

WiFiMon: Overview & Summary of Y1 Activities

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Presentation Outline

- WiFiMon: Introduction & Problem Statement
- WiFiMon: Data Flow & Overall Architecture
- Data Collection Technology: Crowdsourced & HW Probe Measurements
- TNC19 Pilot & Indicative Results
- Feedback from TNC19 & 6th SIG-PMV Meeting Audience
- Revision & Changes in WiFiMon – Feedback Integration
- Future Work

WiFiMon: Introduction

Mission Statement:

"...Is it possible to gather data from multiple sources, including browser-based measurements, in addition to traditional monitoring, and extract meaningful information on the performance of a WiFi network from that data?..."



Wireless Crowdsourced Performance Monitoring & Verification

Kurt Baumann(SWITCH), James Healy(DCU), Nikolaos Kanakis (GRnet), Vasileios Kokkinos(GRnet), Brian Mortensen (NORDUnet), Arne Oslebo (UNINETT), Kostas Stamos(GRnet), Anna Wilson (HEAnet)

How do we measure the USER'S ACTUAL EXPERIENCE on a Campus Network?

Hypothesis

"...Is it possible to gather data from multiple sources, including browser-based measurements, in addition to traditional monitoring, and extract meaningful information on the performance of a WiFi network from that data?..."

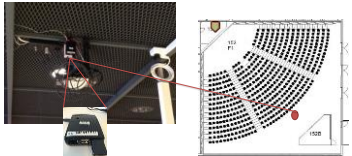
The data that we seek is actually only three items:

- The results of a performance test (Javascript)
- Which access point the user was connected (AP-ID)
- To when that test took place (Time Stamp).

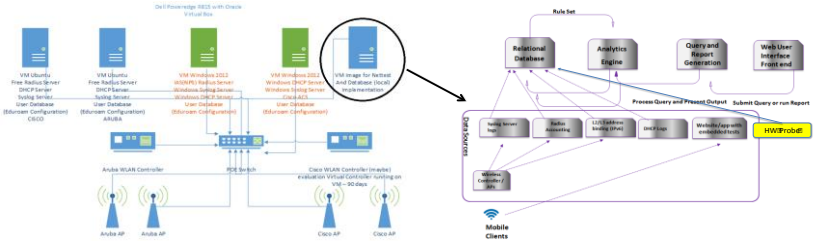
We use Javascript in the users browser to run the performance test, and use existing logs to map each performance test to an access point.

For more detailed information HW probes based on Raspberry Pi are used for collecting more detailed metrics like signal level, retransmissions, packet loss etc.

HW Probe



WiFiMon Testbed / Architecture Building Blocks





User Interface – GUI

The available data from the ROB and the AE is accessible through a network admin Web-UI which allows data querying.

Network administrators are the end-users of this Web-UI, which allows investigation of the collected performance reference data, and in turn, status checks of the wireless network.

This block of the architecture is also responsible for projecting the collected data and allowing real-time visualisation options.





Successful setups in both temporary and permanent installations

Dublin City University

AT DCU we performed pilot tests to determine whether it is possible to measure performance metrics of the wireless network -such as the download and upload rates and round trip time- via JavaScript, and whether these measurements can be contended with the information contained in the Radius and DHCP logs. At the same time, we had the challenge of distributed locations, so to enroll the measurement schema over multiple locations.

TNC 2015

Between 10:15 on Friday 12th June and 10:40 on Friday 19th June, we recorded a total of 1620 performance tests that we were able to associate with an access point on the TNC15 site network.

HEAnet Conference

HEAnet runs its annual conference every November in different locations, attended by over 200 NREN clients, from both Information Services and Libraries. The conference ran over two days and results were displayed in real time.

APAN40

The project team was looking for a further test case, a conference for confirmation the functionality of procedures, collecting and analysing data of the conference WiFi infrastructure. From discussions with SASTx we got a chance to introduce our measurement schema, the JavaScript deployment on the most frequent web-source, main and subpages of the APAN40 meeting. The APAN40 meeting took place from August 10 to 14 2015, at University of Malaysia, Kuala Lumpur, Malaysia.

NORDUnet Technical Workshop

The NORDUnet Technical Workshop took place on 15 - 17 September 2015, at Hotel Park Inn Kastarp, Copenhagen, Denmark. During the workshop, 105 measurements took place (all from the same public IP).








Your network!

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<https://lists.geant.org/sympa/info/wifimon-users>

Contributing Projects

GN4-1-SA3-T3
GN4-2-SA3-T5

Contact: Kurt Baumann <kurt.baumann@switch.ch>

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WiFiMon - Problem statement

Measuring and verifying the performance of WiFi networks is challenging.

There are no tools that:

- Cover all aspects of performance monitoring and verification.
- Determine how end-users experience WiFi at a given place on the network, at a given time.

