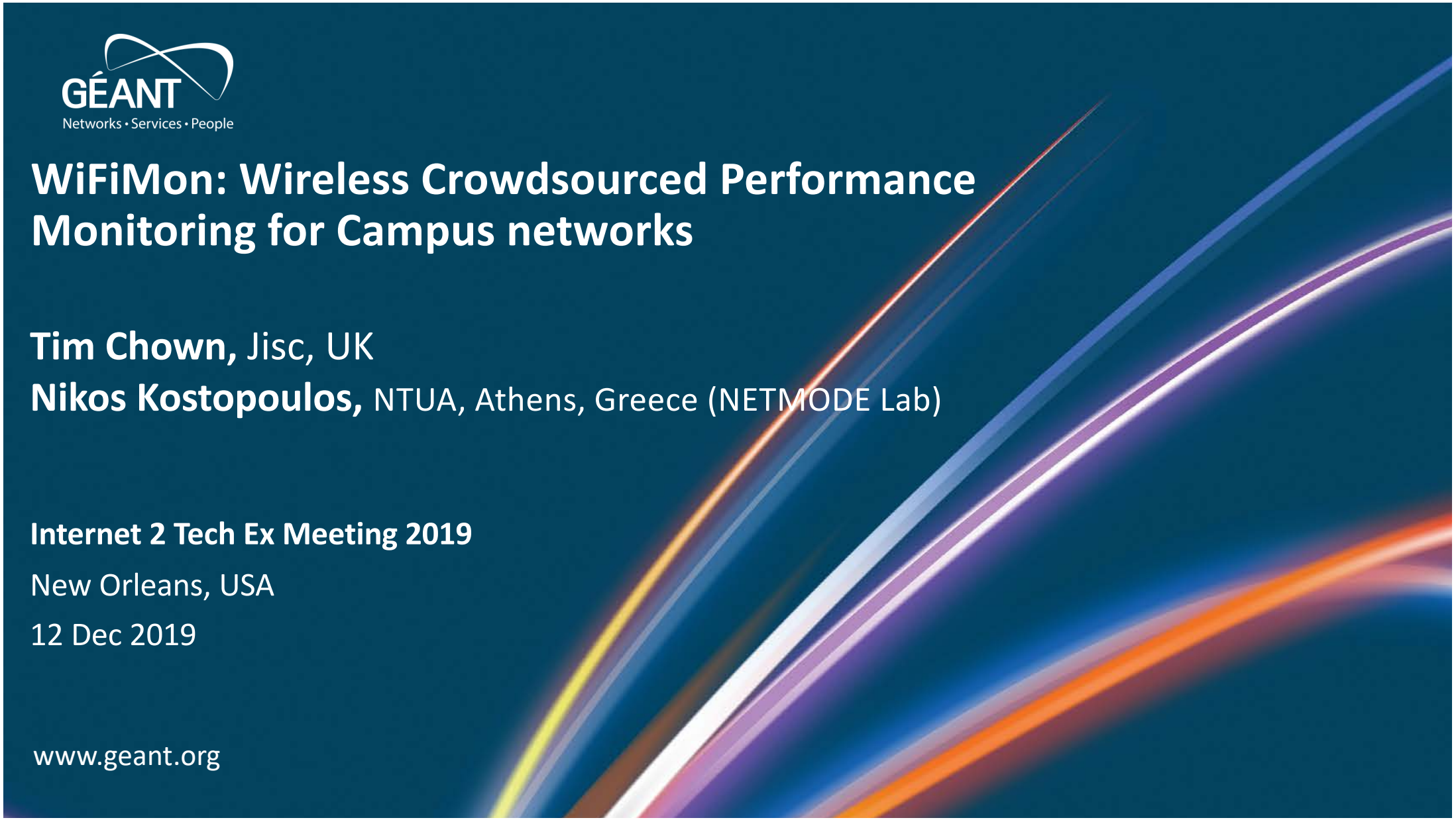


WiFiMon: Wireless Crowdsourced Performance Monitoring for Campus networks

Tim Chown, Jisc, UK
Nikos Kostopoulos, NTUA, Athens, Greece (NETMODE Lab)

Internet 2 Tech Ex Meeting 2019

New Orleans, USA

12 Dec 2019

www.geant.org

Presentation Outline

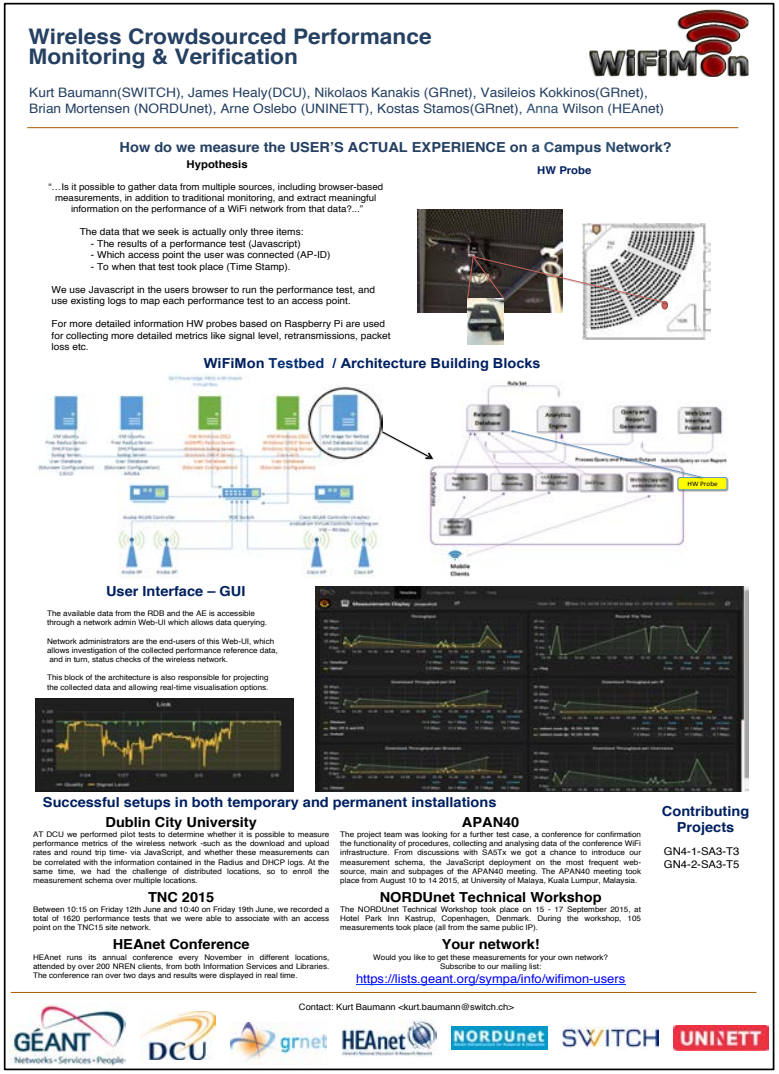
- WiFiMon: Introduction & Problem Statement
- WiFiMon: Data Flow & Overall Architecture
- Data Collection Technology: Crowdsourced & H/W Probe Measurements
- TNC 2019 Pilot & Indicative Results
- Feedback from TNC19 & 6th SIG-PMV Meeting Audience
- Revision & Changes in WiFiMon – Feedback Integration
- 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?…"

