009/136/EC [6] dated 25th November 2009. The regulations are planned to go into operation in the second quarter of 2012. A draft based on the Act (regulation) has also been prepared for the transparent and effective implementation of the obligations stipulated under Article 63 of the Telecommunications Act, which states that: "a provider of publicly available telecommunications services shall publish current information about the quality of those services" [13].

The present position is a non-binding proposal intended to help telecommunications companies to perform statutory duties arising from:

- Article 63 (1), according to which: "a provider of publicly available telecommunications services shall publish current information about the quality of those services,"
- Article 56 (2), according to which "an agreement for the provision of publicly available telecommunications services requires a written form ... and should specify in particular: data on quality of service".

The President of the Office of Electronic Communications (UKE) recommends [13]:

1. The use of a directory of quality indicators of publicly available telecommunications services in order to:

- create uniform, comparable (i.e. transparent to the consumer) information about the quality of service indicators;
- determine appropriate conditions of contracts with customers;

- measure the performances of telecommunications service providers listed in the directory, quality indicators, and then publish their information in accordance with Article 63 (1).

2. Publication of information about the quality of publicly available telecommunications services must take place no less frequently than every six months, and for each year, by:

- publishing the parameters referred to in the Appendix [13] for the reporting period on the websites of providers of telecommunications services. The published information should be comprehensible to customers and easy to find;
- maintenance and provision of such information in the customer service offices of telecommunications services providers.

The President of the UKE also provides for the publication of data on the website of the UKE, having conducted random tests to verify the accuracy of the information.

The Federal Network Agency (Bundesnetzagentur für Elektrizität, Gas, Telekommunikation, Post und Eisenbahnen; BNetzA in this text) is one of the principal regulatory offices in Germany. The Authority arose out of a fusion of the Federal Ministry for Post and Telecommunications (Bundesministerium für Post und Telekommunikation; BMPT) and the Federal Office for Post and Telecommunications (Bundesamt für Post und Telekommunikation; BAPT) and was established 1st January 1998 under the name of Regulatory Authority for Telecommunications and Post (Regulierungsbehörde für Telekommunikation und Post; RegTP). In summer 2005 the Authority was not only entrusted with the regulation of telecommunications networks but was also made responsible for the regulation of energy in the forms of electricity and gas. In view of the fact that the Authority was now responsible for a number of various networks, it was renamed the Federal Network Agency 13th July 2005 [14].

The chief responsibilities of the Agency comprise the preservation and promotion of competition in the networks listed in the Authority's official title. The legal framework governing digital networks and electronic services by which the BNetzA acts is the Telecommunications Act (Telekommunikationsgesetz; TGK). In end effect, Section 67 (1) of the Act empowers the BNetzA to act as watchdog over other laws as well. This goes particularly for consumer protection, but the wording of the Act allows practically unlimited scope.

According to statements issued by the BNetzA in summer 2011, market control in terms of *Net Neutrality and Quality of Service* in Germany can be described as follows:

- The minimum data transfer rate in a broadband network connection is regulated by law (cf. Introduction).
- The maximum data transfer rate for the connection is always to be stated in all contracts with customers. Some network providers also state the minimum data transfer rate.
- The customer has the right to withdraw from a contract if the actual data transfer rate falls 50 % short of the rate stated in the contract.
- At the time of writing it is not yet clear how the BNetzA will effectively control whether the terms of contract are being observed. Elaboration of the registration procedure is pending.
- Network subscribers shall be able to monitor the available data transfer rates for themselves. The BNetzA's own tool "Speedmeter" has been named as a suitable means.
- It is yet to be decided whether the BNetzA itself or a third party will be responsible for conducting the measurements of the available data transfer rates on a permanent basis.
- No catalogue has yet been published that lists which parameters of QoS will be measured and which methods will be used to measure them.
- The Telecommunications Act does not stipulate how the acquired QoS measurements will be made available to the public or who will publish them. This is currently up to the network providers.