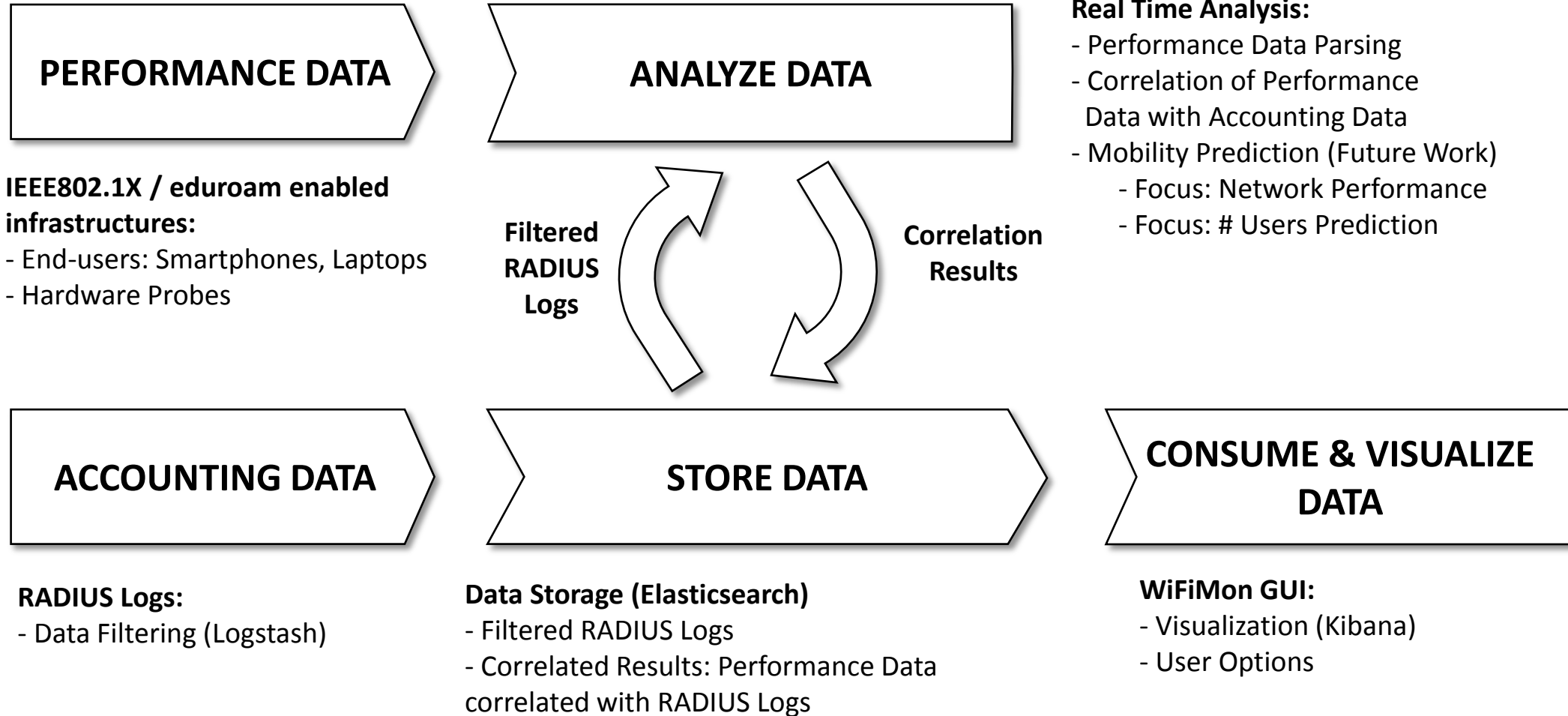
At present, information for wireless networks can be reported in three ways:

- Mobile End-User Device
- Wireless Access Points (WAP) / WiFi-Controller
- Network Management Systems (NMS)

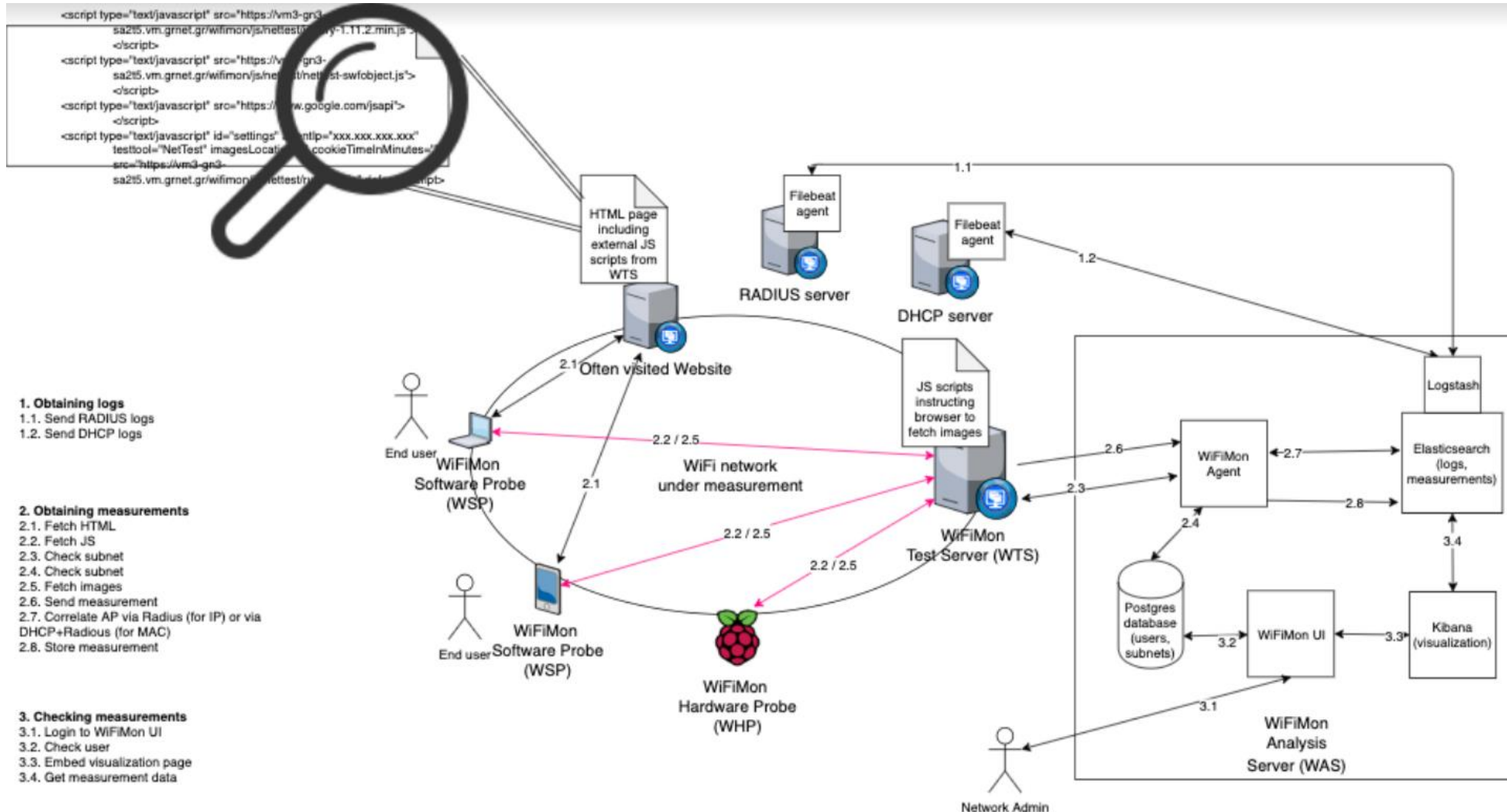
These sources allow “only” determining the wireless network is overall OK, e.g. up/down

- HW probes collect performance measurements but are installed at fixed locations. Crowdsourced measurements are also required.

