Low-cost Indoor Wi-Fi REM Measurements Dataset Documentation

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Contents

1 Introduction

This article documents the data file of the low-cost indoor Wi-Fi REMs measurements available at https://www.inets.rwth-aachen.de/registration.html (after registration) that were used in [1]. If you use our dataset in a scientific publication, we would appreciate citations to the original DySPAN publication:

Z. El-friakh, A. M. Voicu, S. Shabani, L. Simić, and P. Mähönen, "Crowdsourced indoor wi-fi rems: Does the spatial interpolation method matter ?" in *Proc. IEEE DySPAN*, Seoul, 2018

BibTeX reference:

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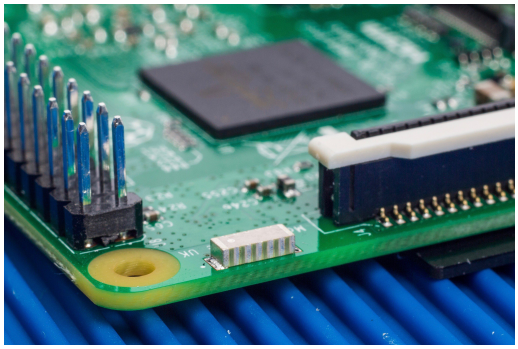
@INPROCEEDINGS{El-friakh2018,

