

Monitoring End-User Wi-Fi Experience with WiFiMon: Capabilities & Results

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Workshop on Network Management &
Monitoring Tools (NEMMO)
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WiFiMon: Introduction

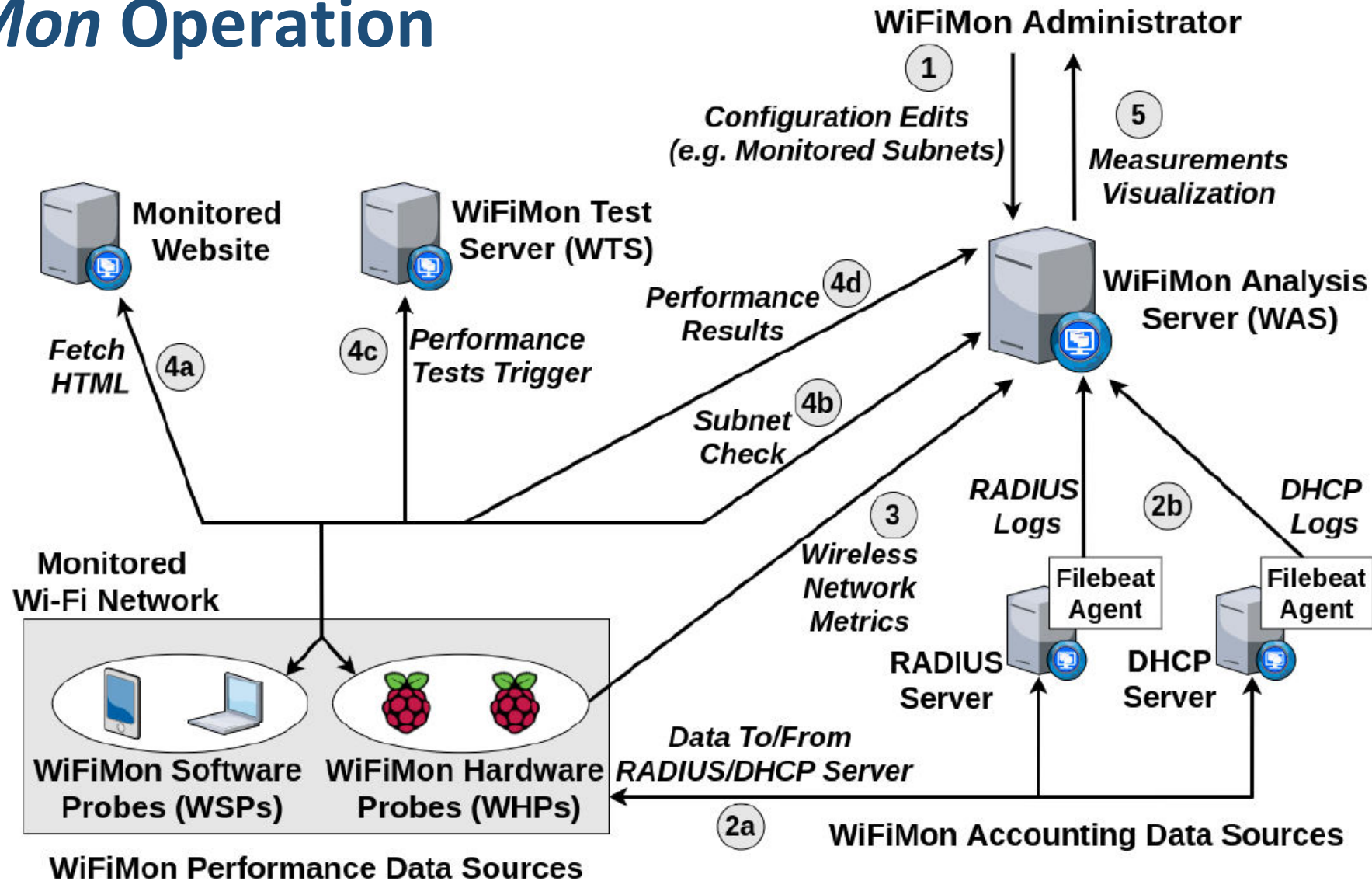
- Monitors the performance of Wi-Fi networks as experienced by their end users using an objective *Quality of Experience (QoE)* approach.
- Combines crowdsourced and hardware probe measurements to provide complete insight into Wi-Fi network performance.
- In IEEE 802.1X networks, e.g. *eduroam*, data from *RADIUS* and *DHCP* logs may be used to provide additional analysis options, e.g. per *Access Point (AP)*.

