Activity Report 2014

Team MUSE

Measuring networks for enhancing USer Experience

RESEARCH CENTER
Paris - Rocquencourt

THEME
Networks and Telecommunications

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Team MUSE

Keywords: Networks, Monitoring, Metrology, Performance, Quality Of Experience

Creation of the Team: 2013 October 03.

1. Members

Research Scientists

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Faculty Member

Timur Friedman [Univ. Paris VI, Associate Professor, from Sep 2014, en délégation chez Inria]

PhD Students

Sara El Aouad [Inria/Technicolor, from May 2014]
Oana Goga [Univ. Paris VI, until Jun 2014]
Diego Neves Da Hora [Inria/Technicolor, from February 2014]
Giuseppe Scavo [Inria/Alcatel, from November 2013]
Stéphane Wustner [Univ. Paris VI/Technicolor, from October 2013 until November 2014]

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Others

Stéphane Archer [Inria, undergraduate intern, from Apr 2014 until Jul 2014]
Omayma Belkadi [Inria, master intern, from Apr 2014 until Aug 2014]
Sarthak Grover [Univ. Paris VI/Georgia Tech, doctoral intern, from May 2014 until Aug 2014]
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Mauricio Santoro [Inria, master intern, from May 2014 until Sep 2014]

2. Overall Objectives

2.1. Overall Objectives

Muse's research is broadly in the area of network measurements. We focus on developing new algorithms and systems to improve user experience online. In particular, we are addressing two main problems of today's Internet users:

1. Technology is too complex. Most Internet users are not tech-savvy and hence cannot fix performance problems and anomalous network behavior by themselves. The complexity of most Internet applications makes it hard even for networking experts to fully diagnose and fix problems. Users can't even know whether they are getting the Internet performance that they are paying their providers for.
2. There is too much content. Users are often lost when deciding which articles to read or which movie to watch, for instance.

3. Research Program

3.1. Active probing methods

We are developing methods that actively introduce probes in the network to discover properties of the connected devices and network segments. We are focusing in particular on methods to discover properties of home networks (connected devices and their types) and to distinguish if performance bottlenecks lie within the home network versus outside. Our goal is to develop adaptative methods that can leverage the collaboration of the set of available devices (including end-user devices and the home router, depending on which devices are running the measurement software).

3.2. Passive monitoring methods

This part our research develops methods that simply observe network traffic to infer the performance of networked applications and the location of performance bottlenecks, as well as to extract patterns of web content consumption. We are working on techniques to collect network traffic both at user's end-devices and at home routers. We also have access to network traffic traces collected on a campus network and on a large European broadband access provider.

3.3. Inferring user online experience

We are developing hybrid measurement methods that combine passive network measurement techniques to infer application performance with techniques from HCI to measure user perception. We will later use the resulting datasets to build models of user perception of network performance based only on data that we can obtain automatically from the user device or from user's traffic observed in the network.

3.4. Content summarisation

We are working on methods to summarise a set of reviews (for example, movie reviews from Rotten Tomatoes or IMDB; or restaurant reviews from Yelp) with a set of representative tags. Each tag is a sequence of two or three words. In parallel, we are building a mobile app that allows users to directly enter tags instead of free-text reviews.

4. Application Domains

4.1. Home Network Diagnosis

With the availability of cheap broadband connectivity, Internet access from the home has become a ubiquity. Modern households host a multitude of networked devices, ranging from personal devices such as laptops and smartphones to printers and media centers. These devices connect among themselves and to the Internet via a local-area network—a *home network*— that has become an important part of the "Internet experience". In fact, ample anecdotal evidence suggests that the home network can cause a wide array of connectivity impediments, but their nature, prevalence, and significance remain largely unstudied.