Development of WiFiMon is supported by the GÉANT GN4-3 project, under the Network Technologies and Services Evolution work package, where European work on perfSONAR is also undertaken



WiFiMon - Problem statement

Measuring and verifying the performance of WiFi networks is challenging.
We have not found any 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.

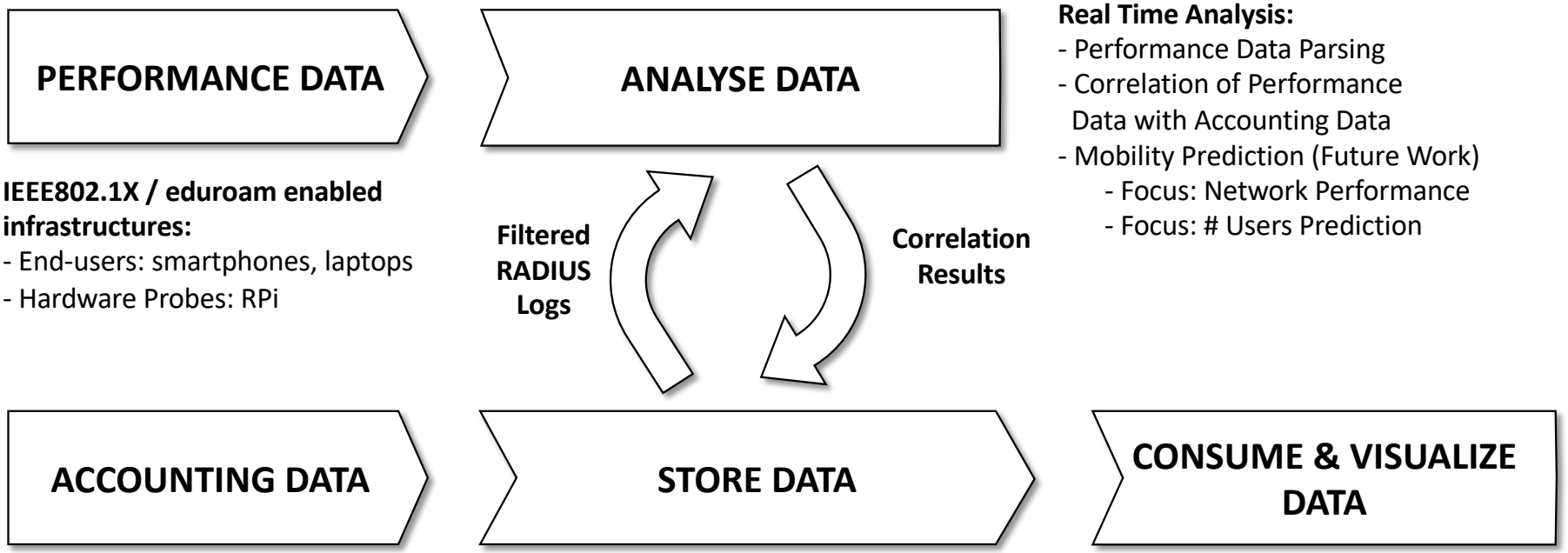
At present, information for wireless networks can be reported in three ways:

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

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

- H/W probes collect performance measurements but are installed at fixed locations. We can improve our view via crowdsourced measurements.

WiFiMon - Data Flow



IEEE802.1X / eduroam enabled infrastructures:
- End-users: smartphones, laptops
- Hardware Probes: RPi