Contribution: Supporting administrators to detect Wi-Fi throughput degradation, hence allowing them to determine underperforming areas in a network and enhance Wi-Fi performance, e.g. by installing more *APs*

WiFiMon vs other monitoring solutions:

- *WiFiMon* monitors from the end user perspective (*end user experience*).
- *WiFiMon* does not require end user intervention or installation of an app.
- *WiFiMon* provides a centralized view of Wi-Fi performance and informs the Wi-Fi administrator of the performance results.

WiFiMon Operation



WiFiMon Components:

- WiFiMon Software Probes (WSPs)
- WiFiMon Hardware Probes (WHPs)
- WiFiMon Test Server (WTS)
- WiFiMon Analysis Server (WAS)

WiFiMon Test Server (WTS)

- **Purpose:** Holds the code and test data required for performance measurements.
- Based on *JavaScript* technology.
- *HTML* lines pointing to *WTS JavaScript*-based test tools are embedded to a frequently visited site.
- Measurements of the *HTTP* service (major part of the Internet traffic).

Three available test tools:

- **NetTest** (<https://code.google.com/archive/p/nettest/>)
- **Akamai Boomerang** (<https://github.com/akamai/boomerang>)
- **LibreSpeed Speedtest** (<https://github.com/librespeed/speedtest>)

WTS Placement: Should be as close as possible to the monitored networks so that the distance between the end devices and the *WTS* is minimized, thus minimizing accuracy loss.

- Even if *WTS* placement close to the monitored network is not possible, *WiFiMon* can capture the **relative changes** among received measurements

WiFiMon Software Probes (WSPs)

