Leveraging on WiFiMon for Efficient Wi-Fi Performance Monitoring (Demo)

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***Abstract*—We demonstrate the basic concepts and functionality of WiFiMon, an open-source tool for efficient Wi-Fi network monitoring. WiFiMon combines crowdsourced and hardware probe measurements to evaluate Wi-Fi performance as experienced by end users. WiFiMon differs from related monitoring tools that neglect end-user Quality of Experience (QoE) and does not consume important resources of end-user devices by not requiring the installation of additional applications. Our demonstration will provide an overview of WiFiMon, focusing on describing the automated installation process of the most complex components and presenting the User Interface based on diverse measurements originating from monitored Wi-Fi networks.**

***Index Terms*—Wi-Fi monitoring, Crowdsourced and hardware probe measurements, Quality of Experience (QoE) estimations**

I. Introduction

Wi-Fi is the most popular Internet access method [1]; increased flexibility compared to wired connections and higher speeds over cellular Internet constitute Wi-Fi the most common choice for work, educational and leisure activities. Monitoring Wi-Fi networks is vital to guarantee seamless connectivity and end-user interaction with the Wi-Fi is considered significant for performance evaluation. However, Wi-Fi monitoring tools typically neglect end-user Quality of Experience (QoE). These tools focus on monitoring access points or require the installation of applications on end-user devices, thereby consuming important memory and storage resources.

WiFiMon [2] is a GÉANT service and an open-source toolset that provides methods for evaluating Wi-Fi performance. WiFiMon combines two kinds of measurements, crowdsourced-based and from hardware probes. Crowdsourced measurements are received from users of the Wi-Fi network and are utilized to evaluate their direct experience of the network performance from their current location, without requiring installation of additional applications. Therefore, WiFiMon leverages on crowdsourced measurements to estimate end-user QoE. Hardware probes complement crowdsourced measurements by monitoring performance from fixed points of the network, thus providing baseline performance results. Moreover, hardware probes provide additional data about the Wi-Fi network, e.g. signal strength, link quality, and perform latency and bandwidth estimations via TWAMP [3].

In IEEE 802.1X networks, such as eduroam [4], WiFiMon provides additional capabilities to network administrators. Specifically, WiFiMon correlates performance results collected from Wi-Fi network end devices with information available from RADIUS and DHCP logs. Therefore, more accurate Wi-Fi performance evaluation is possible, such as throughput estimation per access point within the monitored network.

We will discuss the basic concepts and present the capabilities of WiFiMon for efficient Wi-Fi network monitoring. Our demonstration will focus on features recently added to WiFiMon compared to previous work [2]: (i) automated methods for installing WiFiMon complex components with minimum administrator effort, (ii) the redesigned User Interface (UI) that is more appealing and user friendly and (iii) enrichment of WiFiMon monitoring capabilities by integrating TWAMP and additional open-source tools. The demo will rely on a distributed testbed reporting diverse measurements collected from multiple Wi-Fi networks within university campuses.

WiFiMon documentation is available from [5]. In the next sections, we provide an overview of WiFiMon (Section II) and describe the content of the demo (Section III).

II. Overview

This section provides an overview of WiFiMon and describes basic operational details.

A. Objective

The purpose of WiFiMon is to help administrators detect Wi-Fi network segments that do not perform as expected. Based on lightweight monitoring tools, WiFiMon can detect Wi-Fi throughput degradation resulting from low network capacity, e.g. inadequate access points. Therefore, by relying on WiFiMon, Wi-Fi administrators may reach appropriate

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decisions for strengthening their networks, e.g. by installing additional access points in underperforming areas.

B. Design Considerations

The main idea of WiFiMon is to estimate the performance of Wi-Fi networks from the perspective of end users, thus reporting their QoE about the network. WiFiMon differs from similar Wi-Fi network monitoring solutions by utilizing appropriate technology to perform measurements without end-user intervention. Specifically, WiFiMon does not require installing any software on end-user devices and measurements are not triggered manually, as in relevant tools, e.g. Ookla Speedtest [6], but automatically.

Furthermore, WiFiMon leverages on appropriate lightweight open-source tools to actively monitor Wi-Fi networks without depleting the available bandwidth. Finally, WiFiMon includes mechanisms that secure the exchange and storage of sensitive information, e.g. end-user IP and MAC addresses or information collected from RADIUS and DHCP logs.