WiFiMon - Data Flow



WiFiMon – Overall Architecture



WiFiMon Components:

- WiFiMon Software Probe (WSP)
- WiFiMon Hardware Probe (WHP)

- WiFiMon Test Server (WTS)
- WiFiMon Analysis Server (WAS)

WiFiMon – Data Collection Technology

- The end user visits a web page that includes JavaScript code. This triggers measurements.
- Available Test Tools: Nettetst, Boomerang, Speedtest

```
<html>
<head>
<title>NetTest measurement page</title>
  <script type="text/javascript" src="https://eipa19.eipa.ttu.ee/wifimon/js/nettest/
jquery-1.11.2.min.js"></script>
  <script type="text/javascript" src="https://eipa19.eipa.ttu.ee/wifimon/js/nettest/nettest-
swfobject.js"></script>
  <script type="text/javascript" src="https://www.google.com/jsapi"></script>
  <script type="text/javascript" id="settings" hostingWebsite="https" agentIp="wifimon.switch.ch"
agentPort="8443" testtool="NetTest-1" imagesLocation="https://eipa19.eipa.ttu.ee/wifimon/images/"
cookieTimeInMinutes="0.01"
      src="https://eipa19.eipa.ttu.ee/wifimon/js/nettest/runtests.js" defer></script>

<!--meta http-equiv="refresh" content="30" -->
</head>

<body>
  <h1>Sample https page for WiFiMon measurements using <strong>NetTest</strong></h1>
</body>
</html>
```

WiFiMon - Performing / Storing measurements

Pseudo code for performing/storing measurements

```
1: SET registered subnets //allow measurements only from WiFi subnet
2: CHECK if cookie is set for the user //avoid repeated measurements and
3:           //network overloading
4: IF user_IP inside registered_subnets
5:   IF cookie is not set
6:     GET timestamp
7:     CALCULATE download_throughput, upload_throughput, RTT
8:     GET user_IP, user_agent
9:     GET user_location // with Google API loader
10:    POST timestamp, download_throughput, upload_throughput,
11:        RTT, user_IP, user_agent, user_location to Elasticsearch
12:    SET cookie
13:  ENDIF
14: ENDIF
```

Network Overloading Avoidance:

- Measurements accepted only from registered subnets
- Cookie: repeated measurements in short time intervals are not permitted

WiFiMon - How we manage/correlate performance data

What we need	Javascript	RADIUS/DHCP
Timestamp	Timestamp	Timestamp
Performance result	Performance result	
ID of access point		ID of access point
	IP address	IP address

Pseudo code for correlating measurements with Radius logs

```
1: CHECK user_IP, timestamp //from measurements
2: CHECK client_IP, auth_timestamp // from Radius logs
3: WHILE auth_timestamp < timestamp // in descending order to
4: // select the most recent entry
5:   IF user_IP == client_IP
6:     INNER JOIN measurement and Radius_entry ON IP
7:     BREAK
8:   ENDIF
9: ENDWHILE
```

WiFiMon – Hardware Probes

Hardware Probes:

- A Raspberry Pi 3 Model B+
- A micro SD card with at least 16GB size
- **WiFiMon Raspberry Pi operating system image**
(Size ~ 3.6 GB)



WiFiMon – HW Probe setup steps

Step 1: Write the image to the micro SD card

Follow the instructions at the official Raspberry Pi. Skip the "Download the image" step and use the WiFiMon Raspberry Pi operating system image instead.

Step 2: Start the RPi

- Insert the microSD in the RPi
- Plug the USB keyboard and USB mouse
- Connect the monitor cable to the Pi's HDMI port
- Plug the power supply into a socket and connect it to the micro USB power port
- The Pi will boot up into a graphical desktop