Our long-term goal is to assist users with concrete indicators of the causes of potential problems and—ideally—ways to fix them. We intend to develop a set of easy-to-use home network diagnosis tools that can reliably identify performance and functionality shortcomings rooted in the home. The development of home network diagnosis tools brings a number of challenges. First, home networks are heterogenous. The set of devices, configurations, and applications in home networks vary significantly from one home to another. We must develop sophisticated techniques that can learn and adapt to any home network as well as to the level of expertise of the user. Second, there are numerous ways in which applications can fail or experience poor performance in home networks. Often there are a number of explanations for a given symptom. We must devise techniques that can identify the most likely cause(s) for a given problem from a set of possible causes. Third, even if we can identify the cause of the problem, we must then be able to identify a solution. It is important that the output of the diagnosis tools we build is "actionable". Users should understand the output and know what to do.

We are conceiving methods for two application scenarios: (i) when the end user in the home deploys our diagnostic tools either on the home gateway (the gateway often combines a DSL/cable modem and an access point; it connects the home network to the ISP) or on devices connected to the home network and (ii) when ISPs collect measurements from homes of subscribers and then correlate these measurements to help identify problems.

Assisting end users. We are developing algorithms to determine whether network performance problems lie inside or outside the home network. Given that the home gateway connects the home with the rest of the Internet, we are designing an algorithm (called *WTF*) that analyzes traffic that traverses the gateway to distinguish access link and home network bottlenecks. A measurement vantage point on the gateway is key for determining if the performance bottleneck lies within the home network or the access ISP, but we also need to deploy diagnosis tools in end-devices. First, some users may not want (or not know how) to deploy a new home gateway in their homes. Second, some problems will be hard to diagnose with only the vantage point of the gateway (for example, when a device cannot send traffic or when the wireless is poor in certain locations of a home). We can obtain more complete visibility by leveraging *multiple* measurement nodes around the home, potentially including the home gateway, all participating jointly in the measurement task. We have an ongoing project to realize a home network analyzer as a web-based measurement application built on top of our team's recently developed browser-based measurement platform, *Fathom*. To integrate the home gateway in the analyzer, we plan to engage the BISmark Project. BISmark already provides a web server as well as extensive configurability, allowing us to experiment freely with both passive as well as active measurements. We must develop a home network analyzer that can first discover the set of devices connected to the home network that can collaborate on the diagnosis task. We will then develop tomography algorithms to infer where performance problems lie given measurements taken from the set of available vantage points.

Assisting Internet Service Providers (ISPs). Our discussions with several large access ISPs reveal that service calls are costly, ranging from $9–25 per call, and as many as 75% of service calls from customers are usually caused by problems that have nothing to do with the ISP. Therefore, ISPs are eager to deploy techniques to assist in home network diagnosis. In many countries ISPs control the home gateway and set-top-boxes in the home. We plan to develop more efficient mechanisms for home users to report trouble to their home ISP and consequently reduce the cost of service calls. This project is in collaboration with Technicolor and Portugal Telecom. Technicolor is a large manufacturer of home gateways and set-top-boxes. Portugal Telecom is the largest broadband access provider in Portugal. Technicolor already collects data from 200 homes in Portugal. We are working with the data collected in this deployment together with controlled experiments to develop methods to diagnose problems in the home wireless.

4.2. Quality of Experience

Understanding how users react to different levels of network performance presents two main challenges:

1. User perception is subjective and contextual. Different users may have different tolerance levels to network performance and the same user may have different expectations under different circumstances. Take for example the round-trip time (RTT), a typical network performance metric. If RTTs are larger than usual, a user who is doing remote login may feel that the connection is unusable, whereas another who is watching YouTube may notice no problem (because YouTube has a playout buffer to mask some network delay). Take another example of a user downloading her email. This user may tolerate some delay when she is leisurely checking her email at home, but she may become extremely frustrated with the same delay if she is in an airplane and needs to download her email just before takeoff.
2. It is challenging to "measure" users. We must develop methods to measure the user perception of network performance as users perform their routine online tasks. It is hence important that these methods are not too intrusive. Otherwise, users are unlikely to participate in the experiment. In addition, we must capture user perception at different levels of performance and in a variety of scenarios.

