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Deliverable D2: First Experts' Workshop Report

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List of participant organisations:

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1. FIRST EXPERT WORKSHOP OVERVIEW

The internet is an important critical infrastructure, but efforts to monitor this complex system have been diverse and uncoordinated. This study will analyse existing internet monitoring tools and methodologies and provide 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.

We are gathering information for the study through two workshops as well as a questionnaire. We will present our results at a third workshop. This deliverable captures the results and the information gathered at our first expert workshop, held on October 3 and 4, 2013 in Brussels.

After listing the attendees and describing the agenda of the workshop, we provide in this deliverable a summary of the input obtained from our two days of discussion. Material presented at the meeting is attached at the end of this document. The full schedule for the two years covered in this contract is also provided below, with the actual months indicated for each event and the lead partner identified for each of the key steps.

In this first workshop we obtained feedback on our survey questions, showing a first version of the questionnaire, aimed at research and testing infrastructure owners and operators. We also obtained offers to help in targeting the appropriate recipients for these questions, and are now starting to incorporate these suggestions and contacts into our process.

The first day of the workshop provided input on the requirements of several key stakeholders, as well as considerable information about existing and past efforts to complete a comprehensive survey of measurement and monitoring capabilities. The second day of the workshop focused on Task 2, responsible for the gap analysis. This requires 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) are likely key questions. On the finer scale, characterizing flows in terms of user intentions and needs was discussed. We plan to present a vision incorporating both types of observation into an Internet Observatory. Finally, this part of the study can shed

some light on how the FIRE efforts on federation might work to integrate measurement systems in both the research experimentation and commercial domains.

In reviewing potentially useful outcomes of the study during our initiation meeting, we identified three of particular value. First, identifying new sources of information beyond the classic active and passive measurement tools. Second, finding or creating new opportunities for data sharing to make it possible to manage Internet performance on a wider scale, while managing privacy concerns and exposures. Finally, as we survey the tools and analytical techniques in current use, we anticipate identifying opportunities to employ modern "big data" centered machine learning tools on internet traffic data, to see activities previously hidden in the noise, or to identify causes and development paths for complex behaviours. Each of these topics arose in the course of our first experts' workshop.

We now proceed to capture and summarize the wide-ranging discussion that we enjoyed in the first experts' workshop. Section 2 details the process followed. In 2.1 we provide the instructions sent to each participant and the agenda we followed (at least approximately). In section 2.2 we list the experts who participated and others consulted who gave us valuable advice. This was an unusual group. We brought together measurement experts and regulators. We heard about the capabilities of researchers, of a major content distributor and GEANT, the European academic backbone provider. We heard the practices of two major European telecoms. Finally, we included three experts from the European regulation and policy community, who told us of their novel and as yet unmet requirements.

Section 3 outlines the meat of the meeting. We adopt an outline-like style for this preliminary report, basing the report on detailed notes which the SMART measurement team drafted at the conclusion of the meeting, while our impressions were freshest. Several of the participants brought detailed presentations of their tools or of their practices, in addition to the discussion points that were requested in their invitations. We append a selection of this material as an Appendix, section 4.

2. WORKSHOP ARRANGEMENTS

2.1 Agenda

The following Agenda was distributed before the meeting:

SMART Internet Monitoring Study

Expert Council Workshop 1

Brussels, 3-4 October 2013

Website: http://internet-monitoring-study.eu/index.php/workshops/workshop-1

Venue: Meeting Room 0/54, Offices of the European Commission,

Avenue de Beaulieu 33 (BU33), 1160 Brussels, Belgium

This meeting consisted of:

- one day of discussions - two panels, in which selected participants were asked to comment on key topics, but contributions from all were encouraged and expected, and
- a second day of work to develop position papers to help shape our study and its demonstration projects.

Thursday, 3 October

09:00: Coffee and introductions

09:45: Kickoff: EC study charter and workshop objectives

- Georgios Tselentis, European Commission
- Scott Kirkpatrick, HUJI

10:00: Panel 1: Measurement capabilities and data sharing

What is the state of the art? What is missing? Which other questions should we be asking? Which past surveys should we be aware of? Who else should we be speaking with?

Moderator: Scott Kirkpatrick, HUJI

Discussants:

- Bala Krishnamurthy, AT&T Research
- Alessandra Scicchitano, SWITCH
- Bruce Maggs, Akamai
- Peter Grošelj, Telekom Slovenije
- Daniel Karrenberg, RIPE

- Meredith Whittaker, Google and Measurement Lab

13:00 – 14:00: Lunch

14:00 - 17:30: Panel: Uses and users of this information

Who requires network measurement data? In what ways do they use it? What additional data would they use if they could have it? In what ways is the landscape changing (new technologies, new regulatory initiatives, etc.)? Who else should we be speaking with?

Moderator: Timur Friedman, UPMC

Discussants:

- Ahmed Aldabbagh, Ofcom
- Maxime Forest, ARCEP
- Fabrice Guillemin, Orange
- Nikolaos Laoutaris, Telefónica I+D
- Žiga Turk, Univ. Ljubljana
- Guillaume Valadon, ANSSI

Friday, 4 October

09:00 – 13:00: Working meeting: Developing position papers to use in study's gap analysis

Facilitator: Jerker Wilander, consultant

Topics::

- Data coverage and sharing - the vision
- Regulation - the issues and data requirements

13:00 – 14:00: Lunch

14:00 – 15:00: Working meeting, continued

The discussions and inputs generated were valuable up to the end of the second day, so we simply recorded the many views and examples of measurement technologies and their impacts presented. This report is our first attempt to present all that material in a coherent fashion.

2.2 Expert workshop attendees

For our initial workshop, we selected attendees from the traffic measurement community and added new names to the list from the policy and regulation communities, in order to address users of internet measurements as well as the generation of this information. Attendees were:

- Daniel Karrenberg RIPE Chief Scientist
- Balachander Krishnamurthy,Senior Researcher, AT&T Labs

- Bruce Maggs, Professor, Duke University and VP for Research, Akamai
- Ahmed Aldabbagh, Senior Advisor (IP Networks and Digital Media) Ofcom
- Fabrice Guillemin, Orange
- Alessandra Scicchitano, SWITCH
- Meredith Whittaker, Google, head of Measurement Lab
- Ziga Turk, Professor at the University of Ljubljana (former Minister in the Slovenian Government)
- Peter Groselj, Head of Unit, Telekom Slovenje
- Guillaume Valadon, ANSSI (Agence Nationale de la Securite des systemes d'information.)
- Nikolaris Laoutaris, researcher leading the network economics group at Telefonica I&D
- Maxime Forest, ARCEP
- Jerker Wilander, consultant and FIRE participant

All the organizers of the study participated, as did Georgios Tselentis of the CONNECT Directorate and Marc Hohenadel of the JRC-ISPRA.

Invited for this meeting, unable to attend, but interested in further involvement were:

- Rudolf van den Berg, OECD
- k claffy, CAIDA, at UC San Diego
- Maurice Dean, Open Connect Product Manager, Netflix
- Vasso Gogou, Senior Telecoms Expert at EETT
- Sam Crawford, founder of SamKnows

Because of our intention to direct this workshop into identifying uses and users of internet measurements, we did not invite many of our initial list potential experts, most of whom had academic or telecoms backgrounds. As a result the workshop was quite successful in turning up unexpected requirements and in clarifying what can have an impact on public policy and government regulation of communications on the Internet. We did conclude at the close of the two days, however, that wireless data and mobile telecom was not well represented in our discussions. We will remedy this in the next workshop, or by private communications and interviews in the meantime.

3. WORKSHOP HIGHLIGHTS AND INPUTS

3.1 Scope of the study and major themes

Our objectives in this study and in the workshop were expressed in the questions distributed to the attendees before the meeting. We asked each participant to prepare a very brief statement of their most important accomplishments or concerns, but most had a lot more to see, both initially and in the discussions that developed. We have organized the points covered into several topics and outline their main points in this section. We will be digesting these points and developing a baseline of today's competences to use in the gap analysis that will be central to our next meeting, to be held in May 2014. The importance of network monitoring, failure resolution and measurement is increasing because the Internet is a network of networks maintained by different entities using competing technologies and with varying objectives and business cases

3.1.1 The Internet market and technology evolution

The Internet technologies in current use are being replaced or upgraded very rapidly. Dominating technologies of 5 years ago such as DSL and dial-up are being outnumbered by mobile internet. Fiber to the home is growing fast.. The total number of Internet users in summer 2013 is approximately 2.7 billion. Out of the total number there are approximately 1.8 billion mobile Internet users - in 2018 this figure is expected to be close to 7 billion (source Ulf Ewaldsson CTO Ericsson).

3.1.2 An example from Sweden

In Sweden (population 9.5 million) the number of DSL subscriptions has decreased by 25% since 2008 (peak year) and dial up Internet has almost disappeared. Fiber connections to the home are now increasing (currently 750 000 fiber subscriptions with speed at 100 Mbit - up by ~40% since year before). Since 2008 the number of Mobile Internet Subscriptions has increased from approximately 0.6M to 6M. The number of mobile speech only subscriptions has decreased by ~25% between 2008 and 2012 (source PTS – Swedish Post and Telecom Authority - http://www.pts.se/sv/Nyheter/Pressmeddelanden/2013/Kraftig-okning-av-snabbt-bredband/ - in Swedish). Another demonstration on the change towards mobile Internet is the 3rd quarter report (2013) from Facebook where the advertising revenue from mobile usage is now approaching 50% up from the 2nd quarter figure of 41%. In the emerging area of Internet of things the expected number of connected devices is expected to reach 50 billion within a decade (http://www.ericsson.com/res/docs/whitepapers/wp-50-billions.pdf). This will most surely change many aspects of Internet performance during the next few years

This market revolution will put new demands not only on network performance but also on measurement technologies in order to understand and monitor the Internet. The expected change in user behaviour and technology availability will in many unpredictable ways further emphasize the need of better understanding of network properties. The roles of different technologies are not fully understood and especially the relation between Internet usage from mobile systems as 3G, 4G and WiFi hotspots have not been investigated to date in our study. We shall attempt to remedy this in our second workshop.

3.2 Monitoring capabilities (today, emerging, and missing)

To illustrate the problems for network owners, who have to act and correct problems, we summarize first a few cases that were discussed during the first workshop:

3.2.1 The Orange case (from Fabrice Guillemin, Orange)

Big Over the Top (OTT) players delivering huge amounts of data (notably video files such as are found on YouTube, at Google) have either direct peering with eyeballs (or with affiliated international backbone networks) or deliver content to eyeballs via Internet transit providers. Depending on the resource provisioning policy applied by Internet transit providers, the quality of experience for end users when data are transmitted through a transit network may be much worse (in particular when links between the transit provider and ISP are saturated) than when data are delivered via direct peering. For optimizing the utilization of their resources (peering bandwidth, storage capacities in their data centers, data replication, etc.), OTT players can switch data delivery from direct peering (on-net traffic – with Orange's international backbone network) to transit (off-net traffic – via a transit network different from Orange), causing an alteration of the quality of experience for end users. This phenomenon has been observed for Google traffic in the Orange network in Spain in February 2013. Traffic is either delivered via direct peering with the Orange's International backbone network (OTI) or via several transit networks (saturated on peak hours). Every day during peak hours (from noon to midnight) Google traffic was delivered OFF-NET instead of ON-NET to OTI, causing a degradation of the quality for end users during this period. The change to OFF-NET is evidently leading to saturation of the Orange network to the disadvantage of end users but might reduce the networking cost for the OTT player. For more on the range of measurement capabilities employed at Orange and the concerns that they manage, see section 4.4 .