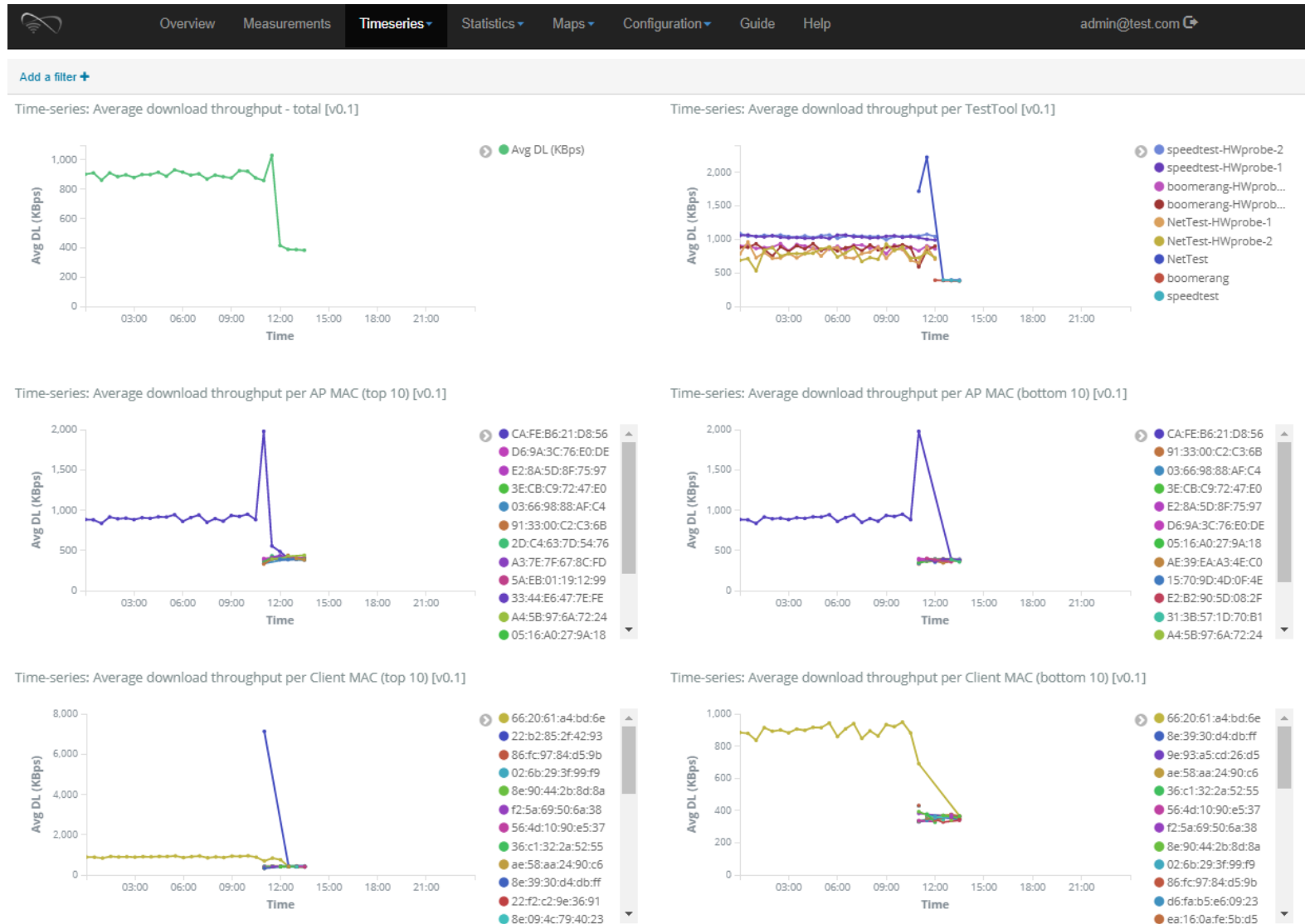
Step 3: Configure the RPi

- Connect to the wireless network you want to measure.
- Set which tests will be executed and how often

A simple crontab (20-minute measurements):

```
18,38,58 * * * * export DISPLAY=:0 && firefox --new-window https://www.google.com >/dev/null 2>&1
00,20,40 * * * * export DISPLAY=:0 && firefox --new-tab URL_TO_nettest.html >/dev/null 2>&1
02,22,42 * * * * export DISPLAY=:0 && firefox --new-tab URL_TO_speedworker.html >/dev/null 2>&1
04,24,44 * * * * export DISPLAY=:0 && firefox --new-tab URL_TO_boomerang.html >/dev/null 2>&1
06,26,46 * * * * scripts/kill-firefox.sh >/dev/null 2>&1
10 0 * * 0 scripts/pi-reboot.sh >/dev/null 2>&1
```

WiFiMon - Web-UI (Timeseries Tab)



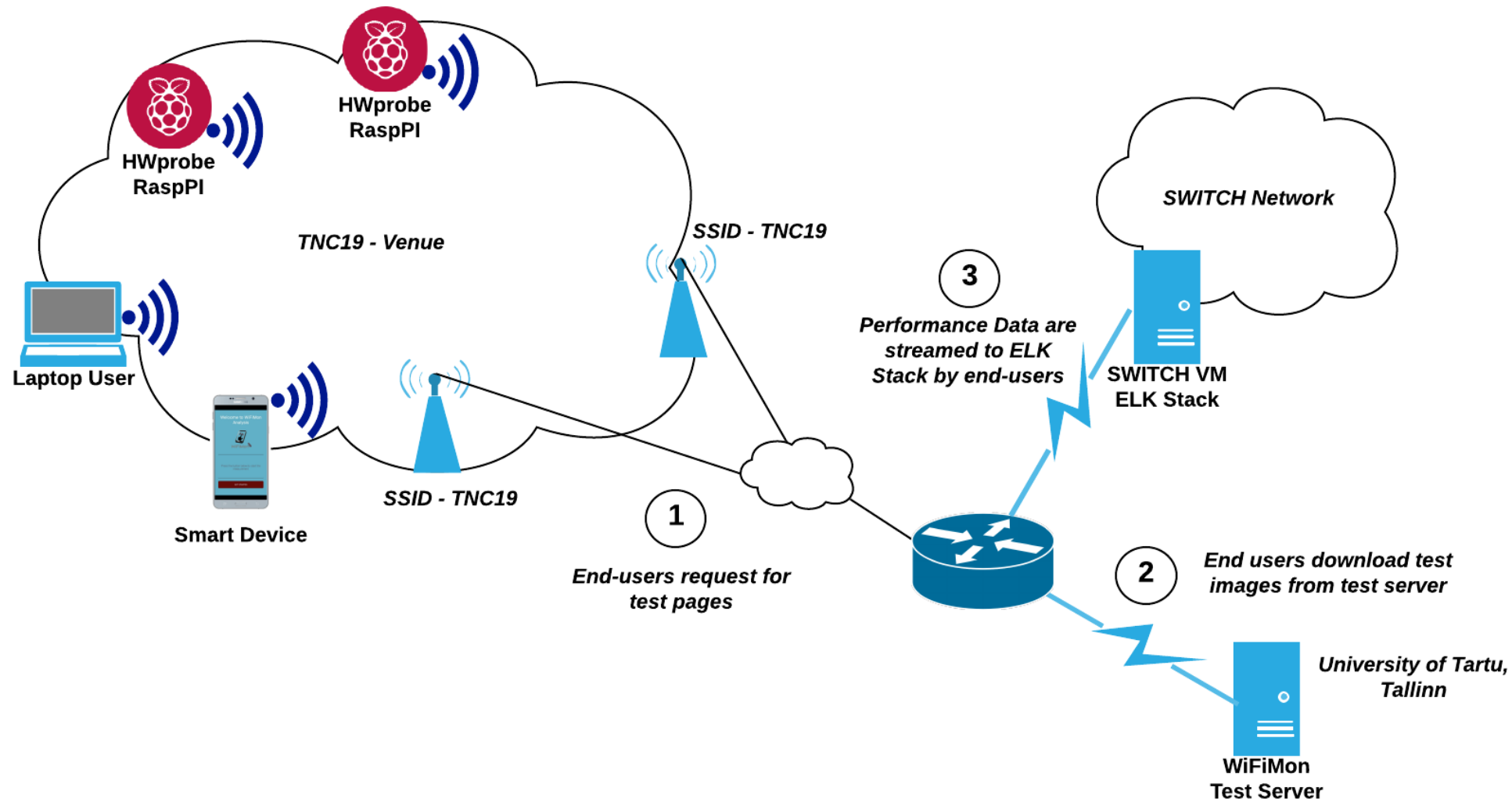
WiFiMon Pilot @ TNC19: Available Equipment