We will develop tools that run on end systems to collect network performance data annotated with the user perception. These tools will adopt a hybrid measurement methodology that combines network measurement techniques to infer application performance with techniques from HCI to measure user perception. We will later use the resulting datasets to build models of user perception of network performance based only on data that we can obtain automatically from the user device or from user's traffic observed in the network. Models of user perception of network performance can be used to detect when performance is poor to trigger diagnosis or to adapt network/application performance to better serve users.

4.3. Crowd-sourced content recommendation

The Internet today serves as a large content distribution platform (online content varies from traditional news, TV series, and movies to specialized blogs and family pictures shared over social networks) as well as a platform for users to exchange opinions about practically everything (from movies to services and restaurants). The amount of information available online today overwhelms most users and selecting which content to watch or what do has become a challenge. We are applying passive measurement methods and content summarisation techniques to help users to identify relevant content in two scenarios. First, we are developing a system called WeBrowse that passively observes network traffic to extract user clicks (i.e., the URLs users visit). A user click is a good measure of interest, as users often have an idea of the type of content they are about to access (e.g., because they saw a preview or because a friend recommended it). Intuitively, the more users click on a URL, the higher the interest in the content on the corresponding page. WeBrowse then promotes "hottest" and most popular content to users of a network. We have a deployment of WeBrowse in a campus network. Second, we are working on techniques to summarise user feedback (for example, movie or restaurant reviews) with semi-structured feedback. Today reviews are either free-form text or star rating. Star rating is too coarse to capture the nuances of why a user likes or dislikes something, whereas free text is hard for users to parse and extract a clear opinion. We are instead working with semi-structured reviewing where users enter *tags* (a short sequence of words describing the user experience). We are working with Technicolor on the summarisation of movie reviews and on building a mobile app (called TagIt) where users can review movies directly with tags.

5. New Software and Platforms

5.1. Fathom v2.0

Contributors: Anna-Kaisa Pietilainen, Stephane Archer

Available at: https://muse.inria.fr/fathom

Fathom [9] is a Firefox browser extension that explores the browser as a platform for network measurement and troubleshooting. It provides a wide range of networking primitives directly to in-page JavaScript including raw TCP/UDP sockets, higher-level protocol APIs such as DNS, HTTP, and UPnP, and ready-made functionality such as pings and traceroutes. Fathom v2.0 is a complete rewrite of the original Fathom using the new add-on SDK from Mozilla. In addition to javascript APIs, we have improved and added new built-in network measurement tools to Fathom such as 'Debug my Connection', 'Homenet Discovery' and 'Baseline Monitoring' that allow users to troubleshoot home network problems and share with us data for further research on home networks usage and diagnosis.

5.2. OpenWRT Packages for Network Measurements

Contributors: Anna-Kaisa Pietilainen, Sarthak Grover

Available at: https://github.com/apietila/browserlab

OpenWRT is a version of the Linux operating system to run on embedded devices, in particular, in home routers and access points. We have developed an OpenWRT package repository that provides fixes for and new ports of several existing network measurement tools (including iperf, iperf3, shaperprobe and pathload) for OpenWRT and an extended JSON RPC API for LuCI (OpenWRT control interface) to collaborate with the Fathom extension on home network diagnosis.

5.3. TagIt

Contributors: Sara El Aouad, Christophe Diot (Technicolor), Renata Teixeira

Available at: https://drive.google.com/file/d/0B-OcOkKOXok2b3lZYmt4QUw0cGM/view?usp=sharing
Video demo available at:

https://drive.google.com/file/d/0B-OcOkKOXok2VUxQR1NmRlg5VE0/view?usp=sharing

TagIt is an android app that makes it easy for users to enter movie reviews and to summarise the set of reviews of each movie. TagIt uses tags (or a short sequence of words) for entering user's opinions about a movie, so it is easy and quick for users to enter their feedback. TagIt also allows users to quickly see the opinion of other users about a movie with a tag cloud that summarises the set of reviews of a movie.

