Demo: MONROE, a distributed platform to measure and assess mobile broadband networks*

Özgü Alay, Andra Lutu
Simula Research Laboratory

Rafael García, Miguel Peón-Quirós, Vincenzo Mancuso
IMDEA Networks Institute

Thomas Hirsch, Tobias Dely, Jonas Werme, Kristian Evensen, Audun Hansen
Celerway Communications

Stefan Alfredsson, Jonas Karlsson, Anna Brunstrom
Karlstad University

Ali Safari Khatouni, Marco Mellia, Marco Ajmone Marsan
Politecnico di Torino

Roberto Monno
Nextworks

Hakon Lonsethagen
Telenor Research

ABSTRACT

This demo presents the MONROE distributed platform and how it can be used to implement measurement and assessment experiments with operational mobile broadband networks (MBBs). MONROE provides registered experimenters with open access to hundreds of nodes, distributed over several European countries and equipped with multiple MBB connections, and a backend system that collects the measurement results. Experiments are scheduled through a user-friendly web client, with no need to directly access the nodes. The platform further embeds tools for real-time traffic flow analysis and a powerful visualization tool.

CCS Concepts

•**Networks** → **Network experimentation; Network performance analysis;**

Keywords

MBB; large scale experiments; Demo

1. INTRODUCTION

Mobile broadband (MBB) networks and operators provide a variety of services using technologies like 3G, 4G and 4G+ to several billions of devices. At the same time, mobile data traffic grows exponentially, with a 69 % increase in 2014 and a tenfold expected increase by 2019 [1].

*Work partially supported by the European Union's Horizon 2020 research and innovation program under grant agreement No. 644399 (MONROE).

WiNTECH'16 October 03-07 2016, New York City, NY, USA

ACM ISBN 978-1-4503-4252-0/16/10.

DOI: http://dx.doi.org/10.1145/2980159.2980172

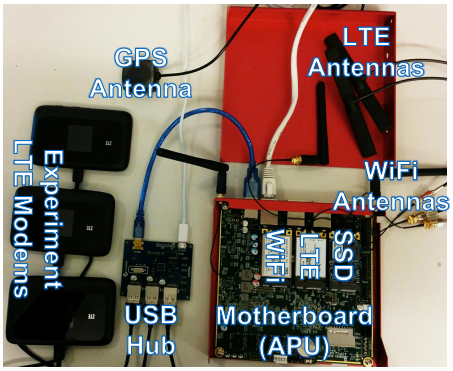

Figure 1: A MONROE measurement node.

With such a diffusion, and considering the variety of technologies and network deployment strategies, monitoring and assessing the performance and reliability of MBB networks is essential to guarantee the existence of appropriate infrastructures for a continued economic development. However, mobile applications that run speed tests [3] or drive-by tests [4] are not enough, because they are inherently not scalable and/or the measurements are not repeatable. Moreover, existing methods neglect the importance of accurate metadata information, e.g., location info, type of equipment, subscription type, which is fundamental to correctly contextualize the measurements.

We have developed a unique distributed platform to conduct independent, repeatable, multi-homed, large-scale measurement and experimental campaigns for collecting data from operational MBB networks. In our interactive demo, we show how to design and deploy measurements in real time using nodes spread over Europe, and how to collect and analyze the results with a user-friendly visualization tool.

2. THE MONROE PLATFORM

Figure 1 illustrates the hardware blocks of a MONROE node, which include a mini motherboard APU1D4,[1] a WiFi 802.11ac/b/g/n module, LTE modems (3 of which are connected via USB and used for experiments), a GPS unit,

[1]http://www.pcengines.ch/apu1d4.htm

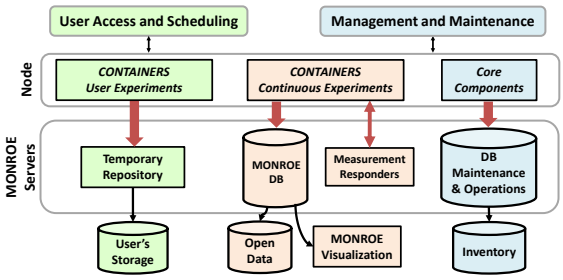

Figure 2: MONROE building blocks.

