



# WiFiMon: Wireless Crowdsourced Performance Monitoring for Campus networks

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# 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 & 6<sup>th</sup> 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

### 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)



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#### 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?...”

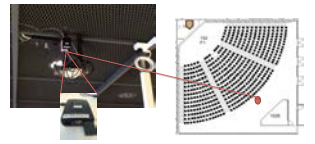
The data that we seek is actually only three items:

- 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 RDB 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 visualization 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 correlated 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 summer test case, a conference for confirmation the functionality of procedures, collecting and analysing data of the conference WiFi infrastructure. From discussions with SAOTx 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 Malaya, Kuala Lumpur, Malaysia.

**NORDUnet Technical Workshop**

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


**Your network!**

Would you like to get these measurements for your own network? Subscribe to our mailing list:  
<https://lists.geant.org/sympa/info/wifimon-users>

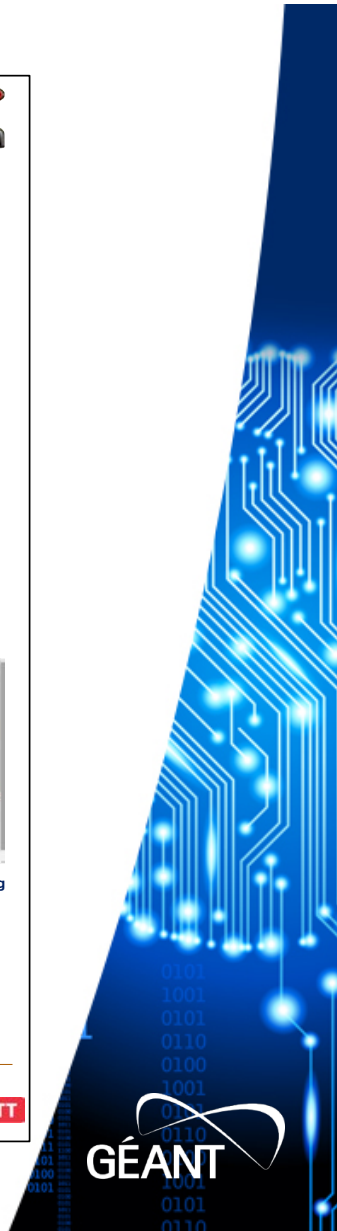
**Contributing Projects**

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.**

**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:**

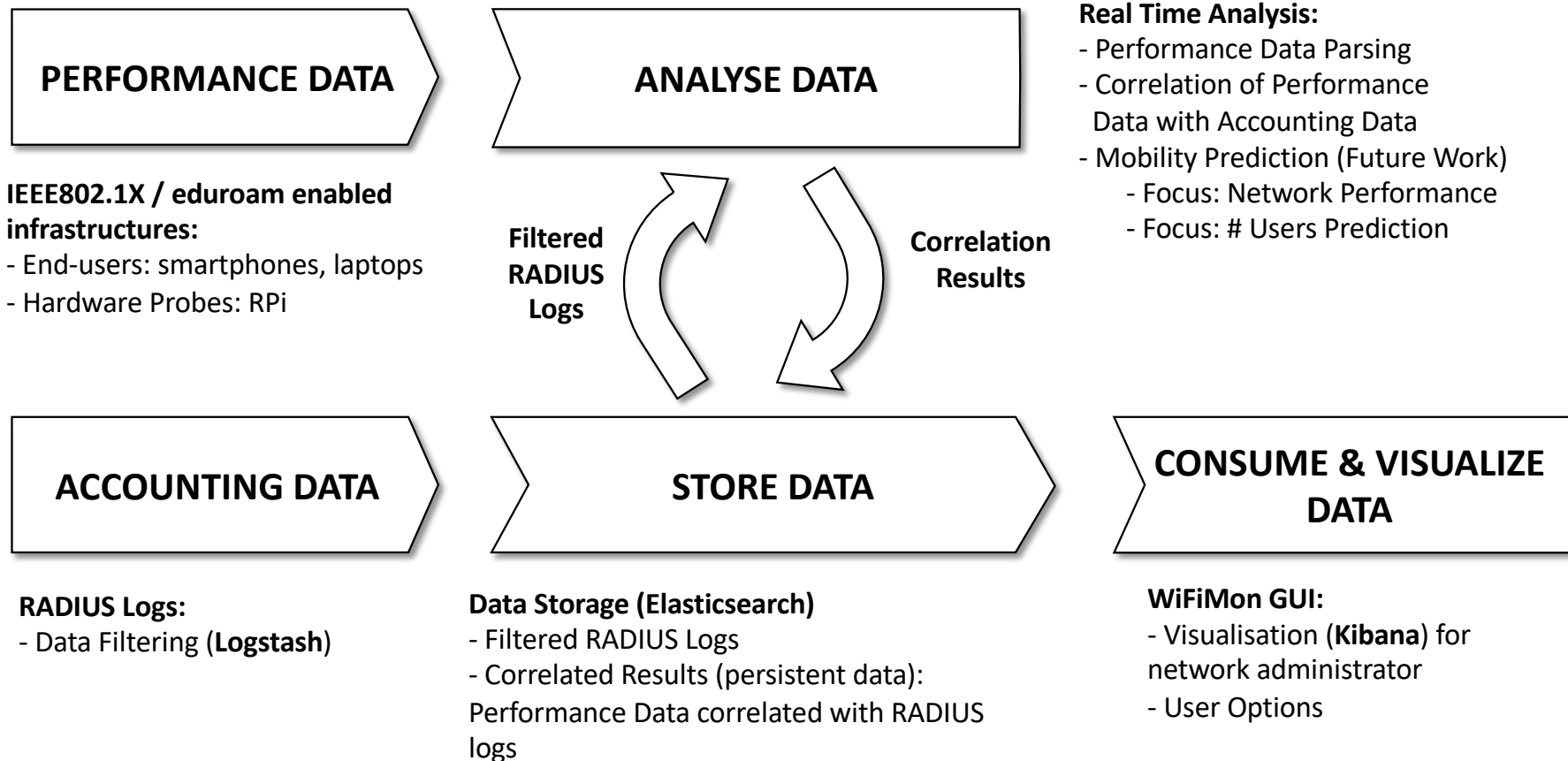
- Mobile End-User Device
- Wireless Access Points (WAP) / WiFi-Controller
- Network Management Systems (NMS)