5.4. Where is the fault?

Contributors: Srikanth Sundaresan (Georgia Tech), Nick Feamster (Georgia Tech), Renata Teixeira

Where's The Fault? (WTF) is a system that localizes performance problems in home and access networks. We implement WTF as custom firmware that runs in an off-the-shelf home router. WTF uses timing and buffering information from passively monitored traffic at home routers to detect both access link and wireless network bottlenecks. We presented a demo of WTF at the ACM SIGCOMM conference in 2014. [4]

5.5. WeBrowse

Contributors: Giuseppe Scavo, Zied Ben Houidi (Alcatel-Lucent Bell Labs), Stefano Traverso (Politecnico di Torino), Marco Mellia (Politecnico di Torino), Renata Teixeira

Available at: http://tstat.polito.it/netcurator/

WeBrowse is the first passive crowdsource-based content curation system. Content curation is the act of assisting users to identify relevant and interesting content in the Internet. WeBrowse requires no active user engagement to promote content. Instead, it extracts the URLs users visit from traffic traversing an ISP network to identify popular content. WeBrowse contains a set of heuristics to identify the set of URLs users visit and to select the subset that are interesting to users [7]. The system proposes the interesting content in a web page available to all users.

5.6. UCN Data Collection

Contributors: Anna-Kaisa Pietilainen, Tom Logde (University of Nottingham), Richard Mortier (University of Nottingham), Peter Tolmie (University of Notthingham), Renata Teixeira

Available at: https://muse.inria.fr/ucn, code https://github.com/ucn-eu

The User-Centric Networking (UCN) project is seeking to understand how people consume various kinds of content when using computer networks. Within this project we are undertaking a detailed user study across a range of environments in order to understand the practices involved in consuming media and other content according to context. For the study, we have set up the following tools and software:

- **Registration and management website:** we have developed a website containing information about the experiment, and user and device registration interfaces.
- **VPN server and clients for network traffic data collection:** we are using OpenVPN open-source VPN server and available free clients on multiple platforms (OpenVPN for Linux, OpenVPN for Android, Tunnelblick for OS X, OpenVPN Connect for iOS) to collect network traffic traces from the participating devices. The VPN server is running on a secure Inria server, and we collect packet headers using tcpdump and http traffic logs with a Squid HTTP proxy. Collected data is stored on another server not directly accessible from the Internet.
- **Activity logging software:** we have developed a small Android application to log additional activity details such as list of running applications, foreground application, screen state, network connectivity details, and system resources (cpu, memory, network, battery) usage.
- **Data collection from Moves and Google Calendar:** we have written some code to import user data from Moves application and a Google Calendar based diary to add user location and daily activity logs to the data set.
- **Data visualisation:** the website contains a section to visualise all the collected data (network traffic as a function of location, time of day, activity) to support interviews with an ethnographer.

We have obtained Ethics approval from Inria's COERLE for conducting the data collection and the user study and have done the CNIL declaration for this data collection. Our data collection and user study will start early 2015.

6. New Results

6.1. Pinpointing Home and Access Network Delays Using WiFi Neighbors

Participants: Lucas Di Cioccio (LIP6/Technicolor), Martin May (Technicolor), Jim Kurose (University of Massachusetts, Amherst), Renata Teixeira

Home Internet users and Internet access providers need tools to assist them in diagnosing and troubleshooting network performance problems. Today, expert users may rely on simple techniques using round-trip-measurements to local and remote points to locate delays on an end-to-end path. Unfortunately, round-trip measurements do not provide accurate diagnoses in the presence of asymmetric link capacities and performance, which is often the case in residential access. Our work [8] introduces *neighbor-assisted delay diagnosis* (NADD) - an approach for pinpointing the location of delays (among the home, access, and wide-area network), leveraging end-host multi-homing capabilities. NADD runs on an end host connected simultaneously to the home gateway and to a neighbor WiFi access point. Our evaluation shows that NADD efficiently detect and distinguish uplink and downlink delays with small error. In addition, we learn from a proof-of-concept deployment in five homes in France that our techniques can work "in the wild." Technicolor filed a patent on this work [8].