3.2.2 eduPERT and NREN's experience (Alessandra Scicchitano SWITCH).

Troubleshooting performance issues between 2 endpoints crossing multiple domains is not an easy thing especially when one of the endpoints is located in a campus i.e. outside of the control of the NREN (iSWITCH).

Campuses are a black-box for eduPERT (Performance Enhancment Response Teams in GEANT). Unless provided, the topology of the network is unknown to eduPERT. Inside the campus Tools like traceroute help in discovering the topology at layer 3 but they don't provide any information about layer 2 or about the presence of middle-boxes like a firewall. The lack of this information very often is source of struggle for the PERT engineers that have to find and fix problems on the path.

Vendors provide layer 2 measurement tools but unfortunately they are not compatible with each other. This means that if in a network there are switches from different vendors, these tools are not usable.

3.3 Measurement infrastructures

There is a wide variety of large distributed measurement infrastructures, which were reported during the workshop, namely:

- RIPE Atlas
  - https://atlas.ripe.net/
- Ookla
  - http://www.ookla.com/
- Measurement Lab
  - http://www.measurementlab.net/
  - the twelve tools available
- perfSONAR
  - http://www.perfsonar.net/
- PlanetLab
  - http://www.planet-lab.org/ (also reported as paper in Brent Chun, David Culler, Timothy Roscoe, Andy Bavier, Larry Peterson, Mike Wawrzoniak and Mic Bowman, *PlanetLab: an overlay testbed for broad-coverage services*, Proc. SIGCOMM CCR, Volume 33 Issue 3 (July 2003))
- Ono plug-in
  - http://aqualab.cs.northwestern.edu/projects/118-ono-reducing-p2p-cross-isp-traffic-while-improving-users-performance (also reported as paper in Mario A. Sánchez, John S. Otto, Zachary S. Bischof, David R. Choffnes, Fabián E. Bustamante, Balachander Krishnamurthy and Walter Willinger. *Dasu: Pushing Experiments to the Internet's Edge*, In Proc. of the USENIX Symposium on Networked Systems Design and Implementation (NSDI), April 2013).
- SamKnows
  - http://www.samknows.com/broadband/index.php
- iPlane
  - http://iplane.cs.washington.edu/ (also reported as paper in *iPlane: An Information Plane for Distributed Services*. Harsha V. Madhyastha, Tomas Isdal, Michael Piatek, Colin Dixon, Thomas Anderson, Arvind Krishnamurthy and Arun Venkataramani. *OSDI 2006*, November 2006.)
- RIPE BGP feed
  - http://www.ripe.net/data-tools/stats/ris/routing-information-service
- RouteViews BGP feed
  - http://www.routeviews.org/
- CAIDA's Ark (Archipelago)
  - http://www.caida.org/projects/ark/
- SONoMA
  - http://sonoma.etomic.org/
- ETOMIC
  - http://www.etomic.org
- DIMES
  - http://www.netdimes.org/new/ (also reported as paper in Yuval Shavitt and Eran Shir, *DIMES: Let the Internet Measure Itself*. ACM SIGCOMM Computer Communication Review, 35(5):71--74, October 2005)
- mPlane (future infrastructure)
  - http://www.ict-mplane.eu/

- BISmark
  - http://projectbismark.net/

On the other hand, there are individual measurement tools such as Lumeta (http://www.lumeta.com/) and commercial products/services for measuring a large corporate network

Additional, unique proprietary tools for IP networks were described in the Orange presentation contained in section 4.4.

Finally, there are Open datasets beyond those of the infrastructures listed above such as Crawdad. Pointers to lists of measurement infrastructures and measurement tools can be found in CAIDA's taxonomy (http://www.caida.org/tools/taxonomy/).

Assessment questions

In the light of the above, the following assessment questions were proposed by the workshop attendees:

- What is the global reach?
- What type of tools/measurements are supported?
  - Metrics/data collected
  - Type of measurement (e.g. active, passive)
- Are the measurement methodologies open source (can the public review and verify)
- Is the data open (to the public)? Who has access to the data? Who has access to which parts?
- Where can data be accessed, if it can? (How is data storage funded?)
- How is the platform deployed and managed? Are there documented standards? Which parts, if any, are closed and proprietary?
- In publishing aggregate data, are the analytic methodologies open? Are the methods by which certain results are achieved evident and reproducible using the available data?
- What is the provenance of a given tool, dataset, etc.?
- What is the deployment method (e.g. are end users opting to test? are researchers implementing passive monitoring? etc.)
- Are the infrastructures federated, cooperative, or proprietary? And, if cooperative, what is the incentive structure?
- What is the syntax/semantics of the data?

How verifiable is the data?

- What is the process for verification?
- What are best practices for making data verifiable?

The questionnaire has been modified accordingly and will be distributed to measurement infrastructure responsible persons soon.

3.4 Standardization activities

The importance of the open standards is beyond debate. This section presents ongoing standardization activities on traffic measurement.

3.4.1 SDOs

3.4.1.1 IETF

IETF has been standardizing internet measurement issues. Currently, two active Working Groups are working on the issue.

Large-Scale Measurement of Broadband Performance Working Group (LMAP WG) standardizes the LMAP measurement system for performance measurements of broadband access devices such as home and enterprise edge routers, personal computers, mobile devices, set top box, whether wired or wireless. Currently, there are two WG documents on discussion:

- draft-ietf-lmap-framework-01.txt, A framework for large-scale measurement platforms (LMAP)
- draft-ietf-lmap-use-cases-00.txt, Large-scale Broadband Measurement Use Cases

IP Performance Metrics Working Group (IPPM WG) standardizes metrics that can be applied to the quality, performance, and reliability of Internet data delivery services and applications running over transport layer protocols (e.g. TCP, UDP) over IP. 16 RFCs are published as proposed standards related to measurement protocol, metrics, etc.. 12 RFCs as informational, and 2 RFC as best current practice, and 1 RFC as experimental are also published. Currently, six WG documents are on discussion:

- draft-ietf-ippm-2330-update-01.txt, Advanced stream and sampling framework for IPPM
- draft-ietf-ippm-ipsec-01.txt, Network performance measurement for IPSec
- draft-ietf-ippm-lmap-path-01.txt, A reference path and measurement points for LMAP
- draft-ietf-ippm-model-based-metrics-01.txt, Model based bulk performance metrics
- draft-ietf-ippm-rate-problem-04.txt, Rate measurement test protocol problem statement
- draft-ietf-ippm-testplan-rfc2680-04.txt, Test plan and results for advancing RFC2680 on the standards track.

3.4.1.2 IEEE

IEEE 802.16 Working Group on Broadband Wireless Access (http://www.ieee82.org/16) launched a new project P802.16.3 on Mobile Broadband Network Performance Measurement in August 2012. The standard will specify metrics, test procedures, communication protocols and data formats for characterizing the performance of mobile broadband networks. There is an internal working document IEEE 802.16-12-0483, “Applications and Requirements for Mobile Broadband Network Performance Measurements.”

3.4.1.3 ITU-T

Internet traffic measurement, measurement and control of QoS/QoE were studied and standardized in many of ITU-T Study groups, including SG2, SG3, SG9, SG11 and SG13.

In the area of future network, SG 13 (Future networks including cloud computing, mobile and next generation networks) published ITU-T Recommendation Y.2770, "Requirements for Deep Packet Inspection in Next Generation Networks" in Nov. 2012. In addition, Q.6/13 where requirements and mechanisms for network QoS enablement (including support for software-defined networking) are standardizing has published Y.3042, Smart Traffic Control and Resource Management Functions for Smart Ubiquitous Network, in Feb. 2013.

3.4.1.4 ETSI

ETSI MOI ISG (Measurement Ontology for IP traffic) has started its work on "Specification of general concepts and data measurement ontologies (DGS/MOI-004)" in July 2013.

3.4.2 Forums and Consortia

3.4.2.1 IRTF

Network Management Research Group (NMRG) (http://irtf.org/nmrg) is a forum for researchers to explore new technologies of internet measurement. The group discusses solutions on new problems that are not well understood enough for IETF.

3.4.2.2 Broadband Forum (BBF)

Broadband Forum develops multi-service broadband packet networking specifications addressing interoperability, architecture and management. A project, WT-304: Broadband Access Service Attributes and Performance Metrics was approved in March 2012 and create a set of standard performance metrics that describe salient attributes of broadband access services.

3.5 Types of data and metrics

Non-traditional sources of active measurements:
Deployment techniques:

- "drive by" studies on the street (Ofcom)
- Crowdsourcing (data from people who download some app, etc.)
    - Car-based, e.g. Waze, for traffic, maps, anomaly or emergency response
- Fixed dongles, testing periodically e.g. Sam Knows

Consumers of data supplied as a new business opportunity (current)

- Data: Telefonica -- location, mobility data taken from subscribers, offered for $$ http://dynamicinsights.telefonica.com/488/smart-steps
  Customers:
    - Retail stores (optimize offering based upon who enters mall)

- Public administration (where do we put a bridge given traffic patterns reported in location data? etc.)

New types of data/metrics (current)

- Traffic patterns, tracking subscriber location and movement
- Usage data (litmus for deciding network upgrades. Switch monitors in the network, 1. "Weathermap" -- dashboard showing state of every link. 2. NfSen -- shows type of traffic, and relative patterns while preserving security and privacy)

Types of data/metrics (aspirational - what can be done in a five year framework)

- Causality data -- e.g. "why doesn't my phone work in my kitchen?"
- Per application measurement -- how to tell whether there's throttling, whether certain protocols aren't working because X, etc.? ("root cause analysis")
- Blocking/throttling detection -- if Skype is being blocked, how to tell?
- Per platform (e.g. device) measurement (or, integrating platform impact into overall picture)
- Collaborative measurements between content providers and operators

It was concluded that there is a need for a global view of measurement information to understand cause and effect, and that it is necessary to correlate data from both mobile and fixed networks to achieve this.

Layer two measurements are needed to bridge this gap, BUT, as just one example, Cisco EOAM measurements are not compatible with Juniper or Brocade measurements.

