

WiFiMon – Wi-Fi Performance as Experienced by the End-User

Kurt Baumann (SWITCH)

On Behalf of the WiFiMon and WiredMon Team

GN4-2-SA3T5 – eduPERT

DeiC Conference, Comwell Kolding, DK

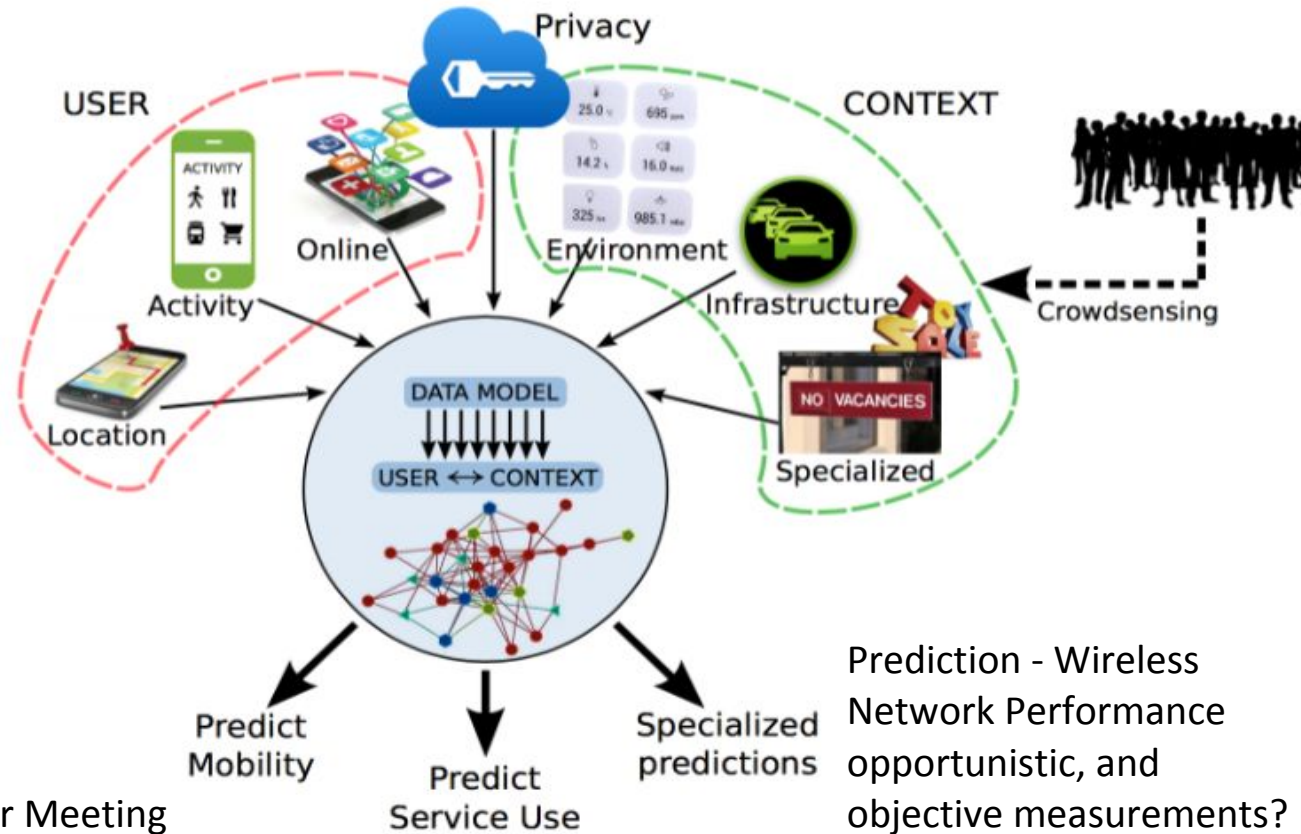
27th of September 2017

- Mobile Crowd Sensing Systems
- Basics on Wireless Crowd sourced Performance Monitoring Verification (WiFiMon)
- Mobile Application Measurement Approach
- Hybrid Approach
- Visibility Web-UI and elastic search
- Discussion Security and Privacy at the End-User Meeting in Zurich – May 2017
- Conclusions and Future Work

Measurement page:

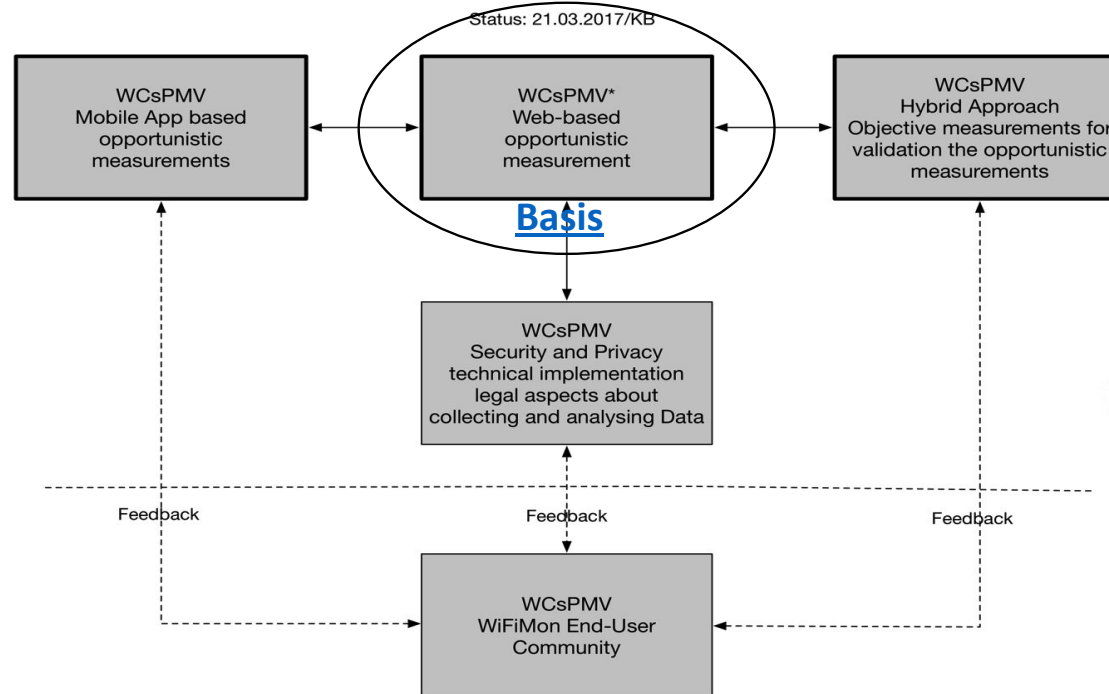
<https://vm3-gn3-sa2t5.vm.grnet.gr/measurement.html>