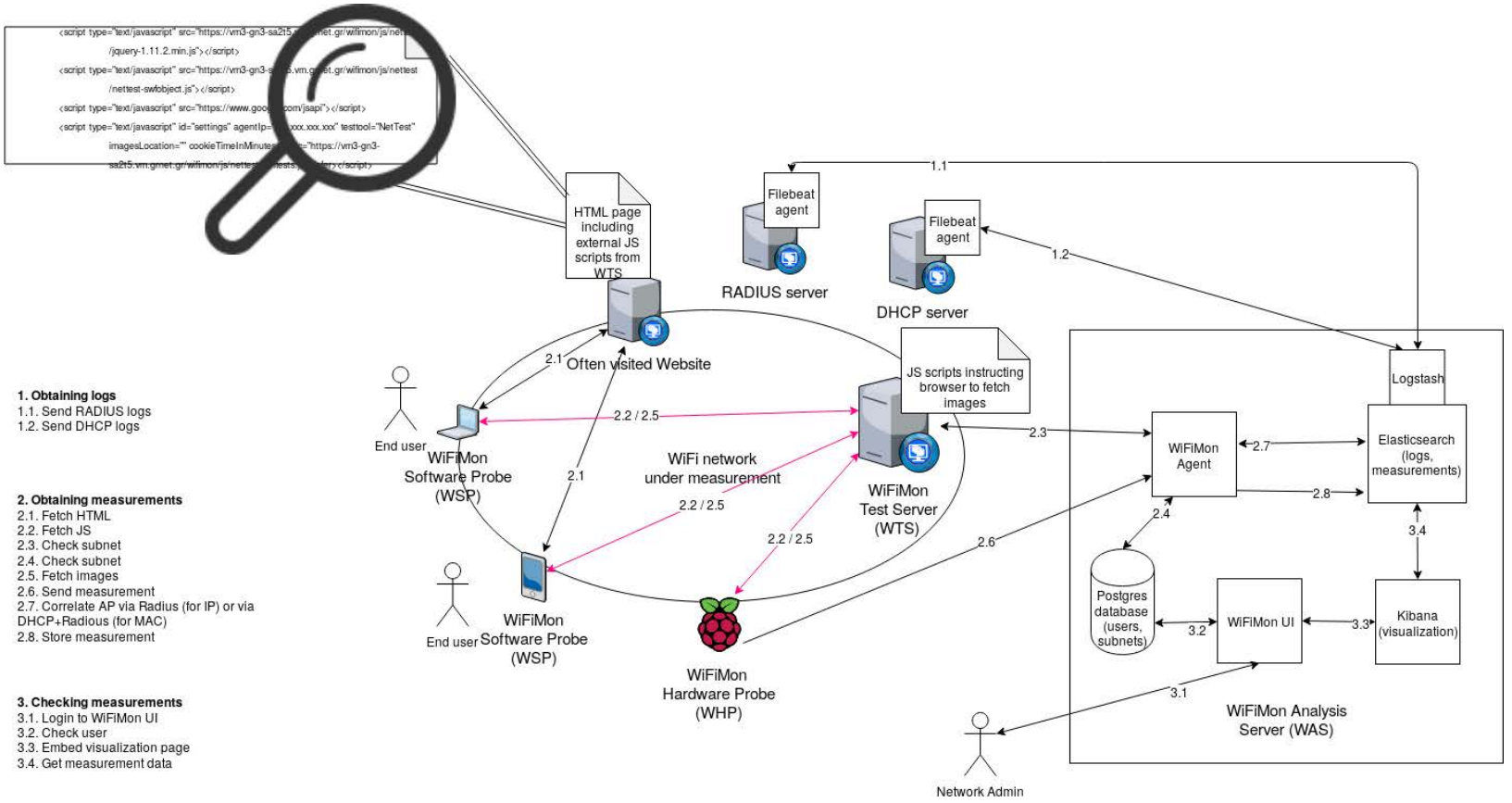
Real Time Analysis:
- Performance Data Parsing
- Correlation of Performance Data with Accounting Data
- Mobility Prediction (Future Work)
  - Focus: Network Performance
  - Focus: # Users Prediction

RADIUS Logs:
- Data Filtering (**Logstash**)

Data Storage (Elasticsearch)
- Filtered RADIUS Logs
- Correlated Results (persistent data): Performance Data correlated with RADIUS logs

WiFiMon GUI:
- Visualisation (**Kibana**) for network administrator
- User Options

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: Nettest, Boomerang, Speedtest
- The process is collect, store, then (optionally) correlate (this and the next two slides)

```
<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

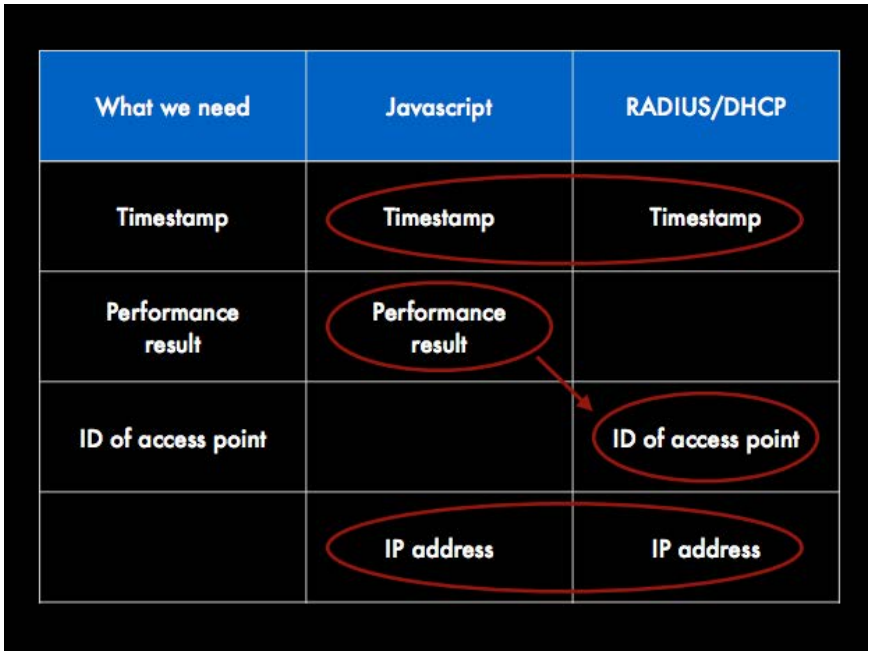
Pseudo code for performing/storing measurements

```
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 (campus/venue)
- Cookie: repeated measurements in short time intervals are not permitted
- Default cookie duration is 1.5mins, can be set lower or higher (e.g., down to 0.01min for our TNC pilot)