6.2. Locating Throughput Bottlenecks in Home Networks

Participants: Srikanth Sundaresan (ICSI), Nick Feamster (Princeton), Renata Teixeira

We developed *WTF (Where's The Fault?)* [4], a system that localizes performance problems in home and access networks. We implement WTF as custom firmware that runs in an off-the-shelf home router. WTF uses timing and buffering information from passively monitored traffic at home routers to detect both access link and wireless network bottlenecks. The Federal Communication Commission (FCC) in the United States deployed WTF in 3000 homes for a few days in November 2014. We are currently analyzing the resulting dataset to help shed light on common pathologies that occur in home networks.

6.3. Measuring the Performance of User Traffic in Home Wireless Networks

Participants: Srikanth Sundaresan (ICSI), Nick Feamster (Princeton), Renata Teixeira

This work [5] studies how home wireless performance characteristics affect the performance of user traffic in real homes. Previous studies have focused either on wireless metrics exclusively, without connection to the performance of user traffic; or on the performance of the home network at higher layers. In contrast, we deploy a passive measurement tool on commodity access points to correlate wireless performance metrics with TCP performance of user traffic. We implement our measurement tool, deploy it on commodity routers in 66 homes for one month, and study the relationship between wireless metrics and TCP performance of user traffic. We find that, most of the time, TCP flows from devices in the home achieve only a small fraction of available access link throughput; as the throughput of user traffic approaches the access link throughput, the characteristics of the home wireless network more directly affect performance. We also find that the 5 GHz band offers users better performance better than the 2.4 GHz band, and although the performance of devices varies within the same home, many homes do not have multiple devices sending high traffic volumes, implying that certain types of wireless contention may be uncommon in practice.

6.4. Characterizing Bufferbloat and its Impact at End-hosts

Participants: Stephane Wustner, Jaideep Chandrashekar (Technicolor), Renata Teixeira

While, on routers and gateways, buffers on forwarding devices are required to handle bursty Internet traffic, overly large or badly sized buffers can interact with TCP in undesirable ways. This phenomenon is well understood and is often called "bufferbloat". Although a number of previous studies have shown that buffering (particularly, in home) can delay packets by as much as a few seconds in the worst case, there is less empirical evidence of tangible impacts on end-users. In [3], we develop a modified algorithm that can detect bufferbloat at individual end-hosts based on passive observations of traffic. We then apply this algorithm on packet traces collected at 55 end-hosts, and across different network environments. Our results show that 45 out of the 55 users we study experience bufferbloat at least once, 40% of these users experience bufferbloat more than once per hour. In 90% of cases, buffering more than doubles RTTs, but RTTs during bufferbloat are rarely over one second. We also show that web and interactive applications, which are particularly sensitive to delay, are the applications most often affected by bufferbloat.

6.5. Measuring and Characterising User Online Activity

Participants: Omayma Belkadi, Mauricio Santoro, Anna-Kaisa Pietilainen, Renata Teixeira

The goal of our work is to identify what people are doing online (or the online user activity) from passively collected network traffic traces. Our analysis of network traffic and application information from 12 end-hosts shows that this task is challenging because there are often many applications running on each user's device, whereas the user is only interacting with one application at a time. Our work with two master students presents the first evaluation of the set of features computable from network traffic alone that can help distinguish user activity traffic from all other traffic flows [6], [10]. We obtain ground truth on user activities and network traffic traces in a controlled setting, and complement this dataset with traces collected by the HostView monitoring tool on the devices of 12 users over several months. We develop simple heuristics to extract user activities for the HostView dataset based on the foreground application and on keyboard/mouse activity. Then, we analyze which network traffic features allow us to distinguish between online user activity and background network traffic. Features related to traffic volumes and timings show the most significant differences.