**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.

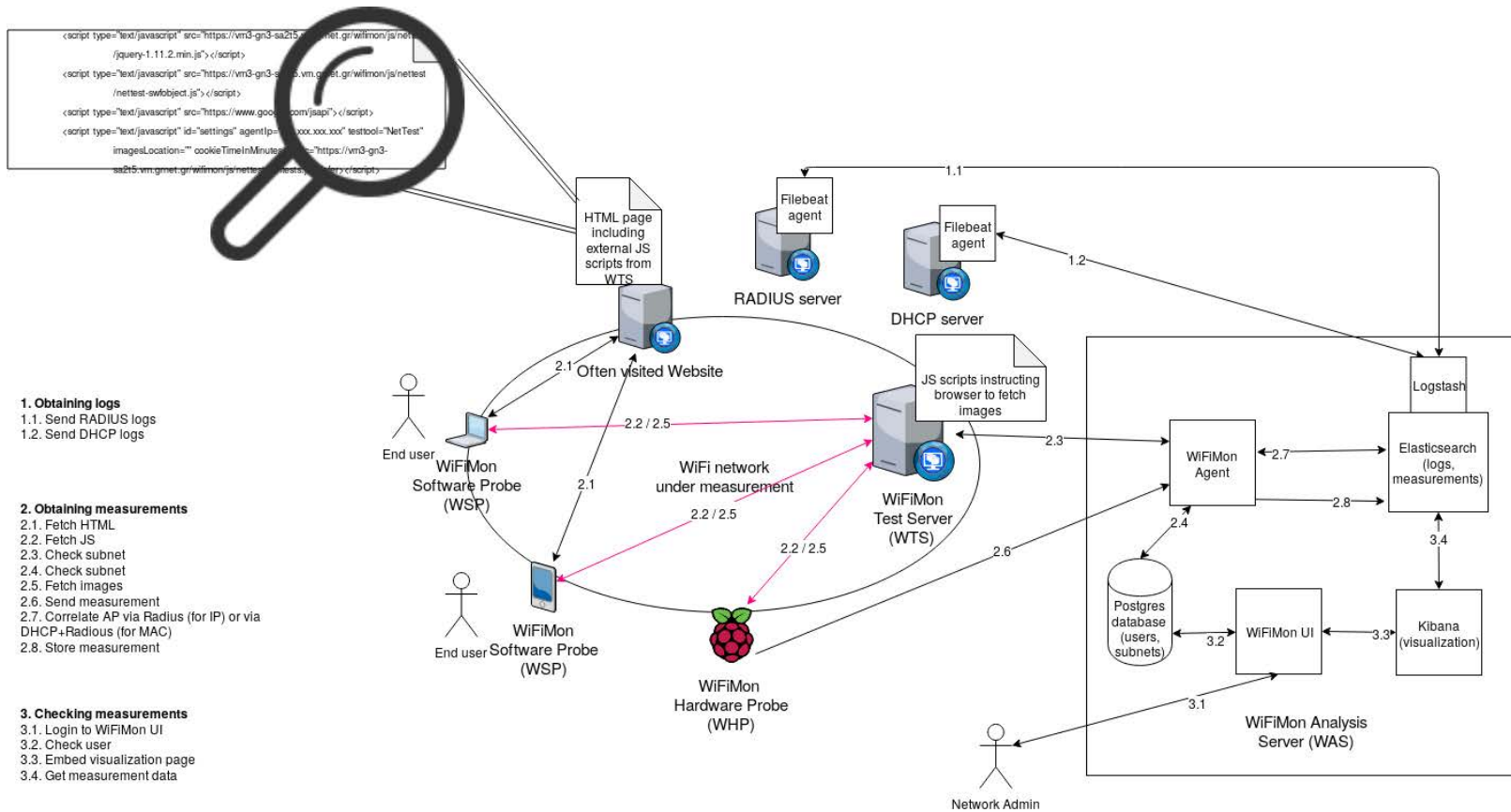


# WiFiMon - Data Flow





# 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
- 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