Mobile Crowd Sensing Systems



Source: WiFiMon End-User Meeting
<https://goo.gl/8FousQ>

GEANT WCsPMV Activities



GN4-2-SA3T5 WiFiMon

*Wireless Crowd sourced Performance Monitoring and Verification

Introduction WiFiMon

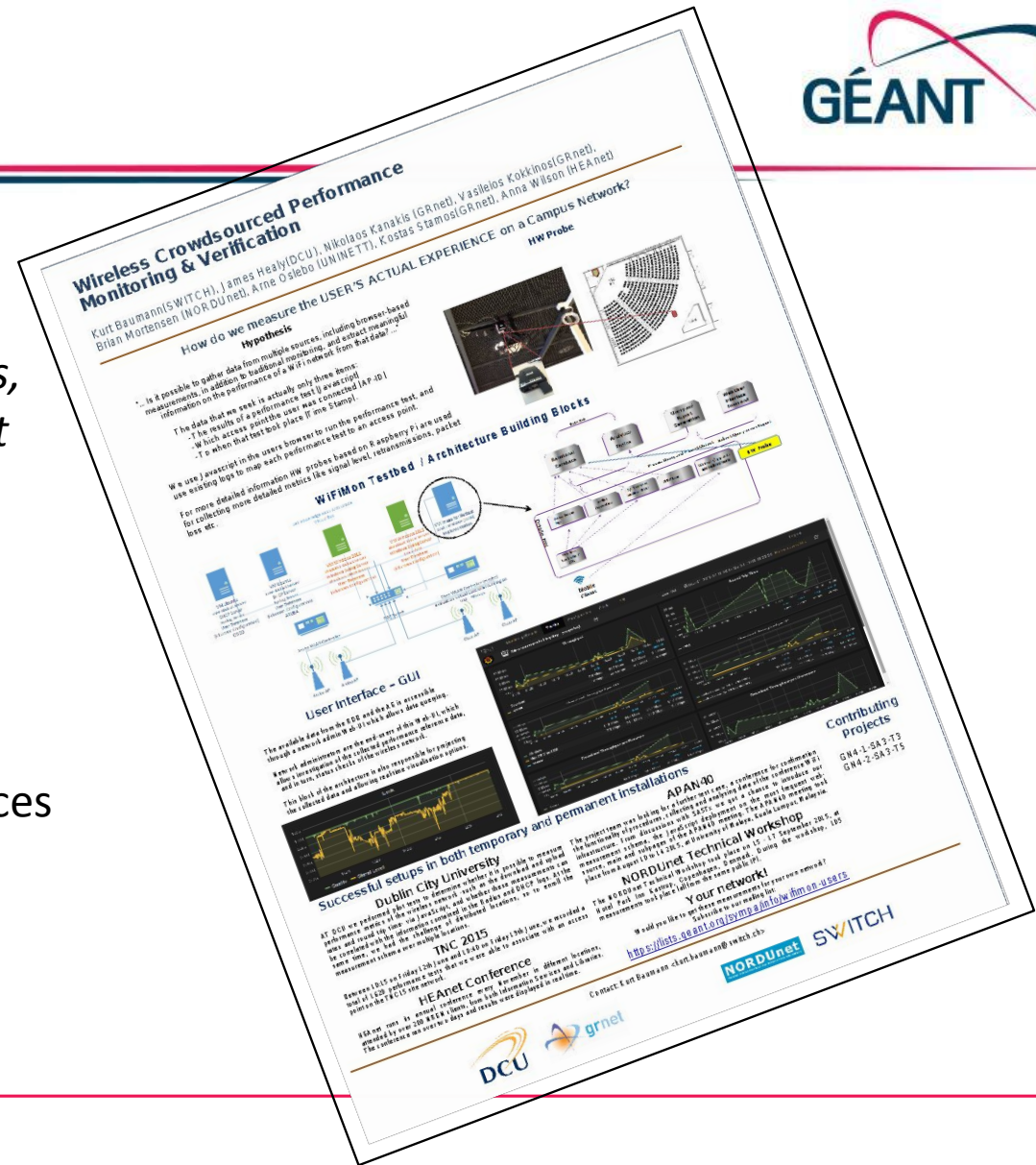


Mission Statement:

"...It is 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..."

WiFiMon Prototype:

- PM architecture design
- Java Script distributed to essential web-sources
- NetTest/Boomerang servers configured
- Upload- / Download Images
- ...and non-invasive...



Measuring and verifying the performance of a WiFi network 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

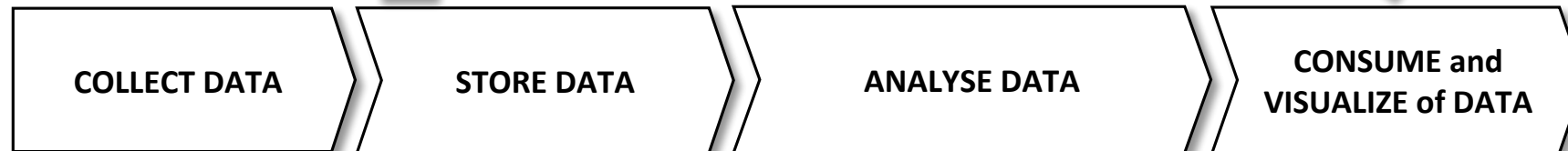
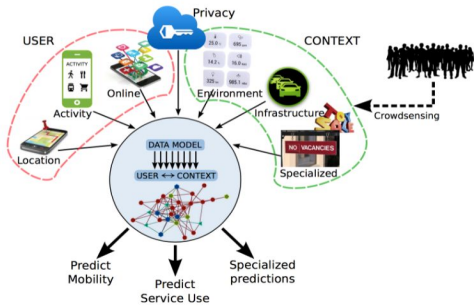
At present, information for wireless networks can be reported in three ways:

- 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 measurement but are installed at fixed locations

WiFiMon Process



WiFi Interface

Focus: WiFi
/eduroam enabled
infrastructure
on Smart Devices

Temporary Data Persistent Data

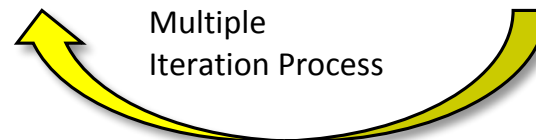
- Raw data from data sources
- Reference data correlated

Real Time Analysis:

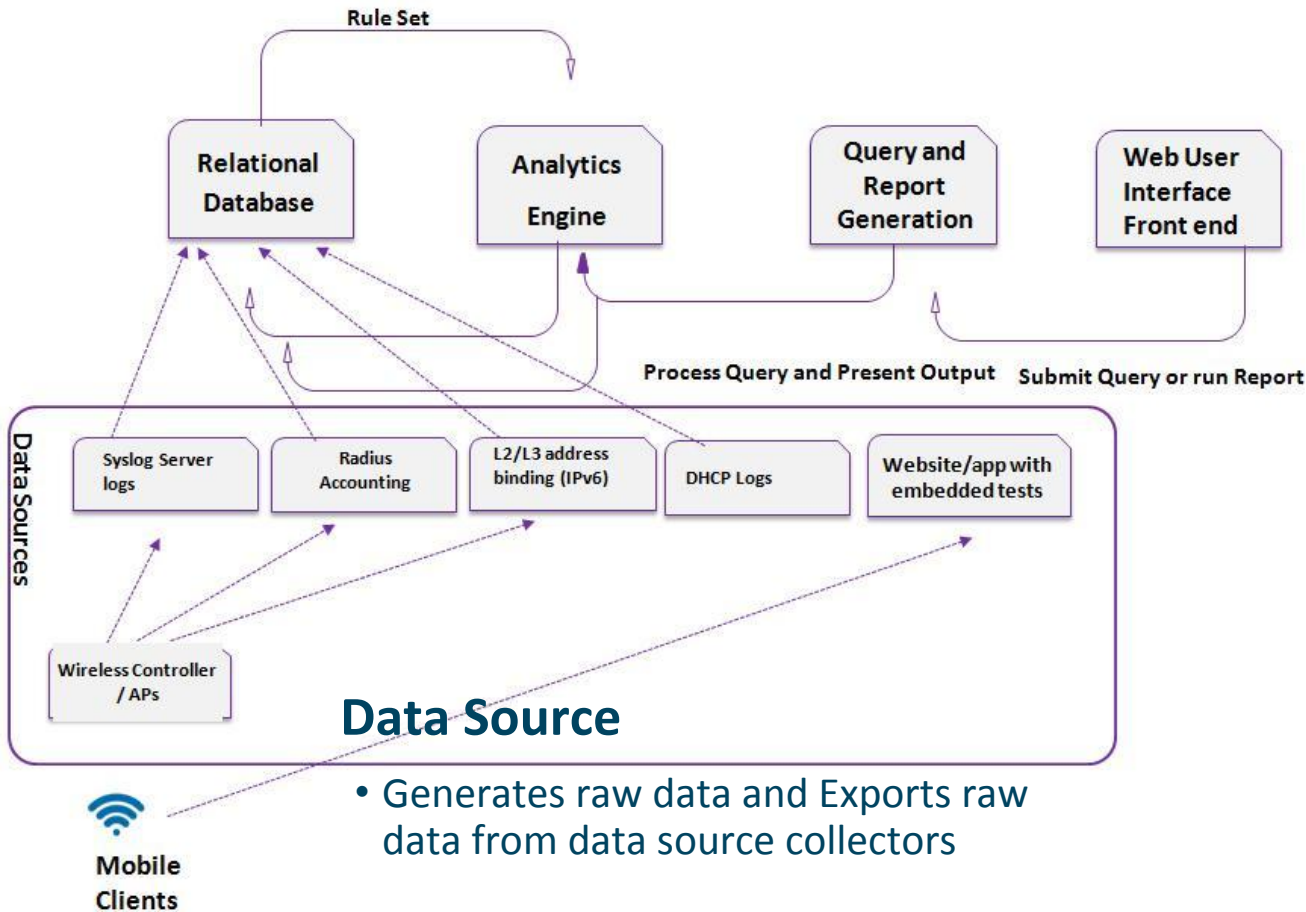
- Correlation: RADIUS Accounting/Performance data
- Mobility Prediction (future)
 - Focus Network Performance
 - Focus Crowd prediction etc.

Web-UI

- Visualization: View Snapshot)
- APIs



WiFiMon Architecture



Relational Database

- Automatically collects the raw data

Analytic Engine

- Sorts the raw data collected, analyze it, and provide visualizations

Query and Report Generation

- Searches for usable information from RDB and AE

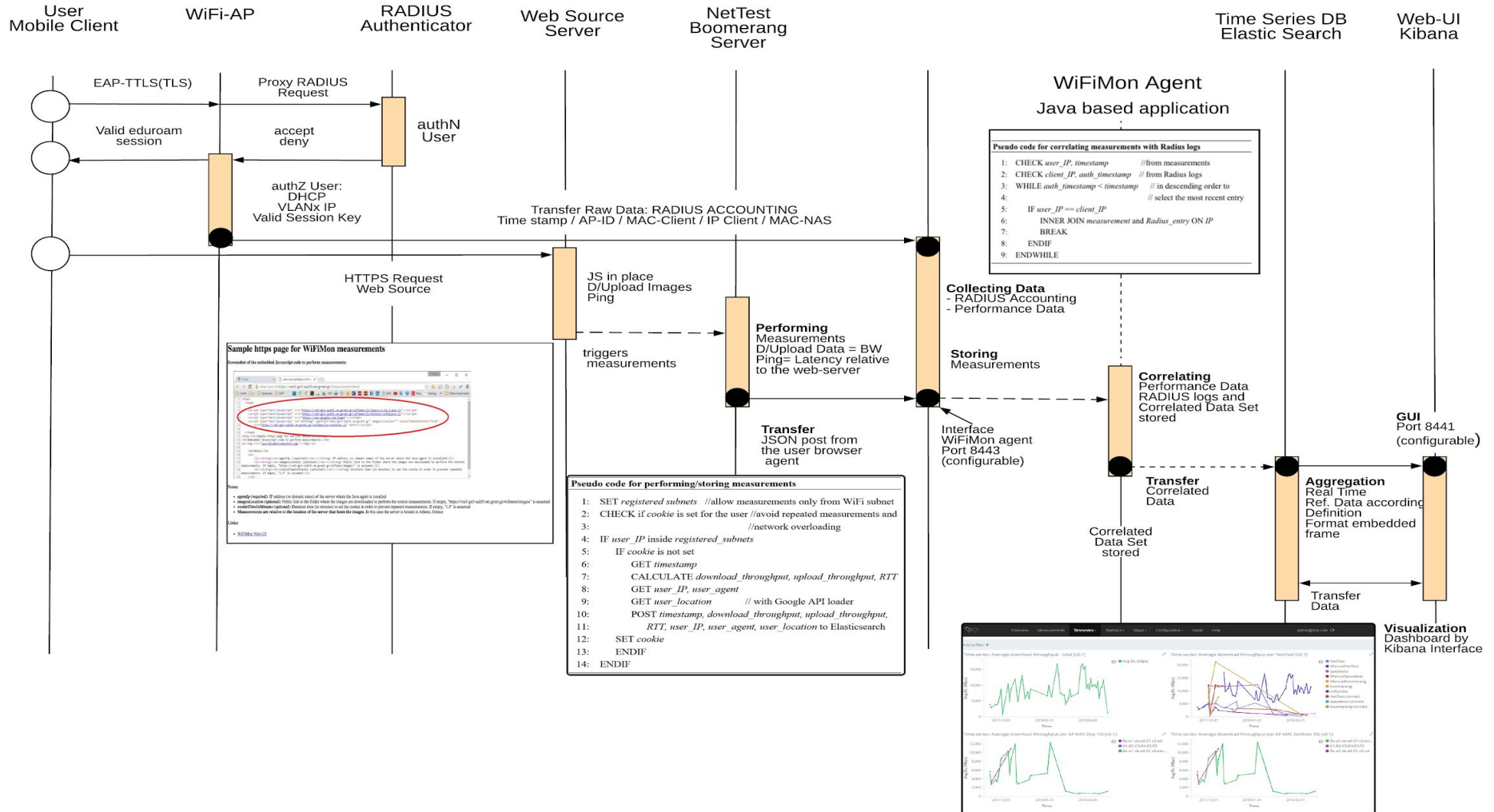
Web User Interface (Web-UI)