6.6. WeBrowse: a Passive Content Curation System Based on HTTP Logs

Participants: Giuseppe Scavo, Zied Ben Houidi (Alcatel-Lucent), Renata Teixeira, Stefano Traverso (Politecnico di Torino), Marco Mellia (Politecnico di Torino)

Content curation refers to the act of assisting users to identify relevant and interesting information in the overwhelming amount of online content available today. Existing curation services rely either on experts or on crowdsourcing to promote content. This work designs, implements, and evaluates WeBrowse, the first passive crowdsourced content curation system. WeBrowse requires no active user engagement to promote content. Instead, it extracts the URLs users visit from traffic traversing an ISP network to identify popular and interesting content. A key challenge to design such a passive curation system is to process network traffic in real-time to identify the small set of URLs that are interesting to users. WeBrowse contains a set of heuristics to identify the set of URLs users visit and to select the subset that are interesting, while preserving their privacy at the same time. We prototype WeBrowse and evaluate it using traces collected at a large European ISP, and in a deployment in a large campus network. We have tested and improved WeBrowse with a small number of users from September 2014 to January 2015. The plan is to announce WeBrowse to all users of the campus network early 2015 to get feedback on their experience with the system.

Available at: http://tstat.polito.it/netcurator/

7. Bilateral Contracts and Grants with Industry

7.1. Bilateral Contracts with Industry

- "Improving the quality of recommendation using semi-structured user feedback" CIFRE contract with Technicolor for thesis of Sara el Aouad from May 2014 to April 2017.

- "Crowdsourced Home Network Diagnosis" CIFRE contract with Technicolor for thesis of Diego da Hora from February 2014 to January 2017.
- "Exploiting Network Content-awareness to provide novel added value services" contract under the Inria-Alcatel Lucent Bell Labs common Lab (ADR ICN) to fund the doctoral thesis of Giuseppe Scavo from November 2013 to October 2016.
- "Automated Network Troubleshooting Based on Collaboration of Home Devices" CIFRE contract with Technicolor for thesis of Stephene Wustner from Feb 2012 to Nov 2014.

7.2. Bilateral Grants with Industry

- "Home Network Troubleshooting with the Fathom Measurement Platform" in collaboration with Christian Kreibich (ICSI), gift from Google/M-lab, 2013-2014.

8. Partnerships and Cooperations

8.1. European Initiatives

8.1.1. User-Centric Networking (UCN)

Type: FP7

Instrument: Specific Targeted Research Project

Duration: October 2013 - September 2016

Coordinator: Technicolor

Other partners: Eurecom, Fraunhofer FOKUS, Intamac, University of Cambridge, University of Nottingham, Martel, NICTA, Portugal Telecom

Inria contact: Renata Teixeira

Abstract: This project introduces the concept of User Centric Networking (UCN), which is a new paradigm leveraging user information at large to deliver novel content recommendation systems and content delivery frameworks. UCN recommendation and content delivery systems will leverage in-depth knowledge about users to help them find relevant content, identify nearby network resources and plan how to deliver the actual content to the appropriate device at the desired time. These systems will additionally account for influences from users' social networks on their content consumption. The goal of this project is to design a UCN system architecture for user-centric connected media services. We will build UCN upon three complementary research pillars:

1. understanding user context: This data can be broadly categorized into three groups. First, the physical and environmental context A second category of data is that which can be extracted from social network interactions. The third category of data is behavioural
2. profiling and predicting user interests: By gaining a deep understanding of the user, we may be able to cast a much wider net in the content ocean and locate a richer catalogue of interesting content for the user
3. personalizing content delivery: Rather than the user (or the service provider) having to worry about the mode of connectivity, device, service, location, etc., the network intelligently directs and adapts the transport stream, or perhaps pre-fetches and replicates content chunks, to the particular and immediate needs of the user.

