WiFiTester: A low-cost device for detecting interruptions in a Wireless Local Area Network (WLAN).

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Abstract

Among the various technologies that allow sending and receiving data through the Internet is IEEE 802.11. Popularly known as Wi-Fi, this wireless network is the leading global traffic medium on the Internet, driving $3.3 trillion in global economic value, as well as being the most widely used wireless communication technology in the world. Wireless Local Area Networks (WLANs) are proliferating and increasingly becoming the leading Internet access technology in homes, businesses and public spaces. In addition to being associated with the coverage area of the wireless network, the quality of access to the Internet through IEEE 802.11 depends on the quality of the signal provided by the Internet Service Providers (ISP). The quality of the Internet user experience is associated with data interruption, i.e., the availability of sending and receiving data over the network. Data interruptions can occur due to several factors, from moving out of coverage area or even the failure of the ISP to provide the service. In Brazil, the National Telecommunications Agency (Anatel) responsible for regulating Internet services establishes rules to ensure the quality of the signal provided by ISPs. According to Anatel Resolution No. 717, ISPs must automatically provide compensation to affected users for interruptions in the services, under penalty of having to return the amounts in double to the user if the reimbursement period is not respected. In order to monitor interruptions in a home WLAN, a low-cost electronic device was developed. WiFiTester recorded data interruption time (DIT) for 30 days, 24/7, and presented the data in the cloud.

Keywords: IEEE 802.11, Wi-Fi, ESP-12E, Resolution no. 717 Anatel, data interruption time

1. Introduction

Wi-Fi (a.k.a. IEEE 802.11) is a wireless communication network, based on the IEEE 802.11 standard, which is commonly used to connect wireless local area network (WLAN) devices to the Internet, enabling digital devices exchange data over radio waves [1]. According to the Wi-Fi Alliance [2], which owns the Wi-Fi trademark, this wireless network is the primary medium for global Internet traffic, driving $3.3 trillion in global economic value , in addition to being the most used wireless communication technology in the world. IEEE 802.11 is widely used due to its simplicity and ease of setup and use, low cost and low power consumption.

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Wireless Local Area Networks (WLANs) are proliferating and increasingly becoming the leading Internet access technology in homes, businesses and public spaces [1]. One of the main disadvantages of IEEE 802.11 is its low coverage area when compared to other technologies such as Long Term Evolution (LTE) and High Speed Packet Access (HSPA). In addition to being associated with the coverage area of the wireless network, the quality of Internet access through IEEE 802.11 depends on the quality of the signal provided by the Internet Service Provider (ISP).

National Telecommunications Agency (Anatel) is responsible for regulating the services provided by ISPs in Brazil, in Resolution No. 717, of December 23, 2019 [3] it establishes:

> Art. 32. Providers shall automatically provide compensation to users harmed by service interruptions until the second month following the event, respecting the billing cycle, in proportion to the interrupted time and the value corresponding to the service plan contracted by the user, as provided in the Operational Manual.
>
> § 1 For the purposes of the reimbursement provided for in the caput, scheduled Interruptions carried out within the period between 0:00 (zero hour) and 6:00 (six hours) for the indoors and between 6:00 (six hours) and 12:00 (twelve hours) to the outdoors network will be disregarded.
>
> § 2 If the deadline established in the caput is not met, an undue charge is set up and the provider must return the amounts in double to the user.

2. Background Review

According to [4], the quality of the Internet user experience is associated with data interruption (DI), that is, the availability of sending and receiving data over the network. DI can occur due to several factors, from moving out of coverage area or even the failure of the ISP to provide the service. The reference [4] presents an indicator to assess the quality of the user experience: data interruption time (DIT). DIT represents the time during which a mobile device cannot transmit or receive data due to unstable connectivity.

3. Methodology

To calculate DIT, an electronic device, called WiFiTester, was developed. It features an ESP-12E Wi-Fi module from Ai-Thinker Co., Ltd that costs USD 1.50. The following Figure 1 presents this module and its main specifications. WiFiTester is a device that records the beginning and end of DI event and sends this data to the cloud, where the DIT for that event is calculated.