III. QUALITY OF SERVICE PARAMETERS IN NETWORKS

The Recommendations of both the ITU-T and the ETSI quantify network and service parameters for access to the Internet. The relevant documents are ITU-T Recommendation G.1020 *"Performance parameter definitions for quality of speech and other voiceband applications utilizing IP networks"* [15] and ETSI EG 202 057-4 V1.1.1 *"Speech Processing, Transmission and Quality Aspects (STQ); User-related QoS parameter definitions and measurements; Part 4: Internet access"* [16]. Table 1 summarizes the main parameters as they are defined in the ETSI Recommendation.

The definitions of the parameters contained in Table 1 can be found in the documents mentioned above; they are not given here for lack of space. The documents also mention further parameters that the regulatory authorities of each member state of the EC could include in the so-called QoS Catalogues. An example of such a catalogue can be found at the Internet addresses [13] and [16].

It is clear that there are already an adequate number of standards that define the parameters of QoS in digital networks and electronic services. And there are several companies on the telecommunications market, e.g. Nextragen [17], Opticom [18], Empirix [19], IXIA [20], NetIQ [21], Ip-Label [22], Telchemy [23], Shenick [24], VoIP Future [25] et al. that provide systems to measure these parameters. There are also public-domain tools available over the Internet, for instance at http://pingtest.net or http://speedtest.net, that can be used to test the properties of network access points. There has been a lot of talk recently about the licence-free tool Measurement Lab, available at http://measurementlab.net, that can be used for this purpose. What can it do, and how good is it? The next chapter of this paper describes a study designed to find that out.

TABLE I. SUMMARY OF QOS PARAMETERS

Parameter	Measure	Measurement Method	Application
Login time	Number of successful logins	Test calls	All IAP services that are accessed via a login process
Data transmission speed achieved	a) The maximum possible data transmission rate in kbps b) The minimum data transmission rate in kbps c) The mean value and standard transmission rate in kbps	Test calls	All IAP
Unsuccessful data transmissions ratio	% of unsuccessful data transmission	Test calls	All IAP
Successful login ratio	% of successful logins	Test calls	All IAP services that are accessed via a login process
Delay (one-way transmission time)	a) The mean values of the delay in milliseconds b) The standard deviation of the delay	Test calls	All IAP

IV. THE TOOL "MEASUREMENT LAB"

Measurement Lab (M-Lab) is an open, distributed server platform for researchers to deploy Internet measurement tools. The goal of M-Lab is to advance network research and grant the public a certain amount of autonomy by enabling them to gain useful information about their broadband connections for themselves [7].

There are currently 48 servers implementing the M-Lab system spread over 16 countries. New York and Amsterdam each have two such servers in operation. In Germany and Poland together there is but a single server in operation in Hamburg. Approximately 1.5 million tests are conducted in the system each day. Some 300 terabytes of data have been acquired and statistically evaluated to date.

The M-Lab system was initiated by the following organisations, that operate it and continue to develop it further:

1) Scientific institutes (e.g. Internet2, Max Planck Institute, SamKnows). They are responsible for further development and implementation of the individual software modules that are inherent parts of the tool.

2) Infrastructure providers (e.g. Voxel, EETT, Google). They furnish the system with fundamental resources such as servers and data transmission lines.

3) Host partners (e.g. Amazon, Google). They secure the access to the terabytes of data that are used whenever the system is started.

Fig. 2 shows the home page of the M-Lab system. Users can currently choose between the following languages: English, French, Spanish, Greek, Chinese and Japanese.

Figure 2. Measurement-Lab Tool Home Page [7]

The M-Lab tool lets users perform the following tests:

1) ***Network Diagnostic Tool (NDT)***: test your connection speed and receive sophisticated diagnosis of problems limiting speed.

2) ***Glasnost Test***: test whether certain applications or traffic are being blocked or throttled on your broadband connection.

3) ***Network Path and Application Diagnostics (NPAD)***: diagnose common problems that impact last-mile broadband networks.

4) ***Pathload2***: see how much bandwidth your connection provides.

5) ***ShaperProbe***: determine whether an ISP is performing traffic shaping.

6) ***BISmark Gateway***: apply to host a router device to test Internet connectivity over time.

7) ***WindRider***: detect whether your mobile broadband provider is performing application or service specific differentiation.