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
```

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

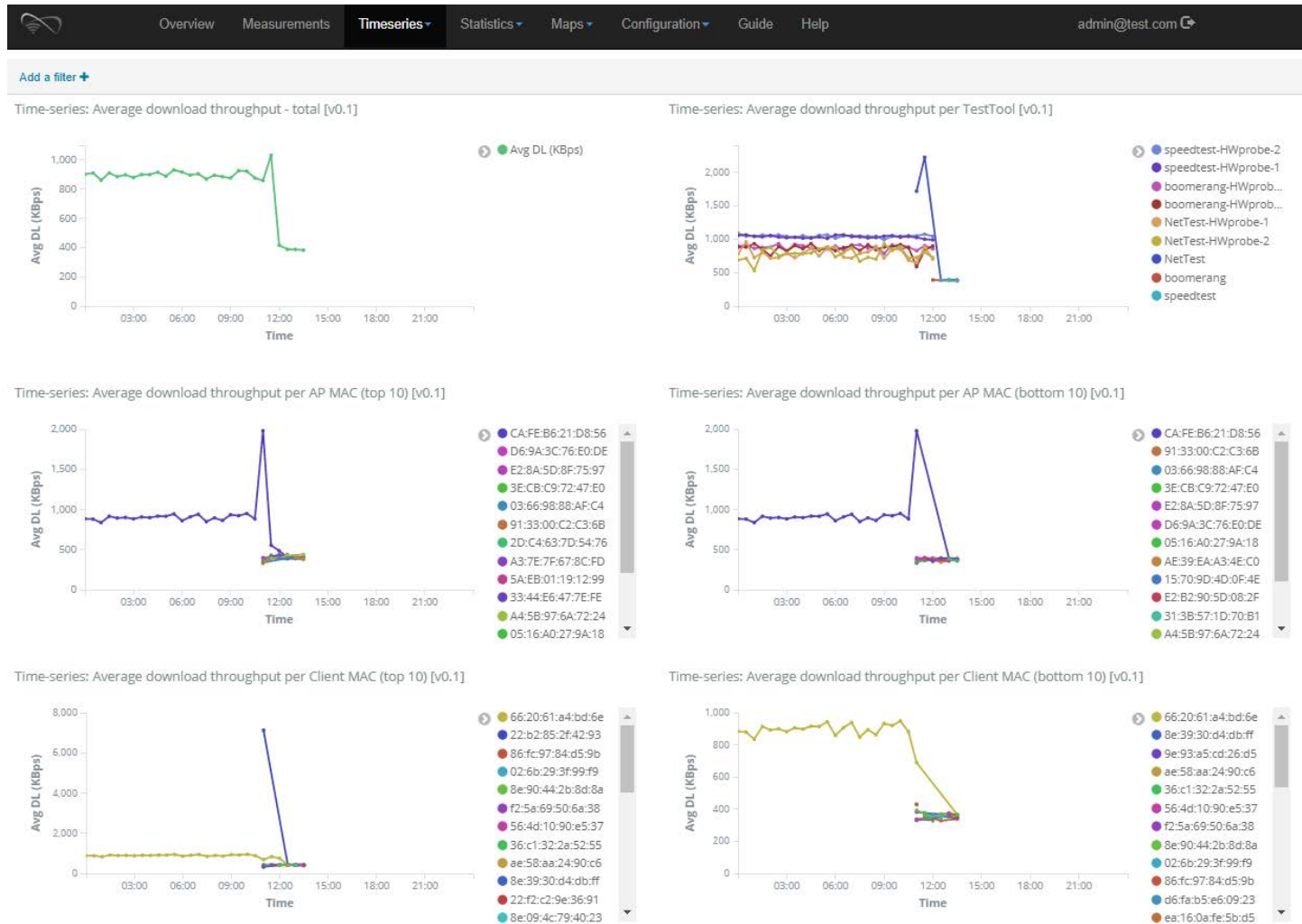
## Step 3: Configure the RPi

- 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

