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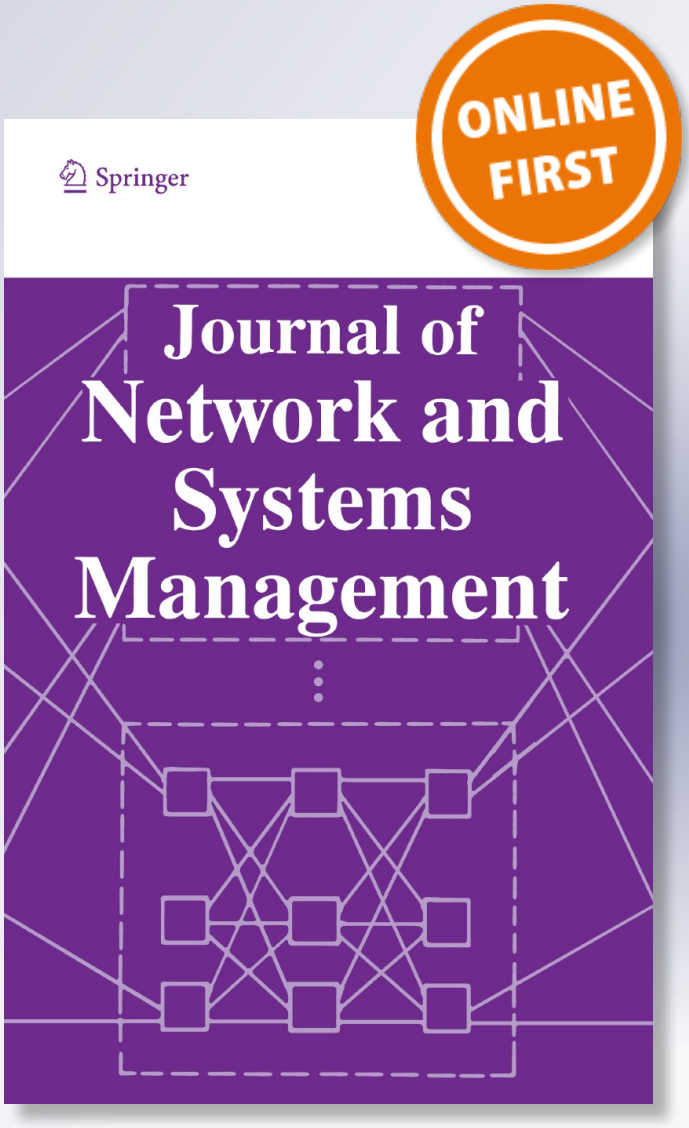


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REPORT

# A Report on the 1st NMRG Workshop on Large Scale Network Measurements

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**Abstract** The 31st Network Management Research Group (NMRG) meeting was organized at the Swissôtel Zürich, Switzerland, on Monday October 14th, 2013, co-located with the Conference on Network and Service Management 2013. This was the 1st NMRG workshop specifically tailored towards large scale network measurements. The goal of the workshop was to bring together researchers and in particular PhD students working in this area. In this report, we describe topics that were discussed at the workshop.

**Keywords** Large scale · Network measurements · NMRG · CNSM

## 1 Introduction

Large-scale network measurement platforms have evolved during the past few years. Some utilize specialized hardware probes (e.g., RIPE Atlas[1] or SamKnows[2]) while others utilize software probes that run on ordinary desktop computers or smart phones (e.g., measurement projects related to M-Lab[3]) or even within Web browsers (e.g., Ookla Speedtest[4]).

[1] http://atlas.ripe.net.

[2] http://www.samknows.com.

[3] http://www.measurementlab.net.

[4] http://www.speedtest.net.

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In this workshop, we invited presentations on topics such as: (a) novel metrics for measuring Internet performance, (b) techniques to estimate Quality of Experience (QoE) [1] from raw measurements, (c) novel data analysis techniques, (d) interactive information visualization techniques, (e) software and hardware tools and (f) interfaces of measurement systems to network management systems.