AUTHOR    = {Zakarya El-friakh and Andra M. Voicu and Shaham Shabani
   and Ljiljana Simi\'c and Petri M\"ah\"onen},
TITLE     = {Crowdsourced Indoor Wi-Fi REMs: Does the Spatial
   Interpolation Method Matter ?},
BOOKTITLE = {Proc. IEEE DySPAN},
YEAR      = {2018},
ADDRESS   = {Seoul},
}
```

The documentation is organized as follows: in Section 2 we describe the hardware and software used in our testbed, Section 3 describes the process of our measurements' campaign, finally, in Section 4 we detail the formatting of the provided datafiles.

(a) Raspberry Pi 3 model B



(b) Wi-Fi/Bluetooth antenna close up

Figure 1: Raspberry Pi 3 model B board computer.

Table 1: 2JE07d antenna specifications.

Directionality	Omni-Directional
Polarization	Linear
Frequency	2.4 to 5.875 GHz
Gain	-1.6 to -0.1 dBi

2 Tesbed

2.1 Hardware

The main goal of our work was to use low-cost devices instead of high-precision sensing nodes during the measurement phase of a Radio Environment Map (REM) construction process. In order to achieve this, Raspberry Pi (RPi) 3 model B computer boards were chosen as sensor nodes (see Figure 1(a) [2]). Released in 2016, the RPi 3 brings a lot compared to its predecessor, it is the first 64-bit Raspberry Pi, is 50% faster than the Pi 2 and, most importantly, comes with onboard wireless local area network (WLAN) (802.11n) and Bluetooth (4.1) capabilities [3]. Additionally the Pi 3 keeps the low footprint of its predecessors (120 mm x 75 mm x 34 mm).
Concerning its wireless capabilities, the RPi 3 comes with an onboard Wi-Fi and Bluetooth antenna. Not a lot of information concerning the specifications of the antenna is available online, however thanks to a few posts on the Raspberry Pi forum [4] (the veracity of which could be argued), the on-board antenna is believed to be a 2JE07d ceramic antenna manufactured by 2J Antennas, its specifications are listed in Table 1 [5].

2.2 System Architecture

As shown in Figure 2, during the measurements campaign, the RPi sensor nodes were organized as follows:

- 17 RPis numbered from 01 to 17 were used.
- Node 01 is used as an access point for the Wi-Fi Network *Raspberrypi_ WLAN*. The other nodes act as sensor nodes and connect to this network to deliver their measurements.
- Node 01 is connected to a laptop using an Ethernet cable and is logged into using SSH. This connection was relayed upon to control the different parameters of the measurements.

2.3 Software

In this section we turn our attention to the different pieces of software that were used in the measurement setup.

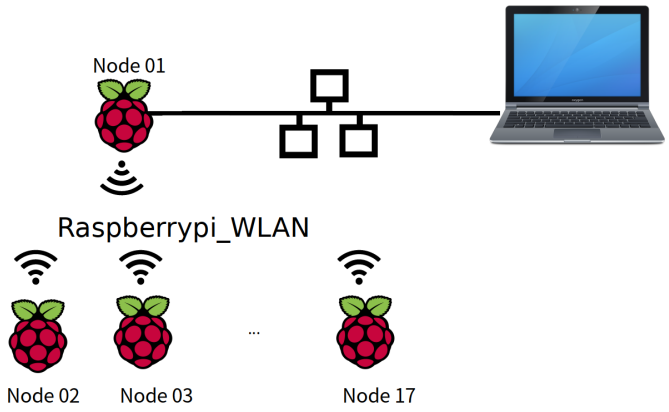


Figure 2: System architecture.

2.3.1 `iwlist`