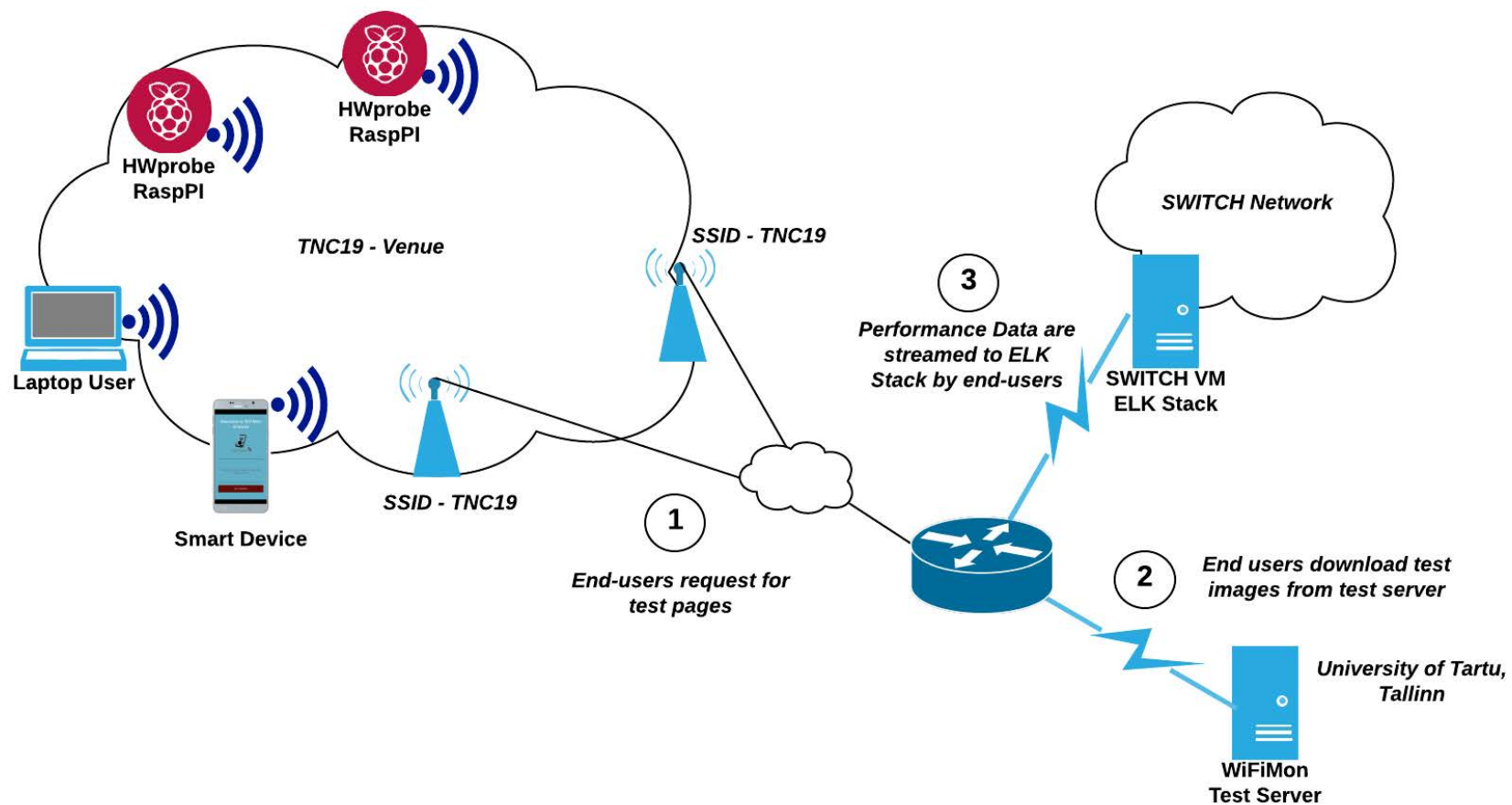
## ***Why did we not include all TNC19 participants (several hundred)?***

- 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

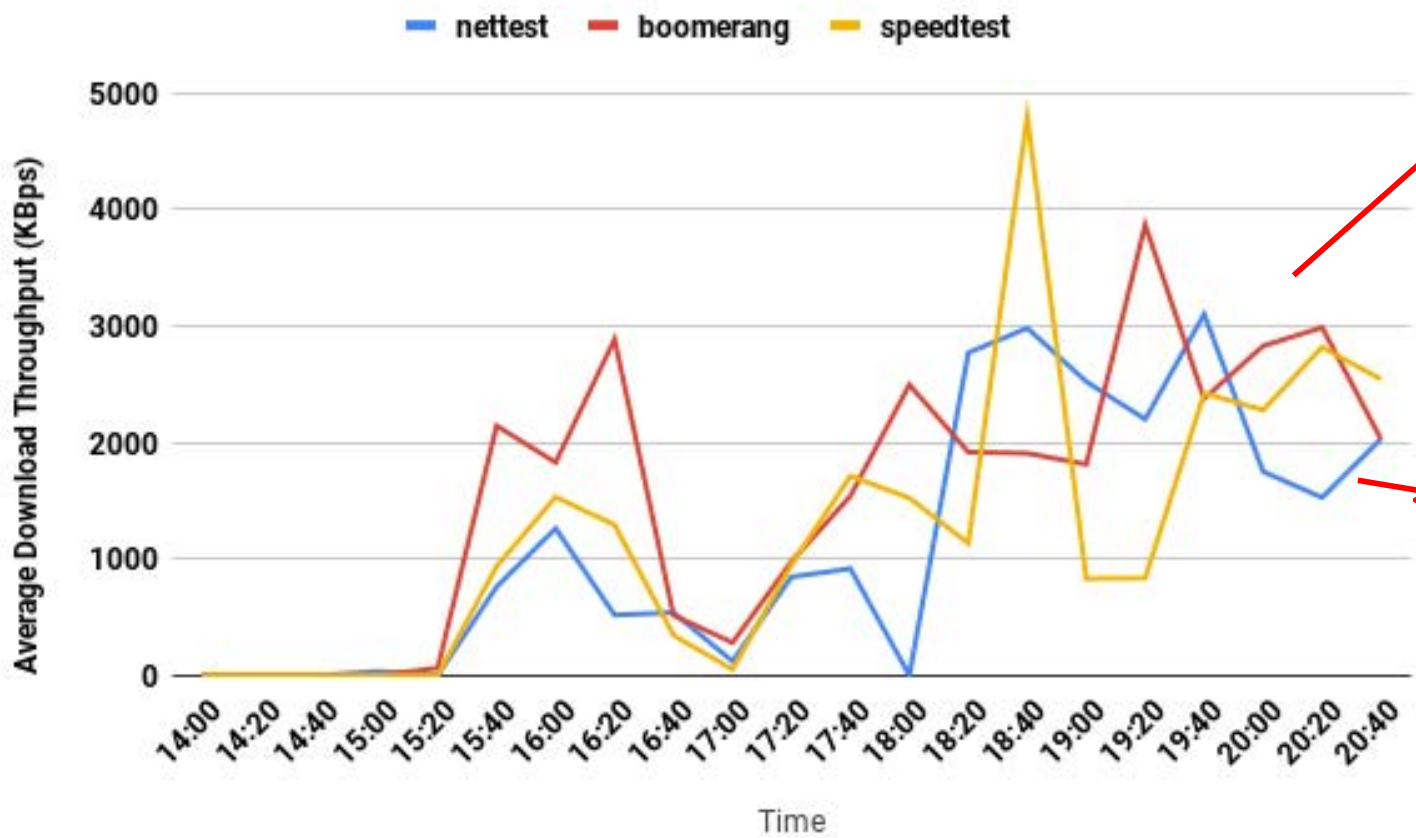