C. Components

WiFiMon consists of the following components:

- WiFiMon Software Probes (WSP's): WSP's are Wi-Fi enabled end-user devices, e.g. smartphones and laptops. These devices trigger crowdsourced measurements, therefore enabling administrators to monitor Wi-Fi performance as experienced by users roaming the network.
- WiFiMon Hardware Probes (WHP's): WHP's monitor Wi-Fi performance from fixed points within the network. Wi-Fi administrators may rely on WHP's to obtain baseline measurements and form a complete network performance landscape in combination with the crowdsourced results delivered from WSP's.
- WiFiMon Test Server (WTS): The WTS includes the software and test data that are necessary for performance measurements triggered by WSP's and WHP's. Moreover, the WTS acts as the server endpoint for TWAMP measurements performed by WHP's. The WTS is typically placed close to the monitored Wi-Fi networks to decrease the distance from end devices, hence reducing the effect of RTT that is added on reported measurements.
- WiFiMon Analysis Server (WAS): This is the central component of WiFiMon that receives measurement results from WSP's and WHP's as well as information available from RADIUS and DHCP servers. Obtained data are then processed, correlated and stored. Finally, the WAS provides appropriate result visualizations.

D. Operation

Measuring with WiFiMon requires from Wi-Fi network administrators to insert a few HTML lines in a frequently visited website under their management. Such a website may be the main university website for campus networks or the website including the agenda for conference venues. End devices within the Wi-Fi network that visit this website, i.e. WSP's occasionally by network users and WHP's in periodic intervals, download the HTML lines injected to the aforementioned websites and measurements towards the WTS are automatically triggered based on JavaScript technology. Subsequently, these devices exchange small images or files with test data, perform calculations on how fast the data were transmitted and measurement results are then streamed to the WAS. Within this server, results are analyzed and correlated with information available from RADIUS and DHCP logs or additional network and system data obtained from WHP measurements. Finally, the results are delivered to the Wi-Fi administrators through appropriately configured dashboards.

E. Reported Measurements

WiFiMon relies on various protocols and open-source tools to collect diverse information about the monitored Wi-Fi networks. Specifically, the following data may be collected from both IPv4 and IPv6 networks:

- Performance metrics, including estimations of the download/upload throughput and HTTP ping RTT between the WTS and WSP's/WHP's. These measurements are based on the following JavaScript-based open-source test tools: (i) NetTest [7], (ii) Akamai Boomerang [8] and (iii) LibreSpeed Speedtest [9]. When correlated with RADIUS and DHCP logs in IEEE 802.1X networks, these measurements may be reported per access point, therefore enriching capabilities of administrators.
- Wireless metrics received from the Wi-Fi interface of WHP's. Specifically, WiFiMon collects the signal level, link quality, bit rate and transmission power reported by WHP's. Moreover, additional information regarding the monitored ESSID and adjacent ones are extracted; these include ESSID names, Wi-Fi frequencies, ESSID signal levels and MAC addresses of associated access points.
- System metrics, including memory and storage statistics, from WHP's. These metrics enable administrators to monitor the operation of the fixed-location devices deployed within their networks and potentially troubleshoot issues that arise.
- Bandwidth, latency and packet loss estimations, e.g. jitter and RTT values, among WHP's and the WTS. These metrics are calculated using TWAMP, a standard protocol widely used for network monitoring. TWAMP measurements complement performance measurements executed via WiFiMon test tools (NetTest, Akamai Boomerang, LibreSpeed Speedtest) and provide baseline comparisons.

F. Installation

Complete WiFiMon setups depend on all four components described in Section II-C. Among these components, the WAS comprises of multiple software packages, thus being the most complex component. Contemplating on the time-consuming and error-prone nature of manual installation methods, fully automated procedures have been developed to reduce administrator effort. The WAS may be installed using:

- Ansible Playbooks: Institutions may rely on Ansible to install and configure the WAS. This method is suitable for

organizations that want all WiFiMon components within their premises, therefore storing end-user data locally.
- NMaaS: Administrators may utilize the NMaaS platform [10] to outsource WAS deployment as a containerized service within a cloud environment. This solution is suitable for organizations that want to test WiFiMon, before performing any installation within their infrastructure, and institutions lacking necessary resources or expertise.