3.6 Consumers of network measurements

3.6.1 Regulators

3.6.1.1 Looking at the wholesale (business) market

see Business Connectivity Market Review

3.6.1.2 Trying to understand whether there is sufficient competition in the consumer market

3.6.1.3 Trying to understand whether customers are receiving what they have paid for

3.6.1.4 Looking at net neutrality issues

- Degradation of service - why is it occurring, who is doing it?
  - Gap: regulators have difficulties determining whether degradation is taking place
  - Gap: regulators have difficulties determining causality
- Traffic management practices (queueing techniques - understanding the impact, detecting the presence of such practices, where is it being applied and by whom?)
- QoS parameters: speed, latency (layer 3 measurements)

- End-to-end experience
- Open area: better measuring the quality of experience of consumers

3.6.2 Commercial operators

- Route stability
    - Gap: hard today to figure out the origin of route flapping
- Quality of service to end-customer
    - Gap: difficulty of root cause analysis - what is the impact of content provider practices on the quality, what is the impact of network practices upstream, and what is the impact of network, and what is the impact of the client-side device?
        - reference: Stanford IMC 2012 paper [PDF] on video player backoff and quality degradation
        - Orange (F. Guillemin) has measurement results that show the impact of client-side players on quality of experience

3.6.3 Higher education and research operators (NRENs)

- Crossing multiple domains (in the NREN world), it is possible to run a measurement from a server to a client, and then one needs to look at shorter paths to understand.
    - problem: starting measurement agents in remote domains (if it is an individual, this can be difficult)
    - problem: behaviours over short paths may be different than behaviours over longer paths (for instance, TCP acts differently when the RTT is less)
    - gap: ability to combine active end-to-end measurements with passive measurements automatically activated hop-by-hop
- Gap: absence of layer 2 monitoring tools, especially for understanding remote networks, which makes it hard to diagnose faults in those networks

3.6.4 Content providers and/or content delivery services (OTT)

- Measurement tools and data available to these actors are inadequate
    - Not sufficient to predict performance -- for instance, which of my servers should I direct my end-user to? (we use some pings, but it's not good enough)
    - Not sufficient to understand the impact that they will have in the network as they switch from serving data from one location to serving it from another location (switching data from coming in through direct peering to coming in through another link, for instance)
        - Gap: ability to make cooperative measurements between OTT actors and ISPs

3.6.5 Network equipment manufacturers

Not represented in our workshop.

3.6.6 End-customers (those who purchase network access and CDN services)

- Individuals (home network customers)
    - including consumer advocacy organizations
- Businesses
    - those using IP telephony, wireless, etc. services
    - those offering services over the web
- Higher education and research institutions
    - High energy particle physics (CERN, …)
- Government

3.6.7 Scientists (those trying to understand the network - IMC and PAM communities)

3.6.8 Policy makers

- BEREC and its members

3.6.9 Insurers

- Not represented in our workshop

3.6.10 Government agencies concerned with the security/integrity of the network

Not policy makers or regulators -- trying to understand if the network can withstand an attack or a disaster and make recommendations to operators on how to improve

Issues faced:

- Data encryption - is it sufficient? (Which algorithms are being used, what key sizes?)
- DDoS attacks on DNS servers (are there open DNS resolvers that are susceptible to compromise?)
- DDoS attacks generally (are there routers with public SNMP communities that are susceptible to compromise?)
    - gap: need tools, methodology
- Mail relays - are they susceptible to relay spam?
    - gap: need vantage points, tools, methodology
- IP spoofing - are networks allowing spoofing of IP addresses (BCP 38) which makes it easier to hide attacks?

    - gap: would like to measure, but no good tool to measure today (need large number of vantage points in the right places, plus the tool, plus the methodology)
- stress testing of anti-DDoS measures
- peering structure of the network, and whether this has any bearing on possibility for disconnection of parts of the network due to attacks, failures, or disasters
    - gap: completeness of available BGP feeds (quite possible that many peering links don't appear)
- vulnerabilities to hijacks of BGP prefixes, hijacks of ASNs

3.6.11 Alternative users of network monitoring data (those using the data for purposes other than understanding the network itself)

- Government public safety authorities (disaster planning, disaster management)
- Public administrations interested in planning, development, Smart Cities, etc.
- Consumer protection agencies and regulators (understanding eCommerce)
- Digital rights holders (and regulators) concerned about copyright infringements (geolocation of IP addresses, possible use of DPI for detection)

3.7 Analysis of the network monitoring data

Include policy issues in sharing and privacy guidelines.

- Trustworthiness of data
- How do we combine data from different sources?

3.8 Policy issues with respect to Internet monitoring data

3.8.1 Ethical and Legal Issues

"Issues and etiquette concerning use of shared measurement data", Mark Allman and Vern Paxson. Proceedings of the 7th ACM SIGCOMM conference on Internet measurement, October 2007, pp. 135-140.

"Legal issues surrounding monitoring during network research", Douglas C. Sicker, Paul Ohm, and Dirk Grunwald. Proceedings of the 7th ACM SIGCOMM conference on Internet measurement, October 2007, pp. 141-148.

3.8.2 Privacy issues

- multiple different jurisdictions having different rules making it difficult to share data across national boundaries
- surveillance by governments and privacy protections afforded to individuals/enterprises with respect to this surveillance

- do we have adequate techniques for anonymizing data? having such techniques facilitates sharing of data

3.8.3 Data sharing

- incentives for data sharing
- developing ways to make it safe for industry to share data (considering the tremendous amount of data that is held privately by industry today)

3.8.4 Government Support for Network Measurement

In U.S., NSF has recently recognized the need to support more mid-scale investments in shared infrastructure for computer systems research. (See, e.g., CISE Research Infrastructure: Mid-Scale Infrastructure - NSFCloud (CRI: NSFCloud) Program Solicitation NSF 13-602). Past examples of mid-scale investments include PlanetLab and GENI.

3.9 Conclusions

This 1st Workshop was organized in order to collect information regarding the state-of-the-art in terms of Internet monitoring and measurement tools and their capabilities. The workshop achieved these goals by gathering together experts from significant commercial and academic communities worldwide, who gave us an excellent insight into the monitoring and measurement tools that are generally available today.

In terms of terminology, it can be concluded that *monitoring* is a passive process of examining live traffic flows. An example of a *monitoring* tool is Netflow. In terms of network performance, *monitoring* Internet traffic can determine throughput and congestion (providing routers in the network adhere to RFC 3068; the IETF recommendation that specifies the return of Explicit Congestion Notification packets to the sender), but nothing else. The monitoring of user actions (or through the Deep Packet Inspection of monitored traffic) can identify what applications are being consumed and therefore infringe European personal data protection laws. If users are to be involved in passive monitoring trials, the minimum pre-requisites are that their consent is obtained and the data is treated with confidentiality.

Measurement, on the other hand, is an active process of injecting additional traffic in order to measure more than merely throughput. For example, to measure jitter, timestamps are added to extra test packets. To determine the paths that traffic is taking, traceroute packets can be launched, and to measure buffer queue lengths, traffic can be injected at rates higher than the line speed, until packets are detected as being lost. Since *measurement* tools use test traffic, they therefore avoid any ethical issues of personal data protection. *Measurement* tools can be classified as (i) stand-alone probes (e.g. RIPE-ATLAS and SamKnows), (ii) software-based (e.g. perfSONAR), and (iii) browser-based (e.g. Ookla).

We heard about traffic measurement and monitoring approaches from two differing experimental paradigms, which might be called the reproducible and the statistically relevant approaches. The more traditional reproducible measurements have been directed at managing proprietary networks and stable overlay structures (like PlanetLab). But statistical relevance

(and caution) are increasingly used to take advantage of measurements from widely distributed sources by crowd-sourcing or distribution of software clients with measurement capability.

In order that measurements can be reproduced with comparable results, measurement traffic can be targeted at and initiated from pre-defined points in the Internet. These points are either Websites or servers (either public or private). An example of a public server is a DNS server, whereas private servers can be nodes located at strategic places throughout the network and programmed to return data to help localize faults (as used in the perfSONAR case), or SamKnows / RIPE-ATLAS devices with which their probes communicate. For making peer-to-peer measurements, the latest SamKnows probes can also act as measurement servers.

The locations from which measurements are currently initiated are:

- Inside the network (typically RIPE-ATLAS "Anchor Hosts")
- Edge of the network, i.e. the end of the access line (typically RIPE-ATLAS NCC probes or SamKnows probes)
- On the end device (browser-based, or Smartphone App)

The Workshop also provided information about the users of the measurements and the uses they make of the data. It was confirmed that the main users of measurement data are:

- ISPs
- End-users
- Regulators
- Researchers and developers

ISPs use the measurements to:

- Identify, isolate and fix problems in the access network or CPE
- Network dimensioning
- Evaluate the Quality of Experience (QoE) of the user
- Measure own network and product performance and compare with competitors
- Understand the impact of new devices

End-users use the measurements to:

- Determine if the ISP service adheres to the SLA
- Diagnose an issue before calling the ISP (if other Measurement Agents are installed in the home network)

Regulators use the measurements to:

- Access datasets to compare multiple broadband providers: http://www.fcc.gov/measuring-broadband-america
- Collect historical data:
  - averaged performance of an operator each quarter, or
  - intermittent fault at one user during, say, the last week
- Frame better policies to help regulate the broadband industry: http:/maps.ofcom.org.uk/broadband
- Ensure government targets are being met (eg. "deliver superfast broadband (24Mbps) to 90% of UK premises by 2015")

Researchers and developers use the measurements to:

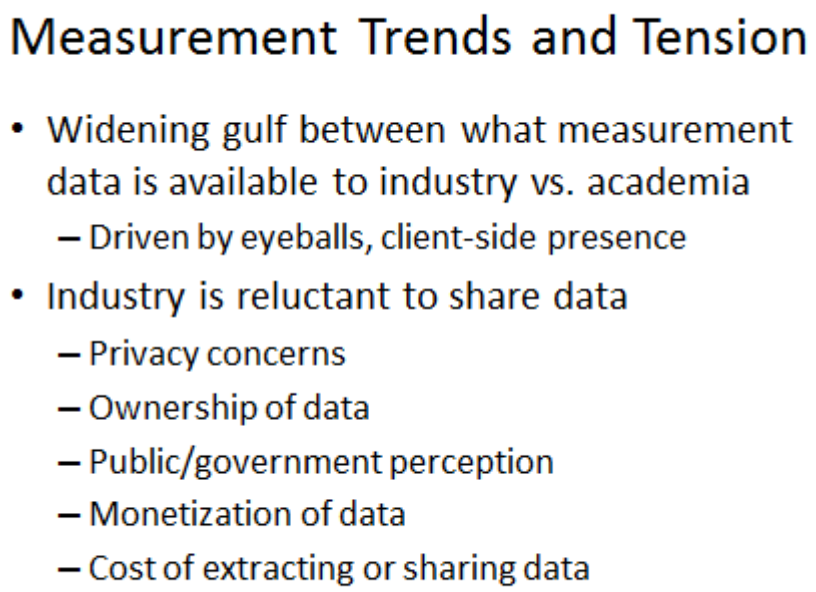
- Develop testing tools
- Locate faults, attacks, ….
- Measure network performance
- Correlate network performance to other issues (BGP errors, …)
- Discover network topology
- Develop new protocols (routing, transport, ….)
- Develop network management tools
- Develop visualisation tools (topology, status, ….)

This shows a richer variety of measurement tools and a wider range of users and uses of this information than even our charter calls for. We shall attempt to include in our scope for further analysis all those efforts whose focus is on the quality of communications between people, their businesses and their governments and social services. Several fascinating directions which addressed measurement and monitoring in order to create new business or change the practices of existing businesses (e.g. shopping assistants that take a world-wide view) will have to be left to future studies. Next we will collect the more detailed information presented by several of our expert speakers.