# TNC19 Testbed Overview



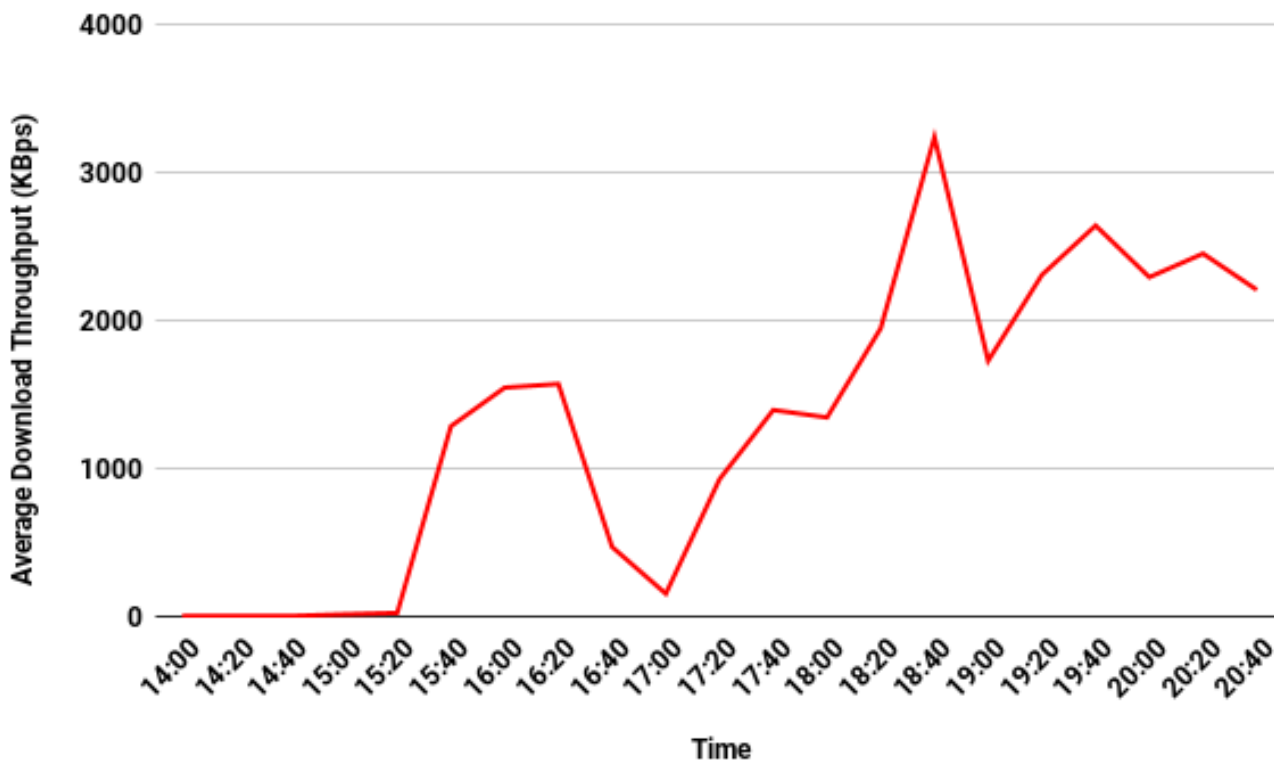
# Average Download Throughput in Main Room for H/W probes, Monday (14.00 - 21.00), including all test tools



**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**