`iwlist` is part of the Wireless Tools utilities that come included with most GNU/Linux-based operating systems. This includes, Raspbian, the most popular operating system for RPi computer boards, and the one we used during our tests. The Wireless Tools utilities allow the user to interact with the used wireless interface(s). In particular `iwlist` allows the user to display information from a wireless interface. Depending on the passed parameter (`scanning`/`scan`, `rate`, `modulation`...), `iwlist` allows to display a multitude of information about the access points (APs) in range [6]. Out of these, only the `scanning` parameter has been used during our tests. This allowed us to detect all APs and ad-hoc cells in range, along with a lot of information about these cells (Extended Service Set Identifier (ESSID), Address, Quality, Frequency, Mode, etc...).

2.3.2 `hostapd`

As mentioned in Section 2.2, one RPi board is configured as an AP to which the other nodes connect in order to communicate their measurements data. To achieve this architecture, `hostapd` (host access point daemon) has been used on the AP RPi. `hostapd` allows implementation of IEEE 802.11 AP and IEEE 802.1X/WPA/WPA2/EAP/RADIUS Authenticator [7]. The default wireless driver included in Raspbian supports Managed mode which is required for AP functionalities.

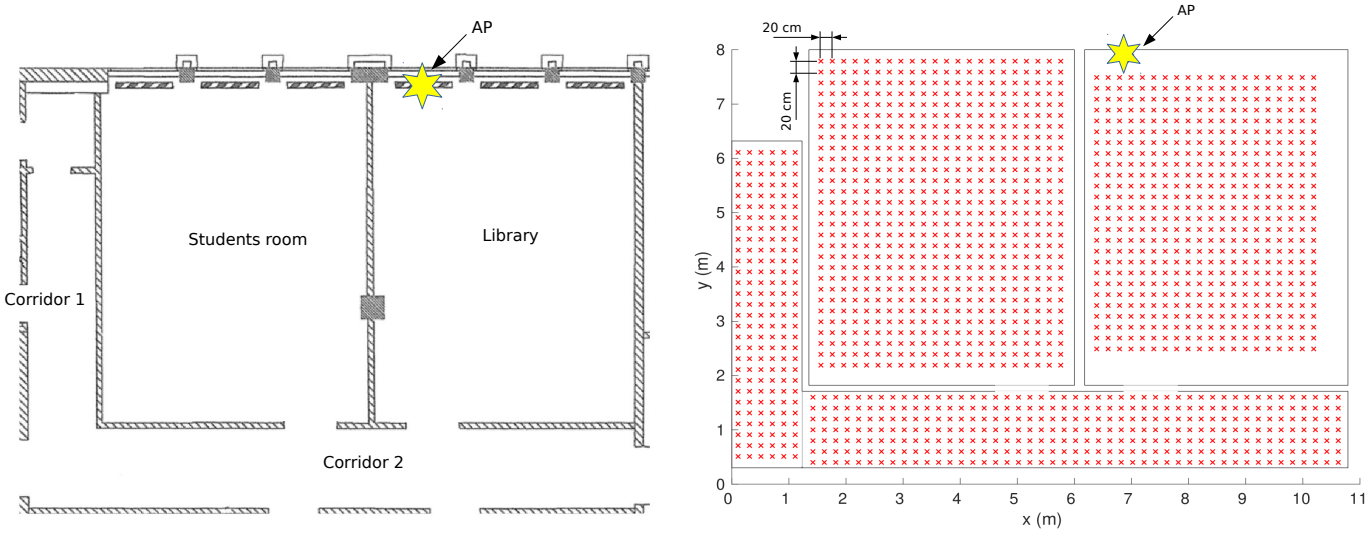
2.3.3 Miscellaneous

Bash scripts were used in order to filter, format and merge the measurement data.

3 Measurements campaign

In our measurement campaign, an indoor environment inside of an office building was sampled using our test-bed. As shown in the floor plan presented in Figure 3(a), the covered area spanned two rooms, and a corridor, for a total area of $\approx$ 8 m x 11 m. The room labeled "Library" contains a large central table, bookshelves and a couple white boards. The "Students room" contains multiple computers. Both rooms have large glass windows shown in the top side of Figure 3(a). The doors of these two rooms, and the facing doors in "Corridor 2" are made of non tinted glass, the walls separating the rooms are plaster-based.

The locations of the carried measurements are shown in Figure 3(b). The nodes were laid down on the floor and a regular grid with a resolution of 20 cm was used inside each room/corridor. At each location, 40 measurements at intervals of 3 seconds between each two measurements were carried. Figures 3(a) and (b) additionally show the location of the AP which was considered for the results published in [1].



(a) Indoor environment floor plan

(b) Measurements locations (x)

Figure 3: Floor plan and measurements position.

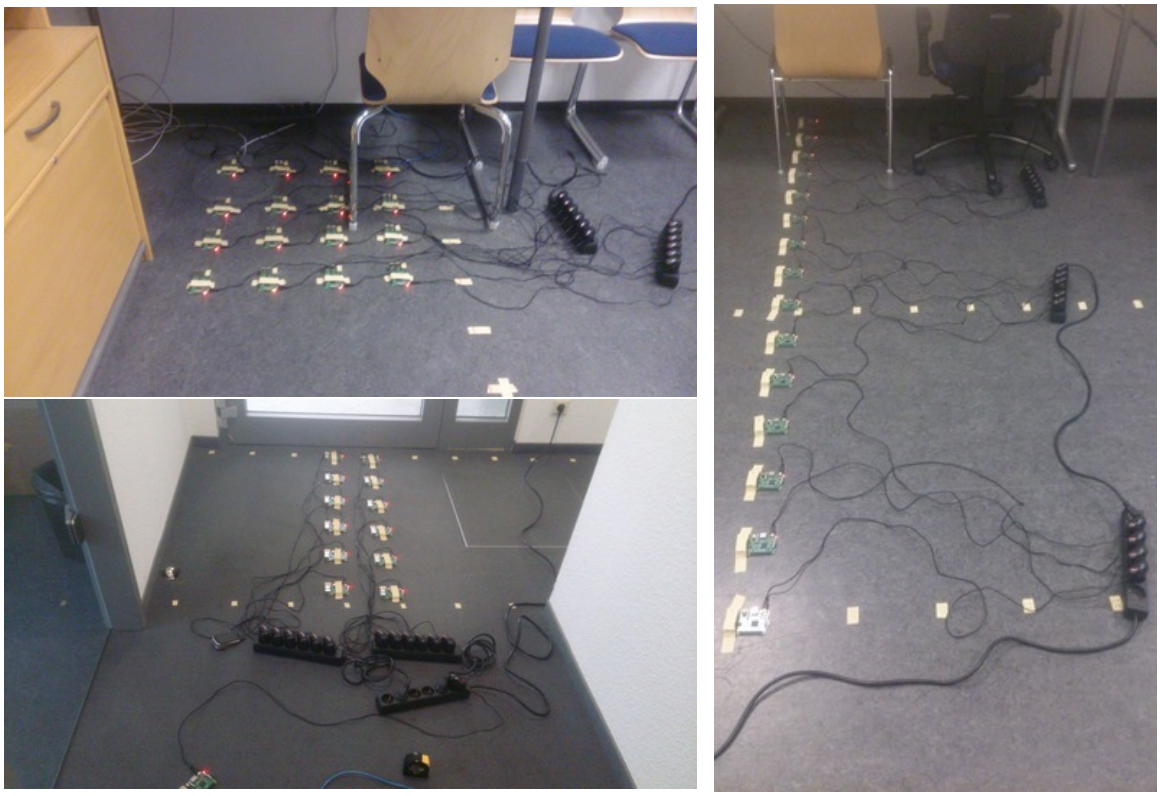