4. APPENDIX: SELECTED SLIDES PRESENTED AT THE WORKSHOP

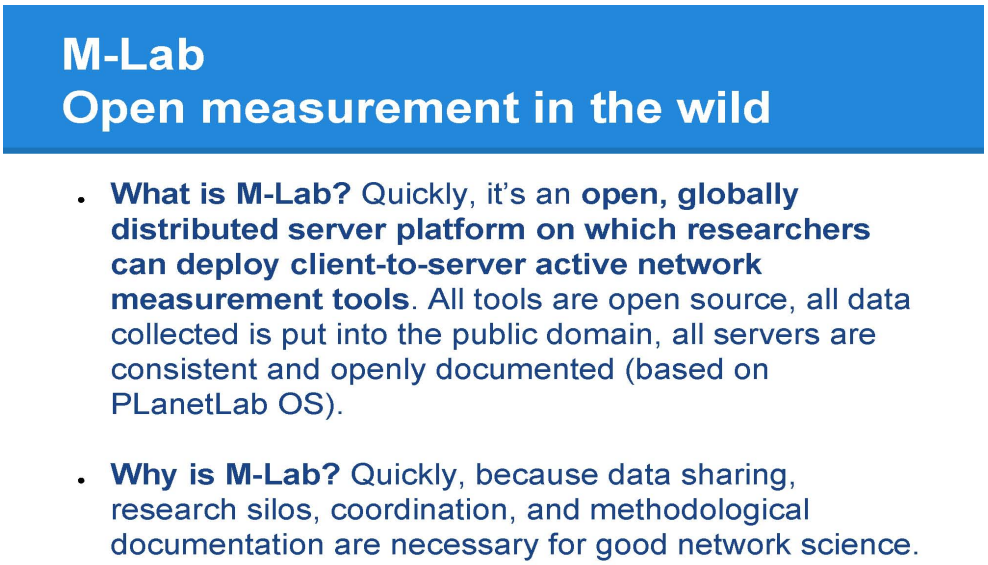
Here we present a selection of the presentations heard at the workshop. Bala Krishnamurthy of AT&T Labs and Bruce Maggs, of Duke University and Akamai, set the stage with a discussion of the overarching issues. We include Bruce's summary slide. Meredith Whittaker, responsible for Google Labs open source M-Lab repository and website, describes the possibilities and uses of that toolset. Alessandra Scicchitano of SWITCH describes the PerfSonar system used in GEANT and its capabilities. Fabrice Guillemin of Orange and Peter Groselj from Telecom Slovenije provide a fairly extensive review of the uses that measurement technologies are put to in today's European telephone companies, uses that extend well beyond enhancing performance and capacity in the backbones of our networks. Finally, Ahmed Aldabbagh from Ofcom describes the objectives of groups in several countries expressed through BerEC towards better regulation based on ongoing measurements, coordinated across several domains.

4.1 Bruce Maggs (Akamai):



4.2 Meredith Whittaker (M-Lab/Google Labs):

o



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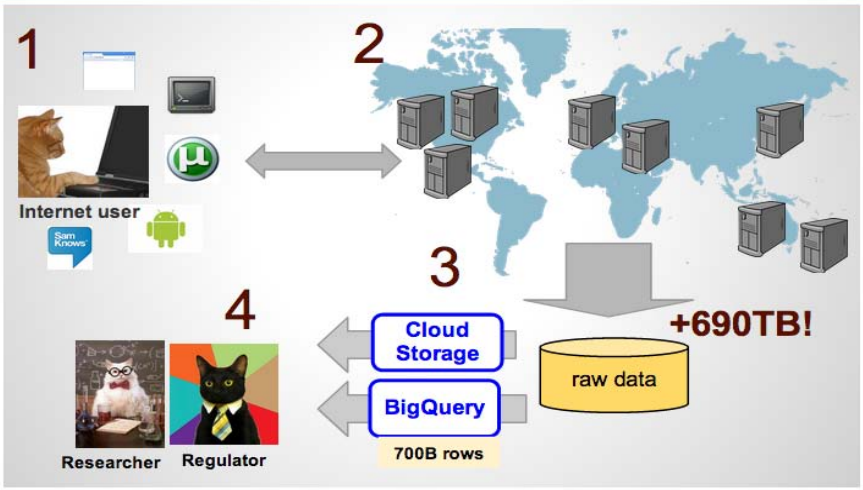
Who is M-Lab: a diverse partnership supporting open network research

Open testing ecosystem



M-Lab's diverse suite of tools

12 tools, more on the way

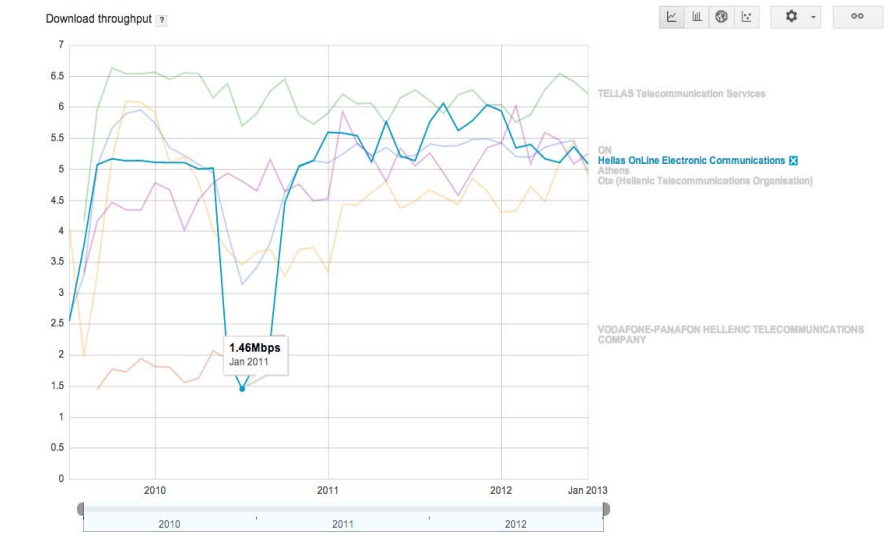
- **Browser-based**
  NDT, Glasnost, Shaperprobe, Neubot, and more
- **Hardware-based**
  BISmark, SamKnows
- **Mobile**
  MobiPerf, NDT, more on the way

Multiple vantages and methodologies provide important layers of meaning. There is no one way to measure. The key to any choice is to ensure that it's open and verifiable.

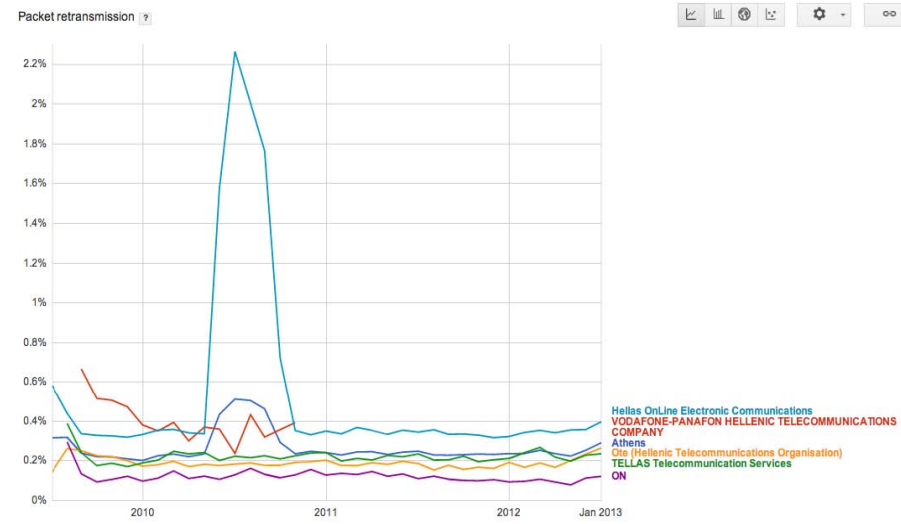
M-Lab's global platform

130+ global servers, and growing. A bird's eye view:

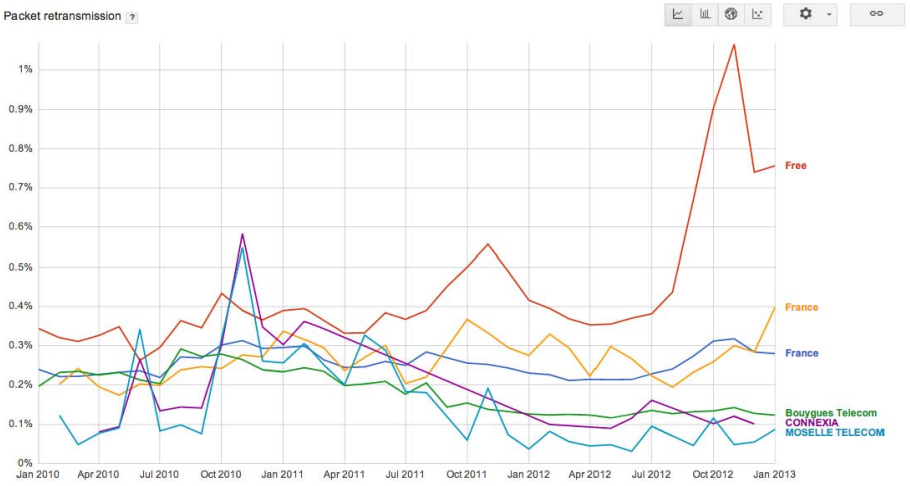
Using open data (Greece)



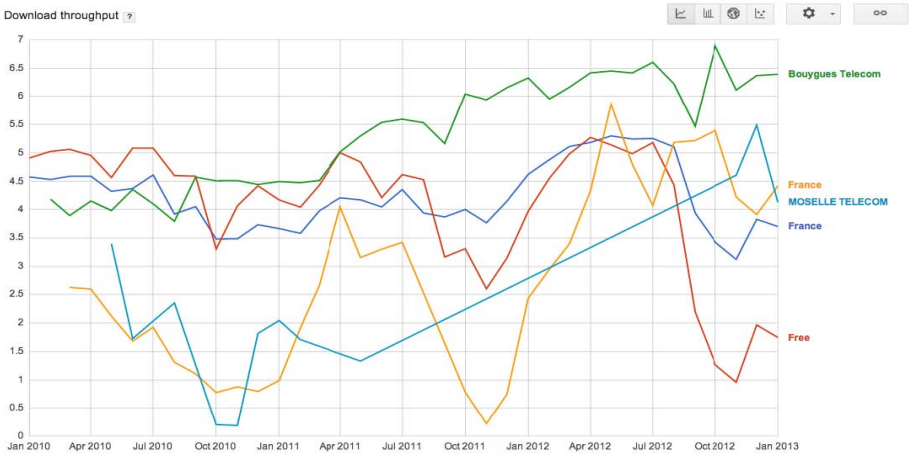
Using open data (Greece)



Using open data (France)



Using open data (France)



If nothing else: openness first

Aim for openness.

Open means:

1. Open-source **tools**
2. Openly available **data** (privacy by design, not post-hoc anonymization)
3. Open, consistent **infrastructure**
4. Open **analysis** (make your methods clear)

M-Lab isn't the only way, it's just the big and established.

Do you want to know more?