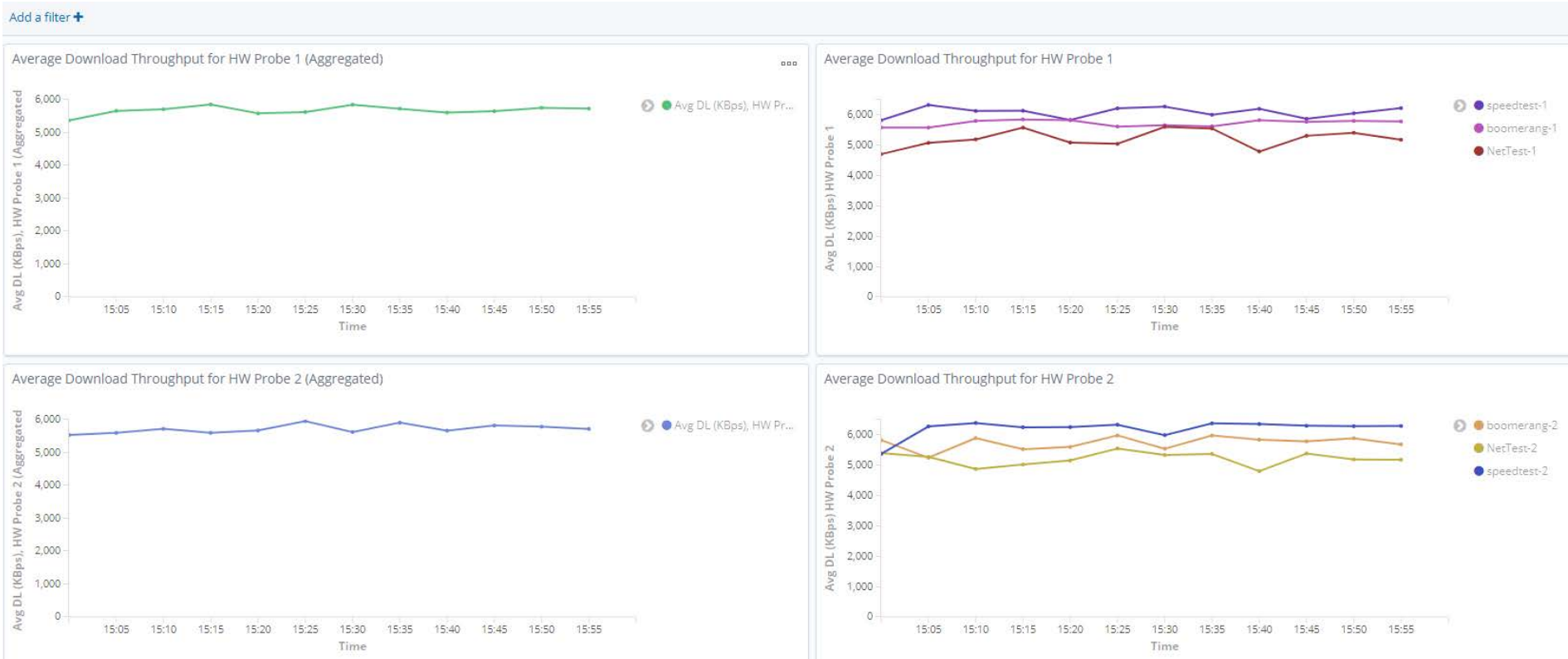


- WiFi problematic during the lightning talks plenary session (14.00 - 15.20)
- WiFi OK in the afternoon when lots of people have left the main room
- Worse throughput seen during the opening reception (17.00)