WiFiMon - How we manage/correlate performance data



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
```

The aim here is to get the most recent measurement for a given (authenticated) IP.

User IP is from measurements (Javascript)
Client IP is from RADIUS authentication

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; available if you contact us for details)

WiFiMon – H/W Probe setup steps

Step 1: Write the image to the micro SD card

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

Step 2: Start the RPi

- Insert the microSD in the RPi
- Plug the USB keyboard and USB mouse and 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

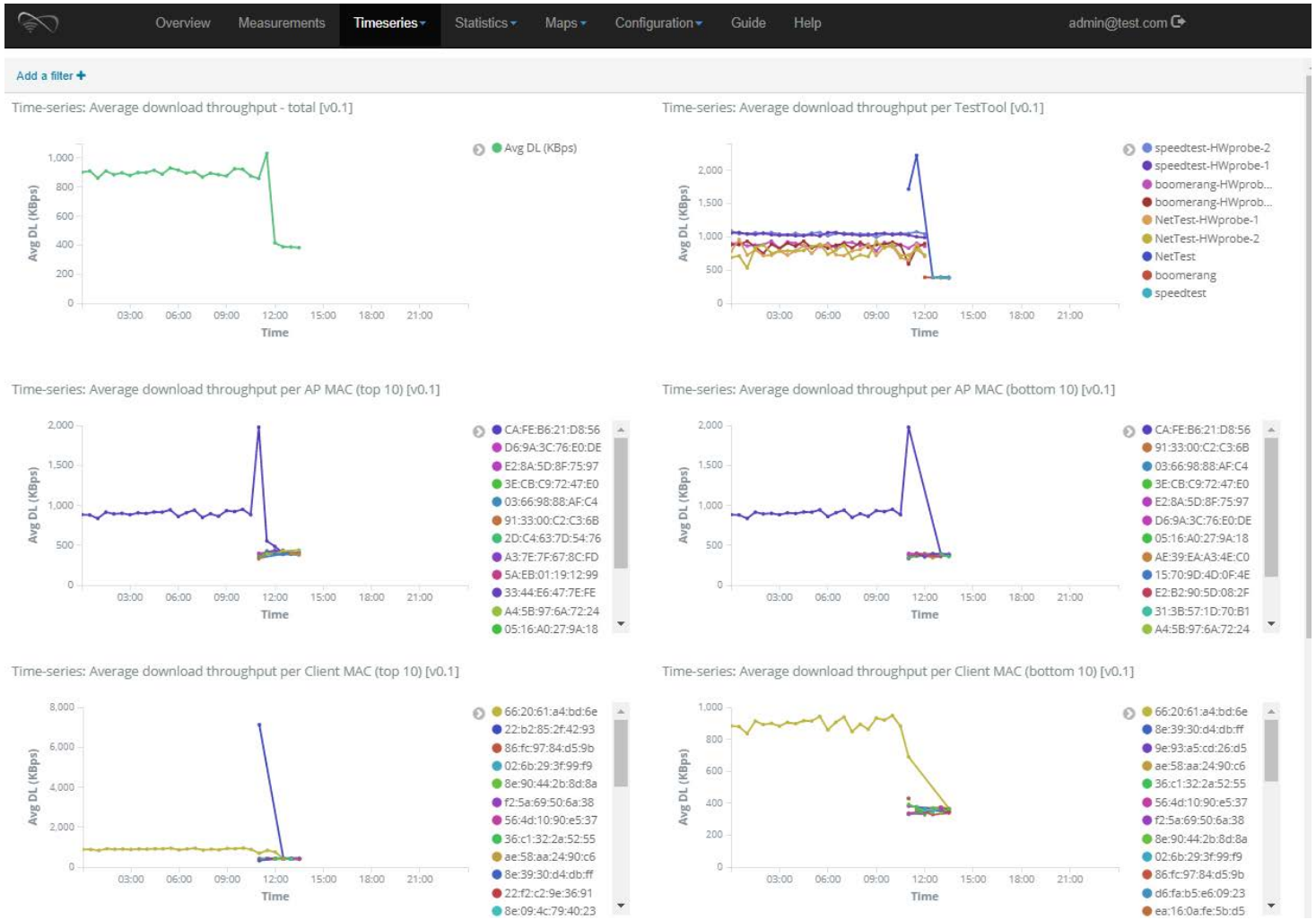
Step 3: Configure the RPi

- 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 of analysis server)



WiFiMon Pilot @ TNC19: Available Equipment

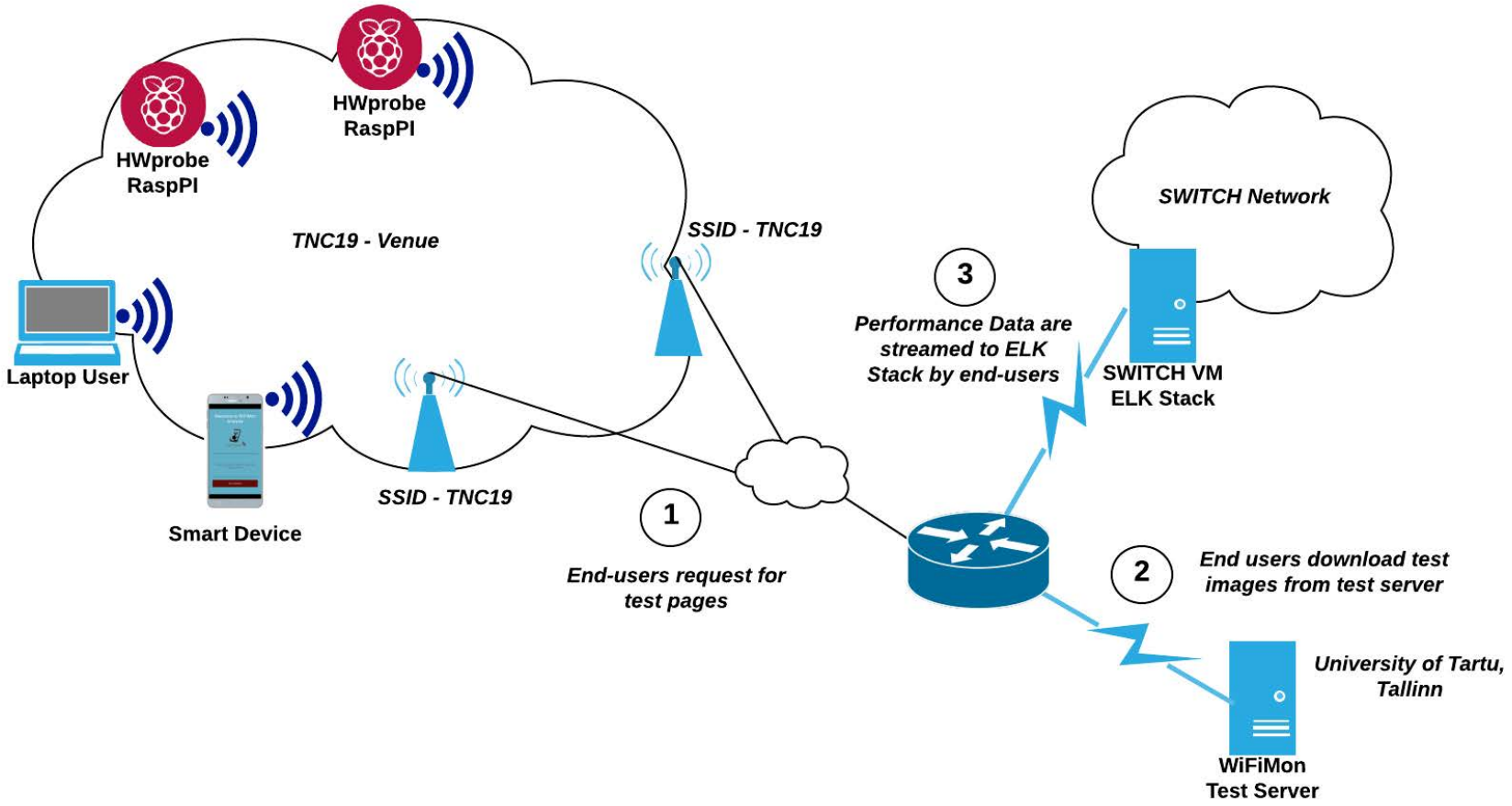
- ***5 Raspberry PI 3 Model B+***, 64-bit quad-core ARMv8 CPU, 2.4 & 5 GHz, 802.11b/g/n/ac Wireless LAN, Bluetooth 4.2 & BLE