- Allows real-time visualization options



08-15-2018

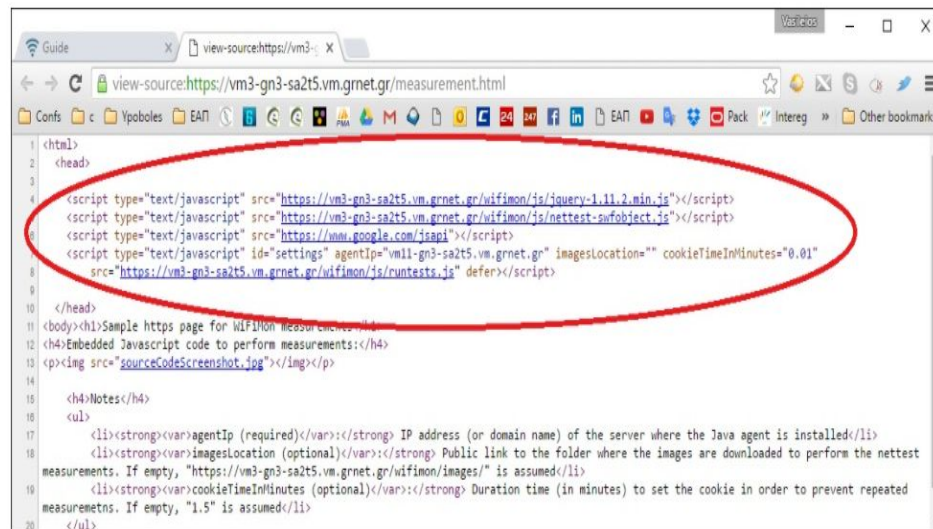
WiFiMon - Data Flow Diagram



WiFiMon – eduroam enabled WiFi Infrastructure: Walk Through

Sample https page for WiFiMon measurements

Screenshot of the embedded Javascript code to perform measurements:



```

1 <html>
2 <head>
3
4 <script type="text/javascript" src="https://vm3-gn3-sa2t5.vm.grnet.gr/wifimon/js/jquery-1.11.2.min.js"></script>
5 <script type="text/javascript" src="https://vm3-gn3-sa2t5.vm.grnet.gr/wifimon/js/nettest-swfobject.js"></script>
6 <script type="text/javascript" src="https://www.google.com/jsapi"></script>
7 <script type="text/javascript" id="settings" agentIp="vm11-gn3-sa2t5.vm.grnet.gr" imagesLocation="" cookieTimeInMinutes="0.01"
8   src="https://vm3-gn3-sa2t5.vm.grnet.gr/wifimon/js/runtests.js" defer></script>
9
10 </head>
11 <body><h1>Sample https page for WiFiMon measurements</h1>
12 <h4>Embedded Javascript code to perform measurements:</h4>
13 <p></img></p>
14
15 <h4>Notes</h4>
16 <ul>
17   <li><strong><var>agentIp (required)</var></strong> IP address (or domain name) of the server where the Java agent is installed;</li>
18   <li><strong><var>imagesLocation (optional)</var></strong> Public link to the folder where the images are downloaded to perform the nettest
19   measurements. If empty, "https://vm3-gn3-sa2t5.vm.grnet.gr/wifimon/images/" is assumed;</li>
20   <li><strong><var>cookieTimeInMinutes (optional)</var></strong> Duration time (in minutes) to set the cookie in order to prevent repeated
21   measurements. If empty, "1.5" is assumed;</li>
22 </ul>

```

Notes:

- **agentIp (required):** IP address (or domain name) of the server where the Java agent is installed
- **imagesLocation (optional):** Public link to the folder where the images are downloaded to perform the nettest measurements. If empty, "https://vm3-gn3-sa2t5.vm.grnet.gr/wifimon/images/" is assumed
- **cookieTimeInMinutes (optional):** Duration time (in minutes) to set the cookie in order to prevent repeated measurements. If empty, "1.5" is assumed
- **Measurements are relative to the location of the server that hosts the images.** In this case the server is hosted in Athens, Greece

Links:

- [WiFiMon Web-UI](#)

eduroam as the entry point

The end user is required to visit a web page with JavaScript installed

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 Postgres and
12:            InfluxDB databases
13:        SET cookie
14:    ENDIF
15: ENDIF
```


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
```