On the basis of accepted proposals, the workshop was organized in four sessions describing: (a) internals of contemporary and upcoming measurement platforms, (b) novel measurement methods for improved network monitoring, (c) metrics, measurement tools and techniques to determine the QoE of end-users, and (d) ideas and trends that may help shape the direction for future network measurement research. A synopses of these four sessions appear in the upcoming sections below.

## 2 Measurement Platforms

In large scale network measurements both the placement of probes and their capabilities impact the type of analysis that can be performed. Additionally challenges in monitoring and measurement could arise from the intended use of the collected data. To substantiate this consideration, the first session was dedicated to understanding the internals of contemporary and upcoming large-scale measurement platforms.

The session was opened by Philip Homburg (RIPE NCC) who presented the internals of the RIPE Atlas measurement platform. The presentation began with a brief introduction of the platform, and then was subdivided into three parts. In the first part, he demonstrated how User Defined Measurement (UDM) specifications are accepted by the platform's user interface, passed on to the backend, and are later sent to probes where they are executed. In the second part, he described the process of remotely managing the probes. He stressed on how the backend must be able to communicate with the probes in a *secure* way not only to submit measurement requests but also to push new firmware releases as soon as they become available. He also stressed how probes periodically must submit statistics and logs, which helps diagnosing problems at a later stage. He concluded the presentation with a brief description of upcoming features of the platform.

Alessio Botta (University of Napoli Federico II) presented two kinds of monitoring platforms: (a) home-router based and (b) client based. (BISmark) [2] is a home-router based platform consisting of home gateways that also perform network measurements. Host Based Broadband Internet Telemetry (HoBBIT) [3] and User-Based Internet Censorship Analysis (UBICA)[5], are client-based platforms consisting of GUI applications that run on host devices as software probes. He described how BISmark and HoBBIT largely have been designed for network performance measurements, while UBICA is specifically designed for censorship detection. He showed how all three platforms provide a management server that orchestrates experiments (scheduling, result collection and probe maintenance) and helper

[5] http://traffic.comics.unina.it/internetcensor.php.

servers to provide support to geographically distributed probes in their measurement.

Brian Trammell (ETH Zürich) spoke about the FP7-mPlane project [4]. mPlane is defining a platform for measurement automation and integration, focussing specifically on supporting iterative measurement for network performance troubleshooting. The goal is to be able to use contemporary measurements to drill down closer to the root cause of an observed network performance issue. This feature will be supported by a reasoner, which can use results from previous iterations to automate the entire process. Brian introduced the platform, and presented the architecture, control protocol, and the type system used for describing measurements. He illustrated the application of the platform using the ubiquitous `ping` and `traceroute` tools as examples, and he compared it to other network performance measurement platforms.

Nicolas Rouhana (Beritech) introduced the Collaborative Measurement of Internet Quality in Lebanon (CoMIQuaL) project,[6] an initiative started in June 2013 by the Saint Joseph University in Lebanon, with the support of the Internet Society (ISOC) Community Grants Program and the Beirut Internet Exchange Point (IXP). The goal of the project is to establish a neutral, transparent, distributed and collaborative platform for measuring the QoE of mobile and Digital Subscriber Line (DSL) users in Lebanon. He explained how measurements will be periodically performed by Measurement Agent (MA)s installed as applications on users' mobile and host devices. A central server will aggregate all measurements statistics, generate Quality Indicator (QI)s for each location and for each network operator, and publish the QIs using users-friendly visualization techniques. The project wants to help providers to enhance their services and the Lebanese government to accelerate the transition to the broadband Internet. He explained how the research community could also use this platform to make more advanced measurements requiring cooperation between agents (e.g., tomography techniques).

## 3 Measurement Methods

Large scale networks and systems require accurate measurements to take appropriate management decisions. However, only a handful of existing approaches address the measurement quality. As the managed system evolves during runtime, the monitoring and measurement system also needs to self-adapt to these changes. The second session was therefore dedicated to understanding novel methods to improve network monitoring and measurement.