A community is waiting to answer your questions

- Ask me, or
- talk to me later today, or
- visit the M-Lab site, or
- contact us directly in the future

measurementlab.net

measurementlab.net/contact

4.3 Alessandra Scicchitano (SWITCH):

-What is the state of the art (in GEANT)?
PerfSONAR

-What is missing:
In general: Open standards and Interoperability. A common way to share sensitive data (Law?)
As eduPERT: Multilayer and "per hop" measurement tools (Big data and virtualization). Tools that can detect middleboxes and their interference for example?

-Who to speak with (users' point of view):
Communities like TF-NOC and eduPERT?

4.4 Fabrice Gullemin (Orange):

Orange view

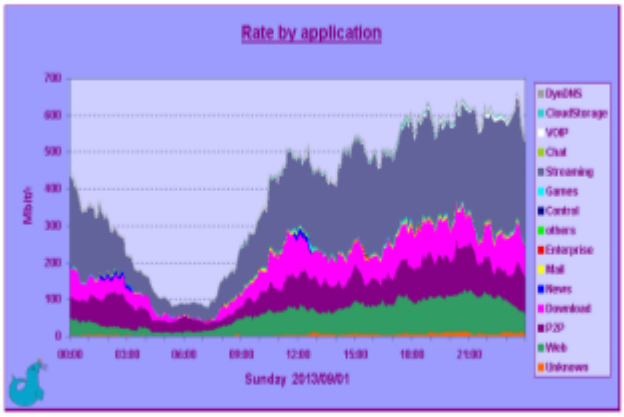
- Who requires network management data? For what?
  - content provider (IPTV), audience (advertising issues)
  - operational services (network dimensioning, quality impairments)
  - benchmark (to compare end-to-end measurements against network data)
  - content providers (network load conditions to control quality in content delivery – cf. ALTO)
- What additional data would they use if they could have it?
  - trusted geolocalization
  - routing information to optimize content delivery
  - actual bit rates to compare against SLA (business customers)
- In what way is the landscape changing (new technologies, network regulation)
  - ARCEP measurements in France to benchmark operators

Measurement tools for IP networks

- OTARIE
  - PC equipped with DAG cards
  - traffic statistics every other 6 minutes
  - breakdowns of applications, volumes, rates, etc.
  - 12 probes in the IP backbone network of Orange in France
- FLAMANT
  - exploits NetFlow records sent by routers (traffic matrices)
  - volume breakdowns by ASes
  - study traffic management by OTTs (Google, Akamai, etc.)
- Amelie
  - QoE of audiovisual services (IPTV and OTT video services)
  - real time analysis of media flows

unrestricted

Typical Otarie breakdowns



Internet video : 50% of peak time traffic
Residential area in France (Bordeaux)
Mostly YouTube (UGC) traffic

unrestricted

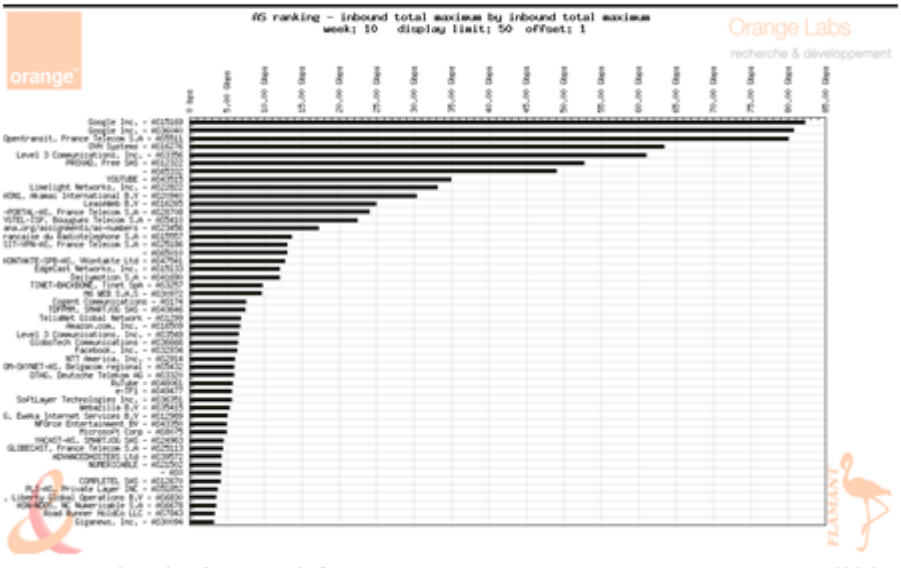
Example of use case: caching

HIT RATIOS (IN PERCENTAGE) FOR THE SIMULATED TREE CACHING SYSTEM.

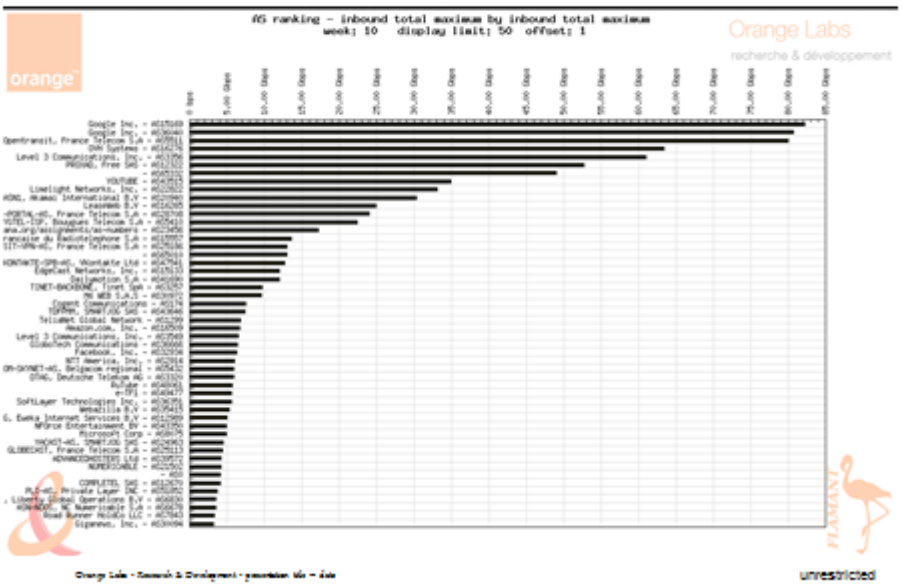
	file hit ratio	byte hit ratio
Local caching		
Bordeaux	33.5	74.65
Lyon	34.2	74.61
Paris	34.6	77.97
Distributed caching		
root	3.54	14.76
Global	37.2	79.68
Centralized caching	46.21	90.52

- Local caching of YouTube traffic is very efficient in all 3 cases
- Byte hit ratio >> file hit ratio due to a small number of highly popular videos
  - A small number of "heavy hitters" (25% of requests) representing at most a few tens of GB
  - A very large number of files requested only once

NetFlow observations



NetFlow observations



4.5 Peter Groselj (Telekom Slovenije):

TelekomSlovenije

Internet Measurement and Monitoring:

Telekom Slovenia IP/MPLS Network

SMART Internet Monitoring Study
Expert Council Workshop 1
Brussels, 3-4 October 2013

Peter Grošelj, BSc
Telekom Slovenije

TelekomSlovenije

Agenda

- Telekom Slovenije Group
- Collecting Data
- Presenting Results
- Built and Maintain Inventory
- Using Measurement Results
- The Future of Monitoring

Monitoring Telekom Slovenia IP/MPLS Network

TelekomSlovenije

Telekom Slovenije Group

Key Facts

- Telekom Slovenije is the leading Slovenian provider of electronic communications.
- Provides high-end mobile, fixed and IP communications, multimedia content, and services to residential and business users.
- Telekom Slovenije Group is present in several markets in SE Europe, in Macedonia, Bosnia and Herzegovina, Kosovo and Albania.
- Listed on the Ljubljana Stock Exchange.
- Stable ownership structure, with the Slovenian state as the majority shareholder (72,38%)

Monitoring Telekom Slovenia IP/MPLS Network

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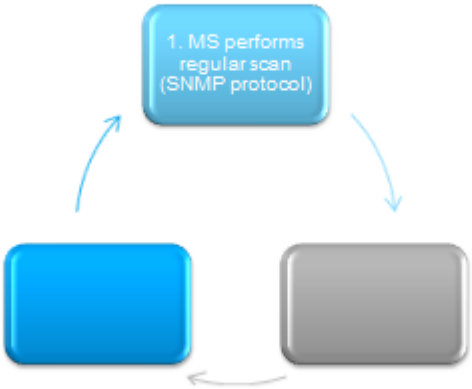
Collecting Data



Monitoring Telekom Slovenia IP/MPLS Network

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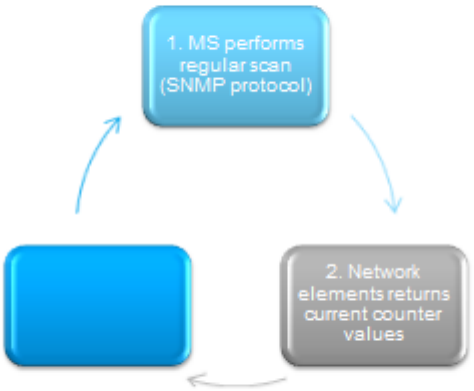
Collecting Data



Monitoring Telekom Slovenia IP/MPLS Network

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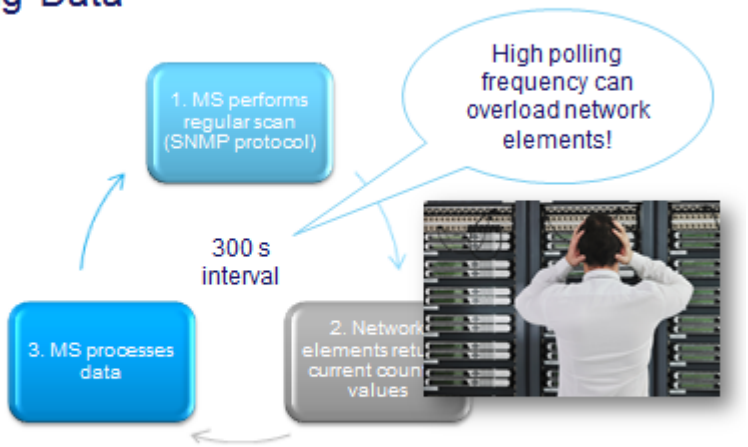
Collecting Data



Monitoring Telekom Slovenia IP/MPLS Network

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Presenting Results

- Web GUI for displaying monitoring system status

Email/SMS notifying

Monitoring Telekom Slovenia IP/MPLS Network

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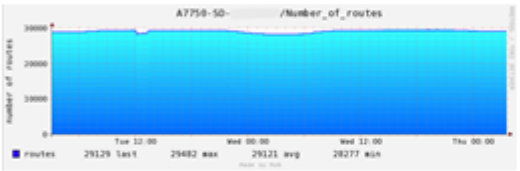
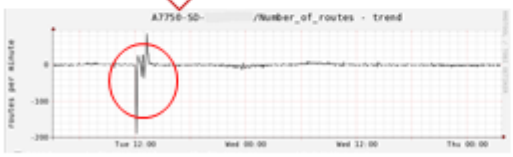
Presenting Results

- Calculated data presented **in a different way**



This does not look interesting, right?