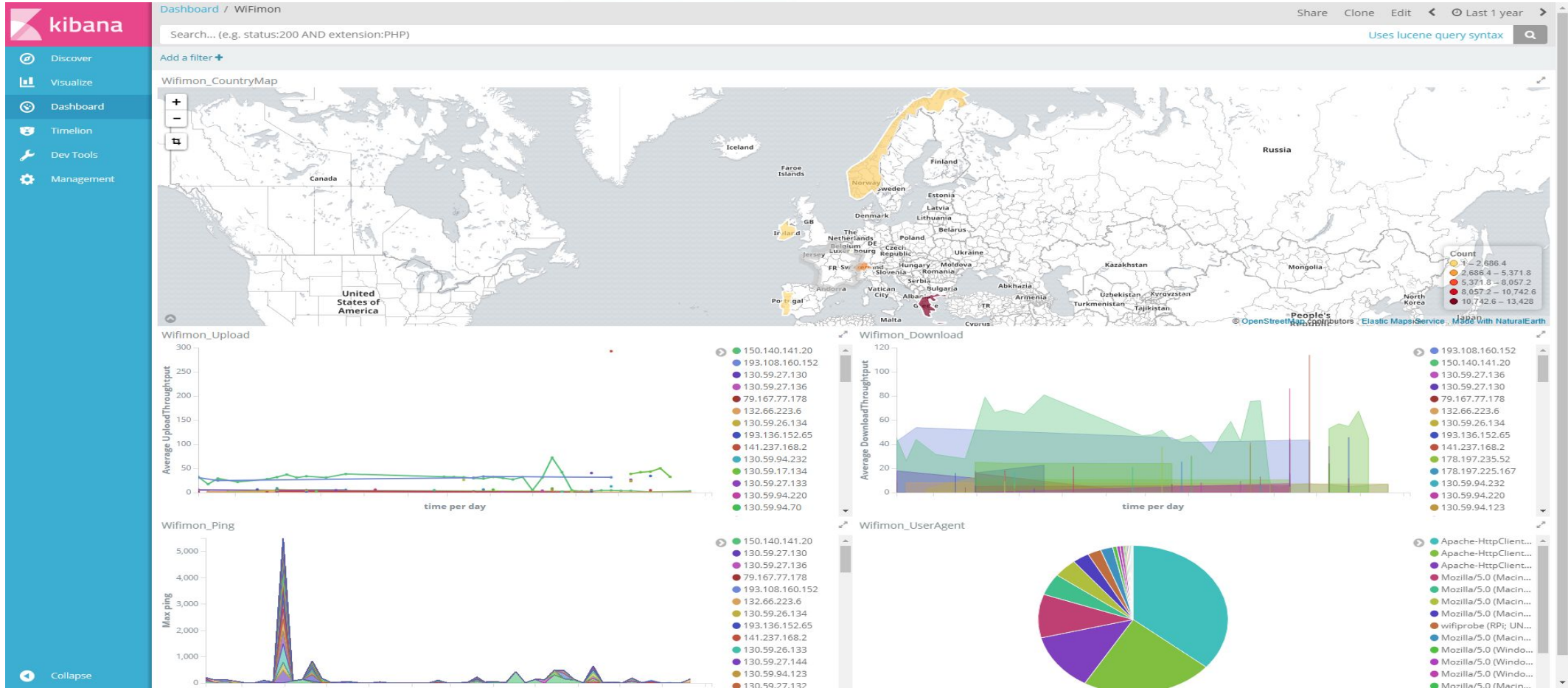

Monitoring Results
Timeline
Configuration
Users ▾
Guide
Help
admin@test.com

Id	Test Date/Time (UTC)	Start Time (UTC)	Username	Download Rate (KB/s)	Upload Rate (KB/s)	Ping (ms)	Client IP Address	Client IP (Logs)	Client MAC Address	AP IP Address	AP MAC Address	NAS Port Type	User Agent
376	2016-05-23 09:27:43.839	2016-02-25 09:09:07.0	kokkinos	9018.0	4312.0	4.5	150.140.141.20	150.140.141.20	00-24-d7-e2-4e-1A	150.140.141.12	00-0c-29-7c-03-7A	Wireless - 802.11ag	Mozilla/5.0 (Windows NT 10.0; WOW64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/50.0.2661.102 Safari/537.36
375	2016-05-19 10:34:34.892	2016-02-25 09:09:07.0	kokkinos	8815.0	4532.0	5.5	150.140.141.20	150.140.141.20	00-24-d7-e2-4e-1A	150.140.141.12	00-0c-29-7c-03-7A	Wireless - 802.11ag	Mozilla/5.0 (Windows NT 10.0; WOW64)

Grafana Interface

GÉANT WiFi Monitoring Agent
 © 2016 GÉANT | Contact

WiFiMon - Elastic Search

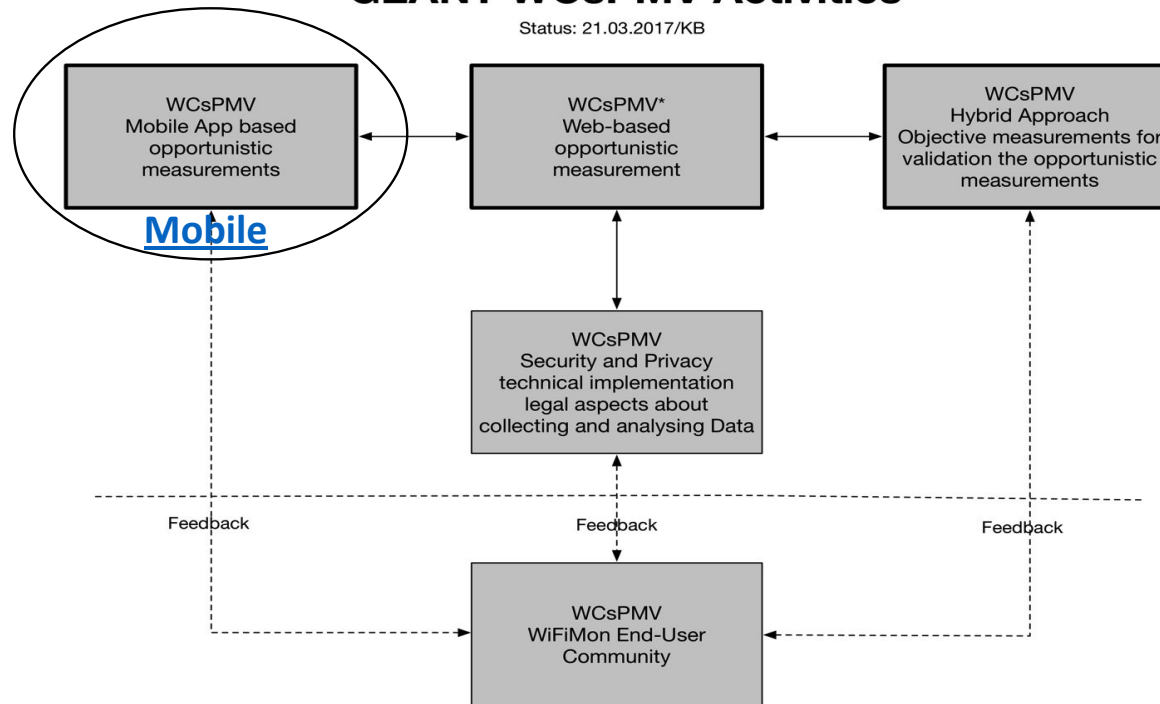


WiFiMon Concept - Overview



GEANT WCsPMV Activities

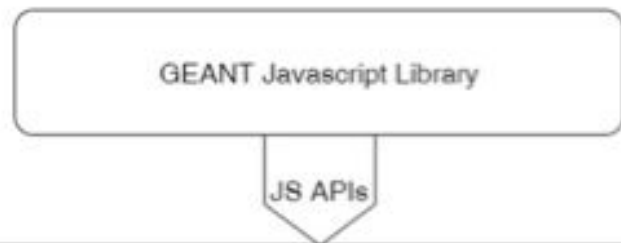
Status: 21.03.2017/KB



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WiFiMon - Mobile App Architecture - Description

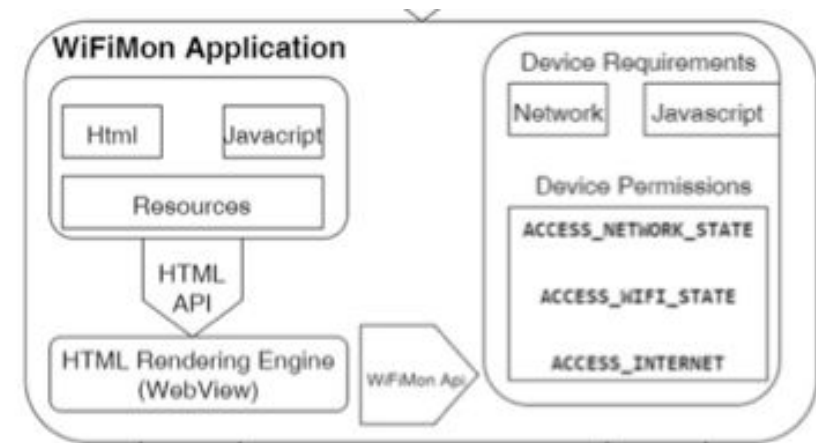


The GEANT JavaScript library and Java-based tools:

- Allows to enable Spring Boot Framework (Application and Metrics and analysis)

The WiFiMon Application:

- Requires the images location, User agentIP and Cookie time
- Download the .js from the GEANT JS Library to Trigger NetTest
 - Send the results to the WifiMon agent
 - Informs the user for the results



Mobile OS using the appropriate APIs to build the mobile application

WiFiMon - Mobile App Architecture – Building Blocks

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
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10:    POST timestamp, download_throughput, upload_throughput,
11:        RTT, user_IP, user_agent, user_location to Postgres and
12:        InfluxDB databases
13:    SET cookie
14:  ENDIF
15: ENDIF
```

Fig 1- Web-based measurement

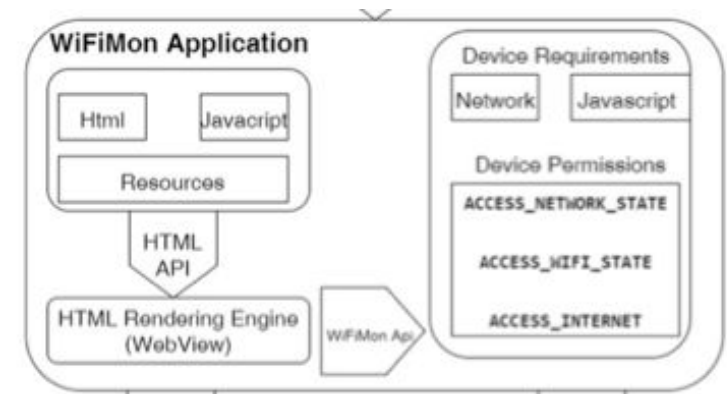


Fig 2 – WiFiMon Application

- The .js-images will be downloaded (Fig 2)
- HTML triggers the measurement (Fig 2)
- Download (.js) done - the measurement will be Started (see Fig 1)

WiFiMon - Mobile App Measurement Process



Fig 1



Fig 2



Fig 3

Step 1: Download the WiFiMon App and install it

Step 2: Open WiFiMon App. Through a friendly User Interface - UI (see Fig 1) . User has to configure measurement options (see Fig2)

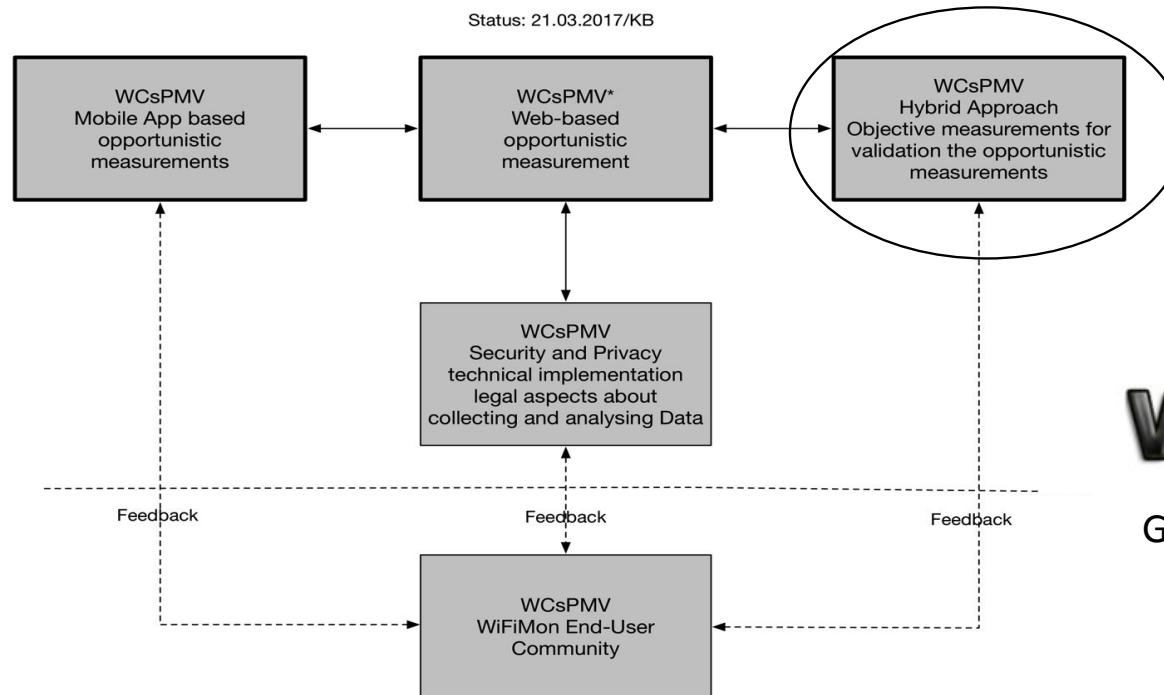
Step 3: Click on Start Measurement button and wait for the response, until monitor performance has been completed (see Fig 3) . Users will receive a notification if measurements are completed.

WCsPMV Concept - Overview



GEANT WCsPMV Activities

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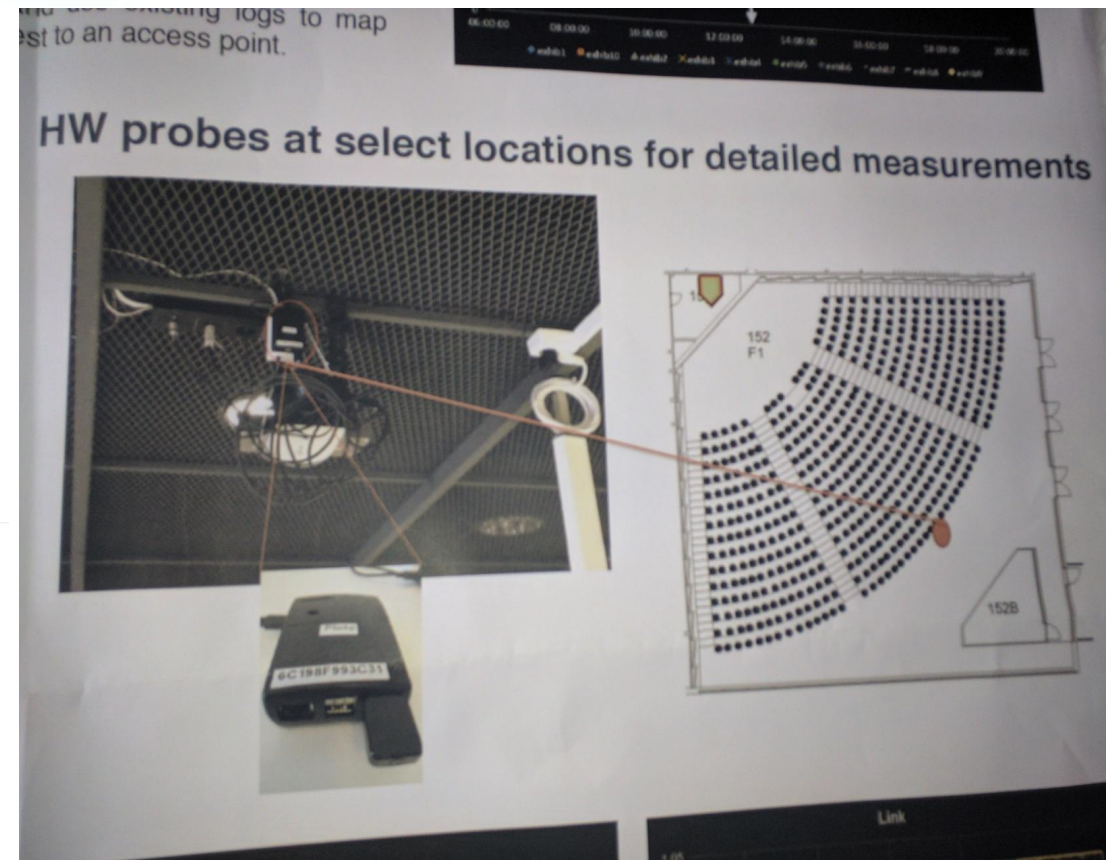


GN4-2-SA3T5 WiFiMon

*Wireless Crowd sourced Performance Monitoring and Verification

WiFiMon – Hybrid Approach

- HW: RPI1, 2 or 3 og D-link SWA-171
- Measurements:
 - Signal strength, channel info, SSID's
 - Association time (auth + asso), DHCP
 - Respons time (dns, http)
 - Up & download speed
- Measurement scripts
 - owamp, iperf3, curl etc

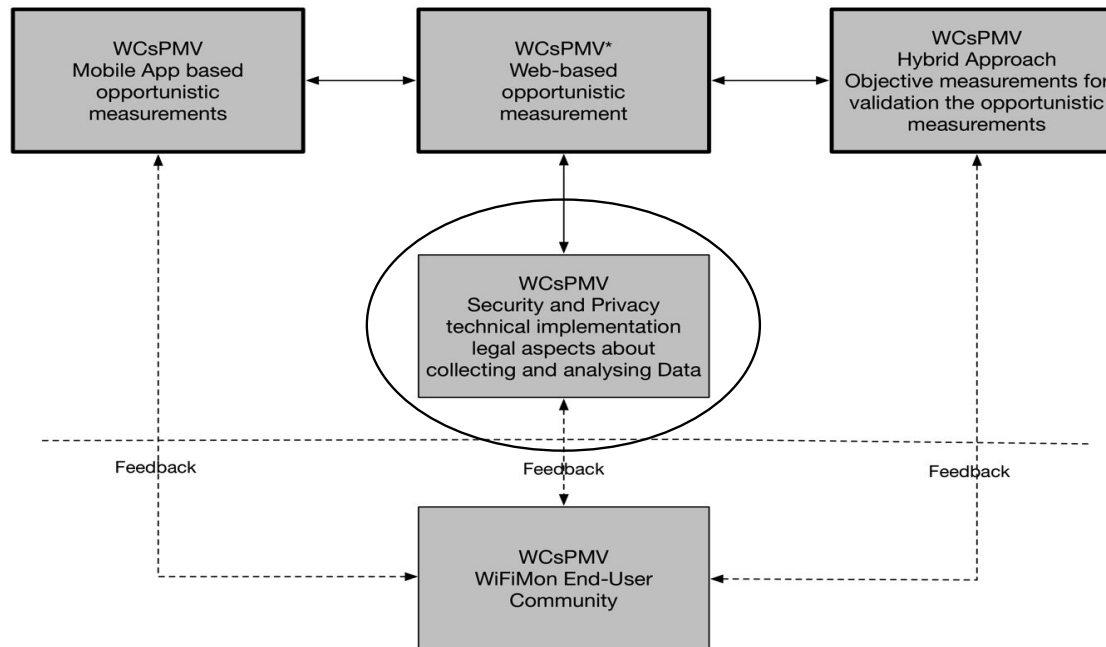


WiFiMon Concept - Overview



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WiFiMon – Security and Privacy



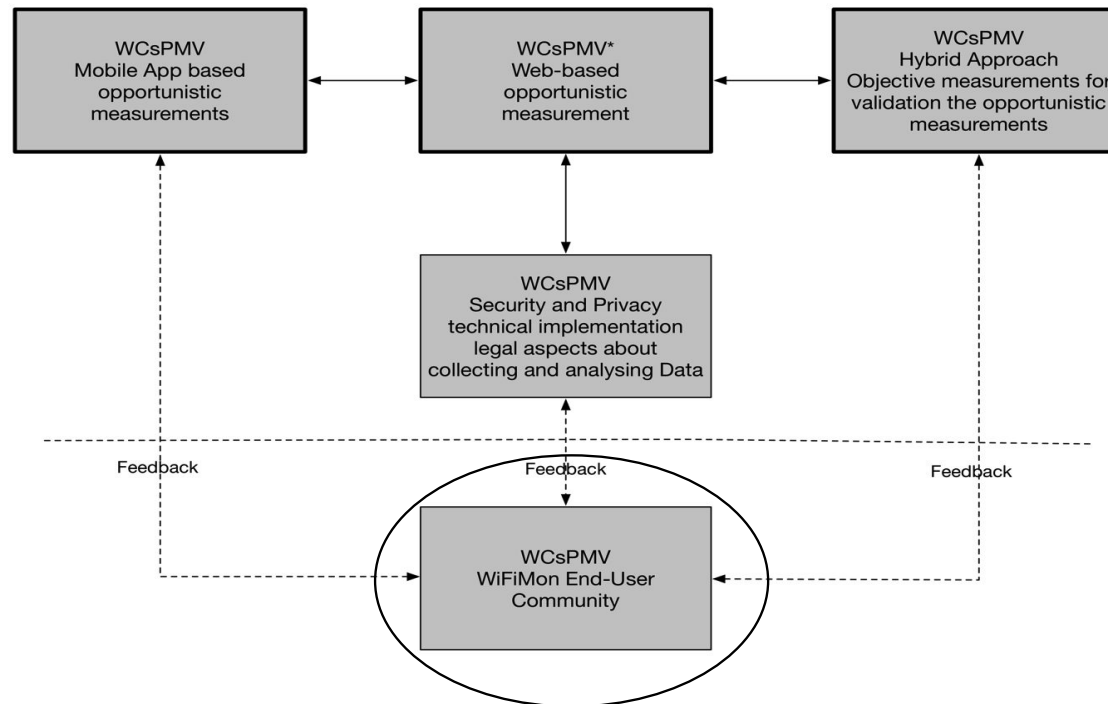
- Beyond WiFiMon
 - Eduroam as a basis → SP and IdP policy >>> Consequences for WiFiMon
 - Eduroam RADIUS Logs
- Process Data Management
 - Legal aspect of Collecting, Storing, Analysing, Consuming and Visualizing of data
 - [Exercising caution when processing personal data](#) (Management at SWITCH)
 - EC point of view about Privacy and Security to WiFiMon → Legitimation
 - [EU General Data Protection Regulation](#)
- Technical aspects
 - From beyond WiFiMon to concrete implementation of features
 - Collection process:
 - Selection of IP ranges, which will be preferred for measurements
 - End-User dialog through popups (agree / disagree measurement)
 - Storing: Only correlated information (raw data will not be stored)
 - Web site – proper disclosure on WiFiMon process / data kept
 - AP Geolocation / Mobile Geolocation (mobile app) ...

WiFiMon Concept - Overview



GEANT WCSPMV Activities

Status: 21.03.2017/KB



GN4-2-SA3T5 WiFiMon

*Wireless Crowd sourced Performance Monitoring and Verification

What might be measured?

- Opportunistic measurements
 - (Dynamic), web/app based, Java Script, measurements/WAP,
 - (Radius Accounting) Data correlation (Valid Session (time stamp) / WAP-ID / User-IP)
 - Measuring quality of device,
 - ⇒ User Experience (trends)