8) ***SideStream***: collect statistics about the TCP connections used by the measurement tools running on the M-Lab platform.

9) ***Neubot***: perform periodic tests to measure network performance and application-specific traffic throttling.

The M-Lab tool offers a wide variety of what it calls visualisations of the acquired data relative to the countries of the world. Unfortunately there are many uncharted areas,

owing to the fact there simply are no servers in those parts of the world. This can only be seen as a great weakness of the measuring system.

This work examines how user-friendly and efficient the M-Lab tool is. The following chapter deals with the results obtained.

V. THE RESULTS OBTAINED

The M-Lab measuring system was tested by several specialists independently at the Office of Electronic Communications in Warsaw, at the Wroclaw University of Technology and at the Flensburg University of Applied Sciences. The insights that were gained and the conclusions that were drawn at the three locations proved to be remarkably similar. As soon as the tests started, it became obvious that measurements cannot be made from terminals within a LAN that uses a firewall or a proxy; direct access to the ISP is necessary. For some of the tests (e.g. NDT: Network Diagnostic Tool) additional programmes, notably JAVER from Oracle, are needed, and sometimes additional applications as well, that must be loaded and run on the servers in the system as EXE files (e.g. Tests NPAD: Network Path and Application Diagnostics). Since such programmes can be suspect, that might just put some people off using the tool. Colleagues at all three locations shared the opinion that in many cases the representation of results on the user overlay left much to be desired. Moreover, the interpretation of the acquired data often assumed sufficient to good knowledge of network administration on the part of the user (e.g. Test NPAD). In view of that, the system MLab is an unsuitable tool for the average Internet subscriber who simply wants to test his connection. Some tests take too long (e.g. Glasnost Test up to 8 minutes). Quite often tests could not be completed successfully or were even aborted. Some tests, e.g. Pathload2, will not run on operating systems older than Windows7. The most reliable tests seem to be NDT and Neubot. They can be used to conduct a range of tests.

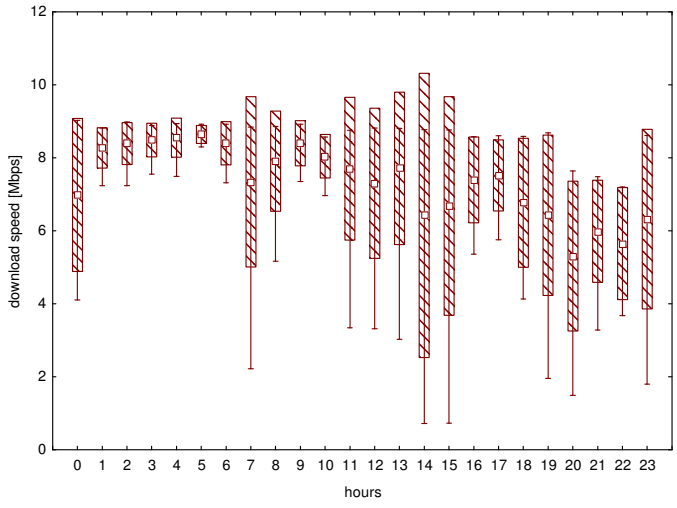

Figure 3. Available download bandwidth measured during the day / night

Figures 3 and 4 show examples of the results obtained with Neubot (SpeedTest). One of the measurements was a test of an ASDL connection that had been tariffed according to the "InternetMax" principle, i.e. the ISP informs the end-user of the maximum possible bandwidth for his connection. In this case the maximum bandwidth had been set at 20 Mbps. Figures 3 and 4 show the statistically evaluated results of the measurements. The measurements were initiated automatically at the same time on all seven days of one week. The figures contain the mean values (small squares), the minimum and maximum values (whiskers) and the standard deviation (boxes). The figures show that the available bandwidth fluctuated considerably between the values of 8 to 6 Mbps. This can also be seen from the standard deviation. By contrast, upload bandwidth remained quite constant at a level of approx. 700 kbps. Similar tests of the download bandwidth, conducted using NDT, yielded values that were up to 20 % higher. So it is evident that different tests can deliver quite different results. Conclusion: the credibility of such tests is questionable.