- **5 Raspberry PI 3 Model B+**, 64-bit quad-core ARMv8 CPU, 2.4 & 5 GHz, 802.11b/g/n/ac Wireless LAN, Bluetooth 4.2 & BLE
- **Laptops & Smartphones** of WiFiMon team members

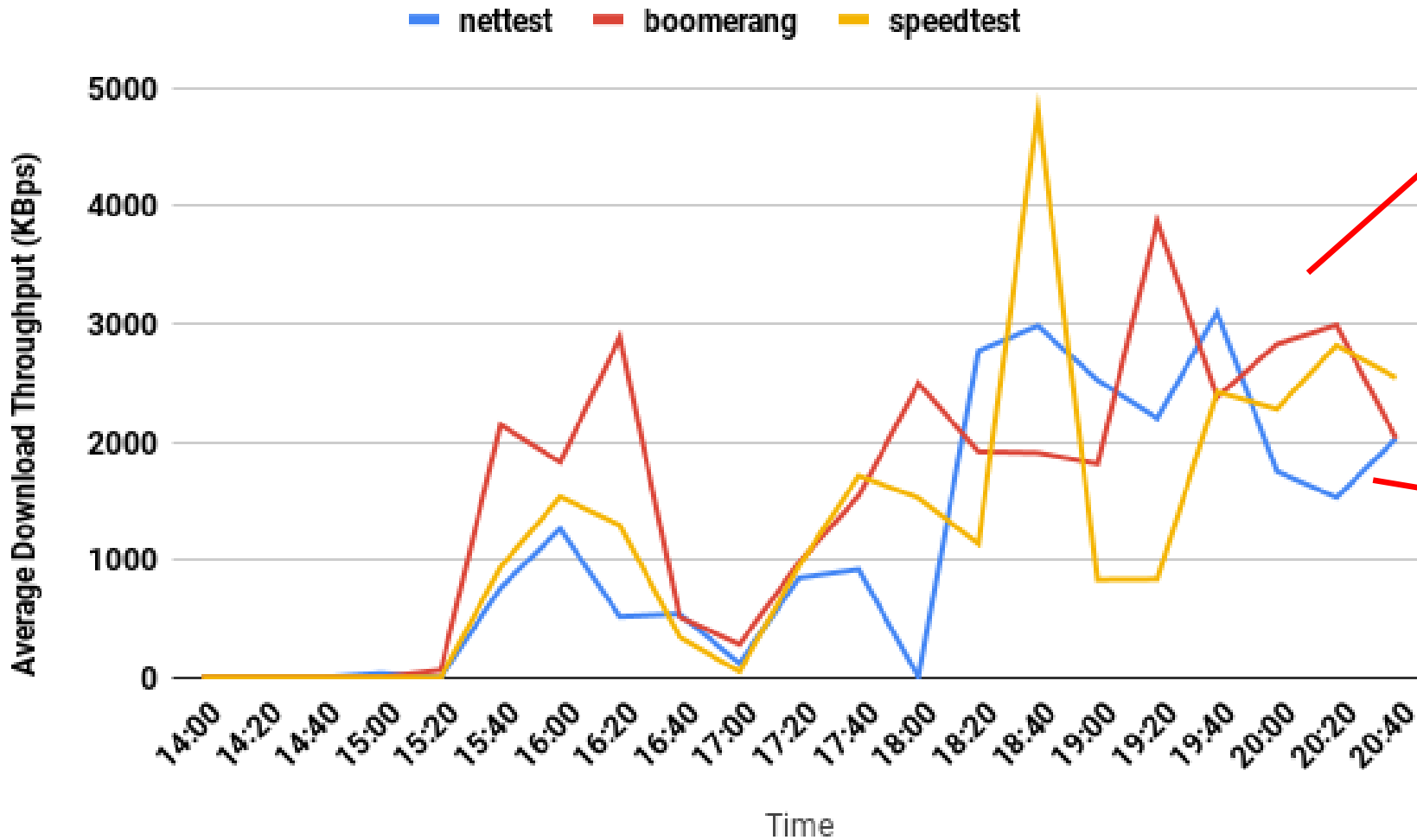
Why not TNC19 participants?

- GDPR issues
- WiFiMon was late to include its purposes in TNC19 privacy notice
- Definitely in the future

