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Deliverable D8: **Third Experts' Workshop Report**

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List of participant organisations:

Role	Participant name	Participant short name	Country
Tenderer	Hebrew University of Jerusalem	HUJI	Israel
Supporting partner	Alcatel Lucent Bell N.V.	ALB	Belgium
Supporting partner	Martel GmbH	MAR	Switzerland
Supporting partner	Universidad Autónoma de Madrid	UAM	Spain
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TABLE OF CONTENTS

1. THIRD EXPERT WORKSHOP: OVERVIEW AND HIGHLIGHTS

1.1 Overview

The Internet is an important critical infrastructure, but efforts to monitor this complex system have been diverse and uncoordinated. This study analyses existing Internet monitoring tools and methodologies and provides concrete recommendations about the needs and the next steps that Europe should take in this area.

The outcomes of this study will be:

1. An up-to-date, and as-complete-as-possible cartography of existing monitoring tools and methodologies.
2. A gap analysis of the needs for new methods and tools, taking into account how the Internet is evolving today and considering future Internet design and policy directions. The gap analysis can point both to possible new tools and methods as well as innovative ways to use current tools and methods.
3. A proof-of-concept showcase for the tangible ways some of those tools and methods can be used with real data.
4. A set of recommendations on how to close the gaps that have been identified, and suggestions for mechanisms that could support useful Internet monitoring for stakeholders in Europe.

This document reports on the 3rd Experts' Workshop organized within the EC-funded "Study on European Internet Traffic: Monitoring Tools and Analysis". This workshop took place on April 22, 2015, as a satellite workshop preceding the Seventh International Traffic Monitoring and Analysis workshop (TMA2015) in Barcelona, Spain. It provided an opportunity to present results obtained so far from background research, two workshops as well as a questionnaire, and to gather feedback from the broader community of traffic monitoring researchers and practitioners.

In this meeting we reviewed the draft version of our results in the measurement study to date, indicated the areas in which we are focusing our gap analysis, and the use case prototypes that we will present in the Brussels meeting on 21st May 2015. We also heard about and discussed in particular the Net Neutrality issue, from both US and European perspectives, given the recent prominence given to the topic by President Obama.

After describing the agenda of the workshop, we provide in this deliverable a summary of the presentations, as well as a review of the discussions that took place and the issues raised. A final Appendix provides the list of registered attendees who participated, with their affiliations.

The final event in this study will be a meeting between various interested parties within the EC and the study team on 21st May 2015 in Brussels.

1.2 Objectives of this workshop

In our first workshop we presented the initial version of our survey questionnaire aimed at

research and testing infrastructure owners and operators, and obtained feedback. We also received offers to help in targeting the appropriate recipients for these questions, and incorporated these suggestions and contacts into our process.

In the second workshop we reviewed the almost completed survey with the experts present and heard several presentations of the overall view and major issues facing network owners and regulators. It focused on the gap analysis, the - as yet - unmet needs seen in our discussions and by our experts. This required a reality-based status from the survey and agreed-upon objectives, which we discussed. The discussion focused on the likely challenges that will be addressed, covering "telescopes," or large scale behaviour, and "microscopes," which expose detailed traffic flow information.

On the large scale, identifying growth rates and trends, and rapid identification of distributed anomalies (which might be attacks) were identified as important. On the finer scale, characterizing flows, in terms of user intentions and needs, was discussed. It also shed some light on how the FIRE (Future Internet Research and Experimentation) efforts on federation might work to integrate measurement systems in both the research experimentation and commercial domains.

This 3rd workshop is organized in 3 main parts:

Section 1 "Future Opportunities" is planned to bring new insights into Internet measurement work from around the world. Invited presentations are from (i) the new FIRE project MONROE "Measuring Mobile Broadband (MBB) Networks in Europe", (ii) M-Lab, and (iii) RIPE (Atlas probes). A fourth study of monitoring by access from large numbers of mobile smartphones, which was performed as a use case in the current effort, was presented in this section.

Section 2 reports on the current status of the study, use cases and our recommendations.

Section 3 focuses on Net Neutrality and Transparency; the pros and cons and how to measure if ISPs are in compliance. A number of questions had been developed in advance by the organisers with the speakers in order to guide the presentations and address the issues of similarity and differences between Europe and the US.

As a preparation for this workshop, we created a private web space (using Google+) for the registrants. In that space we made available our Gap Analysis document (deliverable D5) and several relevant review and analysis papers:

All are currently to be found at
https://plus.google.com/u/0/communities/105553281521079554695

A Survey on Internet Performance Measurement Platforms and Related Standardization Efforts, by Vaibhaj Bajpai and Juergen Schoenwaelder, to appear in IEEE Communications Surveys and Tutorials (2015).

Mobile Traffic Analysis: A Survey, by Diala Naboulsi, Marco Fiore, Stephane Ribot, Razvan Stanica, Research Report INRIA Grenoble CNR-IEIIT <hal-01132385>.

Urban Sensing Using Mobile Phone Network Data: A Survey of Research, by Francesco Calabrese, Laura Ferrari, and Vincent D. Blondel, ACM Computing Surveys **47,** #2 Article 25 (Nov 2014).