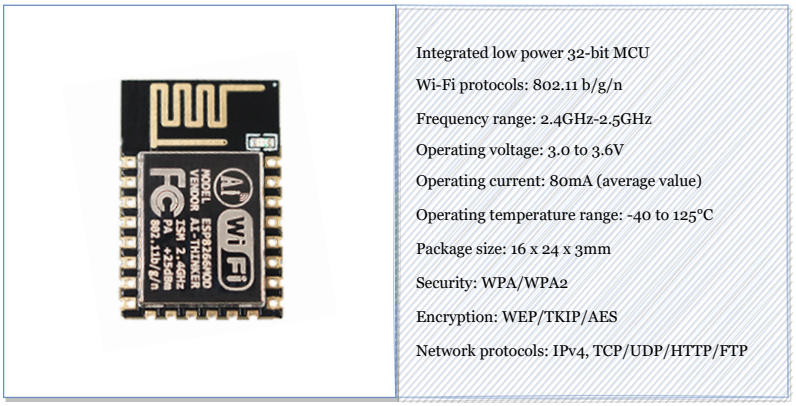

Figure 1: ESP-12E Wi-Fi Module by Ai-Thinker Co., Ltd and its main specifications [5].

3.1. WLAN's block diagram

WiFiTester has two main units, called *Device* and *Cloud*. The first refers to hardware capable of connecting to a wireless access point (WAP) and processing the Internet signal. The second unit receives the data, calculates DIT, stores and displays data through a dashboard. WiFiTester clock synchronization is done using Network Time Protocol (NTP). The block diagram depicted in the Figure 2 presents a WLAN with the device, where the arrows indicate the data sending and receiving flows in the network.

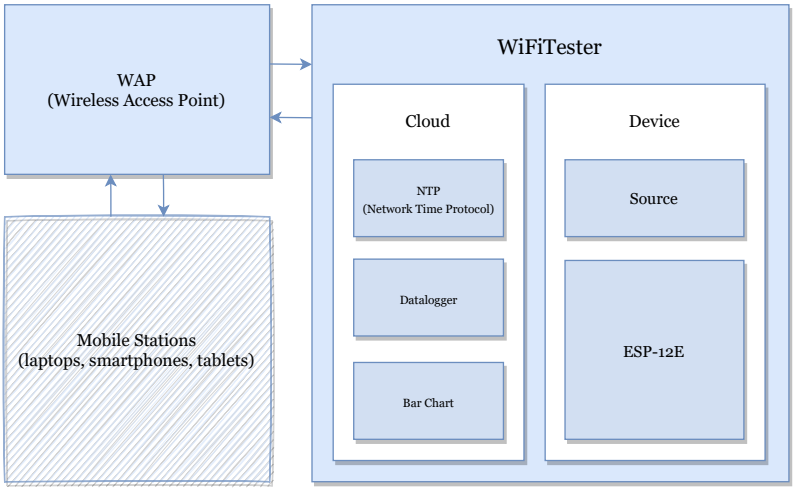

Figure 2: Block diagram of a wireless local area network (WLAN) with WiFiTester.

3.2. WiFiTester's flowchart

WiFiTester runs based on a connection with a WAP. The device checks continuously its connection with the WAP. If is not possible to send and receive data over the network during this checking, a DI event is counted and *DI_Beginning* is registered with the date and time at which the interruption starts. Once the connection is re-established, the date and time of the end of the interruption is stored in the variable *DI_End*. Then these two variables are sent to the cloud where DIT is calculated (1) and the data is presented through bar charts.