(last result) – (previous result) = **trend**



Fast change indicates problem in lower layers of the network

Monitoring Telekom Slovenia IP/MPLS Network

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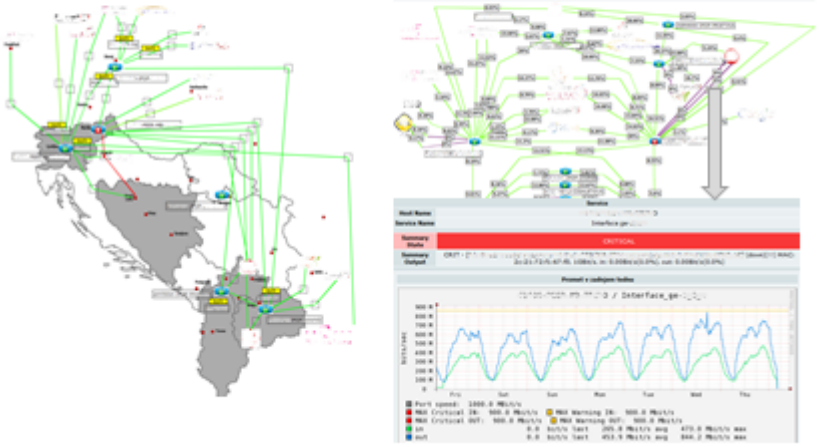
Presenting Results

- Weathermap: connection status and current utilization



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Maps Integration

- Using maps to show status of hosts and services

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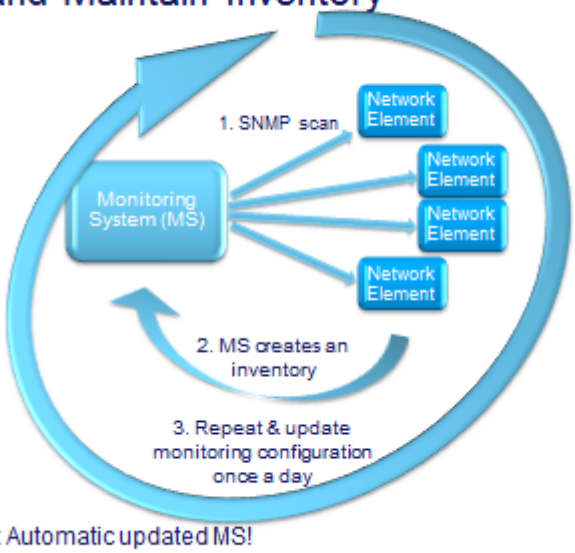
Built and Maintain Inventory



Result: Automatic updated MS!

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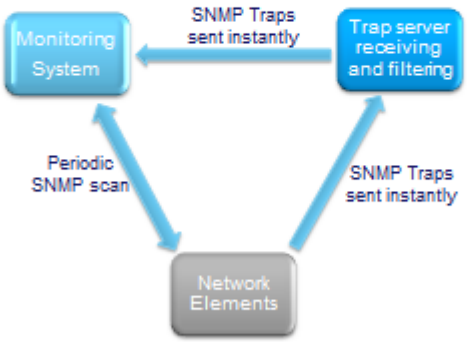
Integrating MS with SNMP Traps

- Resolves problems regarding collecting frequency
- Using seperate Trap server filtering traps avoids MS ***event storms***



- Result: Real-Time monitoring!

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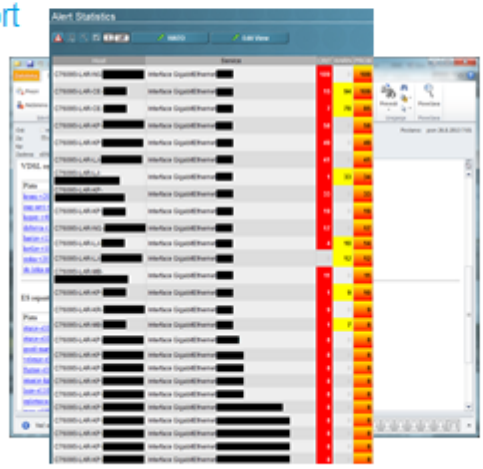
Using Measurement Results: Reporting

- Create alert statistics based on ticket events
- Email report



Monitoring Telekom Slovenia IP/MPLS Network

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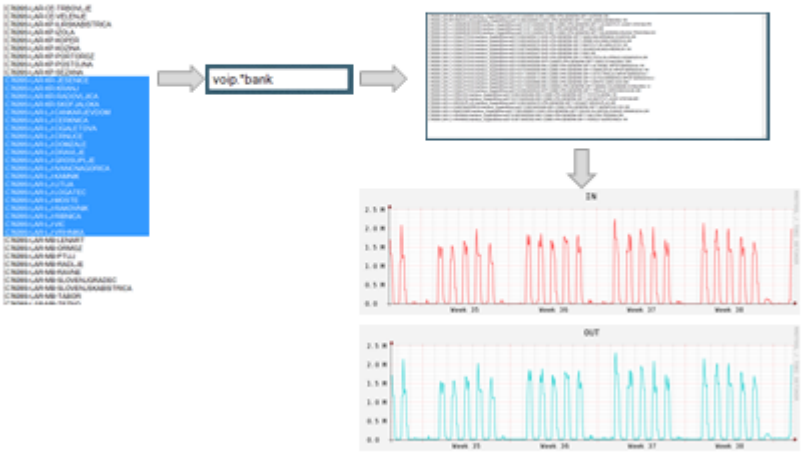
Using Measurement Results: Aggregation

- On demand traffic aggregation



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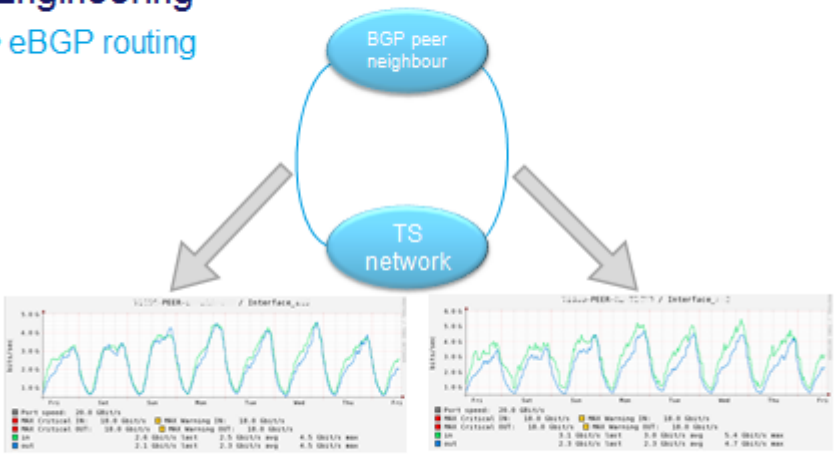
Using Measurement Results: Traffic Engineering

- eBGP routing



Balanced traffic!

Monitoring Telekom Slovenia IP/MPLS Network

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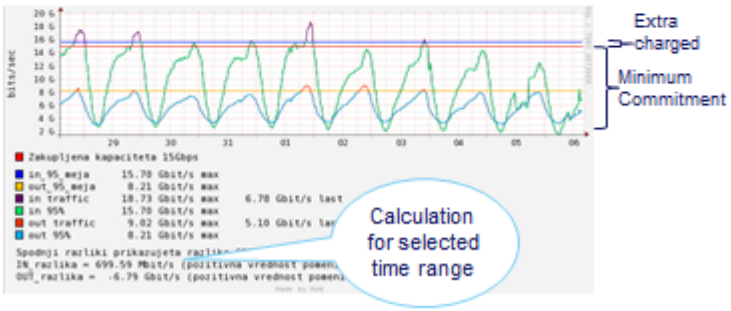
Using Measurement Results: Burstable Billing

- Measuring bandwidth based on peak use
- Using 95th percentile to evaluate regular and sustained use of a network connection
- Avoid traffic burst on rented links

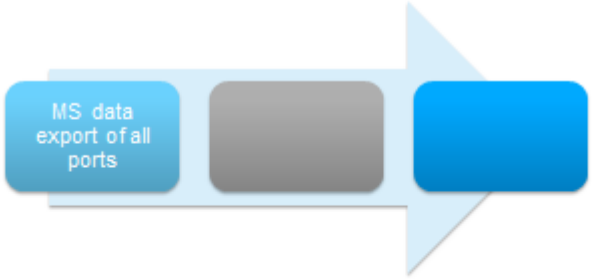


Monitoring Telekom Slovenia IP/MPLS Network

TelekomSlovenije

Using Measurement Results: Automatic Re-configuring User ADSL Ports

- Connecting MS with own-built Dynamic Port Configuring System (DPCS)
- Eliminates Near-End-Crosstalk (NEXT)



Monitoring Telekom Slovenia IP/MPLS Network

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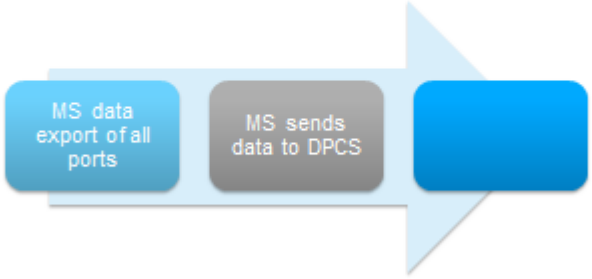

Monitoring Telekom Slovenia IP/MPLS Network

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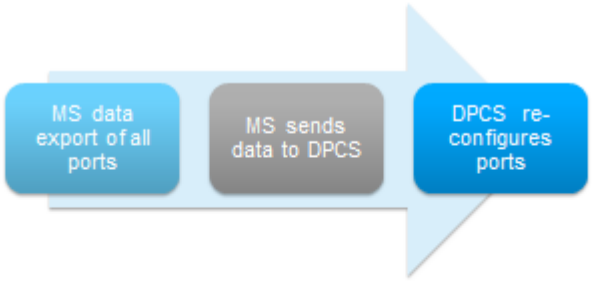

- Long term result: Better IPTV-user experience!

Monitoring Telekom Slovenia IP/MPLS Network

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The Future of Monitoring

- Monitoring system:

Service Monitoring
- Internet √
- VoIP √
- IPTV √
- ...

Customer Care
- QoS monitoring
- End-To-End monitoring

Dynamic thresholds

Manufactures:

Better SNMP support!
(or other monitoring protocol)

Monitoring Telekom Slovenia IP/MPLS Network

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„Network monitoring is far more strategic than its name implies. It involves watching for problems 24/7, but it's also about optimizing data flow and access in a complex and changing environment.“ (cio.com)

Thank you

peter.groselj@telekom.si

Monitoring Telekom Slovenia IP/MPLS Network

4.6 Ahmed Aldabbagh (Ofcon):

Body of European Regulators for Electronic Communications

BEREC

Net Neutrality QoS Monitoring: a Regulatory Perspective

A presentation on behalf of BEREC NN EWG
to the Expert Council Workshop
SMART Internet Monitoring Study
Brussels, 3-4 October 2013

1

BEREC

Outline

- Acknowledgement
- Who are we & what we do
- Why are we here?
- Requirements
- Standards and methods
- The need for statistical robustness
- Early thoughts towards harmonisation

1

BEREC

Who are we & what we do...