"Beyond Frustrated," the Sweeping Consumer Harms as a result of ISP Disputes, report of Open Technology Intitute @ New America Foundation

2. WORKSHOP ARRANGEMENTS

2.1 Agenda

The following Agenda was distributed before the meeting:

SMART Internet Monitoring Study

Expert Council Workshop 3

Barcelona, 22nd April 2015

Website: http://internet-monitoring-study.eu/index.php/workshops

Venue: Meeting Room A3

UPC, Campus Nord, Barcelona, Spain

Wednesday, 22nd April, 2015

9:00: Future Opportunities -- presentations and direct questions

Speakers:

- Ozgu Alay, Simula, Norway
- Bert Wijnen, RIPE (retired)
- Collin Anderson, M-Lab
- Scott Kirkpatrick, HUJI

Chair and question-tabulator: Jerker Wilander

Scribe: Jorge Lopez, UAM

10:30: Coffee break

11:00: SMART team summarizes questions and recommendations (discussion to continue after afternoon break)

Speakers:

- Scott Kirkpatrick, HUJI
- Eunah Kim, Martel
- Jorge Lopez, UAM
- Dimitri Papadimitriou, Alcatel-Bell

Chair and question-tabulater: Timur Friedman, UPMC

12:00: Lunch break

13:00: Net Neutrality and Transparency -- structured discussion

Speakers:

- Scott Jordan (by video conference)
- Frode Sorensen, Nkom
- Marco Mellia, Polito
- Collin Anderson, M-Lab

Chair and question-tabulator: Scott Kirkpatrick, HUJI

Scribe: Martin Potts, Martel

15:00: Coffee break

15:30: Discussion and Feedback

3. SPEAKERS AND PARTICIPANTS

Georgios Tselentis, EC, program officer
Scott Kirkpatrick, HUJI, study leader
Ozgu Alay, Simula, coordinator of MONROE project
Frode Sorensen, NKom, Chair of BEREC's Net Neutrality WG
Collin Anderson, MLab, author of several censorship studies
Bert Wijnen, RIPE (retired from Alc atel and from RIPE, IETF participant
Scott Jordan, FCC (remote), CTO of the FCC

A complete list of our registered attendees and their institutional affiliations appears in the Appendix. In addition, several participants and lecturers from the concurrent PhD school held at the TMA-2015 meeting attended the third session in our workshop. Their comments were very helpful.

4. WORKSHOP INPUTS

4.1 Session 1: Future Opportunities

4.1.1 MONROE: Measuring Mobile Broadband Networks in Europe

Özgü Alay, Simula, Norway

Özgü explained that MONROE is a FIRE+ project related to mobile broadband (MBB) networks. She said that:

- The goal is to constantly monitor the performance and reliability of 3G/4G/WiFi networks and compare the differences in configurations, operator policies, regulations within - and between - countries. The project will run active, systematic end-to-end measurements with long and uninterrupted sessions where it will also collect metadata. Partners will then try to identify the key performance metrics of MBB networks by analysing these measurements.
- It is assumed that MONROE's measurements will become the benchmark, since the platform is a dedicated infrastructure just for MBB measurements. The project uses modems that are available in the market, and measures the performance from the user's perspective and runs the same test for all the operators simultaneously.
- MONROE is designing, building and operating an open, European-scale, and flexible platform with multi-homing capabilities to run experiments on operational 3G/4G networks.
- MONROE can be used for monitoring and performance assessment, and to evaluate innovative protocols and services for MBB networks, including combinations of wireless technologies.
- Who can benefit?
    - Operators
    - Regulators and society at large
    - Organizations and business
    - Users/consumers: choose network provider
    - Researchers, innovators and experimenters
- MONROE is built on NorNet Edge, with 200 nodes in Norway, but it has been extended to Sweden, Spain and Italy. The testbed has now 450 nodes of which 150 are mobile nodes. These nodes will be connected to at least 3 different operators.
- The mobile nodes are installed in buses, trains and trucks, to assess the impact of mobility, as well as rural vs city coverage.
- 3x MBB operators are involved, as well as WiFi providers. The project explores combinations of 4G and WiFi, handover, etc.
- Fixed nodes are often in schools, as opposed to being outside.
- They are considering to add sensors.
- Future Open Call experiments are expected to be in areas of:
    - Impact of mobility
    - Rural vs City environments

  - Experiments with different access technologies
  - Exploring new ways to combine the use of multiple access technologies to increase performance and robustness.
  - New opportunities: 4G/WiFi handover
- After the Open Calls, there will also be a period of Open Access.

Raised questions/comments:

- Operators are somehow reluctant to collaborate in this type of platform. ☹
- Do operators know which nodes they are measuring on? It is difficult, because many of the nodes are mobile. Nevertheless, having access to implementations in 4 different countries is expected to lead to interesting comparisons of differences in configuration, regulations, frequencies and operator strategies.
- Apps are not included in the platform in the first stage of the project, but maybe in an extension. They are considering now to use real smartphones as measurement targets, as it is important to mimic the user behaviour.
- What about external interferences (with WiFi and between multiple operators)? They measure the same situations that real users experience.
- Many people stay with the same operator (45%).
- Marketing costs are 60-70% of operator costs.

4.1.2 Measurement Lab – Measurement at scale

Collin Anderson @MLab

Collin explained that Measurement Lab operates infrastructure for making performance measurements. It has 900 nodes (points of measurement) globally.

When you install uTorrent, it tests your network performance with the Measurement Lab infrastructure. The test is based on saturating the link for 10 seconds downloading and uploading data. All measurements are public; users have to give informed consent; the incentive for taking part is “mutual self interest”.

Thanks to this, there are some measurements about countries such as Iran (as well as from the rest of the world):

- About 3’000 people every month install and test the network there, performing the network measurement.
- Based on these measurements, M-Lab found there was a clear correlation between the Internet connectivity and network policies in Iran (candidates vetted and results announced were the milestones where the network was slower and later faster again), “to preserve calm in the country during the election period”.

BitTorrent is not an illegal activity itself. The Glasnost tool detects several types of traffic shaping. This could be throttling of BitTorrent traffic, but throttling of other packet types, such as VOIP, is also tested for.

For M-Lab, an IP address is not Personal Information (PII), so they could provide it without danger. Anyway, they just give the AS number instead, to avoid privacy problems.