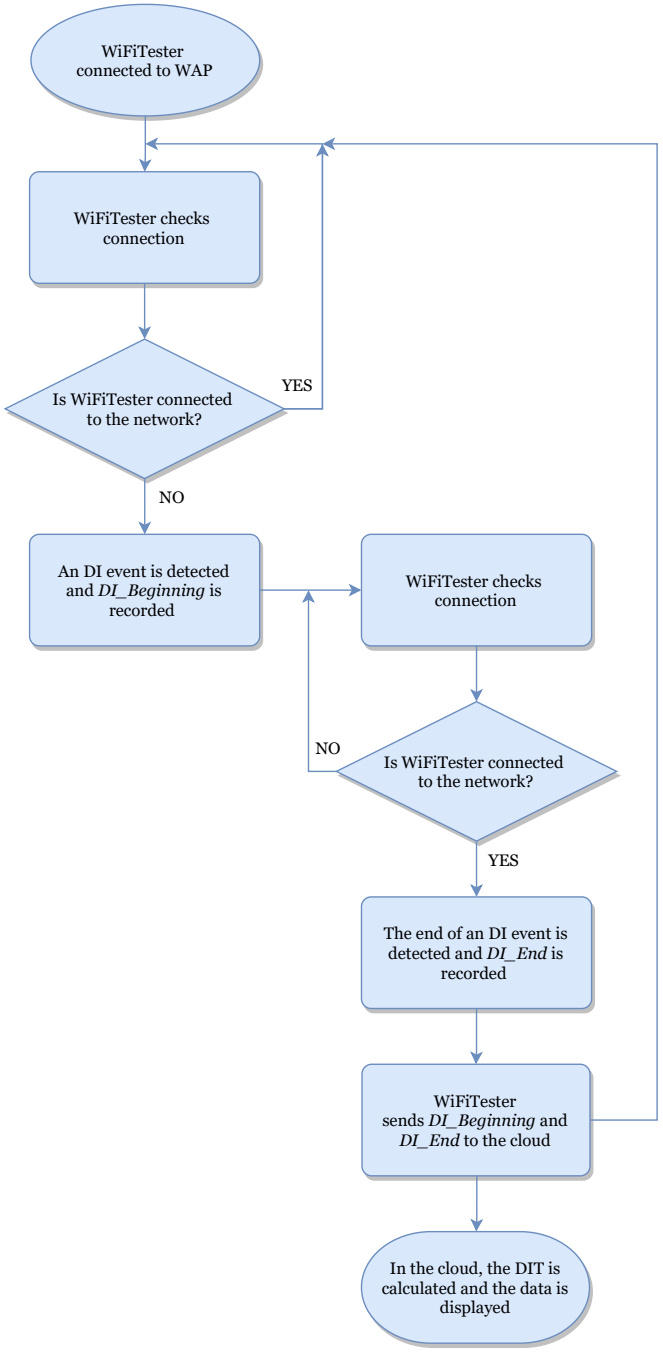

Figure 3: WiFiTester's flowchart.

3.3. Calculating DIT

An DI event is characterized when there is no data exchange between WAP and WiFiTester. The DIT is calculated as a function of the beginning and the end of a DI, as shown in (1):

$$DIT = DI\_End - DI\_Beginning\ , \tag{1}$$

where DI_End is the date and time of the DI end, and $DI\_Beginning$ is the date and time of the DI beginning.

4. Results and discussions

The proposed electronic device was connected to a WAP on a residential WLAN with a wireless Internet plan *Fibra Home Combo 100M Lite* and remained within the network's coverage area. The study began on October 1, 2021 and lasted 30 days, 24 hours a day and 7 days a week. The results recorded by WiFiTester have been stored and displayed in the cloud. The Figure 4 below summarizes the results obtained.