- WiFi then OK in the evening

## 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.

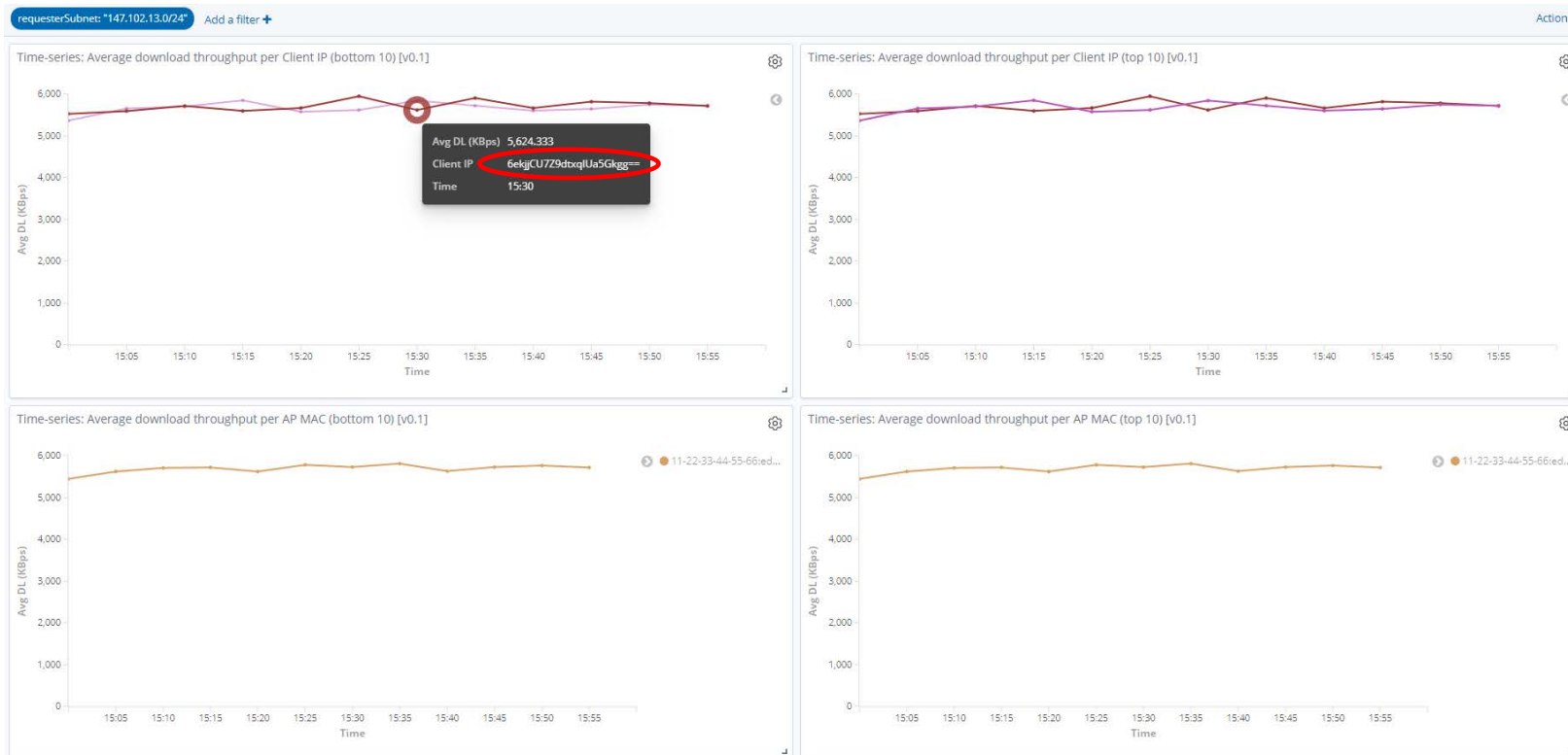
# Feedback Integration – H/W Probe (only) Visualisation



- 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