They provide data which is considered to be of public interest data; for instance, related to information about network neutrality, transparency, throttling, etc. Thanks to this, the Indian operator Airtel has been questioned on their network neutrality policy.

Raised questions/comments:

- M-Lab emphasized how open their data will be for other researchers.
- The Iran example shows that measurements can reveal a lot on neutrality issues. He has another example about Turkey, and there are lots of stories about Pakistan and China. It was not asked if there are similar findings from countries closer to home.

4.1.3 RIPEstat, RIPE Atlas

Bert Wijnen, independent, retired from RIPE

Bert informed that RIPE has more than 8'000 Atlas probes around the world, 7'000 active users and about 100 active Atlas anchors. Probes are small-sized devices (raspberry pi like in size), and anchors are rack-mounted PCs. They collect more than 2'500 measurements per second. Statistics are available at: https://atlas.ripe.net

The RIPE Atlas Website shows all probes that are installed and active. Tests are typically pings, traceroutes, DNS, SSL

Users can ping a probe from anywhere in the world, so RIPE Atlas can be used to look at your network from the outside.

Tools such as Nagios or Incinga can receive input from RPE Atlas, via an API, by:

- Creating a RIPE Atlas ping measurement account
- Going to the "Status checks" URL
- Adding the alerts to Icinga or Nagios

Measurements are scheduled by:

- Logging into atlas.ripe.net
- Going to "My Atlas" and "Measurements"
- Choosing "New Measurement" or "One off"

The test workload is controlled by RIPE through a "credit system". Credits are earned by hosting a probe. Credits can be shared with others. Interesting tests can be hosted "for free". This assures fairness and protects from overload.

The results can be checked with a RESTful API.

Raised questions/comments:

- How do these measurements compare to Akamai?
    - Not clear. No member from Akamai in this workshop.
- RIPE would like to have probes and anchors where there are none at the moment, in order to get a more complete picture. Although there are strong similarities between the capabilities offered by RIPE's probes and the similar hardware-based CAIDA systems, the question of whether the value of the increased coverage that might be obtained using both systems justified the inevitable headaches of combining them, did not get addressed.
- Location precision is very important in some cases.
    - Atlas probes are geo-located by their IP address and they ask hosts for information about the location (from their postal address). They try to be as accurate as possible. GPS in the probe would be a future possibility.
- How do you handle anycast addresses? Depending on the Internet site where the probe is located, the measurement target would be a different place.

  - This is why the geo-location has to be accurate enough to know if the anycast address is working properly and to permit longitudinal study of anycast usage and practices.
- All code is open-source, so it could be ported to mobile phones if needed.
- A hackathon was held recently that worked for a weekend to create new measurements scripts.

4.1.4 Vision of smartphones as the ultimate observation platforms

Scott Kirkpatrick, HUJI

- Realtime observation platforms exist today
  - DIMES: more than 1'000 software installations since 2006 (DASU/ONO are similar, although used collaboration instead of altruism to attract downloads)
  - CAIDA and RIPE have more than 10'000 installed probes
  - SamKnows: Offers probes for users in USA, Europe, Brazil, Canada and Singapore for testing their broadband performance.

    >2'000 panelists took part in the UK Broadband Study in 2014 and 4'000-7'000 in the corresponding FCC *Measuring Broadband America* study.

    They work with BT to install measurement capability directly in BT's "HomeHub".
- WeFi
  - Mobile phone app. It is possible to create heatmaps about how many people are at any place in a map, and study where humans are moving every day, for instance in Los Angeles, where the app is installed on 50'000 smartphones and 450 million measurements are made per month. The app provides Internet performance characteristics every few minutes to as often as 1'000 times per hour.
  - There are two types of test:
    - User-initiated
    - All-the-time (every 5 mins, or when the phone moves, eg., 10mtrs)
  - The measurements have been shown to have business implications, producing a profitable consulting business -- transport companies (bus, train). An interesting observation is the rapid changing of network provider depending on performance along the specific routes on which they operate.
- Next steps
  - Multi-observer studies provide aggregate view.
  - Smartphones can give simultaneous comparisons of routes from multiple sources to all popular destinations. Analysis into links can use existing solutions, but will require adding traceroute capability to the toolset.
  - New analytical methods are needed to reduce all this data and anomaly detection on this extreme scale.

Raised questions/comments:

- Big data analysis is able to detect many aspects that are less sensitive than the Iran problem above. However, there are still ethics issues in this area. Big data analysis can anyway serve as an early warning system.

4.2 Session 2: SMART Team Results and Recommendations

4.2.1 Results so far

Scott Kirkpatrick, HUJI

Scott pointed the audience to the upcoming IEEE Communications Surveys and Tutorials paper, by Bajpai and Schoenwalder (TU Bremen and Leone partners). This paper assesses the tools available today.

He also said that the Internet hierarchical structure is breaking down (becoming flatter). This requires new ways of looking into the network.

Currently, measurement mechanisms for wired networks are proprietary and dispersed:

- AKAMAI
- PerfSONAR
- CAIDA/RIPE/SamKnows
- MLab

There are wireless speedtests using apps from, eg., Ookla (for cellular and WiFi networks) and SamKnows (used in the FCC's Measuring Broadband America study, since 2014).

There seem to be no tests for IoT measurements, even though M2M needs stringent real-time constraints. However, power consumption is critical for sensors and any extra activity, such as monitoring and measurement, will consume power.

Several study members held an extended debriefing with Phil Eardley of BT and the Leone project (funded by the EC and ending in spring 2015). One important conclusion of that work was the development of a generally accepted measurement architecture framework, which is close to becoming a standard. Another success was the definition of metrics and development of corresponding tests for assessing users' QoE for streamed video and web browsing at home. Furthermore, they demonstrated the integration of new root-cause analysis techniques (based on traceroutes) into a commercial network management visualisation tool.