The session was opened by Hoang Dinh (Osaka University) who proposed a distributed method for measuring the quality of end-to-end paths in large scale network systems [5]. His method relies on a hypothesis that the IP level routing paths between end hosts often overlap with each other. Neighboring MAs can exchange route information to detect such overlapping paths. He reasons how this will not only allow the MAs to adjust the measurement frequency, but also allow

[6] http://ieee.usj.edu.lb.

sharing of measurement results on overlapped paths. He explained that neither a central controller, nor knowledge of entire IP network topology is required to leverage this method. The presented simulation results show how relative error in the measurement results can be decreased by half when the measurement metric is latency, and by 65 % when the metric is available bandwidth.

Jeferson Campos Nobre (University Rio Grande do Sul) proposed a decentralized method of detecting Service-Level Agreement (SLA) violations using Peer to Peer (P2P) technology [6]. The method helps improve probe activation decisions that are used to monitor service levels. He described three major principles that are employed in order to enhance these decisions: (a) past service level measurement results to prioritize paths; (b) correlated peers to provision the management overlay; and (c) coordinated measurements to optimize resource consumption. These principles are materialized through probe activation strategies which define how local and remote information is used to infer the destinations that are more likely to violate the SLA and, therefore, should be monitored. He explained how these probe activation strategies do not require human intervention, and are therefore adaptive to changes in network conditions, and independent of the underlying active measurement technology.

Julien Broisin (University of Toulouse) proposed a novel, model-based, adaptive monitoring framework that can improve the Quality of Service (QoS) levels provided by the autonomic system [7]. He explained how such an adaptation is based upon high-level QoS objectives that are directly linked with monitoring activities. The resulting models dynamically drive the operational adaptation of the monitoring system according to the detected evolution of the functional system during runtime. He demonstrated a simulation-based validation of their approach through an implementation of a cloud data center that delivers continuous measurements to clients. He showed how, when the cloud provider detects a huge number of virtual machines, the monitoring system self-adapts to maintain the measurements freshness that was agreed on the initial SLAs.

## 4 Metrics and Measurement Tools

The Internet traffic patterns have rapidly changed over the last decade. The popularity of specific web (Facebook) and video (YouTube) services make them of particular interest while designing QoE measurements for the end-users. In addition, the overall stability of the Internet and the rapid growth of middleboxes that impact real traffic also need some scrutiny. The third session was therefore dedicated to novel metrics, measurement tools and techniques that help ascertain QoE of the Internet from raw measurements.

Andrey Sapegin (HPI Potsdam) opened the session by proposing a novel method for estimating the locality in propagation of Border Gateway Protocol (BGP) routing events through the Internet [8]. He showed how their methodology is able to detect correlated BGP updates in the area covered by available route collectors. This allows estimation of the spread of individual routing events in the Internet backbone and investigate BGP propagation, BGP spikes and scalability of BGP.

Ahsan Saba (Aalto University) presented challenges in designing active measurements for YouTube that can accurately model the performance from an end user's perspective. She reasoned how the diversity of the types and formats of videos available in YouTube, alongwith need for client-side intelligence and the evolving nature of the service itself makes it hard to benchmark its performance using active measurement techniques. She presented a methodology and preliminary results using a dataset of popular YouTube videos. She showed how the dataset was used to identify different characteristics that can describe a "representative" video and she explained how these characteristics are eventually used to model video for active measurements.

Fabien Duchêne (University of Louvain) introduced `tracebox` [9], an extension to the widely used `traceroute` tool, that is capable of detecting various types of middlebox interference over a path. He described how `tracebox` operates by sending Internet Protocol (IP) packets containing Transmission Control Protocol (TCP) segments or User Datagram Protocol (UDP) datagrams with different Time to Live (TTL) values to a destination. It later analyses the packet encapsulated in the returned Internet Control Message Protocol (ICMP) message over each hop. By comparing the response with the request, `tracebox` is not only able to detect modifications performed by middleboxes, but is also often able to pinpoint the network hop where the middlebox interference occurs. Fabien also presented measurement results obtained through a deployment on PlanetLab nodes.