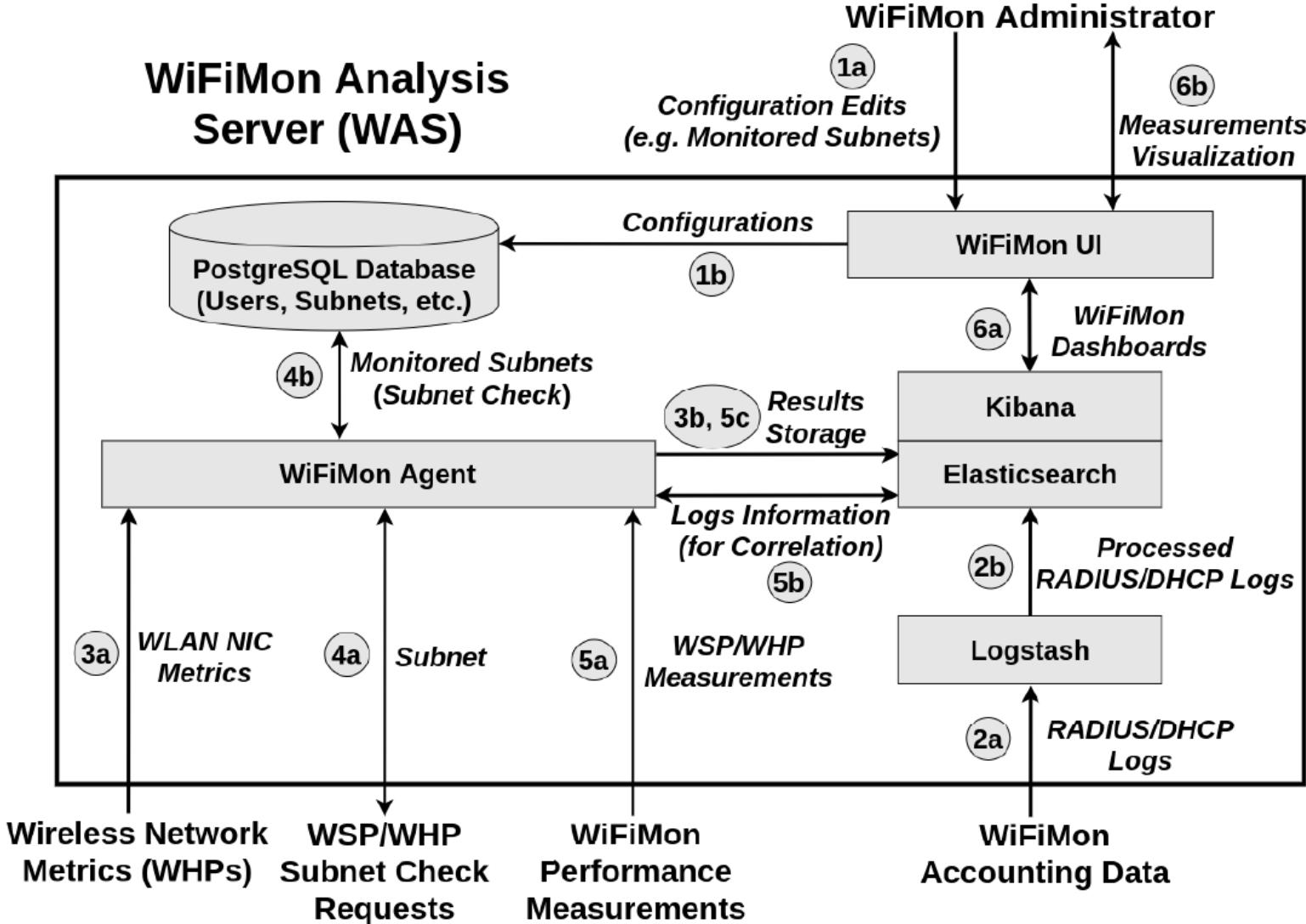
- **User devices**, e.g. laptops, smartphones, etc.
- Crowdsourced measurements are triggered against the WTS when users visit a *WiFiMon*-enabled site (**not triggered by end users themselves**).
- *WiFiMon* does not require additional software to be installed on user devices.
- *WiFiMon* regulates repetitive measurements through a cookie parameter in order not to overload WAS and WTS.

```
<html>
<head>
<title>Boomerang measurement page</title>
  <script type="text/javascript" src="https://fl-5-205.unil.cloud.switch.ch/wifimon/js/boomerang/jquery-3.5.1.min.js"></script>
  <script type="text/javascript" src="https://www.google.com/jsapi"></script>
  <script src="https://fl-5-205.unil.cloud.switch.ch/wifimon/js/boomerang/boomerang.js" type="text/javascript"></script>
  <script src="https://fl-5-205.unil.cloud.switch.ch/wifimon/js/boomerang/bw.js" type="text/javascript"></script>
  <script src="https://fl-5-205.unil.cloud.switch.ch/wifimon/js/boomerang/rt.js" type="text/javascript"></script>
  <script type="text/javascript" id="settings" hostingWebsite="https" agentIp="fl-5-205.unil.cloud.switch.ch" agentPort="8443"