4.2.2 Recommendations so far

Scott Kirkpatrick, HUJI

- Interoperability, standards are required for end-to-end transparency
- Certification of measurements for regulators are needed, for SLAs to become effective
- Privacy issues (anonymising collected data)
- Observers should be everywhere
    - Automation, scheduling, archiving and analysis
    - Overcome the dense jungle of the interior of the Internet by maximizing observability across all paths that end-users care about.

4.2.3 Standardisation

Eunah Kim, Martel

Eunah explained that ISPs are measuring different QoS parameters (vendor and technology specific), which makes comparisons - or collective usage - of results impossible. There is, however, a table in the ECC report 195 which suggests which (ETSI/ITU) standardized reference

to use for each QoS parameter.

There are also ongoing efforts to standardise the process of controlling measurements and collecting the results:

- IETF LMAP and BBF (active (and passive) measurements, in principle)
- IEEE P802.16.3 Architecture Reference Model for Mobile Broadband Network Performance Measurement (for active measurements only)

While IEEE P802.16.3 targets only for mobile broadband, there is much in common between these 2 standards, eg., the concept of Measurement Agents, Controllers, Collectors, IPPM metrics.

QoS is a key factor in the roll-out of new technology, but regulators are more interested in the QoE perceived by the customer.

In the mobile area, ETSI 3G-PPP and ITU-T are working on QoS for LTE, but it is so far limited to voice services

What is needed?:

- Guidance of common understanding on performance metrics and QoS parameters (including application-specific QoS measurements)
- Definition of compatible reporting formats.
    - Certified common registries for harmonized sets of performance metrics and QoS parameters
    - Standardized reporting formats

4.2.4 Use Case – Merging Heterogeneous Network Measurement Data

Jorge Lopez, UAM

The UAM Use Case is oriented towards large organisations.

Network measurement data can come from different sources:

- Network-oriented sources:
    - SNMP MIB instances
    - Netflow records
    - Pcap files
    - …
- Application-oriented sources
    - Logs
        - Some are standardised (Apache web log)
        - Some are proprietary (application specific)
    - Important to deal with encrypted traffic
- It is necessary to provide ways to merge them

Requirements for making high-speed measurements include:

- Capture at core networks. This is difficult, since line speeds are >10Gbps, sometimes links are virtualized, and the measurement must not introduce packet drops.

The following examples of available off-the-shelf resources can help with this tough task:

- Intel +10G network cards
    - Intel DPDK

    - Other developments: HPCAP at UAM
- Mellanox +10G network cards
    - Mellanox Messaging Accelerator (VMA)
- Multicore processors
    - CPU affinity and isolation for key tasks
- Lots of RAM memory
    - Use of hugepages and mmap

Data integration alternatives:

- SQL databases
    - Pros: reliable, normalized schemas, consistent with defined constraints
    - Cons: slow, need to use materialized views to go faster, creating materialized views is costly and sometimes it can't be done concurrently, which means that it is not valid for dealing with high-speed network measurements
- Plain files, no SQL
    - Pros: much faster
    - Cons: inconsistencies, lack of normalization. The use of plain files is necessary to deal with high-speed network measurements, but keeping in mind its limitations

Log processing:

- Requirements (real scenario)
    - Process 3 million events per second (about 5 Gbps)
        - Put together application logs and network flows
    - Several disks in parallel are necessary to store the events at the appropriate rate
    - Fast access to time series and aggregated statistics (which is what operators demand)
    - Slower access to raw data (which is what IT analysts demand)
- Elasticsearch and Kibana tools provide some support, but it is necessary to tune them

Conclusions:

- There is a need for different network measurement data sources:
    - Combine network and application data
    - Necessary to find sources of problems
        - Is the slowdown caused by the network, the server or the application
        - This question can only be answered if all information from different layers is provided and analysed
- Huge amount of data, which means that it is necessary to work with fast processing systems
- Processing tools are available from the Cloud Computing community, but It is necessary to adapt them to the network measurement processes

4.2.5 Use Case – Concurrent Measurements of Home Broadband Internet

Fraida Fund (NYU), Scott Kirkpatrick, HUJI and Martin Potts, Martel

This Use Case, done last year, was not presented at the meeting, but consists of an analysis of

edge measurement data from 2013 provided by SamKnows.

It shows the sort of inferences that can be made from a small set of active measurements launched from edge equipment:

- Network metrics:
  - Downlink speed
  - Uplink speed
  - Latency and round trip time
- QoE metrics:
  - DNS resolution
  - Web page load
  - Total bytes downloaded into the home

Earlier studies have determined that conclusions can be drawn about access line technologies and national differences. Comparing homes with the same contracts also shows that the termination equipment has a big impact. It is also the case that users rarely use the full capacity of their lines.

4.2.6 Session as a whole

Raised questions/comments on the session as a whole:

- Georgios asked for advice on how to support the monitoring of all EU operators. This could be implemented as a measurement infrastructure applied on all ISPs. This should be seen as supporting all end-users, operators and regulators. An implementation of this could be financed from the Infrastructure Unit in the EC, not Research. What this really should lead to is not easy to understand. Georgios wants the proposals to be mainly directed towards fixed line networking, however, the strong market changes towards mobility could influence this viewpoint. On the other hand, other Units in the EC have a focus on mobile (eg. 5G). This workshop – as have previous ones - highlighted the isolation of measurement and monitoring within individual ISPs/Member States; people serving a single constituency, not thinking more broadly.
- The use-cases attracted little interest; the text of the upcoming calls is already decided (subject to minor changes) and Internet monitoring and measurement is not a topic. This does not prevent work being done in a follow-on "call for tender".
- The IEEE standard seems to be immature. IETF and BBF are converging on an architecture framework, but there is more that needs to be done if we want to be able to share measurement data between ISPs in a way that will make Internet monitoring effective globally. Also, consensus will become more difficult, the more details we try to standardise. The ITU-T role is unclear - will they just take what the IETF agrees?
- The Broadband Forum and the ITU are rather closed societies, which leads to little public awareness of what is happening there. Perhaps there is a shift towards industry-led ad hoc groups??