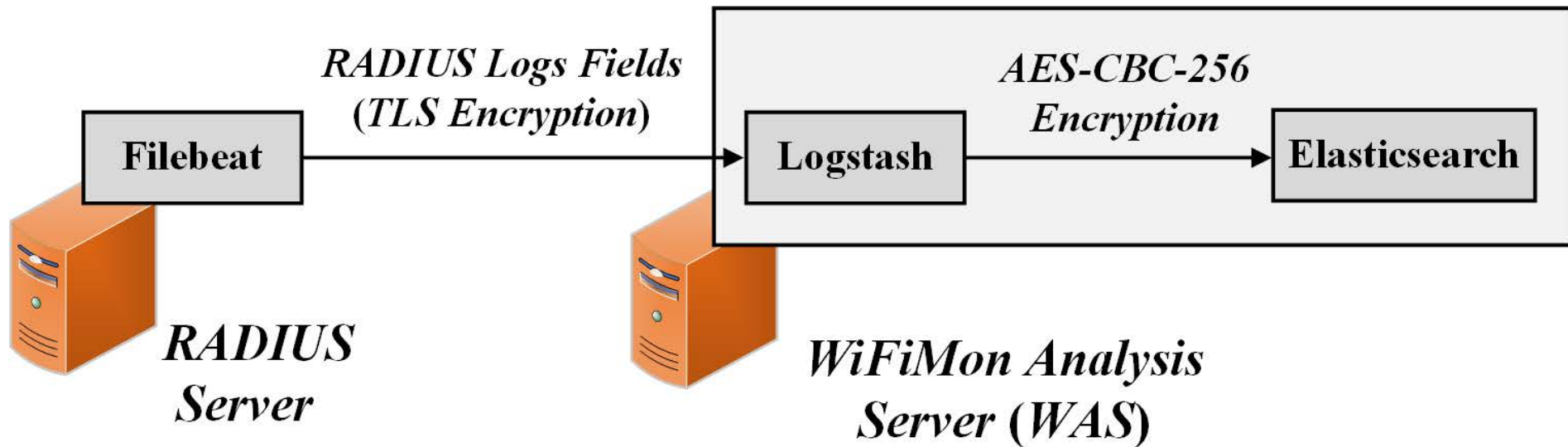
Export: Raw Formatted

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**



# Thank you

Any questions?

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