- ***Laptops & Smartphones*** of WiFiMon team members

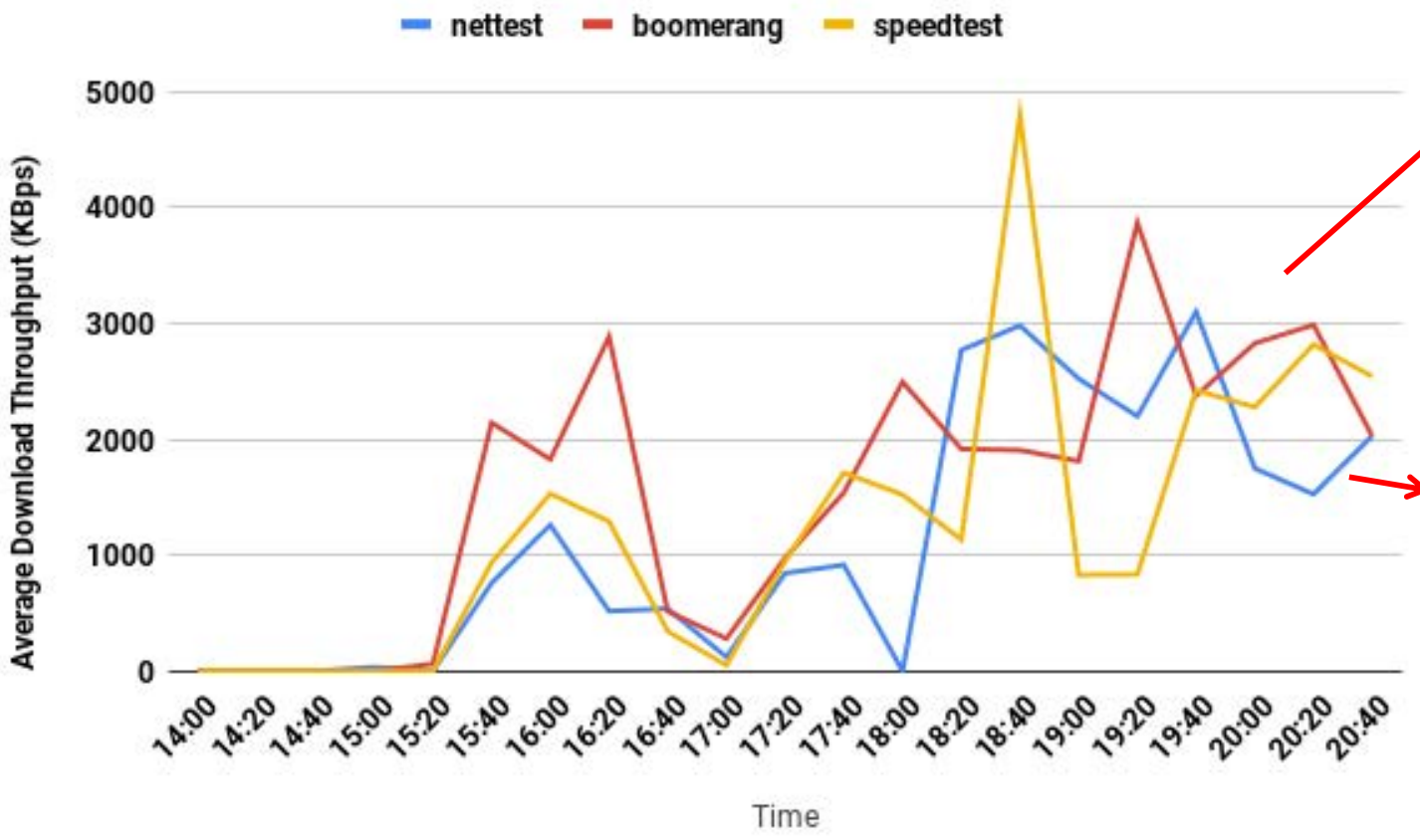
Why did we not include all TNC19 participants (several hundred)?

- GDPR issues
- WiFiMon was too late to include the required TNC19 privacy notice
- Running fuller pilots in the future, e.g., at the GÉANT Symposium, Feb 2020

TNC19 Testbed Overview



Average Download Throughput in Main Room for H/W probes, Monday (14.00 - 21.00), including all test tools



Too many lines!

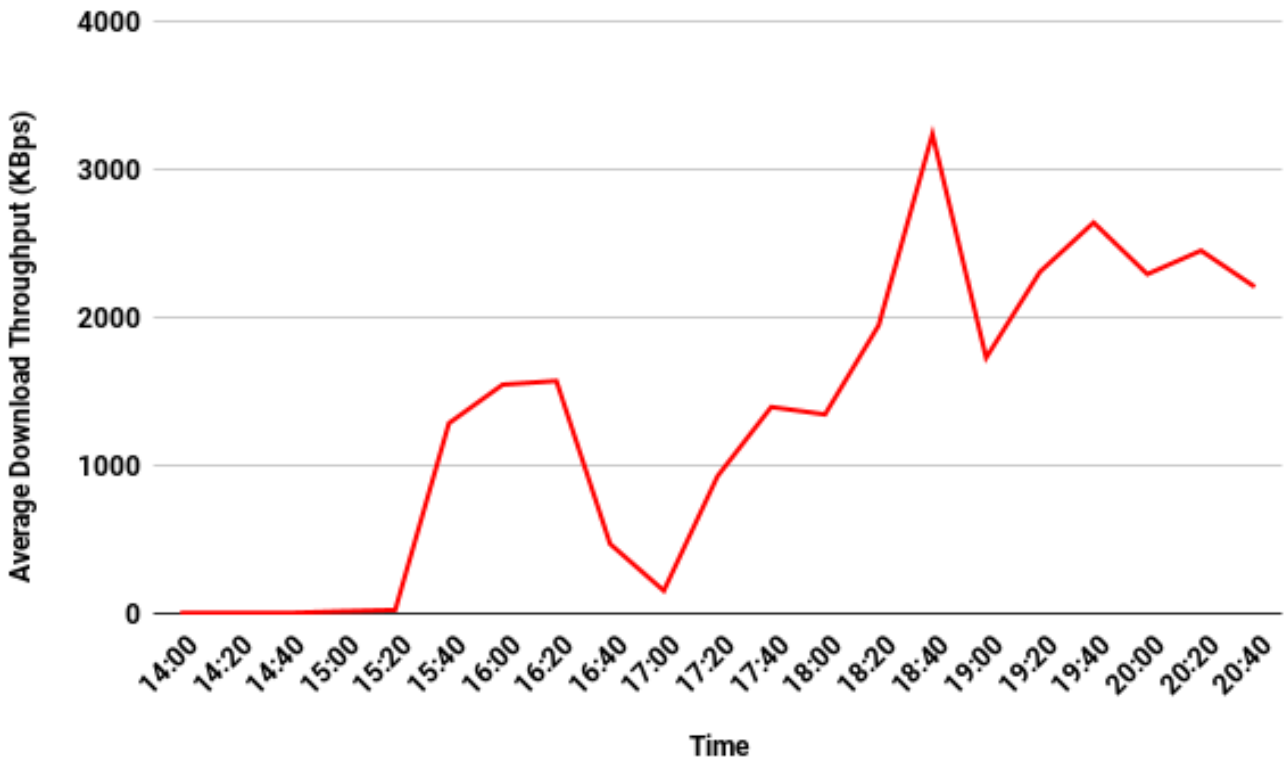
Problem reaching useful conclusions

Infrequent Measurements!

20 minute intervals not ideal

Should increase the frequency

Average Download Throughput in Main Room for H/W probes, Monday (14.00 - 21.00), Test tools average



- WiFi problematic during the lightning talks plenary session (14.00 - 15.20)
- WiFi OK in the afternoon when lots of people have left the main room
- Worse throughput seen during the opening reception (17.00)