4.3 Session 3: Net neutrality and Transparency

4.3.1 Introduction

Scott Kirkpatrick, HUJI

Scott introduced the 4speakers in this session: Scott Jordan (FCC), remote presentation; Frode Soerensen (Senior Advisor at the Norwegian Post and Telecommunications Authority/ BEREC);

Marco Mellia (mPlane project coordinator). Collin Anderson, who spoke in the first session, contributed as well.

He listed the following questions about Net Neutrality and Transparency, which he hoped would be answered through the session:

Net Neutrality:

- In the US/EU, what are the objectives to be achieved by net neutrality? For which stakeholders? What is the history of efforts in this direction?
- Does regulation as a common carrier mean the same thing in EU as in US? To whom does it apply? Or more broadly, are there important differences between the operators and services the underly the Internet in the US and in the EU?
- How do you distinguish "fast lanes," "paid prioritization," "reasonable traffic management practices," and "special services"? Let's talk about concrete instances as well as distinguish the cases logically. What seems "reasonable"? Can we trust marketplace forces to lead to "reasonable business practices" that do not injure other parties from congestion? Are the classic "customer-provider" and "peering" relationships adequate to describe how today's network behaves?
- To some Europeans the degree of public interest in net neutrality in the US is surprising. But is the European concern for privacy not just as important an issue? And one requiring a different sort of "transparency?"
- What problems may arise from conflict or arbitrage between regulations in different countries?

Transparency:

- What information will operators and carriers be required to share and with whom, to achieve transparency?
- What measurements are needed to achieve transparency and to ensure net neutrality?
- Do we have the standards needed to make these measurements certifiable?
- Are the observations that M-Lab, CAIDA, RIPE have been able to obtain sufficient? Do you need different observations or just more of them from more directions?

4.3.2 The FCC's Open Internet Order

Scott Jordan, Chief Technologist, FCC, Professor of Computer Science, UC Irvine

Scott gave a definition of the Broadband Internet Access Service as being "… a mass-market retail service, that provides the capability to transmit data to - and receive data from - all, or substantially all, Internet endpoints."

He said that the scope of the FCC regulation is focused on residential customers.

His definition of "reasonable" network management was that it should be for network management, and not for any other purposes. 3 key rules:

- No blocking of lawful content (but can block unlawful content)
- No impairment of lawful (or non-harmful) traffic on the basis of content
- No paid-prioritisation (favouring of some traffic over another)

Other general conduct rules are:

- No interference with users' choice of Broadband Internet Access Service Provider, content, applications, services or devices of their choice

- No interference with an edge provider's ability to make lawful content, applications, services, devices available to customers.
- Transparency of: Commercial Terms, Performance Characteristics, Network Practices

4.3.3 A Comparison between Europe and US approaches to Net Neutrality

Frode Sorensen, Norwegian Communications Authority (Nkom) and member of BEREC

Frode started his presentation by explaining Norway's position as having the longest running Net Neutrality regime in Europe. The Netherlands and Slovenia also have Net Neutrality rules.

He then compared the European vs US approaches to Net Neutrality by stating that significant restrictions on Internet access in the European market are imposed by some strong national states in the EU. 1 in 5 wired ISPs blocks/throttles; 1 in 3 mobile ISPs blocks/throttles.

He described the fundamental elements of Net Neutrality regulation, and described each in detail:

- Application-agnosticism, ie.:
  - Equal treatment of traffic from different applications,
  - Non-blocking, non-throttling - FCC is even clearer: non-prioritisation).

  The European Council proposes to "equally treat equivalent types of traffic", which would allow traffic classes.
- Reasonable traffic management, with exceptions for:
  - Legal obligations
  - Integrity and security
  - Network congestion (complex to assess
  - Unsolicited communication etc.
- "Specialised services" (non-Internet Access Services) are exempted from Net Neutrality regulation. Therefore, they:
  - Must be isolated from Internet traffic
    - The US proposes to "use some form of network management" to isolate the capacity
  - Must not be provided at the expense of IAS
    - The wording in Europe is "not impaired in a material manner", which actually *allows* the degradation of the quality of the IAS!
  - Specialised services use built-in QoS mechanisms, and they do not need protection against IAS!
    - It is the other way round; IAS needs protection against specialised services!
- Zero-rating and price discrimination
  - Simple data caps can be application-agnostic.
  - Exempting particular applications from the cap, so-called **zero-rating**, is not application-agnostic.
  - In the legislative initiatives this is not resolved yet.
  - US indications are given about a case-by-case basis.
  - In Europe there are a few national initiatives:
    - In the Netherlands and Slovenia, regulatory action is based on the national laws.
    - In Norway, it would be a breach of the national guidelines

Raised questions/comments:

Obama's comments were key to raising the issue of Network Neutrality in the US.

There were 4 million individual responses to the FCC's Net Neutrality document, generally in favour (many comments along the lines of wanting a "level playing field" and *I* want to be in control of what I get from the Internet … not the ISP). The 4 million answers to FCC and the 100'000 to the Indian regulator shows that there is a public interest in Net Neutrality issues. The European side in this is less clear.