Installing the remaining WiFiMon components is simpler. The WTS requires a TWAMP server and a web server, including software for the WiFiMon JavaScript-based test tools, i.e. resources for NetTest, Akamai Boomerang and LibreSpeed Speedtest. WHP's are implemented within Raspberry Pi's and can be installed using preconfigured images that are loaded on these devices. Finally, WSP's do not involve any installation process as they do not depend on additional software, therefore not impacting end-user experience.

G. User Interface (UI)

The WiFiMon UI has been designed to be appealing to network administrators and easy to use. Indicative screenshots showing parts of the WiFiMon UI dashboards are provided below: (i) Fig. 1 depicts the login page of WiFiMon, (ii) Fig. 2 depicts performance measurement results, specifically average download throughput, obtained from three WHP's that utilize the LibreSpeed Speedtest test tool, (iii) Fig. 3 includes TWAMP measurement results, i.e. jitter values between WHP's and their local WTS.

III. Demonstration

Our demonstration will present the basic aspects of WiFiMon for Wi-Fi performance monitoring. Initially, we will explain the objective and design considerations of WiFiMon. Afterwards, we will briefly demonstrate the fully automated WAS installation based on Ansible playbooks and NMaaS. The demo will continue with the WiFiMon UI and description of the available dashboards; our focus will mainly be on the dashboards related to WHP performance and TWAMP measurements. We will conclude our demonstration by performing crowdsourced measurements from the presenter's laptop to provide performance estimations of the venue Wi-Fi network.

Our presentation will be based on a distributed testbed, incorporating sites across Europe. Our testbed consists of two Wi-Fi networks; the first one located at National Technical University of Athens, Greece, and the second one located at University of Belgrade, Serbia. Each Wi-Fi network includes a local WTS installation and several WHP's implemented within Raspberry Pi's (version 3 and 4) that monitor eduroam ESSID. Data received from these devices include performance measurements executed via WiFiMon test tools (NetTest, Akamai Boomerang, LibreSpeed Speedtest), wireless network metrics, memory and storage statistics as well as TWAMP measurements performed between WHP's and their corresponding local WTS installation. Measurements are streamed for processing and stored within a WAS located at SWITCH, the Swiss National Research and Education Network (NREN).

References

[1] K. Pahlavan and P. Krishnamurthy, "Evolution and Impact of Wi-Fi Technology and Applications: A Historical Perspective", International Journal of Wireless Information Networks, Volume 28, Issue 1, pp. 3-19, March 2021

[2] N. Kostopoulos, S. Gjeçi, K. Baumann, P. V. Vuletić and K. Stamos, "WiFiMon: Combining Crowdsourced and Probe Measurements for Wi-Fi Performance Evaluation", IEEE/IFIP WONS 2021, pp. 1-8, Virtual Event, March 2021

[3] K. Hedayat, R. Krzanowski, A. Morton, K. Yum and J. Babiarz, "A Two-Way Active Measurement Protocol", RFC 5357, October 2008

[4] eduroam Homepage, https://www.eduroam.org/, Accessed 9/2022

[5] WiFiMon Homepage, https://wiki.geant.org/display/WIF

[6] Speedtest by Ookla, https://www.speedtest.net/, Accessed 9/2022

[7] NetTest, https://code.google.com/archive/p/nettest/, Accessed 9/2022

[8] Akamai Boomerang, https://github.com/akamai/boomerang, Accessed 9/2022

[9] LibreSpeed Speedtest, https://github.com/librespeed/speedtest, Accessed 9/2022

[10] V. Kjorveziroski, P. V. Vuletic, Ł. Łopatowski and F. Loui, "On-Demand Network Management with NMaaS: Network Management as a Service", IEEE/IFIP NOMS 2022, pp. 1-3, Budapest, Hungary, April 2022