testtool="boomerang" imagesLocation="https://fl-5-205.unil.cloud.switch.ch/wifimon/images/" cookieTimeInMinutes="0.01"
  src="https://fl-5-205.unil.cloud.switch.ch/wifimon/js/boomerang/boomerang-trigger.js" defer></script>
</head>
<body>

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

**Example: HTML lines required for Akamai Boomerang test tool
(injected in the frequently visited web site)**

WiFiMon Analysis Server (WAS)



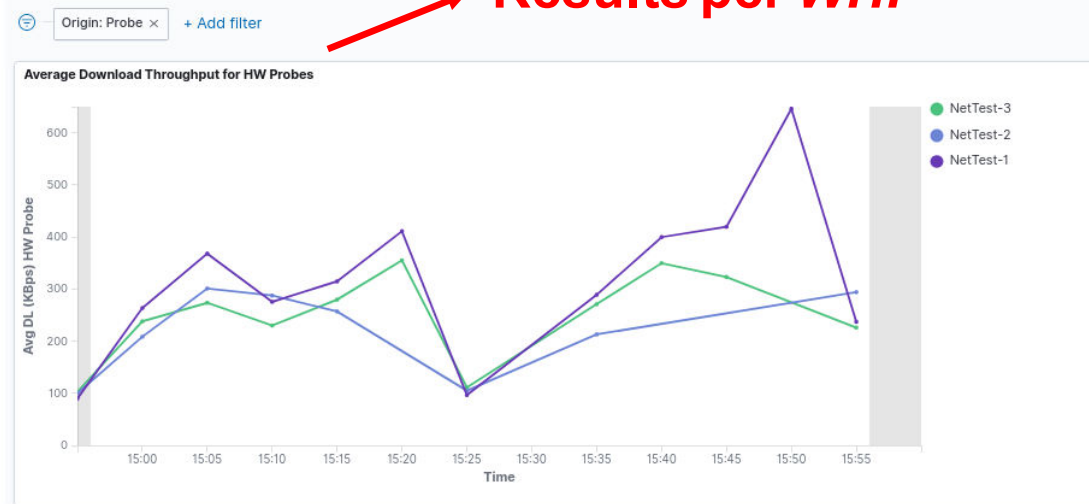
WAS Modules:

- **WiFiMon Agent:** collects and processes the received monitoring data
- **WiFiMon User Interface (UI):** depicts the results of data processing

WiFiMon User Interface (UI)

Results per WHP

Aggregated Results



Results from 3 WiFiMon Hardware Probes during an hour

Correlation with *RADIUS/DHCP* Logs

Logs are:

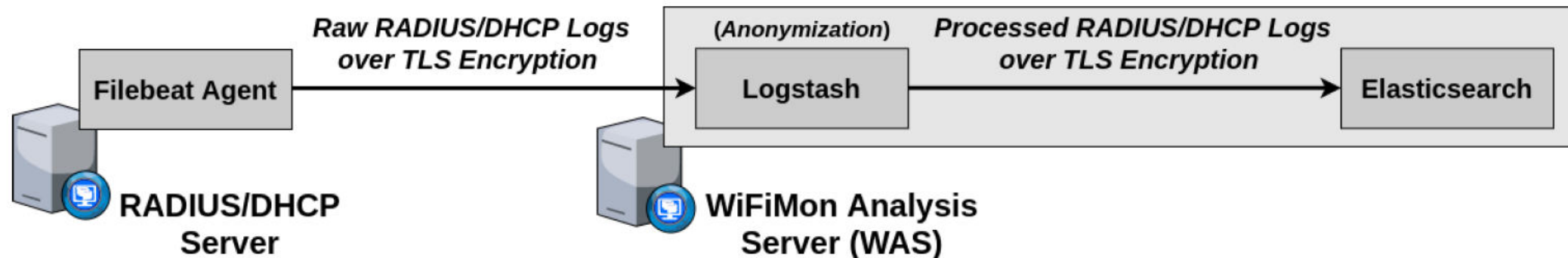
- Extracted from *RADIUS/DHCP* servers using **Filebeat**
- Processed and transformed by **Logstash** in WAS
- Stored in **Elasticsearch** of WAS

Correlation options:

- With end user IP address (relying solely on *RADIUS* logs)
- With end user MAC address (using both *RADIUS* and *DHCP* logs)