Christophe Diot, Technicolor CTO and former Head of Technicolor's Paris Lab suggested that Net Neutrality implies higher costs for the end user, since the ISPs would have to upgrade the whole network, just to be able to guarantee the necessary throughput to those customers wanting to view high quality video services at peak time.

A TID employee agreed, saying that "paid-prioritisation" is a way for ISPs to generate more money and use their networks more efficiently, and Net Neutrality will stifle investment by telcos because they already charge too little in Europe. Christophe compared the prices for Triple Play in the US vs Europe ($90 vs €30).

Frode argued that technology advances have so far ensured that customers have continuously got increased performance for the same price and that, because it is content that drives the Internet market, access to video content without having to pay an extra charge would bring more customers to the ISPs. However, it is clear that Europe will have a more complex position initially than the US.

Chris remarked that, whist mobile networks might sometimes be congested, the wired network is not. However, there are no reliable figures on traffic growth – the latest one that he is aware of is from Scott Marcus, WIK Consult (Cisco VNI data).

"Specialised services" are more tightly defined in the US than in Europe. Specialised services must be given more attention since "Best Effort" is not enough and research into QoS over the last 20 years has not led to anything really useful. Introducing specialized services will pose problems, since who should decide what degradation a specialized service is allowed to create. Especially since dimensioning of the network is not a fixed matter. This will become a serious problem in mobile environments since the radio spectrum will be used and even with pico cells and mixed networks.

Experiments are needed on running specialised services in parallel to Best Effort services. Which would grow the most? Where would innovation bring the most improvements?

Frode asked if regulated local loop unbundling is sufficient to ensure Net Neutrality.

It is evident that the most successful content and application providers are US based.

Both ends of a connection (and the networks in between) need to also operate according to open Internet rules, if users are going to get an "open Internet experience".

Does the publication of Net Neutrality violation figures encourage adherence to the rules, or reduce the level of "self-reporting"? There was a sense that the measurement community shows things that force regulators to do their jobs.

Why do US citizens show such enthusiasm in protecting Net Neutrality?

Chris Marsden said that regulators need to know that this SMART Measurement Study group exists, as we can help them.

Should GÉANT be involved?

M-Lab wants to get more involved in Europe.

The Google moving of a large content delivery site from Milan to Frankfurt (?) resulted in poor video performance, which consumers (and their ISPs) had no control over. The ISP gets blamed for the drop in QoE, but the problem lies elsewhere. Correlated *observations from everywhere* are needed to pinpoint such occurrences.

Congestion recognition in the Internet is not good enough to manage performance since it sometimes leads to the fact that all users will have bad performance (voice in old fashioned telephony normally allowed that small number of users would have their call setups delayed). ie. Fairness is not enough to ensure happy customers.

Blocking and throttling and regulation has still things to investigate.

IMS as a tool for specialized services in mobile, might create a Net Neutrality problem. The 1st example is Voice over LTE.

4.3.4 Internet Interdomain Congestion

Collin Anderson (M-Lab),

Background jnformation was presented on 4 points regarding congestion factors:

- Modern peering disputes manifest as congested links
- Disputes among access, content and transit providers
- Some content is carried over inadequate links between access and transit networks
- Congestion on transit links affects everybody, not just parties to the peering dispute

There was evidence of censorship by repressive regimes (Turkey and Pakistan) - by measuring access times and download bandwidths from two access ISPs to two Content Providers, it could be seen which links were causing problems, while proving that the service itself was working OK. This is another example of a good use of multiple observers to see deeper into the Internet

A series of slides from CAIDA/MIT consortium was presented **on behalf of KC Claffy (CAIDA) and D. Clark (MIT)**

1st slide: Method used to measure the congestion: Time Series Ping.

2nd slide: RTT Measurements of Border Routers which showed records for different days of the week in November 2013 in New York. It can be seen that there is more congestion on the weekends than on weekdays. Monday 11th was Veterans Day.

3rd slide: Shows RTT Measurements of Border Routers vs the loss rate to the far Border Router.

4th slide: Challenge: Reverse Path. It is difficult to know that the response from the far router returns over the targeted link. Methods that support inference are: Reverse path traceroute, IP record route, IP timestamp option, and tomography.

5th slide: Congestion Trends which shows 3 transit links of Comcast in Bay Area over time. Time period began Feb 2013 and was in 2 month intervals ending in April 2014.

6th slide: Congestion Trends. Two Interpretations are shown:

- Ability of content providers to shift traffic “firehose” (from Level3 to TAT in June 2013).
- Demonstrates year-long, worsening, congestion patterns (until the Netflix/Comcast peering agreement).

It was concluded that, even after a year of congestion this ended instantly when the Netflix/ Comcast business agreement was reached.

4.3.5 mPlane

Marco Mellia (mPlane coordinator, Politechnico di Torino)

Marco introduced himself as a measurement expert, but not a Net Neutrality expert. He began his presentation with a measurement case of observing YouTube traffic. A problem occurred and they measured Internet traffic to find the source. After observing the traffic, they found that the problem occurred because Google changed its cache-selection policy on the same day when the anomaly started occurring. He claimed that in this case, ISPs were not responsible for the problem, and on the contrary they were victims and were blamed unfairly by their customers for the poor performance. He presented that the network has never been neutral: Ethernet is not neutral, WiFi is not neutral, TCP is not neutral, BGP is not neutral, ADSL is not neutral, etc. Thus, the argument is that "**the network has been designed to be NOT neutral**". His argument was that academia and industry researchers have studied the introduction of different QoS services over the Internet for more than 20 years.

He brought a different case that YouTube drops support for the 2nd Generation Apple TV, iOS 6 devices and lower. He questioned if applications are supposed to be neutral as well. Another example was an Italian leading newspaper, whose web page is free if you access from a PC, but not if you enter from a smartphone web browser, where you have to pay for the same service.