- WiFi then OK in the evening

Feedback from TNC19 & 6th SIG-PMV Meeting Audience

- Probing period of deterministic h/w probe measurements should be decreased. In the TNC19 pilot it was 20 minutes; for the next pilot we will use 5 minutes. Kibana can aggregate crowdsourced measurements (for the same IP) to specific intervals.

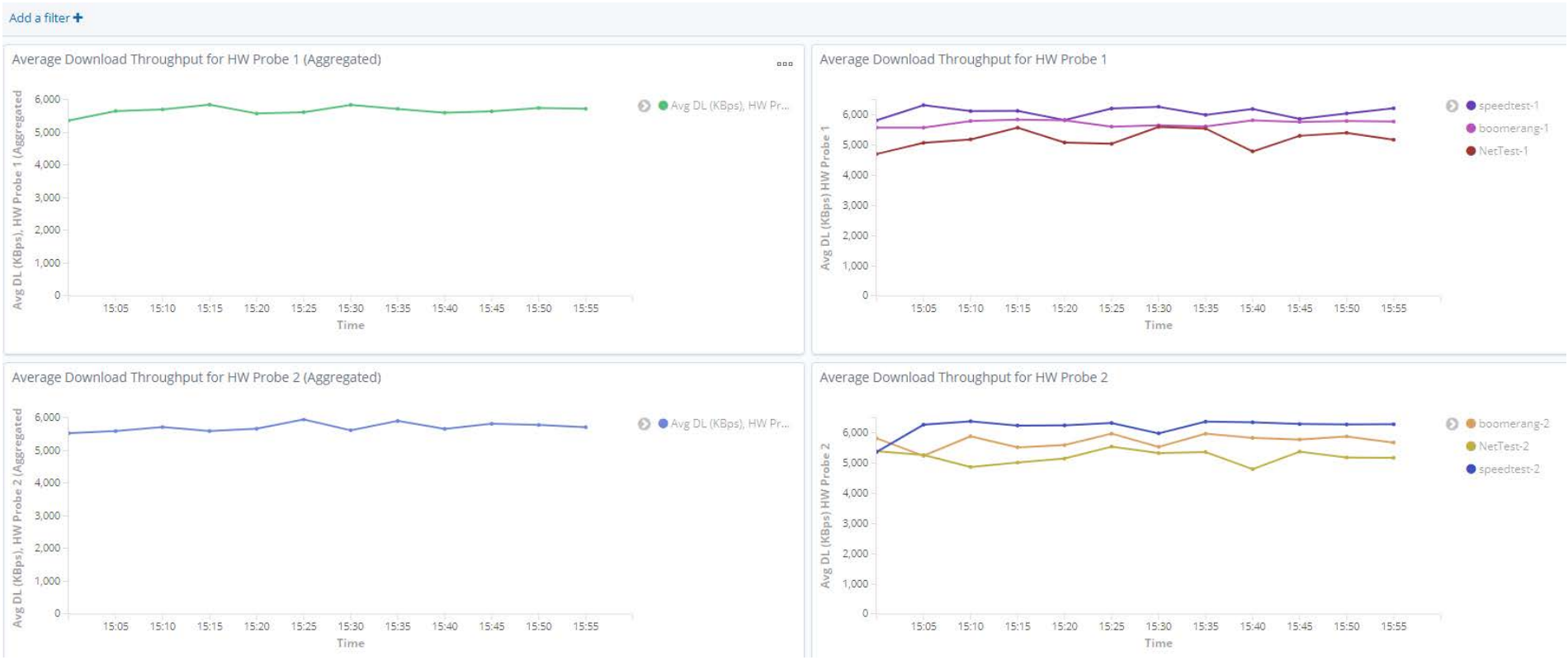
- Charts that show more than a single line, e.g., three lines corresponding to the measurements of all the available test tools, can hinder a viewer from reaching quick and useful conclusions.

- The WiFiMon dashboard needs to become GDPR compliant, and work needs to be done on RADIUS log privacy.

- The WiFiMon Analysis Server & WiFiMon Test Server installation needs to be automated.

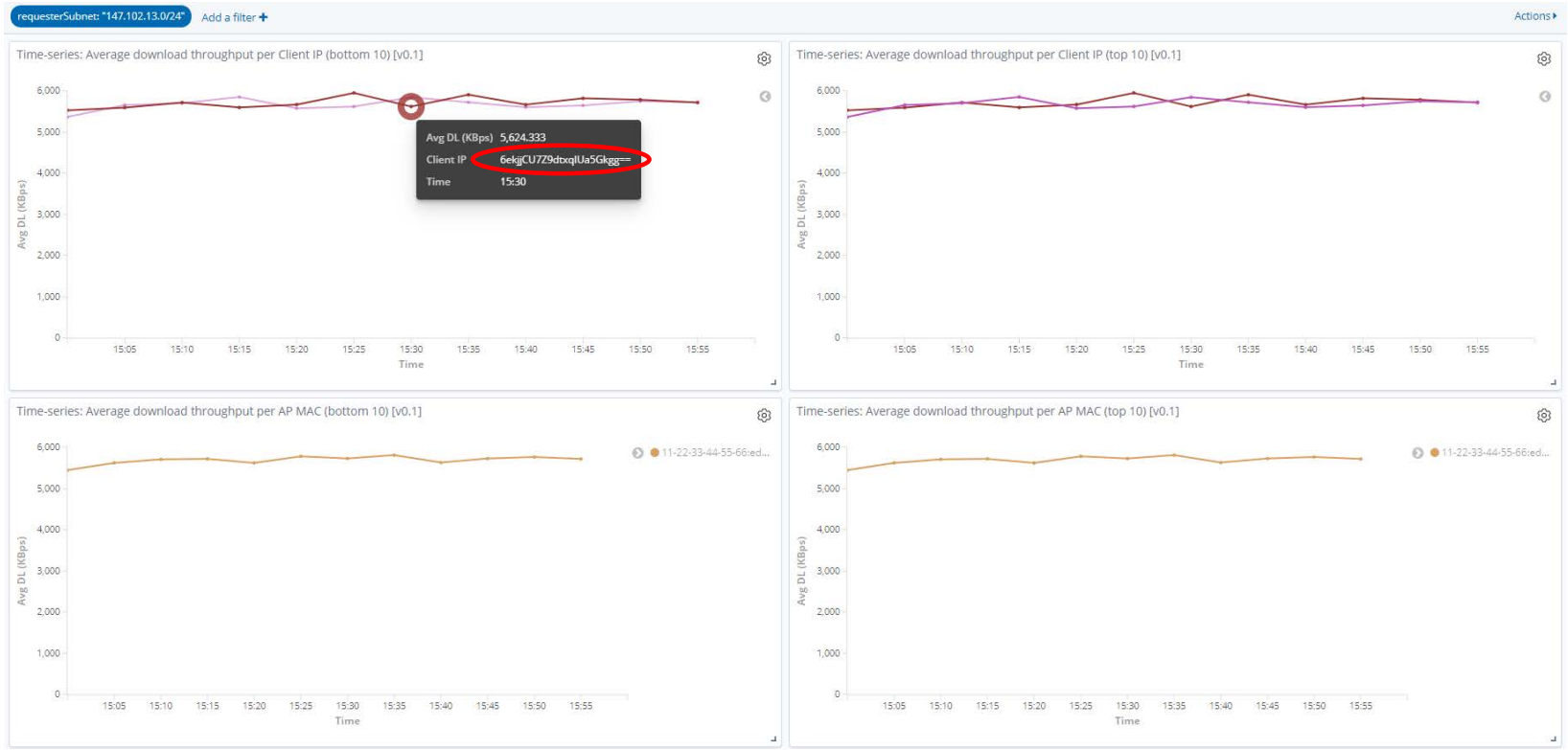
- Additional information could be extracted from Hardware Probes, e.g., signal strength to detect specific connection problems.

Feedback Integration – H/W Probe (only) Visualisation