Personally Identifiable Information (PII): IP and MAC addresses are secured in transit using a TLS-encrypted channel and stored hashed in WAS (based on *X-Pack*)

→ Correlation comparisons are performed on hashed strings.



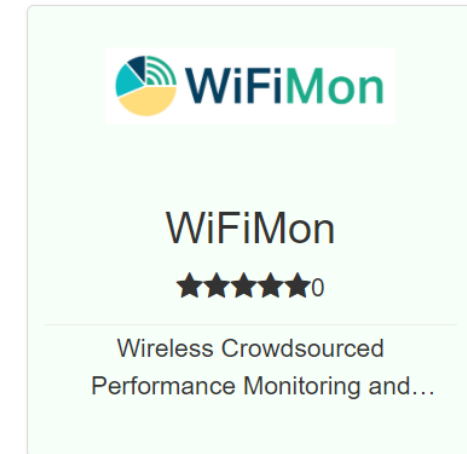
Installing *WiFiMon*

GÉANT Service since 2020!

Options:

- Interested institutions install all the components **on their premises**
 - Download and installation by institutions.
 - All data stay within the premises of the institution.
 - Support from *WiFiMon* team for all components.
- ***NMaaS*** (more appropriate for testing/trying *WiFiMon*)
 - *WiFiMon* WAS instance per institution deployed on *NMaaS*.
 - WTS installation still required by institutions (***should be close to the monitored network***).
 - Support from *WiFiMon* team in interfacing WTS and Dockerized WAS on *NMaaS*

NMaaS Portfolio



Recent addition: Ansible script for automating WAS installation (1st option)

Evaluation

Based on pilots in 2 recent conference venues:

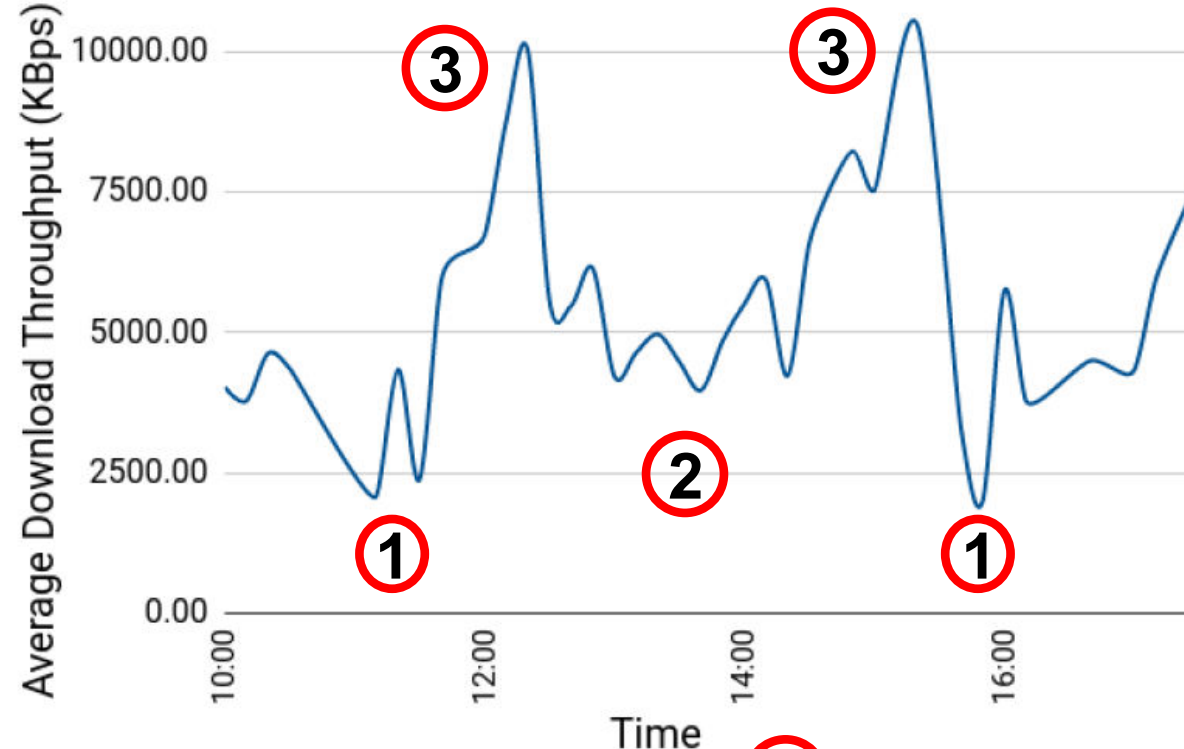
- TNC19 Conference (Tallinn, 2019) → *Skipped in this presentation* (see older ones!)