His final statement was that transparency and its exposure to privacy concerns was a big potential problem. He presented that:

- 233 out of the top 500 hostnames contacted by users are tracking service
- 196 of the 233 are contacted also using HTTPS (for protecting their business?)
- The 1st tracker is contacted within 1second for 78% of users
- 71% of services embed at least one tracker

Overall, his presentation showed a different point of view on the discussion of Net Neutrality - he approached this issue as an academic expert on measurement, and focused more on "what problems impact on Internet performance". Thus, he seemed to believe that the blame shouldn't always be placed on the local ISPs, but also on the big service/content providers.

5. CONCLUSIONS – WHAT WE LEARNED

This 3rd workshop was organized in 3 parts:

5.1 Future Opportunities

Section 1 "Future Opportunities" surveyed some of the latest developments in Internet measurement work around the world. The new FIRE project MONROE "Measuring Mobile Broadband (MBB) Networks in Europe", will extend a stable, proven mobile access monitoring system to four European countries, basing a few 100 probes in each country in fixed locations and on trucks and busses. They have the cooperation of several mobile telcos in this effort, and expect to make a significant fraction of their capabilities available to external researchers through the Open Call and Open Access mechanisms. M-Lab has established a presence for their servers on all three regions of the globe, hosting measurement tools and archiving data for public use in a "public CDN" which currently is in 20 or more physical locations. RIPE's public Internet data, based on thousands of active Atlas hardware probes, merged with comparable coverage from CAIDA (at UCSD in the US) gives near real-time coverage of much of the more heavily used portions of the Internet, and permits user programmability of specific measurements on specific probe devices.

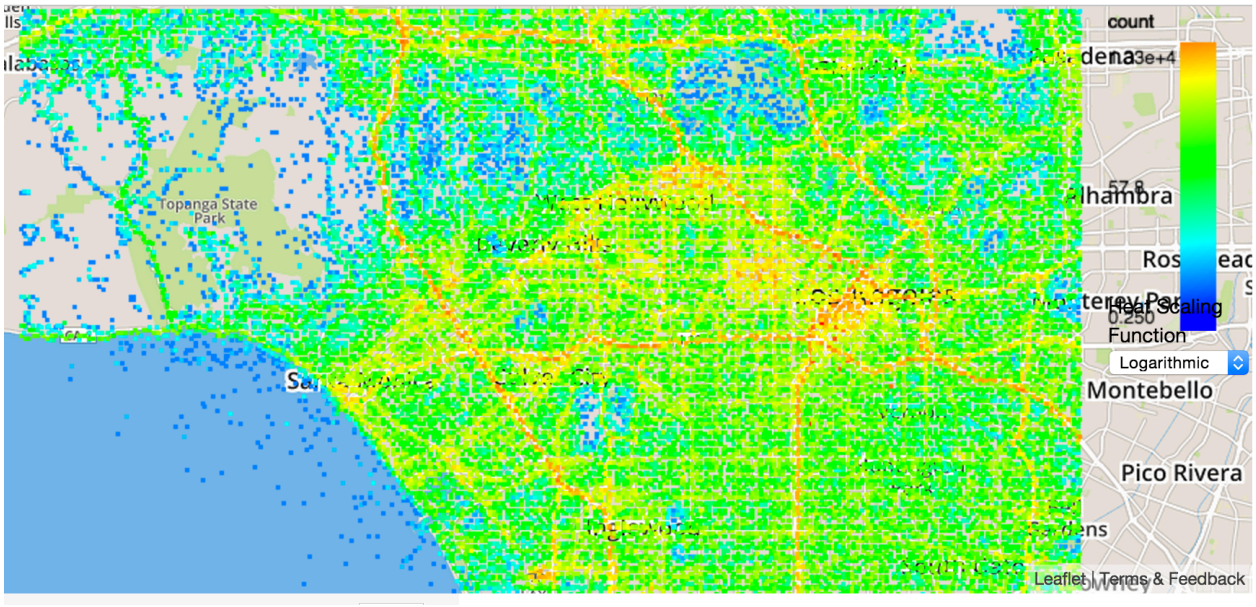

Figure 1: Smartphones showing maps using cellular Internet, LA Nov 2014

In summarizing the session, we highlighted smartphones as ubiquitous resources that should be exploited in the increasingly mobile environment in which we now operate, and which may dominate the Internet's "edge" in years soon to come. This area has been relatively neglected until now, except for user-initiated "speed tests" and operators monitoring their own networks (often through apps of which the user is unaware). We cited a startup, WeFi, which has obtained this type of information with extensions for Internet performance observation in over a million software downloads. The sort of coverage that this permits is shown in Figure 1. But none of these existing capabilities are ready to deal with measuring the performance of IoT.

5.2 Current status of the study

Section 2 reported on the current status of the study. Scott mentioned an informative IEEE tutorial which surveys measurement tools, from Jacobs University (Leone partners). He also identified the need to be able to correlate observed events from many different sources, if "we"

(researchers, ISPs and regulators) want to have the "big picture" (telescopic) status of the Internet at all times. Eunah followed up on this topic by describing the work in IETF and BBF to standardize an interoperable measurement framework in which measurements are controlled and the results collected. However, it was remarked that there are still inconsistencies in the metrics used and the frequencies of the tests performed, making it impossible to make comparisons between - and correlations of - results from different ISPs. But we judged progress in creating standard frameworks for network measurement as quite promising (e.g. the fairly similar approaches taken by mPlane and Leone). And some of the tests for QoE developed by Leone are good candidates for certifiable use in assessing broadband access providers' quality of service. Similarly, we hope that the mobile access measurements provided by MONROE will become ad hoc standards for this class of end user.