TNC19 Testbed Overview



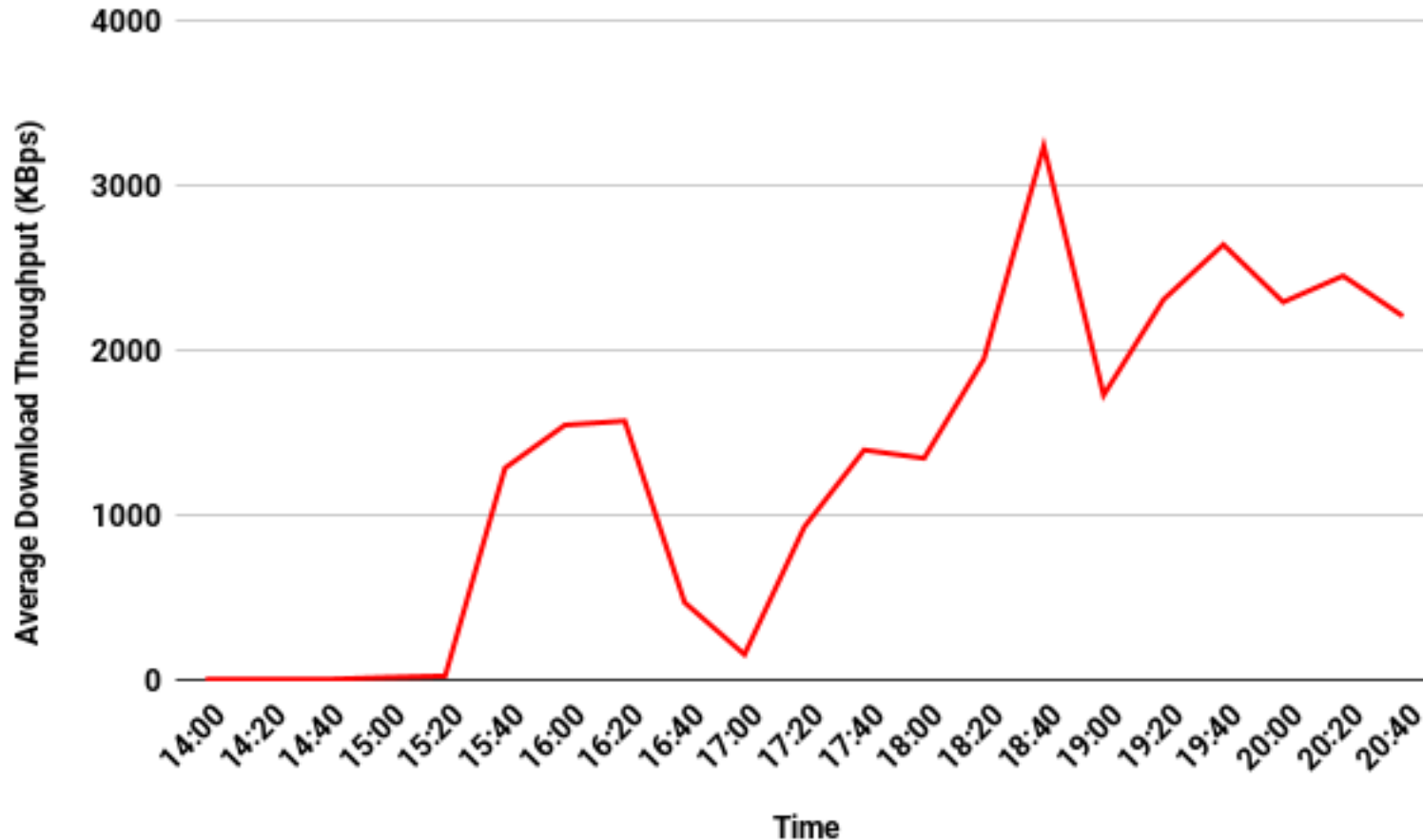
Average Download Throughput in Main Room, Monday (14.00 - 21.00), including all test tools



Too many lines!
Problem reaching useful conclusions

Infrequent Measurements!
Intervals of 20 minutes are not sufficient

Average Download Throughput in Main Room, Monday (14.00 - 21.00), **Test tools average**



- WiFi problematic during lightning talks (14.00 - 15.20)
- WiFi OK in the afternoon when lots of people have left the venue
- Worse throughput during the opening reception (17.00)
- WiFi OK in the evening

Feedback from TNC19 & 6th SIG-PMV Meeting Audience

- Probing period of deterministic measurements should be decreased. In TNC19 pilot it was 20 minutes.
- Charts demonstrating more than a single line, e.g. three lines corresponding to the measurements of all the available test tools, obstruct the audience from reaching quick and useful conclusions.
- WiFiMon dashboard should become GDPR compliant.
- Work needs to be done on RADIUS logs privacy.
- WiFiMon Analysis Server & WiFiMon Test Server installation should be automated.
- Additional information should be extracted from Hardware Probes, e.g. signal strength to detect Internet connection problems.

Software Revisions

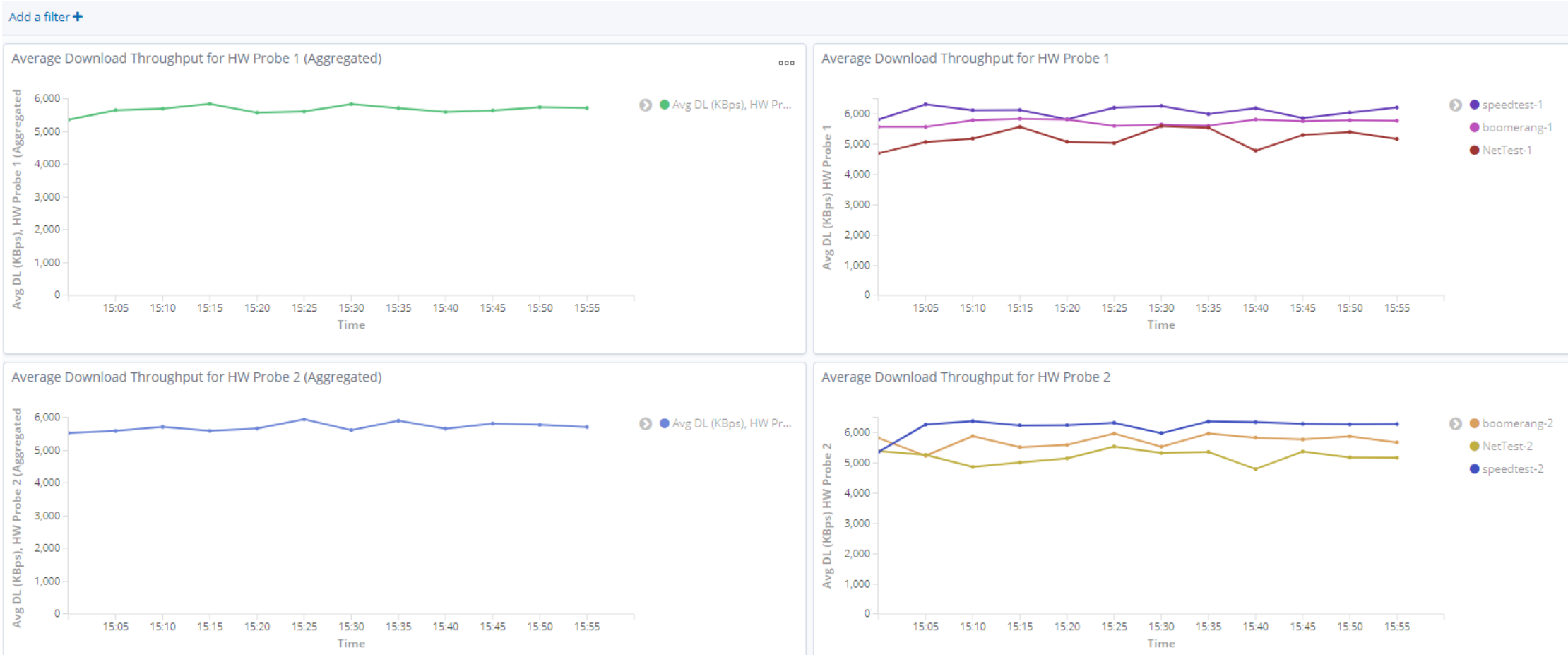
- Migration from the soon to be deprecated Elasticsearch Transport Client to the novel Java High Level REST Client.
- Migration from Spring Boot 1.4.2. version to Spring Boot 2.1.2 version.
- Migration from ELK stack version 5.6.2 to version 6.8.3