Figure 4: Radio environment sampling campaign.

4 Datafiles' Format

The output files obtained from the measurement campaign have been merged into one single file per room (`merged_measurements_Library.csv`, `merged_measurements_Students_room.csv`, `merged_measurements_Corridor_1.csv`, and `merged_measurements_Corridor_2.csv`,). An additional file containing data from all rooms (`measurements_from_all_rooms.csv`) is also provided. The files are simple Comma Separated Values (CSV) files, organized into the following columns:

1. Timestamp: contains the time of the measurement
2. Node: is the number of the node which conducted the measurement
3. X_pos: is the position on the x axis in cm. see Figures 3(b) for x and y axis.
4. Y_pos: is the position on the y axis in cm. see Figures 3(b) for x and y axis.
5. MAC: is the MAC address of the AP considered for the measurement
6. Freq: is the beacon frequency reported by `iwlist` for the considered AP
7. Qty: is the "quality" parameter returned by `iwlist`
8. Sig: is the signal strength measured in dBm
9. ESSID: is the ESSID broadcast by the AP

Unlike in [1] where the results were obtained considering data emanating from the AP highlighted in Figure 3, in the files provided here, we kept data emanating from all APs detected by our testbed. For reference, the Medium Access Control (MAC) address of the one AP considered in [1] is: `30:85:A9:E7:BC:08`.

A Abbreviations

AP access point

ESSID Extended Service Set Identifier

MAC Medium Access Control

REM Radio Environment Map

WLAN wireless local area network

CSV Comma Separated Values

References

[1] Z. El-friakh, A. M. Voicu, S. Shabani, L. Simić, and P. Mähönen, "Crowdsourced indoor wi-fi rems: Does the spatial interpolation method matter ?" in *Proc. IEEE DySPAN*, Seoul, 2018.

[2] "Raspberry Pi 3 Model B single-board computer with wireless LAN and bluetooth connectivity," https://www.raspberrypi.org/products/raspberry-pi-3-model-b/, [last visited: 2018-04-03].

[3] A. Allan, "Meet the new Raspberry Pi 3 – a 64-bit Pi with built-in wireless and bluetooth LE," https://makezine.com/2016/02/28/meet-the-new-raspberry-pi-3/, [last visited: 2018-04-03].

[4] "RPi3: Wireless and bluetooth antenna," https://www.raspberrypi.org/forums/viewtopic.php?t=137981, [last visited: 2018-04-03].

[5] "Technical specifications of the 2je07d SMC antenna," https://www.everythingrf.com/products/all-antennas/2j-antennas/741-944-2je07d, [last visited: 2018-04-03].

[6] "iwlist(8) - linux man page," https://linux.die.net/man/8/iwlist, [last visited: 2018-04-03].

[7] "hostapd: IEEE 802.11 AP, IEEE 802.1X/WPA/WPA2/EAP/RADIUS Authenticator," https://w1.fi/hostapd/, [last visited: 2018-04-03].