Jorge presented a Use Case for making the data obtained in a large organization managing high capacity networks with equipment from multiple vendors interoperable and useable, by aggregating performance information from a range of high speed routing equipment in multiple locations and presenting it in a comprehensible dashboard format.

Two further Use Cases showed some of the value to be obtained from near-simultaneous use of multiple observers to look at simple performance metrics characterizing access to popular web services. This requires a large number of points of observation and "simultaneous" is sometimes replaced by combining measurements made at the same time but on different days or at the same hour but in different weeks., as these variations are highly predictable. The SamKnows measurement platform deployed in both the US and Europe/UK provides such information, as does the WeFi smartphone deployment in the US, and to a smaller extent in Europe. A final Use Case explored the use of novel machine learning technology to extract observed source-dependent routing policies from the routing information broadcast by BGP access routers. As this will still be a research topic for the next few years, we have not included that discussion in this report.

5.3 Net Neutrality, Transparency and Privacy

Section 3 focused on the exciting and currently relevant issues of fairness in the operation of the Internet as now addressed by regulators in both the US and in Europe, exploring the concepts and implementations of Net Neutrality and Transparency, and perhaps the eventual costs in terms of Privacy.

The Internet is affected by the services provided and the operators who transport its bits, all of whom need to make profits to survive, and affects the end users and advertisers, who provide the revenue from which these profits are extracted. So these questions are not purely technical. We brought together for this session the two senior technical people at the FCC (in the US) and BEREC (the Board of European Regulators for Electronic Communications) to compare notes on a wide range of issues from definitions to actual or expected practices. Net Neutrality regulations have existed for some years in three European countries, and are expected to continue to spread. The FCC has stated some simple precepts: no blocking, throttling or "paid prioritization," and issued some guidelines about the transparency expected. Implementation will begin soon, but the threat of litigation is still present. As with any area of administrative law, some of its meaning will only be clarified by case by case decisions. It is apparent that the European regulators are more open to the idea of "special services," such as "fast lanes" as a way for carriers to increase their revenue, as long as these lanes are kept entirely separate from the basic Internet access provided to end-users. How this separation is to be achieved, or even if it is possible, is not clear. Both Scott Jordan and Frode Sorensen felt that understanding what constitutes "reasonable network management" would be critical to establishing such a separation. The critical factor is that such management should not depend upon the identity of the user or the type of traffic involved. In Europe, managing traffic by identifying the type of

flow is indeed practiced in a significant fraction of both wired and mobile ISPs. Price guidelines which depend on the application used (such as "zero-rating" in which certain applications are exempted from a bandwidth cap) are also under discussion in some European countries.

It appears to be a bit of a mystery to the Europeans, both regulators and operators (some of whom participated in our discussion) why the Americans are so exercised about Net Neutrality. Yet our earlier workshop 2 provided an example, in Switzerland, in which public awareness of broadband access performance statistics by ISP published in the newspapers had caused the weaker ISPs to improve their performance year-to-year, so the European consumer may be ready for this information and prepared to act on it.

The next three talks in the session pointed out measurement activities which have pinpointed business disputes or network management activities in which both the direct effects and the side effects had negative impact on consumers. M-Lab and the CAIDA/MIT collaboration, using two different methods were able to observe significant extra delays and packet losses that resulted from the throttling of NetFlix content delivery by access ISPs. mPlane described the severe performance degradation seen from Italy when Google changed its recommended cache selections for popular YouTube content to a different country in Europe. All three groups have been able to show that in skilled hands, measurement can expose the causes of problems that end users will be seriously affected by.

6. RECOMMENDATIONS – WHAT WE PROPOSE

Traditionally, measurement and monitoring technology has developed to meet the needs of telecommunications operators, often with the research laboratories of those operators playing a leading role. But now tools to get a general, albeit sometimes crude idea of Internet performance are in the hands of every end user. The EC has espoused the Digital Domain as a focus area in which to assure full European involvement and benefits. And regulators are now ready to act on behalf of the end users as well as European business interests, if given the tools with which to do this.

The biggest current opportunity that the EC faces is to meet the needs of end users and European Internet services more effectively through a focus on the transparency part of these new demands, putting critical information into the hands of regulators and customers. This is not the traditional area of improving network management at its high performance center, and extending the reach of management information over greater distances (as PerfSonar is doing within the reach of GEANT) to permit root cause determination when things go wrong, although there are many useful things to be done in that areas as well.

The resources and skills to meet this exist or can be extended from current EC projects, such as Leone (and SamKnows), RIPE's Atlas, MONROE, OneLab, and from startups with mobile Internet presence such as WeFi. M-Lab's presence as a "public non-profit CDN" provides a key component for knitting such data together into a visible archive. The CNECT-ICT community has people who can express the lessons to be learned from such an archive and in real time in ways that the public can understand. And there is evidence that exposure of the structures and consequences of network management deep inside the Internet can be the basis for successful actions on the part of the regulators.

Although CNECT-ICT people have the skills to make this happen, it is not a traditional research project. Such a project as Leone, to take only one example, can effectively transfer information to the next stage through prototypes, conference and transaction papers, and personal interactions with large companies. But this does not leave in place a continuing operation that will monitor on behalf of the larger European community, as RIPE does for the community of European carriers. And obtaining continuing research funding for an activity that is justified by its impact in areas beyond research is difficult. Still, a permanent public measurement and monitoring infrastructure for Europe is needed (and US participation should be invited). The uncertainty associated with the current attention to defining and enforcing network neutrality, and developing stronger guidelines for transparency makes this a perfect opportunity for the EC to step up to this responsibility. The tools and teams that can make it happen exist. An Internet that is actively monitored to ensure fairness and steadily increasing performance is within reach.

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