Body of European Regulators for Electronic Communications

BEREC

- BEREC and NN Expert Working Group
- Previous work (Theoretical, market development, etc):
  - BEREC's Response to the European Commission's consultation on the open Internet and net neutrality in Europe (2010)
  - Guidelines on Transparency in the scope of Net Neutrality: best practices and recommended approaches (2011)
  - A framework for Quality of Service in the scope of Net Neutrality (2011)
  - BEREC findings on traffic management and other practices resulting in restrictions to the open Internet in Europe (2012)
  - Report on differentiation practices and related competition issues in the context of Net Neutrality (2012)
  - An assessment of IP interconnection in the context of Net Neutrality (2012)
  - Guidelines for Quality of Service in the scope of Net Neutrality (2012)
  - **Summary of BEREC positions on net neutrality (2012)**

2

Why are we here?

- **Current – QoS Measurement Platforms**
  "Monitoring Quality of Internet Access Services in the Context of Net Neutrality"

  ⇨ **Studying the diversity of solutions in light of regulatory objectives, and may promote ways to harmonise national initiatives**

- This is an opportunity to share our knowledge and experience
- The presentation is based on the current work of the BEREC NN EWG
- It draws on the work of a number European NRAs
- It is hoped that this the work of the BEREC NN EWG can
  - Shed some light on important issues
  - Provide guidance for this project

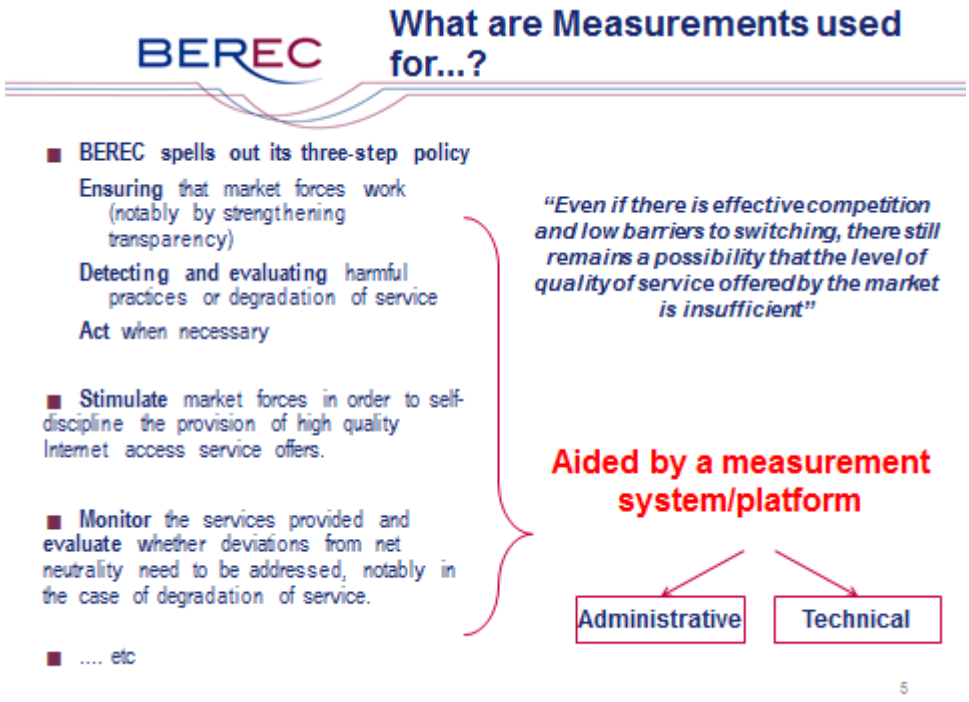
3

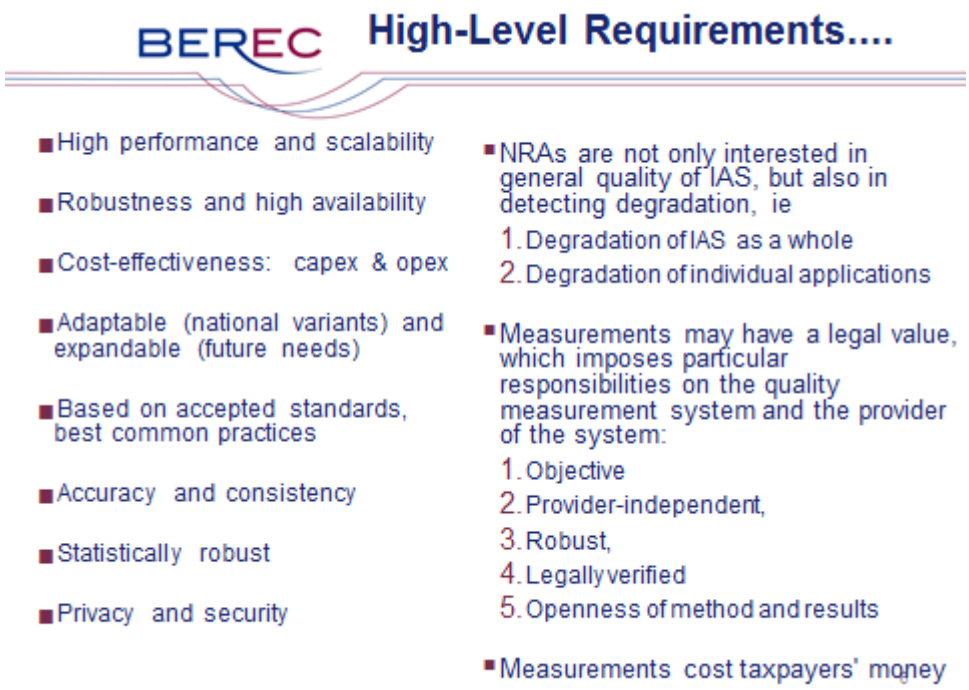
Why regulators are interested in measurements..?

- Legal aspects
  - FWDs & USDs
  - Art 20(1)
  - Art 21(3)
  - Art 22(1)
  - Art 22(2)
  - Art 22(3)
- NRAs worry about
  - Competition
  - Switching
  - Transparency
  - ..etc

- Enhancing transparency
- Prevent degradation of service (USD 22(3))
- Measurements would motivate all parties
  - Enhance their practice towards a NN friendly approach
  - Better comms perceived by the consumers
  - Provide richer information enabling consumers make better decisions
  - Better predictability of market behaviour
- Aides intervention with appropriate corrective measures, e.g. through imposition of minimum quality requirements.
- etc

4


BEREC
What are Measurements used for...?
BEREC spells out its three-step policy
Ensuring that market forces work (notably by strengthening transparency)
Detecting and evaluating harmful practices or degradation of service
Act when necessary
Stimulate market forces in order to self-discipline the provision of high quality Internet access service offers.
Monitor the services provided and evaluate whether deviations from net neutrality need to be addressed, notably in the case of degradation of service.
.... etc
"Even if there is effective competition and low barriers to switching, there still remains a possibility that the level of quality of service offered by the market is insufficient"
Aided by a measurement system/platform
Administrative
Technical
5


BEREC
High-Level Requirements....
High performance and scalability
Robustness and high availability
Cost-effectiveness: capex & opex
Adaptable (national variants) and expandable (future needs)
Based on accepted standards, best common practices
Accuracy and consistency
Statistically robust
Privacy and security
NRAs are not only interested in general quality of IAS, but also in detecting degradation, ie
1. Degradation of IAS as a whole
2. Degradation of individual applications
Measurements may have a legal value, which imposes particular responsibilities on the quality measurement system and the provider of the system:
1. Objective
2. Provider-independent,
3. Robust,
4. Legally verified
5. Openness of method and results
Measurements cost taxpayers' money

BEREC Standards

- Different applications have different requirements.
  Browsing and streaming need speed.
  VoIP and gaming are mainly sensitive to delay.

But what about measurement techniques for NN, e.g. Detection of TM practices, detection of degradation of services, etc?

- Standards
  ETSI EG 202 057;
  ECC report 195;
  ITU-T recommendations Y.1541 and G.1010; and
  IETF RFC 6673, RFC 2679, RFC 2680, RFC 2681, RFC 3148, RFC 3393 and 6349.

- In the ECC report 195 five quality parameters have been selected, namely:
  Upload and download transmission speeds (minimum and average values),
  Delay (average value),
  Delay variation (average value),
  Packet loss ratio (average value), and
  Packet error ratio (average value).

- Variations in the metrics and their definition amongst the different standards.

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BEREC Measurement methods

- Measurement of the ISP leg
- Measurement to the IXP(s)
- E2E measurement
- Hardware vs software based methods
- Passive vs active measurements
- Targeted vs crowd-sourcing

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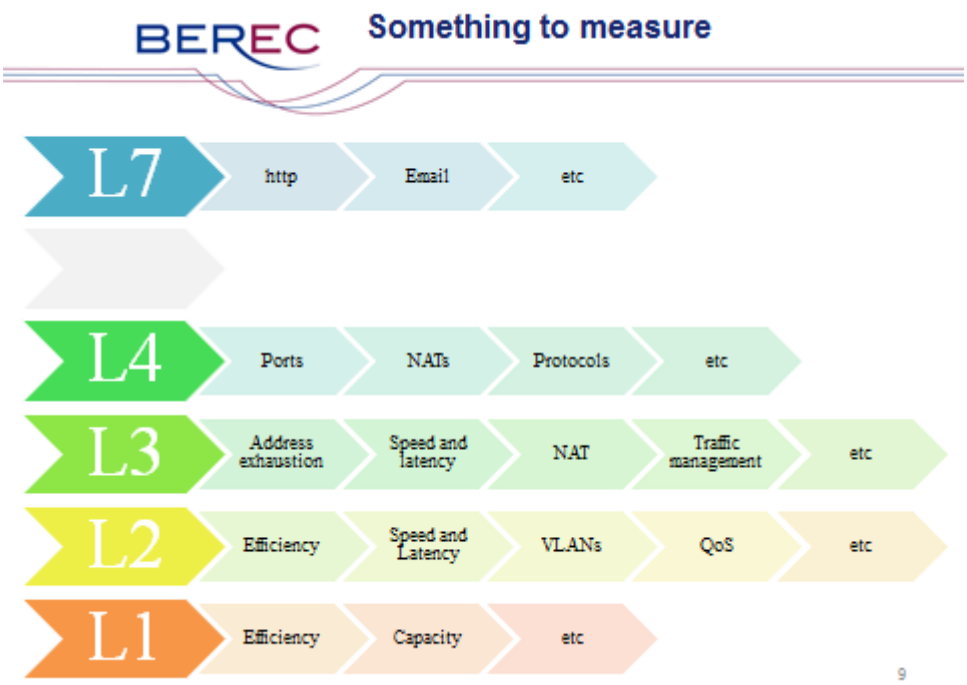
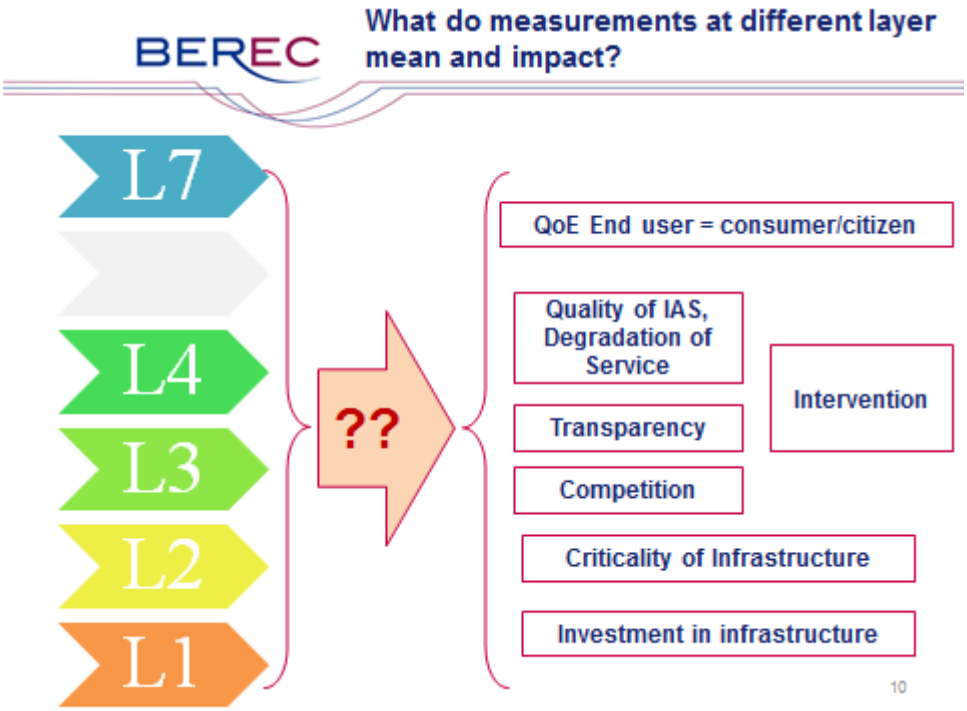
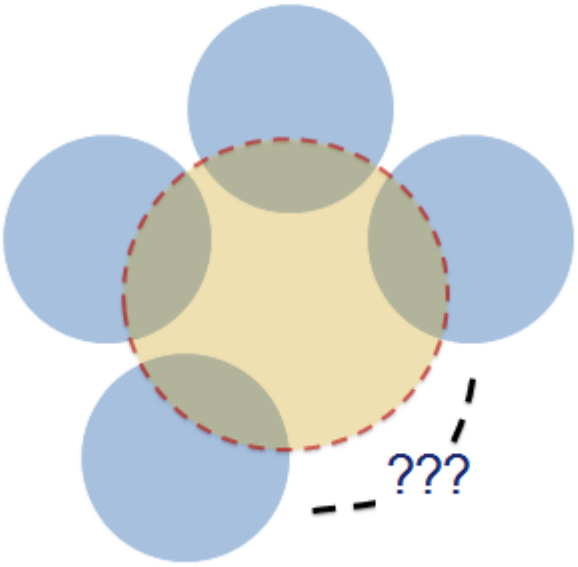