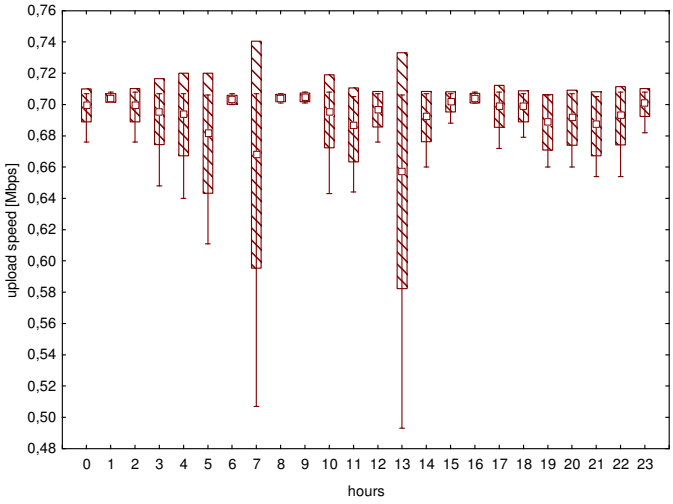

Figure 4. Available upload bandwidth measured during the day / night

Resume

The MLab system has the following strengths:

- Open platform, useful for any interested user.
- Easy access from any PC with an Internet connection.
- Unlimited access to all data stored in the MLab system.
- Selection of several languages for the user overlay.
- Allows for coordination between participating countries, so avoiding duplication of measurements.
- Some tests are recognised by the NRAs as standard procedures for measuring network parameters. NDT is, for instance, recognised by the Federal Communications Commission in the USA. This can only enhance the attractiveness of the MLab tool.

The MLab system has the following weaknesses:

- The configuration of the user's PC can affect measurement results.

- No guarantee for the successful completion of tests. MLab must be contacted when failures occur.
- Additional applications often have to be installed before the tests will run. Such programmes can be of dubious origin.
- Low stability and lack of reproducibility of measurement results. The geographical location of system servers can severely affect results.
- Frequent chaotic representations of intermediate results. Good knowledge of networking is often necessary for their interpretation.
- Far too few servers throughout the world.
- Tests are often manual unless the user is prepared to write routines to automate them. An exception here is the test Neubot.

In summary it can be said that the measuring system MLab is an academic tool that helps developers and researchers to complete research projects. The tool is in many respects unsuitable for average Internet users. In order to gain reliable measurements of the properties of an Internet connection, there is no alternative to using professional measuring systems such as those from companies cited in references [17-25].

VI. CONCLUSION

The focus of this paper has been a concise presentation of the latest information about transparency and neutrality of telecommunications networks and services in Europe. Sources were given and the purport of the most important provisions of the European Parliament and of the European Council was presented and discussed in detail. Following that, there was an account of how these provisions are being put into operation in Poland and Germany. It was shown that their implementation has already come quite far in Poland, whereas Germany still has a lot of catching up to do. One thing is clear: efficient supervision of digital network operators, providers and services can only be guaranteed when a legal basis has been sanctioned and made available to the public.

A further part of this paper discussed the most important impairment parameters in digital networks and digital services in the light of the latest recommendations of the ITU-T and the ETSI. It was shown that it is very important in practice that systems to measure these parameters are readily available. Consequently, the new, open measuring system MLab was described in detail and its functionality was put to the test. Its strengths and weaknesses were demonstrated in an exhaustive series of tests. They revealed that MLab is clearly an academic tool that can only be understood in its full scope by experts. It is not suitable for the typical end-user.

The tool MLab was also tested by the authors of this paper in realistic analysis scenarios. The results obtained were presented graphically. In the hands of experts MLab is demonstrably a useful measuring system that can deliver realistic results. To optimise the tool further improvements are needed both in the dimensioning of the system itself, i.e. worldwide coverage, and in the design of the user overlay through clearer presentations of the measurement results. Seeing as the system is an open platform, researchers and engineers should feel motivated to use it habitually and effectively. At least the authors of this paper will be.

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