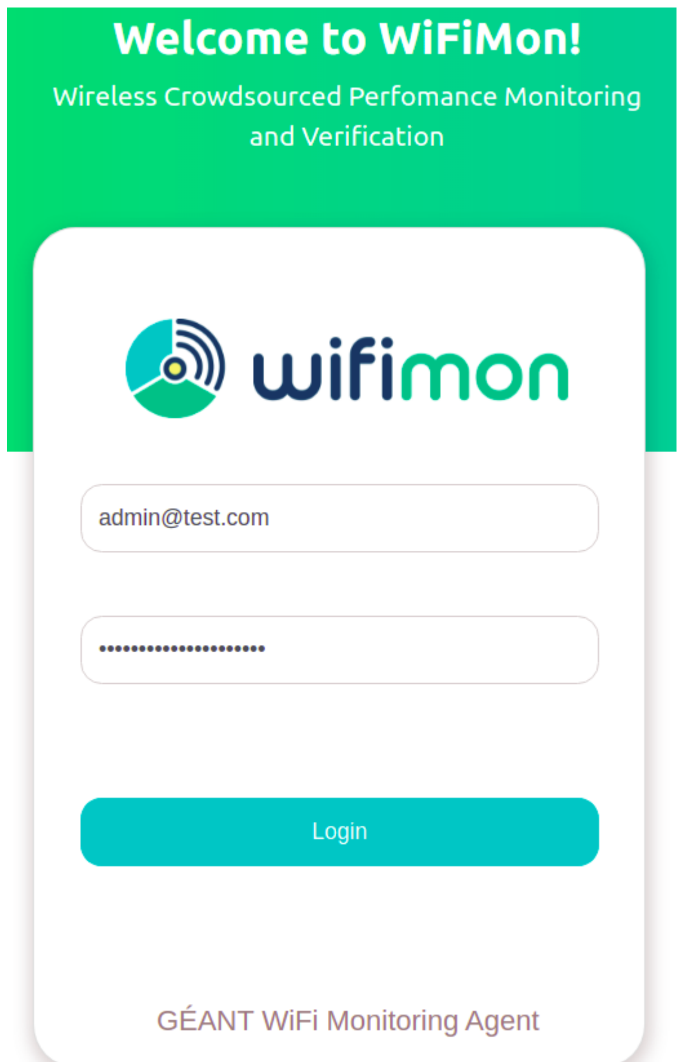

Fig. 1. WiFiMon User Interface - Login Page

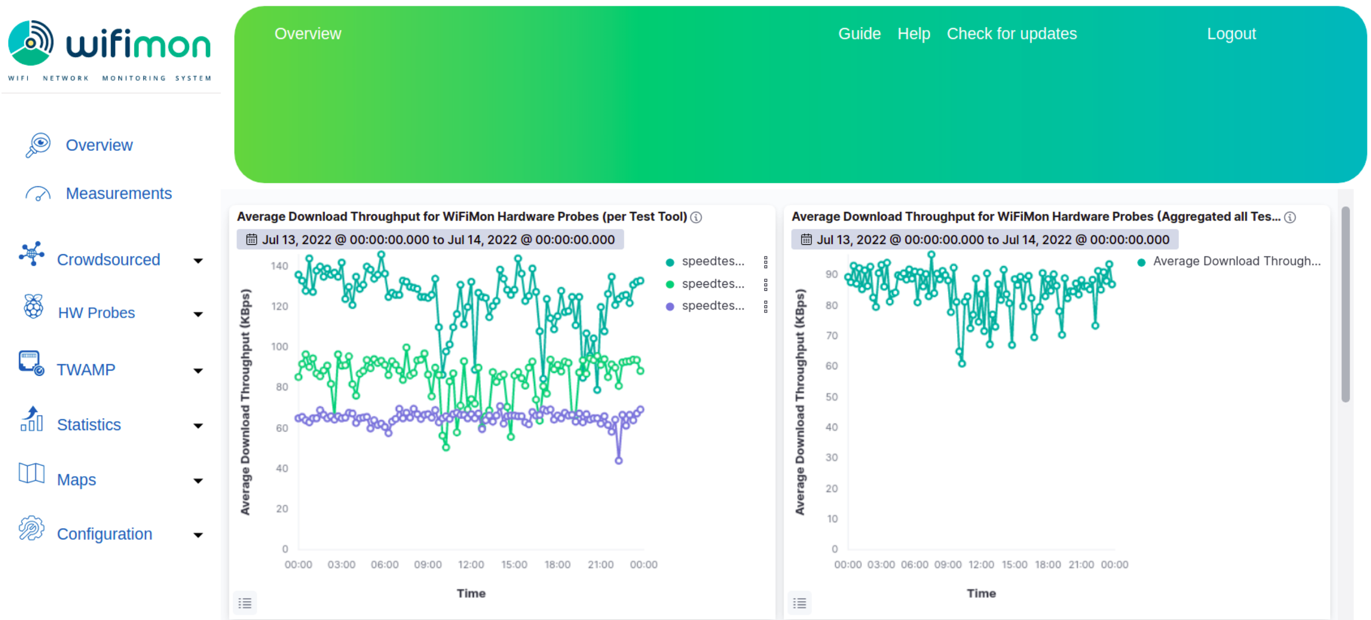

Fig. 2. WiFiMon User Interface - Part of WiFiMon Hardware Probe Measurements Dashboard: The left chart depicts the average download throughput calculated between three WHP's and their corresponding WTS using the LibreSpeed Speedtest test tool. The right chart shows the aggregated download throughput of all three WHP measurements. The duration of depicted measurements is 24 hours. Apart from average values, WiFiMon includes