- Objective measurements by HW probes
 - Static, Signal strength associated SSID, list seen BSSID's
 - Network authentication, association and DHCP time
 - RTT, http and DNS response times
 - Throughput measurement
 - ⇒ Infrastructure (locally, status)

How objective measurements could support opportunistic measurements and vice versa?

Collaboration - Hybrid approach

- Combine collected data to a “complete” picture
 - User Experience data combined with Infrastructure, environmental data)
 - Common APIs transfer essential data sets

How Security and Privacy has to be considered ?

- End-User information needed? Yes /NO ?
 - Measuring performance quality at the WAP
 - End-User Device Information

WiFiMon - Dissemination



TNC2015 – Porto

Wireless Crowdsourced Performance Monitoring and Verification

WiFi Performance Measurement Using End-User Mobile Devices

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 HEAnet
 Dublin, Ireland
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IEEE: ICUMT- Lisbon
 October 2016

Abstract—The use of crowdsourced-based network performance measurement services and technologies is set to increase continually among the National Research and Education Networks (NRENs) in the near future. This requires an understanding of the behavior of network performance issues and their localization and verification in wireless campus networks. The approach presented in this paper is based on the mobile device performance in real time.

TNC2016 - Praha

Wireless Crowdsourced Performance Monitoring & Verification

Kurt Baumann (SWITCH), James Healy (DCU), Vasileios Kokkinos (GRNET), Brian Mortensen (NORDUnet), Arne Ostermann (SWITCH), Nikolaos Papachristos (GRNET), Kostas Stamos (CTI)

How do we measure the USER'S ACTUAL EXP?

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 (jmeter)
 - Which access point the user was connected (AP-ID)
 - To when that test took place (Time Stamp).
 We used a 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.



User Interface - GUI

The available data from the SDG and the AGN is accessible through a central admin WebUI which allows data querying and real administration over the end-user of the Wi-Fi network and the status checks of the wireless network.
 This level of the architecture is also responsible for the collection of data and allowing real-time visualization.



Successful setups in both temporary and permanent.

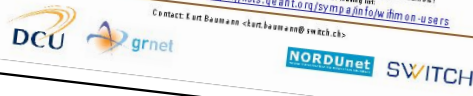
Dublin City University
 AT DCU we performed pilot tests to determine whether it is possible to measure performance metrics of the wireless network tests on the desktop and mobile devices and record the time via javascript, and whether these measurements can be correlated with the information contained in the logs and SDG logs at the same time. We had the challenge of distributed locations, so to avoid the measurement stations over multiple locations.

TNC 2015
 Between 10:15 and 11:45 (12th June) and 11:45 and 12:15 (13th June) we used a total of 1500 performance tests that we were able to associate with an access point on the FRCIS site network.

HEAnet Conference
 HEAnet met their annual conference every November in different locations, attended by over 200 HEAnet Users from 300 Information Systems and Services. The conference was over two days and results were displayed in real-time.

NORDUnet Technical Works