- **GÉANT Symposium 2020 (Ljubljana, 2020)**

GÉANT Symposium 2020 :

- Around 250 participants
- Monitored **eduroam** *ESSID*
- **WHPs**: Seven *Raspberry Pi* 3 model B devices (Interval: 5 minutes)
- **WSPs**: *HTML* lines in the **conference agenda** after receiving consent during the online registration process
- **WTS**: in *ARNES*, the Slovenian *NREN* (**close to the Symposium venue**)

GÉANT Symposium 2020 Pilot (1)

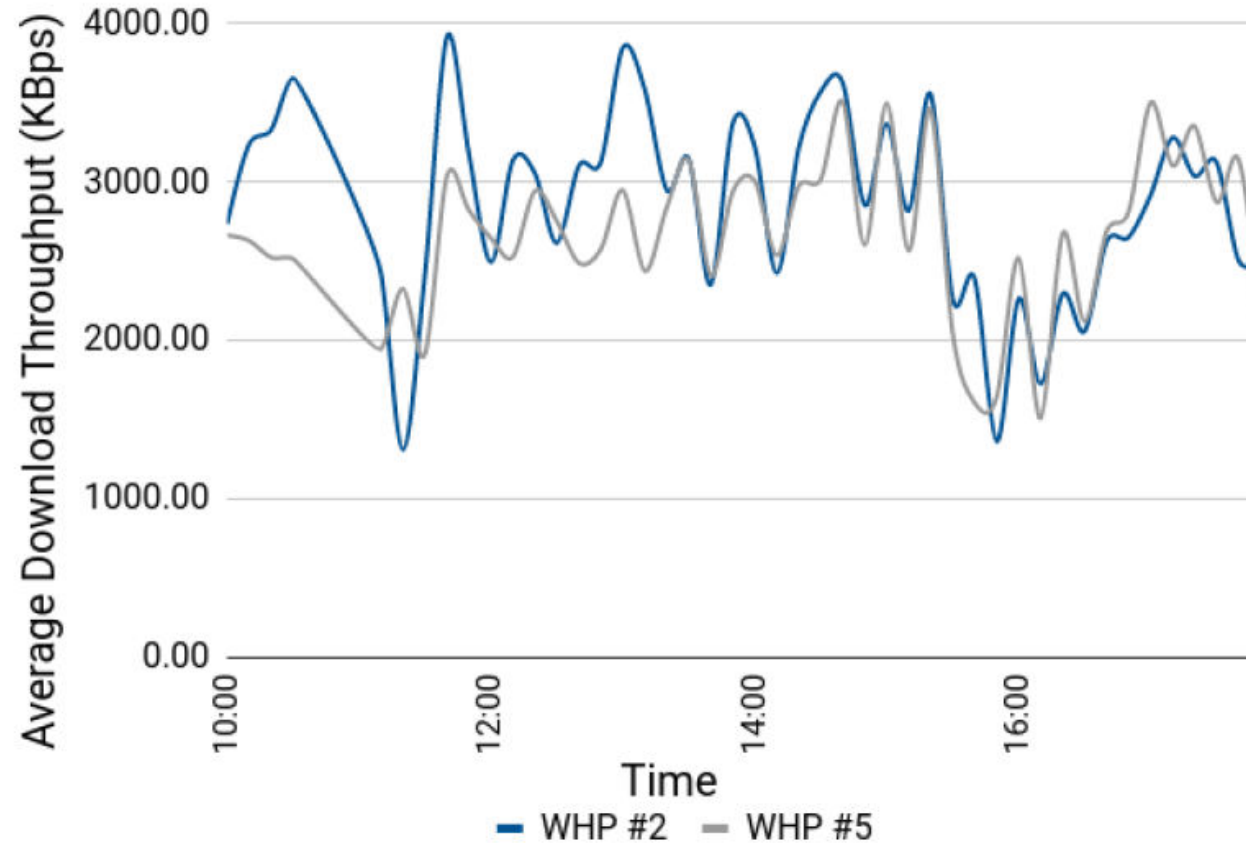
Average download throughput reported by crowdsourced measurements (1st Symposium Day between 10:00 and 17:00):



- **Major drops:** 11:00 – 11:40 and 15:30 – 16:00 **1**
→ periods after coffee break (more people visiting symposium agenda)
- **Notable drop:** 12:30 – 14:00 **2**
→ during and after lunch time when most participants gathered in less space
- **Higher levels:** around 12:20 and 15:20 → participants distributed across many different sessions **3**

GÉANT Symposium 2020 Pilot (2)

Average download throughput reported by *WHPs* #2 and #5 (1st Symposium day):



- Both *WHPs* follow similar trends
- Both *WHPs* conceive the throughput drops reported by *WSP* measurements