dashboards reporting median, minimum, maximum and the 95th percentile values of WHP measurements.

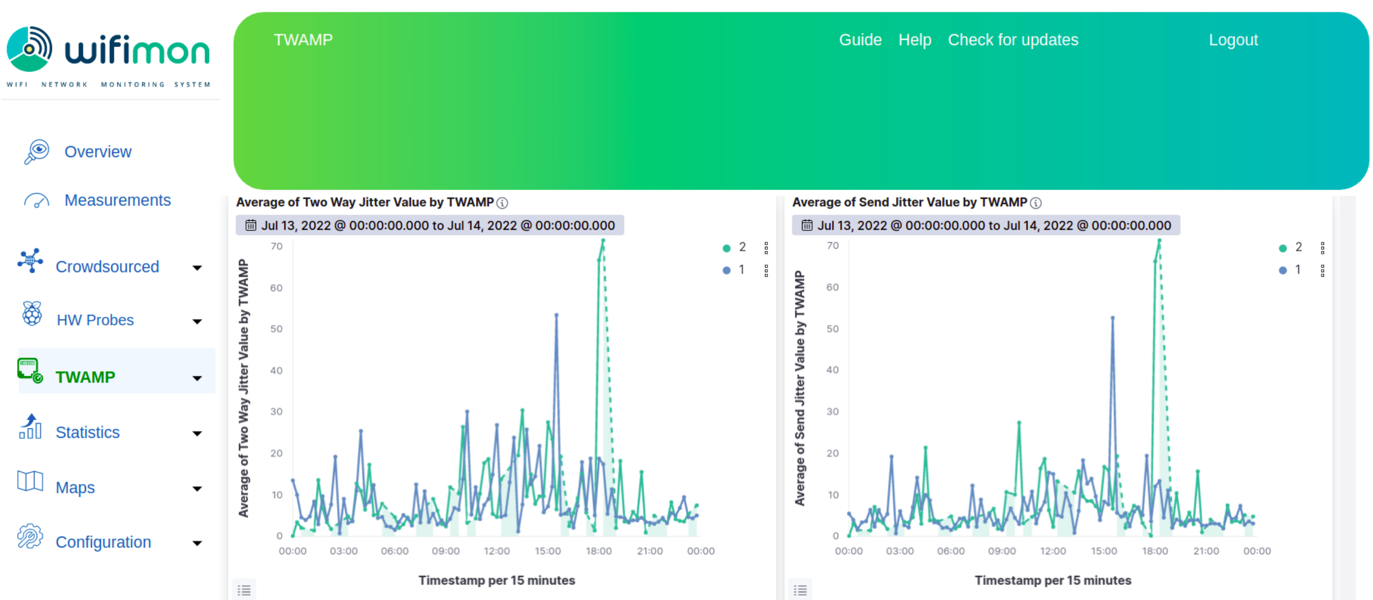

Fig. 3. WiFiMon User Interface - Part of TWAMP Measurements Dashboard: The left chart depicts the average value of two-way, i.e. round-trip, jitter calculated between two WHP's (TWAMP client devices) and their corresponding WTS (TWAMP server). The right chart includes the average value of send, i.e. one-way, jitter calculated between the WHP's and the TWAMP server. The duration of demonstrated measurements is 24 hours.