 The NORDUnet Technical Workshop took place on 15 - 17 September 2015 at the Hotel Tivoli, the location, Copenhagen, Denmark. During the workshop, 100 measurements took place in the testbed.

Your network!
 Would you like to see these measurements for your network? Submit to our mailing list: <http://lists.geant.org/subscribe.html?list=WiFiMon-users&listid=115>



WiFiMon App Measuring Wi-Fi Performance as Experienced by End-Users

Kurt Baumann¹, Christos Bouras^{2,3}, Vasileios Kokkinos^{2,4}, Nikolaos Papachristos³, Kostas Stamos^{2,4}
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²Network SWITCH, Zurich, Switzerland
³Computer Engineering and Informatics Dept., Univ. of Patras, Greece
⁴Greek Research and Technology Network, Greece
 kurt.baumann@switch.ch, bouras@cti.gr, kokkinos@cti.gr, papachristosn@upatras.gr, stamos@cti.gr

The measurement of quality and efficiency of a wireless Wi-Fi network is particularly difficult, as there is not a single tool that can record measurements from all sides of the system, i.e. from both the access point and the end-user. Existing tools are able to monitor the overall quality of the wireless network at a given time. In this paper we present a novel tool, named WiFiMon, which enables measuring, recording and exporting statistics regarding the quality of a Wi-Fi network by the end-users. The measurements and are recorded without users' intervention. Main goal of WiFiMon is to give network administrators a better overview on how the end-users experience the conditions of the Wi-Fi network.

The tool presented in this paper (named WiFiMon) tries to fill this gap, by integrating a Server Side (written in Java) and a service supplied by the end-user (written in JavaScript) based on end-users' behaviour on the campus wireless network. Previous works, like [2], have tried to understand patterns of activity in the network [3] and improve the capacity of Wi-Fi infrastructures by increasing the AP deployment density [4]; however currently there is not a single tool that can trigger and record measurements from the end-user can trigger and record actually intervening to initiate the performance tests.

IEEE: ICT-2017, Limassol
 May 2017

Conclusions and future work

The expertise gained so far revealed that it is possible to:

- Measure specific parameters of a wireless network through JavaScript
- Correlate these measured raw data from various log files
- Monitor and validate the performance of WiFi as experienced by end-users

Future steps:

- Verification of JavaScript measurements accuracy (comparison with HW monitoring probes)
- Mobile app development to allow measurements (expand browser-based measurements)
- Explore privacy issues so as to be in accordance with campus policies
 - Inform the end-user through pop-ups, approve performance tests
 - Links or pop-ups that explain the process of data collection.
 - If tests are performed without user intervention, ensure that sensitive data will be analysed with caution.
- Data Analysis (Elastic Search)
 - To process a long time history
 - To elaborate a “PERFORMANCE Benchmark”
- Design a Service (roll out to the most of the NRENs)
 - Commercial aspect in focus of our investigations

Thank you Any Questions?

Contact us

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Kurt Baumann, GN4-2 SA3T5 Task leded: kurt.baumann@switch.ch



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This work is part of a project that received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 731122 (GN4-2).