- All Hardware Probes in one Tab (up: H/W Probe #1, down: H/W 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 view 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 for their own network (subnets).

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

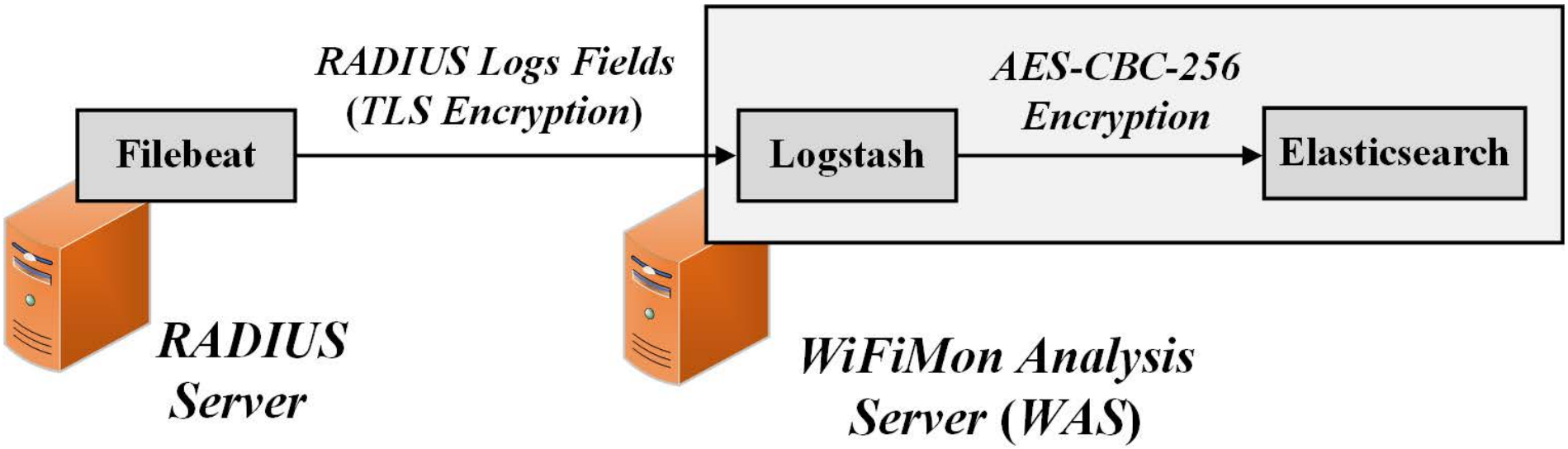
Export: Raw Formatted

1 2 3 4 5 … 9 »

Personal Information is removed:

- Username (where determinable; this is not required for performance analysis)
- Client IP address
- Client MAC address

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.

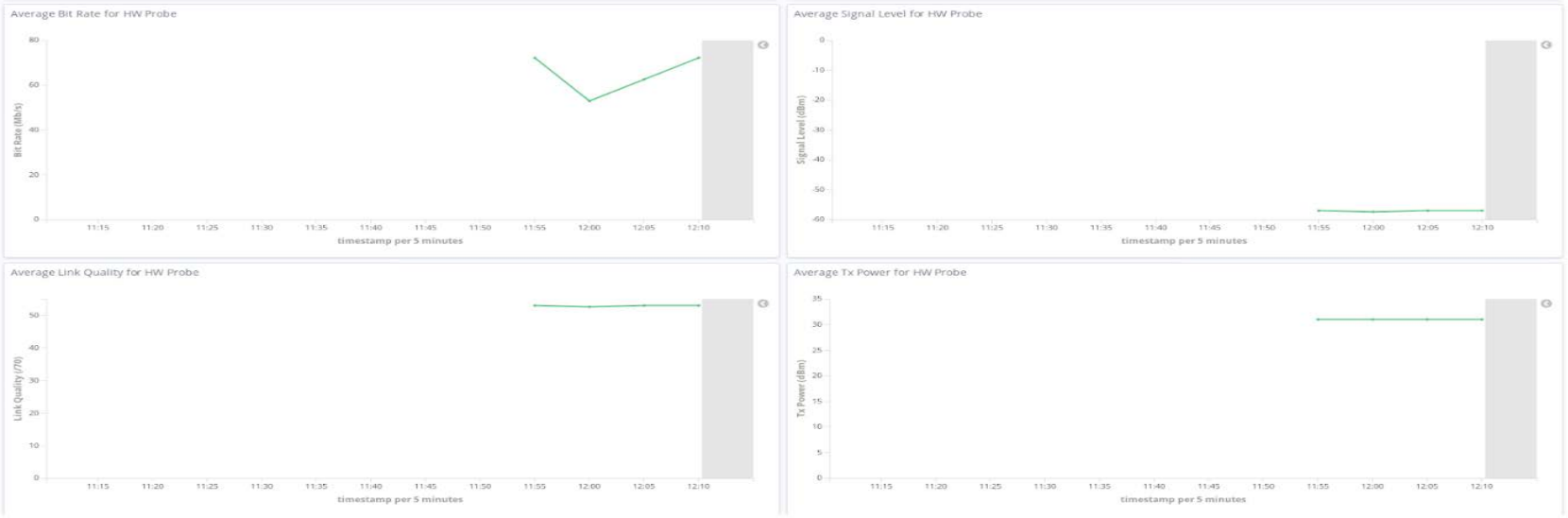
Integration of Additional Information from H/W Probes

- ***Raspberry PI***: A simple *Python* script parses the output of the "**iwconfig**" command and streams a JSON object to the ***WiFiMon Analysis Server*** (***WAS***) on intervals specified in a crontab

```
pi@rasp2:~ $ iwconfig wlan0
wlan0     IEEE 802.11  ESSID:"NETMODE_2.4GHz"
          Mode:Managed  Frequency:2.427 GHz  Access Point: E8:DF:27:DB:10:60
          Bit Rate=19.5 Mb/s   Tx-Power=31 dBm
          Retry short limit:7   RTS thr:off   Fragment thr:off
          Power Management:on
          Link Quality=60/70  Signal level=-50 dBm
          Rx invalid nwid:0  Rx invalid crypt:0  Rx invalid frag:0
          Tx excessive retries:68  Invalid misc:0   Missed beacon:0
```

Collected Metrics

- ***Kibana***: New visualizations to display the collected metrics per H/W Probe:



Future Work

- Automation of WiFiMon Agent & Test Server installation.
- WiFiMon Pilot involving end users & RADIUS logs correlation

The WiFiMon Service is planned to be released through the GÉANT GN4-3 project in 2020

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Thank you

Any questions?

Email: tim.chown@jisc.ac.uk

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The research leading to these results has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 856726 (GN4-3).