BEREC
Something to measure
L7
http
Email
etc
L4
Ports
NATs
Protocols
etc
L3
Address exhaustion
Speed and latency
NAT
Traffic management
etc
L2
Efficiency
Speed and Latency
VLANs
QoS
etc
L1
Efficiency
Capacity
etc
9


BEREC
What do measurements at different layer mean and impact?
L7
L4
L3
L2
L1
??
QoE End user = consumer/citizen
Quality of IAS, Degradation of Service
Transparency
Competition
Intervention
Criticality of Infrastructure
Investment in infrastructure
10

BEREC Many Internet measurement projects



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BEREC Perspective

Source	Average speed for UK lines (Mbit/s)	Comments
Ofcom	19.1	May 2012 raw measurements (simple average of measurements)
	9.0	May 2012 published data (after post-processing)
Ookla	19.2	Dec 2012/Jan2013 measurements
Akamai	5.7	Q2 2012 measurements

1 http://www.ookla.com/
2 http://www.akamai.com/

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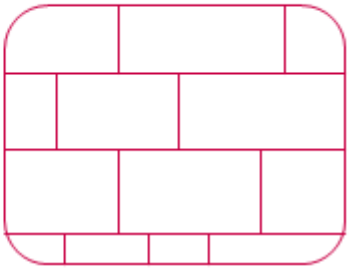
There are many ways in which measurements can be analysed...



- Given a set of measurements, the data set could be dissected and analysed along different themes
- Technical → what technology is delivering what
- Market → how well packages are performing
- Operators → how well each operator is performing
- Geography → how well different regions are being served, e.g. urban, suburban, rural, etc..
- National → how national infrastructure is evolving...

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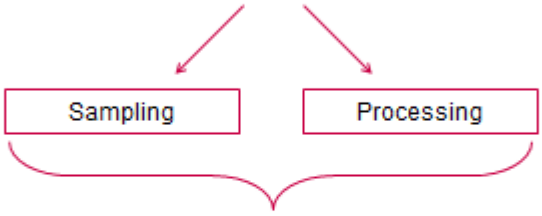
The need for statistical robustness..



The more information collected, the more detailed the results

- ISP packages offered (e.g. throughput ratio, access technologies etc.);
- List of operators in the market and their market shares;
- Geographical distribution of ISP packages;
- Geography of interest, e.g. urban, suburban, rural, etc.; and
- Other aspects deemed important, operator network footprint, line lengths, etc.

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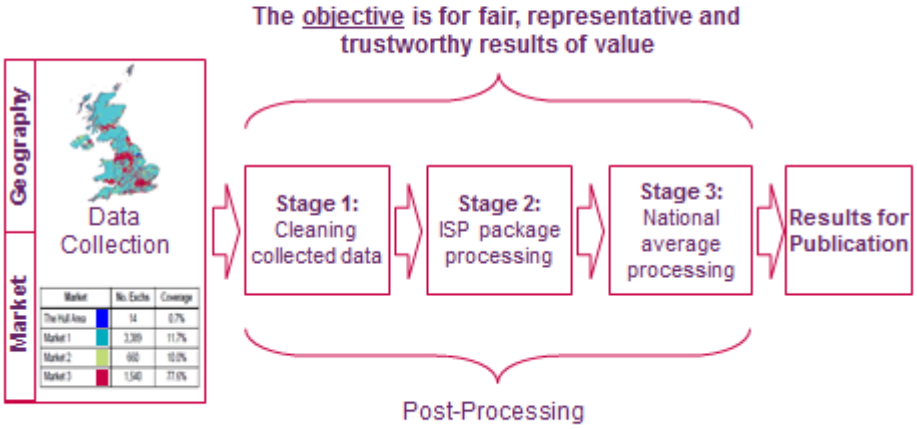
BEREC General process (targeted method)



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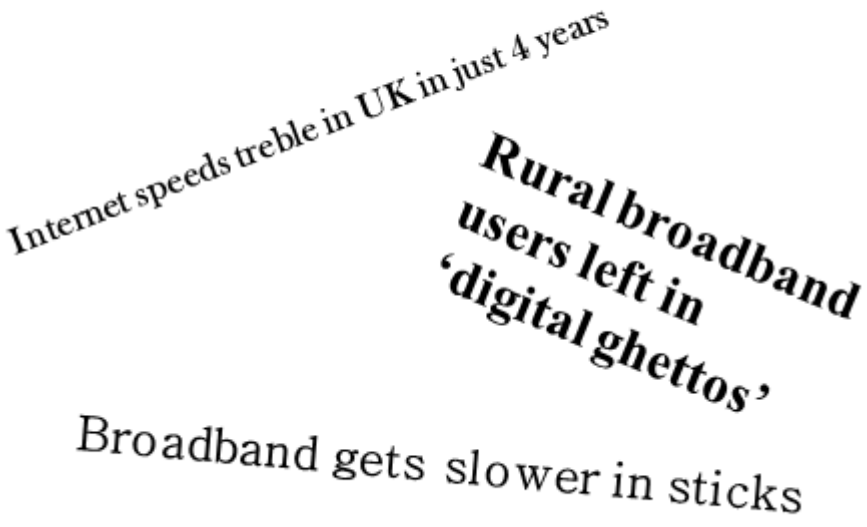
BEREC In the media...



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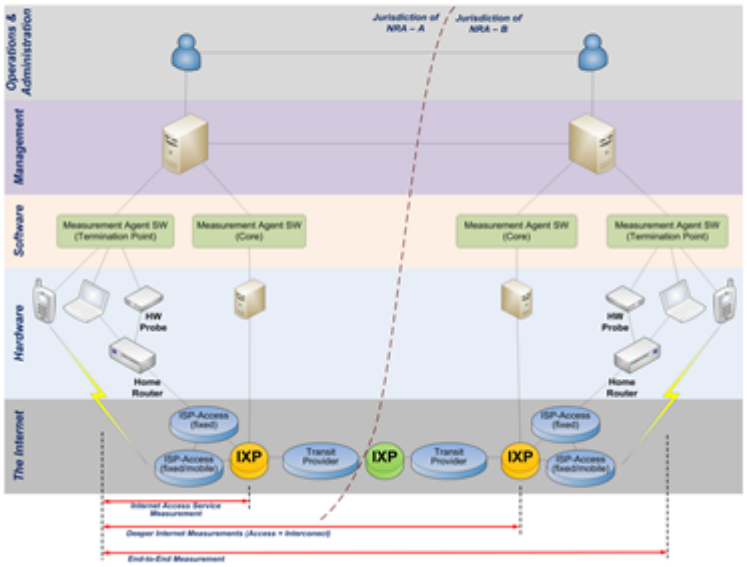
BEREC Early thinking....Towards harmonisation amongst NRAs

The potential for a future multi-NRA measurement platform



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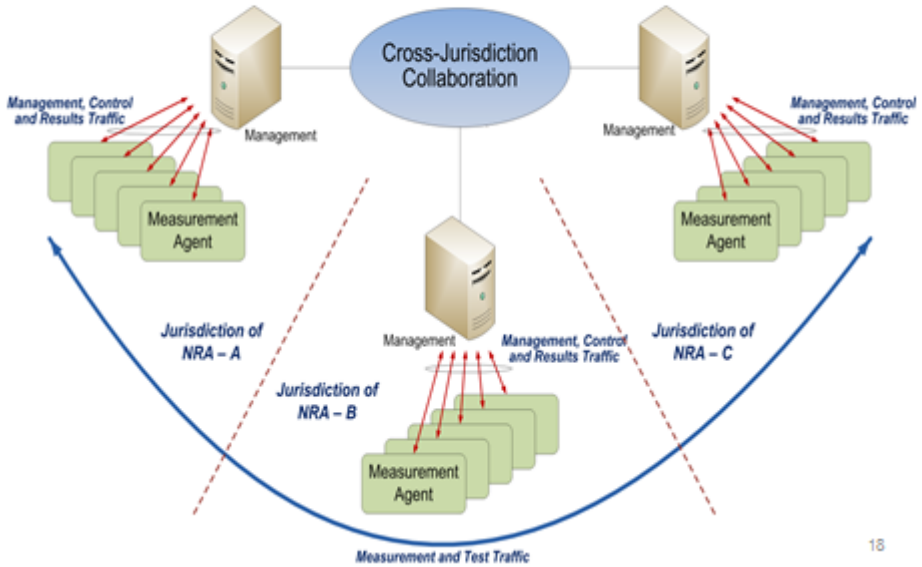
BEREC Early thinking....Towards harmonisation amongst NRAs

The potential for a future multi-NRA measurement platform



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