- *WHPs* reported less throughput as they were placed near the available power plugs, typically farther from *Access Points* than the audience (e.g. on the floor)

GÉANT Symposium 2020 Pilot (3)

Wireless network metrics and performance measurements for the 1st Symposium day:

WHP No	Average Signal Level (dBm)	Average Bit Rate (Mbps)	Average Link Quality	Average TX Power (dBm)	Average Download Throughput (KBps)	Average Upload Throughput (KBps)	Average Ping Latency (msec)
1	-43	71	67/70	31	1588	763	48
2	-52	49	58/70	31	2883	1500	30
3	-59	78	51/70	31	2644	1429	44
4	-59	59	51/70	31	1431	650	41
5	-66	75	44/70	31	2678	1514	23
6	-62	65	48/70	31	1758	890	41
7	-55	66	55/70	31	2730	1562	32

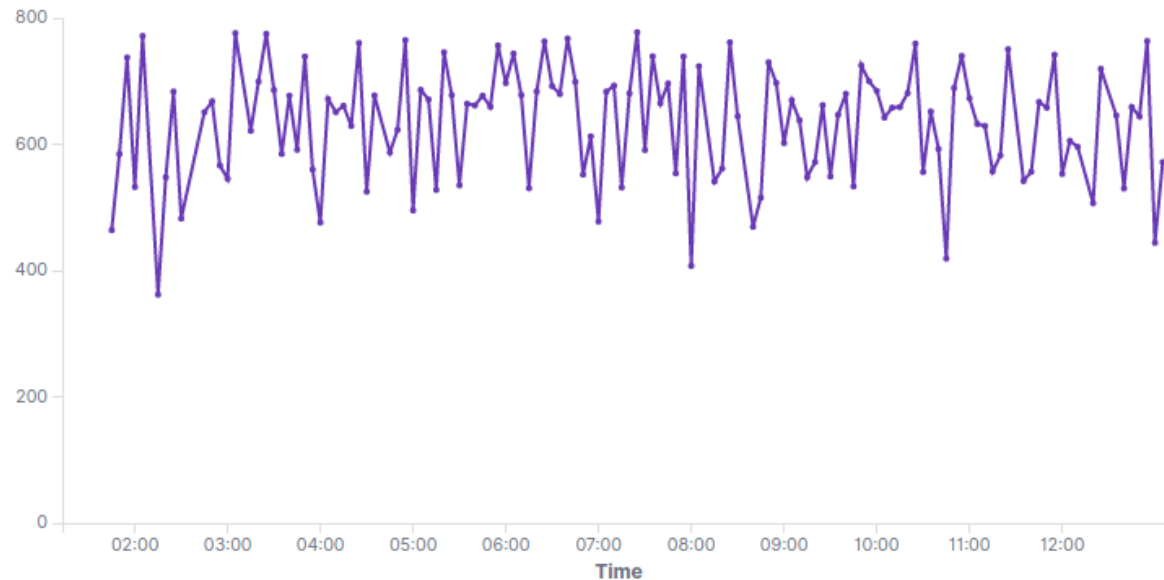
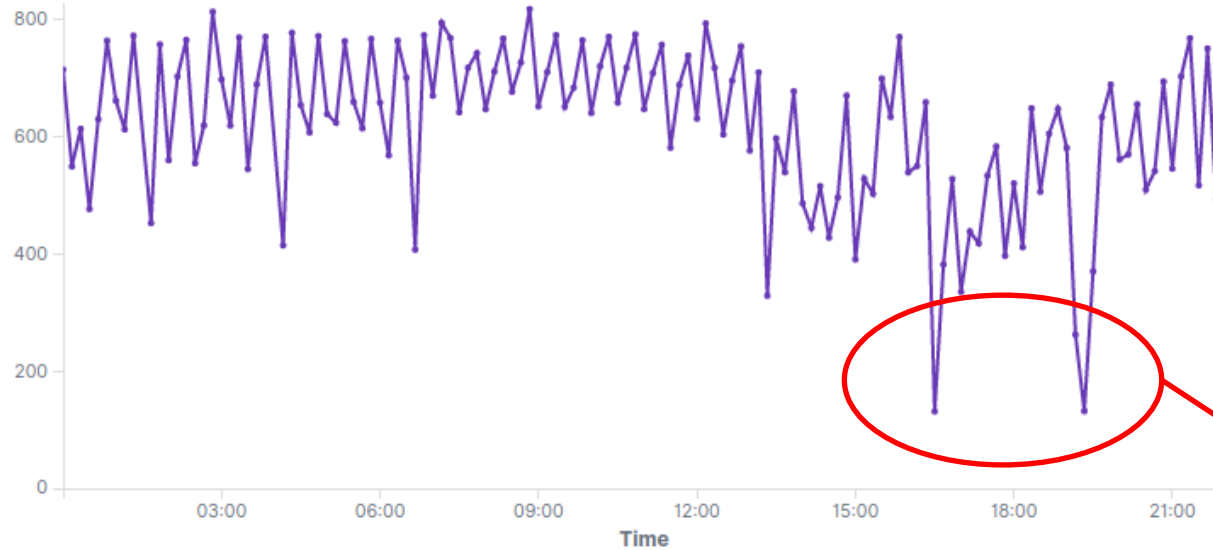
Observation: The trends of wireless network metrics do not necessarily follow those of the performance measurements

- **WHP #1:** *best* average link quality, but among the *worse* throughput results
- **WHP #5:** *worst* average link quality, but among the *best* throughput results

Conclusion: Multiple sources of performance information, i.e. crowdsourced and probe measurements, are vital for the proper evaluation of Wi-Fi performance
→ High values of signal strength and link quality do not necessarily guarantee high Wi-Fi throughputs

Results from a Home Network

Average Download Throughput (KBps)



- **Depicting Average Download Throughput reported by a *WHP***
- **Two different days**

Two notable drops, while downloading a big file from another PC within the network

Future Steps

- Enrich *WiFiMon* toolset with additional Wi-Fi performance monitoring options
- Contacting interested *NRENs* and assisting them in installing *WiFiMon*
- ***Most recent setup in RENU***
- *WiFiMon* setups in home/enterprise networks of *WiFiMon* team members for long term analysis
- Version tracking for *WiFiMon*

Check out the *WiFiMon* video!

<https://www.youtube.com/watch?v=9LuGIF6JSnA>

... or the *WiFiMon* Infoshare

<https://www.youtube.com/watch?v=VXQV2zWRKgo>

... or earlier presentations

<https://wiki.geant.org/display/WIF/WiFiMon+Publications>



Thank you

Homepage:

<https://wiki.geant.org/display/WIF>

WiFiMon Mailing List:

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