Feedback Integration – Frequent Probing Periods

```
19,39,59 * * * * export DISPLAY=:0 && firefox --new-window https://www.google.com >/dev/null 2>&1
00,05,10,15,20,25,30,35,40,45,50,55 * * * * export DISPLAY=:0 && firefox --new-tab URL_TO_nettest.html >/dev/null 2>&1
01,06,11,16,21,26,31,36,41,46,51,56 * * * * export DISPLAY=:0 && firefox --new-tab URL_TO_speedworker.html >/dev/null 2>&1
02,07,12,17,22,27,32,37,42,47,52,57 * * * * export DISPLAY=:0 && firefox --new-tab URL_TO_boomerang.html >/dev/null 2>&1
18,38,58 * * * * scripts/kill-firefox.sh >/dev/null 2>&1
0 10 0 * * 0 scripts/pi-reboot.sh >/dev/null 2>&1
```

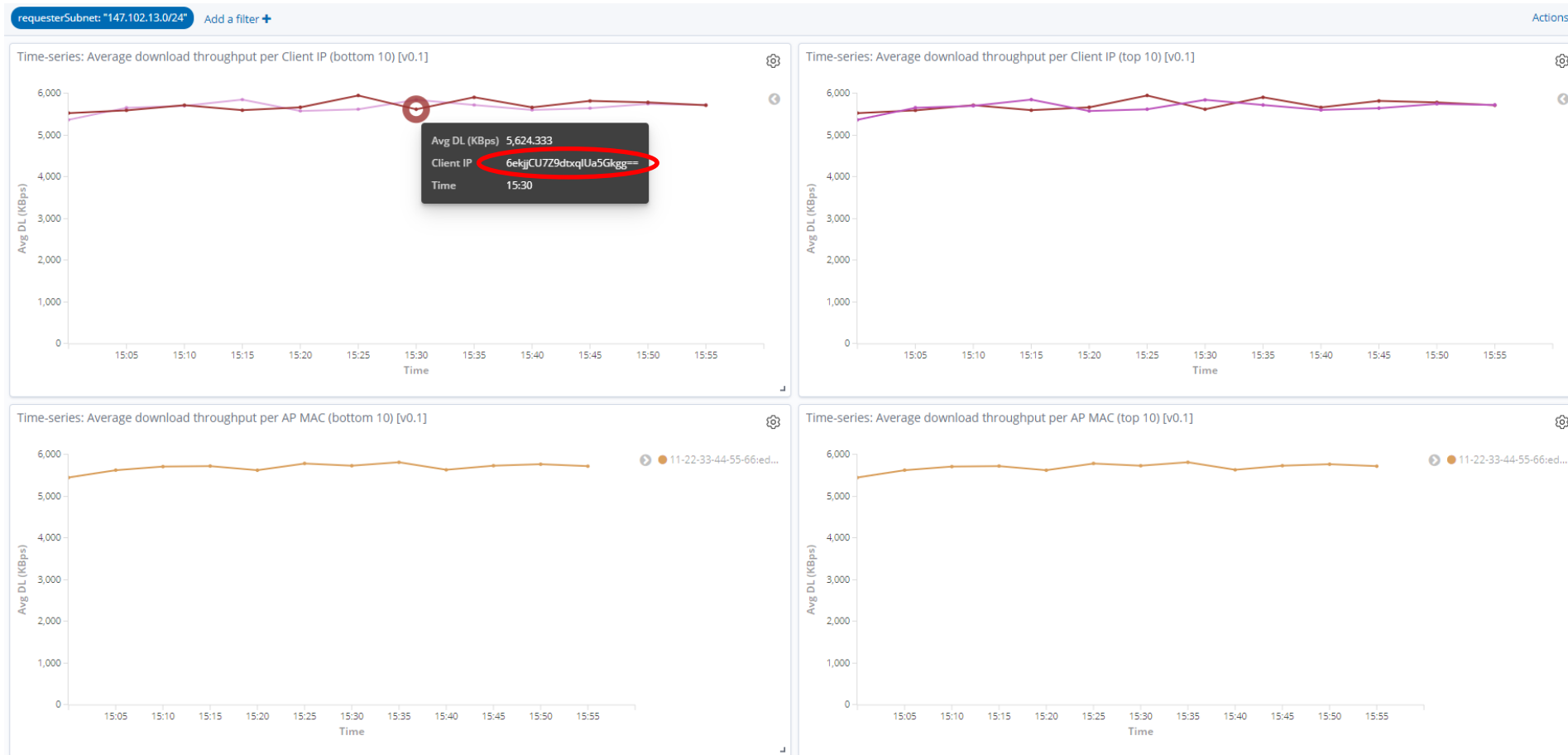
Each test tool performs a measurement every 5 minutes.