See also: http://usercentricnetworking.eu/

8.2. International Initiatives

8.2.1. Informal International Partners

- Georgia Institute of Technology (Prof. Nick Feamster and his doctoral students Srikanth Sundaresan and Sarthak Grover): We have a long-term collaboration on measuring the performance of residential broadband Internet access networks and more recently on home network diagnosis.
- ICSI, UC Berkeley (Prof. Vern Paxson, Dr. Christian Kreibich, Dr. Robin Sommer): With V. Paxson and C. Kreibich, we have been developing Fathom, a browser-based network measurement platform. We are now adding home network diagnosis capabilities to Fathom. In addition, with Robin Sommer we are working on the potential of matching the profiles of a user across multiple online social networks.

8.3. International Research Visitors

8.3.1. Internships

- O. Belkadi, master intern, National School of Applied Sciences (ENSA), Tangier, from Apr 2014 until Aug 2014.
- S. Grover, doctoral intern from Georgia Tech, from May 2014 until Aug 2014.
- M. Santoro, master intern, Universidad Politecnica de Valencia, from May 2014 until Sep 2014.

9. Dissemination

9.1. Promoting Scientific Activities

9.1.1. Scientific events organisation

9.1.1.1. Member of steering/executive committee

- R. Teixeira, Vice-chair of ACM SIGCOMM (since Jun. 2013).
- R. Teixeira, member of the steering committee of the ACM Internet Measurement Conference (since Nov. 2009)

9.1.2. Scientific events selection

9.1.2.1. Chair of selection committee

- R. Teixeira, Workshop co-chair of ACM SIGCOMM 2015.

9.1.2.2. Member of conference program committee

- R. Teixeira, ACM SIGCOMM 2014
- R. Teixeira, ACM SIGCOMM Poster and Demo 2014
- R. Teixeira, ACM CoNEXT 2014

9.1.3. Journal

9.1.3.1. Member of editorial board

- R. Teixeira, Editor of IEEE/ACM Transactions on Networking (since Feb. 2011)
- R. Teixeira, Area editor of ACM Sigcomm Computer Communication Review (Feb. 2010 – July 2014)

9.1.3.2. Reviewer

- A.-K. Pietilainen, ACM Transactions on Multimedia Computing; Elsevier Pervasive and Mobile Computing

9.1.4. Tutorials and invited presentations

- R. Teixeira, “Internet measurements: topology discovery and dynamics”, tutorial at the Rescom summer school, Corsica, May 2014.

- A.-K. Pietilainen and R. Teixeira, “Measurements close to users”, tutorial at the 4th PhD School on Traffic Monitoring and Analysis (TMA), London, April 2014.
- R. Teixeira, “Measuring Internet Experience from Home Networks”, seminar at Federal University of Rio de Janeiro (UFRJ) and at Federal Univeristy of Minas Gerais (UFMG), Brazil, October 2014. Seminar at University of Washington, USA, November 2014.

9.2. Teaching - Supervision - Juries

9.2.1. Teaching

Master: Renata Teixeira, “Methodology for research in networking”, 21.5h eqTD, M2, UPMC, France

9.2.2. Supervision

PhD: Oana Goga, “Matching User Accounts Across Online Social Networks: Methods and Applications”, EDITE, May 21, 2014, advisor: Renata Teixeira

PhD in progress:

- Sara el Aouad, “Improving the quality of recommendation using semi-structured user feedback”, May 2014, advisors: C. Diot and R. Teixeira
- Diego da Hora, “Crowdsourced Home Network Diagnosis”, February 2014, advisors: C. Diot and R. Teixeira
- Giuseppe Scavo, “Exploiting Network Content-awareness to provide novel added value services”, November 2013 advisors: Z. Ben-Houidi and R. Teixeira

9.2.3. Juries

Renata Teixeira: member of PhD committee of Zachary Scott Bischoff (Northwestern University, 2014) and Srikanth Sundaresan (Gorgia Tech, 2014)

10. Bibliography

Publications of the year

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International Conferences with Proceedings

[4] S. SUNDARESAN, N. FEAMSTER, R. TEIXEIRA. *Locating Throughput Bottlenecks in Home Networks*, in "ACM SIGCOMM (demonstration)", Chicago, United States, August 2014 [*DOI :* 10.1145/2619239.2631440], https://hal.inria.fr/hal-01100729

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