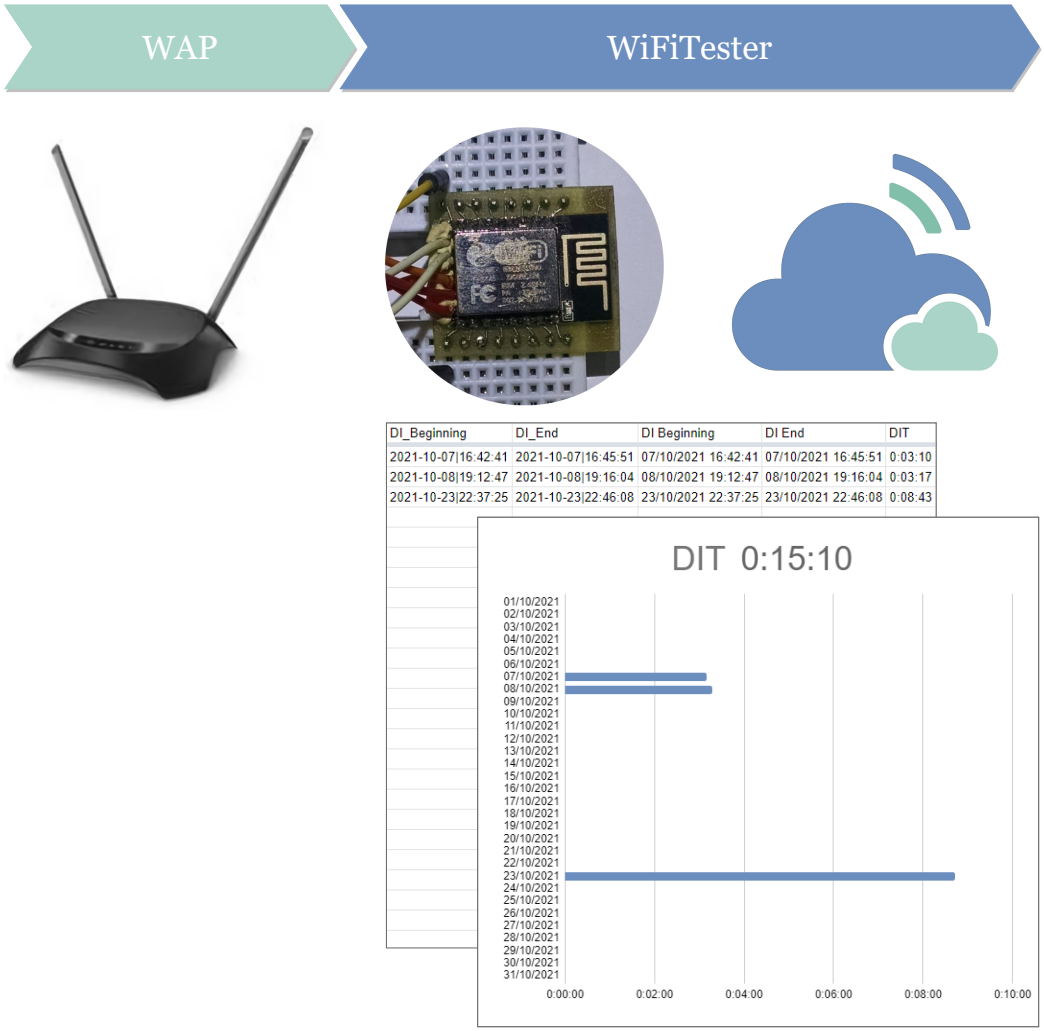

Figure 4: WiFiTester results: *Device* connected to WAP, database with stored variables and generated bar chart.

Overall, WiFiTester has proven to be an effective tool to monitor the connection between WAP and the device. Thus, it was possible to calculate DIT and assess the availability of sending and receiving data through the network during the monitored period. Based on these results, the proposed device can be a useful tool for contesting ISPs' services, especially in cases where signal interruption events are frequent and there is no other way to prove the problem. Likewise, WiFiTester can be a technology incorporated by ISPs in order to improve the quality of Internet services provided.

5. Conclusion

In this article, a low-cost electronic device for detecting data interruptions in a WLAN was presented. The index calculated by WiFiTester is DIT. The proposed device is based on a Wi-Fi microcontroller manufactured by Ai-Thinker Co., Ltd, called ESP-12E. In this study, DIT was monitored for 30 days, 24/7, on a residential WLAN.

During the monitoring, interruption events detected by the device were processed and the result of DIT was graphically represented in the cloud. In this way, it would be possible to attest to the quality of the connection between WiFiTester and WAP, facilitating compliance with Anatel Resolution No. 717, of December 23, 2019, specifically its article 32. In this sense, WiFiTester can be a useful tool for consumers of Internet services and also for ISPs.

The results demonstrate that it is possible to detect interruption events on a WLAN from a low-cost device. In order to improve WiFiTester, other elements can be incorporated. For instance, use the other power consumption modes of the ESP-12E and power the module through a battery, or even incorporate it into another WLAN device. In addition, other indicators of quality of Internet access could be added and also a dedicated service for storing and displaying data, thus, the device would gain new functionalities and a commercial aspect.

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