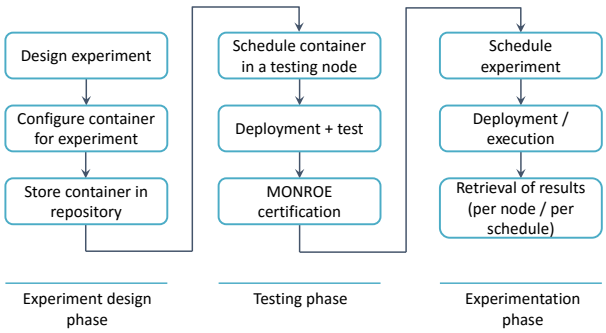

Figure 3: Experiment phases.

storage, and antennas. We have designed and built several hundreds of nodes and a software framework that is responsible for the orchestration of experiments and for the collection, analysis, visualization and sharing of measurements. Nodes are either statically placed or mobile, i.e., deployed on trains, trucks and busses. MONROE nodes act as normal MBB static or mobile users, with their off-the-shelf or custom applications.

The MONROE framework is illustrated in Figure 2 and comprises six main components: i) *User access and scheduling system:* Measurements are handled by a scheduling system through a user-friendly web interface. User access and provisioning of resources follow Fed4FIRE[2] federation specifications. ii) *Management and maintenance system,* which tracks node status, operational state and location. iii) *Node SW modules,* including MONROE core components (watchdog, routing, network monitor, etc.) and a set of Linux Docker containers[3] in which both basic MONROE and user experiments are executed in isolation. iv) *Remote repositories and databases:* Data and metadata are sent to remote repositories after each experiment, and then imported into an Apache Cassandra non-relational database. v) *"Measurement responders,"* used for active tests. vi) *Visualization:* It provides a near real-time graphical representation of the nodes status and experiments via a public web page.

Notably, the MONROE framework does not only allow monitoring and analyzing the behavior of network connections in real-time, but also jointly storing measurements and metadata in the form of open data for offline analysis.

3. EXPERIMENT LIFECYCLE

Figure 3 illustrates the lifecycle of an experiment. First, experimenters have to define the measurements they want to obtain and implement them in Docker containers, so they can consist of virtually any piece of software. Secondly, during the testing phase, a MONROE administrator checks that the behavior of the container adheres to a set of minimum safety and stability rules; approved container images are cryptographically signed and moved to our repository. Finally, the experimenter uses a web-based interface to schedule the experiment, selecting the number and types of nodes and suitable time-slots.

Experiments can collect active and passive traffic measurements from multiple MBB networks. For active measurements the platform provides both standard/well-known tools (e.g., ping, paris-traceroute) and project-crafted ones. For passive measurements, it embeds tools such as `Tstat` [2] to analyze the traffic generated. Moreover, each node passively generates a metadata stream with modem and connectivity status, and the measurements of several embedded HW sensors (GPS, CPU usage, temperature, etc.). Experimenters can either subscribe their experiments to the stream in real-time or consult the database afterwards. Considering that experimenters can deploy any additional measurement tools, the set of possible measurements is flexible and open.

[2]http://www.fed4fire.eu/
[3]http://www.docker.com

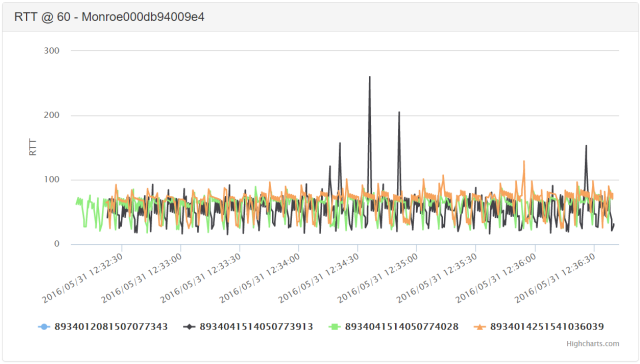

Figure 4: Interactive RTT chart.

Data and metadata stored in the database can be visualized using MONROE's web-based visualization tool, which produces interactive graphs such as time-based performance measurements, connection type/quality tracking and GPS location. For instance, Figure 4 shows the RTT graph for the MBB networks a node connects to.

4. CONCLUSIONS

This demo shows how to use MONROE as a distributed platform for the measurement and assessment of MBB networks. We show how to deploy active measurements on MONROE nodes. Then, we focus on interactive analysis and visualization of data and metadata collected in the tests.

5. REFERENCES

[1] Cisco Systems, Inc. *Cisco visual networking index: Global mobile data traffic forecast update, 2014 - 2019*, February 2015.

[2] Finamore, A., Mellia, M., Meo, M., MunafÃš, M. M., and Rossi, D. Experiences of internet traffic monitoring with tstat. *IEEE Network 25*, 3 (May 2011), 8–14.

[3] Kreibich, C., Weaver, N., Nechaev, B., and Paxson, V. Netalyzr: illuminating the edge network. In *Proc. of the 10th ACM SIGCOMM Conf. on Internet Measurement* (2010), pp. 246–259.

[4] Tektronix. Reduce Drive Test Costs and Increase Effectiveness of 3G Network Optimization. Tech. rep., Tektronix Communications, 2009.