Feedback Integration – HW Probes Visualization



- All Hardware Probes in one Tab (up: HW Probe #1, down: HW Probe #2)
- Left Chart: Average of all test tools
- Right Chart: Measurements from each test tool (Nettest, Boomerang, Speedtest)

Feedback Integration – Subnets Tab (GDPR Compliance)



- Separate Tab for each monitored Subnet.
- Client IP & MAC addresses are stored / displayed encrypted with AES-CBC-256 algorithm.
- Qualitative Approach: Subnet Administrators do not know which IPs triggered the measurements, but they are interested in the results to learn about their network.

Feedback Integration – Measurements Tab (GDPR Compliance)

Add a filter +

Table: Current measurements [v0.1] ...

Time ↕	DL (KBps) ↕	UL (KBps) ↕	Ping (ms) ↕	AP IP ↕	AP MAC ↕	User OS ↕	User Browser ↕	Test tool ↕	Count ↕
15:00	4,706	2,233	7	147.102.13.100	11-22-33-44-55-66:eduroam	Linux	Firefox	NetTest-1	1
15:00	5,398	2,209	6	147.102.13.100	11-22-33-44-55-66:eduroam	Linux	Firefox	NetTest-2	1
15:01	5,824	5,545	6	147.102.13.100	11-22-33-44-55-66:eduroam	Linux	Firefox	speedtest-1	1
15:01	5,828	0	8	147.102.13.100	11-22-33-44-55-66:eduroam	Linux	Firefox	boomerang-2	1
15:02	5,374	5,821	6	147.102.13.100	11-22-33-44-55-66:eduroam	Linux	Firefox	speedtest-2	1
15:02	5,582	0	9	147.102.13.100	11-22-33-44-55-66:eduroam	Linux	Firefox	boomerang-1	1
15:05	5,078	2,454	4	147.102.13.100	11-22-33-44-55-66:eduroam	Linux	Firefox	NetTest-1	1
15:05	5,275	2,361	4	147.102.13.100	11-22-33-44-55-66:eduroam	Linux	Firefox	NetTest-2	1

Export: Raw Formatted

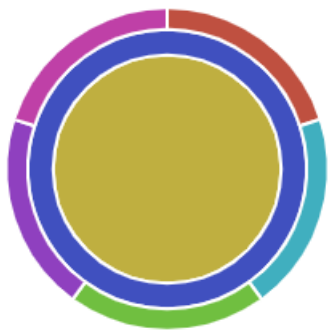
1 2 3 4 5 ... 9 »

Personal Information is removed:

- Username
- Client IP address
- Client MAC address

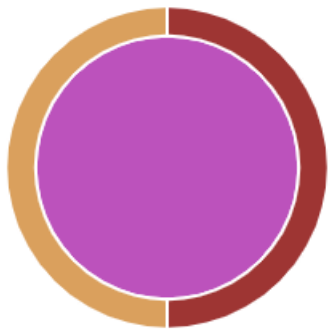
Feedback Integration – Pie Statistics Tab (GDPR Compliance)

Add a filter +
Pie: Measurements count per OS per Browser per TestTool [v0.1] ☰



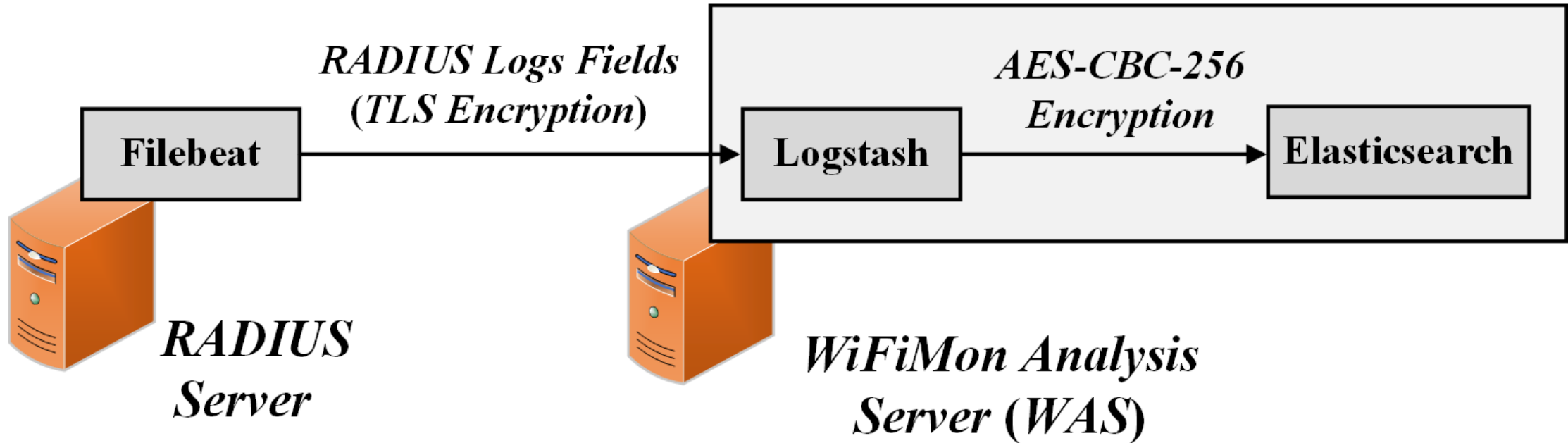
- Linux
- Firefox
- NetTest-1
- NetTest-2
- boomerang-1
- boomerang-2
- speedtest-1

Pie: Measurements count per AP MAC (top 5) per Client IP (top 5) [v0.1] ☰



- 11-22-33-44-55-66:ed...
- 6ekjCU7Z9dtxqIUa5...
- XwUq32r6M9ipY3wSf...

Feedback Integration – RADIUS Logs Privacy



- **Filebeat:** RADIUS logs are streamed encrypted (TLS) to the WiFiMon Agent. Only fields of interest are streamed to reduce total size.
- **Logstash:** RADIUS logs information is encrypted by Logstash using the AES-CBC-256 algorithm. Thus, they are stored encrypted in elasticsearch.

Future Work

- Automation of WiFiMon Agent & Test Server Installation.
- Integration of new metrics collected from Hardware Probes.
- WiFiMon Pilot involving end-users & RADIUS logs correlation

WiFiMon Service planned to be released in 2020

Thank you

Any questions?

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