Vaibhav Bajpai (Jacobs University Bremen) introduced `happy` [10], a metric to measure TCP connection establishment times to popular dual-stacked web services . He presented the measurement methodology, the web-services selection rationale, alongwith the scope and geographical distribution of the measurement trials. He showed how he ensured access to certain services were not being administratively blocked from the deployed probes. He presented preliminary data analysis results that showed several cases where the TCP connection establishment times and their variations over IPv6 were higher.

## 5 Future Outlook

A vision that outlines the challenges of the future and is able to critique current state-of-the-art tools and techniques can help drive the measurement research forward. The last session was therefore dedicated to ideas and trends that may help shape the direction for future network measurement research.

Jair Santanna (University of Twente) opened the session by introducing the Distributed Denial of Service (DDoS) as a Service (DDoSaaS) phenomenon [11]. He described how the goal of his research is to characterize the DDoSaaS phenomenon by investigating techniques to fingerprint and to mitigate these attacks. He presented two approaches to pursue this goal: (a) utilize a large-scale network measurement platform to monitor the DDoSaaS behavior, and (b) buy/hire attacks and perform them against one controlled and monitored test-subnetwork to study their characteristics. Jair also presented preliminary results to demonstrate the scale

of such attacks where the highest attack measured had a peak of 4.2 Gbps and two different DDoSaaS were sharing more than six thousands IP addresses.

Dimitri Papadimitriou (Alcatel-Lucent) presented the foundational principles and techniques of hypergraph mining. He motivated the problem by explaining how graph modeling fails to capture group-level interactions between entities. He explained how hypergraphs fill this gap by modeling many-to-many relationships among entity attributes thereby enabling handling of problems such as similarity, clustering and construction of classifiers. He demonstrated the technique by clustering and classifying network traffic data modeled as a time series. He went further to explain how a probabilistic hypergraph, by also maintaining the probability that a vertex belongs to a hyperedge, allows correlation of information among vertices to be described more accurately. He demonstrated its usefulness by applying the problem of analysing the relationships between (attributes of) traffic directed to certain AS/prefixes (vertex) and content caches/servers (hyperedge) as a probabilistic hypergraph.

Lukáš Kekely (CESNET) introduced the concept of Software Defined Monitoring (SDM), a hardware-accelerated approach to network monitoring [12]. The hardware accelerator is a Field-Programmable Gate Array (FPGA) board with an application-specific processor firmware tailored for stateful flow processing. The software on the other hand is a flow exporter with plug-in support for advanced monitoring tasks. He explained how by tightly coupling the hardware and software, they were able to offload the elementary NetFlow monitoring tasks to the 100 Gb/s hardware accelerator, while the software application focused more on anomaly detection and application protocol parsing tasks. He demonstrated a proof-of-concept implementation and proposed future plans to deploy SDM probes at the CESNET network perimeter to improve the quality of network security monitoring.

Daniel Dönni (University of Zürich) introduced the concept of Value-of-Service (VoS), which captures the price-performance ratio of an IP network by relating QoS and QoE metrics to its normalized price. It provides a generic VoS definition and determines the key set of relevant VoS metrics. He presented scenarios demonstrating how these VoS metrics can be used to assess the quality and performance of an IP network by keeping it sensitive to the price of the product.

## 6 Conclusion

The 1st NMRG workshop on Large Scale Network Measurements co-located with the CNSM conference[7] concluded successfully on October 14th, 2013. All of the presentation material and contact information of presentors are archived online at the workshop proceedings website[8]. A second iteration of the workshop is planned for 2015. Announcements on upcoming Network Management Research Group NMRG workshops and call for presentations are usually made on the NMRG

[7] http://www.cnsm-conf.org/2013.

[8] http://www.ietf.org/proceedings/interim/2013/10/14/nmrg/proceedings.

mailing list[9]. The readers can also directly contact the authors of this report to learn more about the organization of the next workshop in the measurement space.

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