THE IMPACT OF SEVERAL PARAMETERS ON RECEIVED SIGNAL STRENGTH IN INDOOR ENVIRONMENT

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REZUMAT. În prezent, sistemele de poziționare bazate pe tehnologii Wi-Fi au devenit din ce în ce mai populare, fiind studiate de către mulți cercetători. O tehnică pentru găsirea poziției folosind un asemenea sistem se bazează pe puterea semnalului receptionat. Acest lucru face ca sistemul sa fie foarte sensibil la schimbările de mediu. Prin urmare, în scopul de a crește performanța sistemului, în această lucrare vom prezenta câteva experimente pentru înregistrarea puterii semnalului Wi-Fi, prin utilizarea unor parametrii propusi.

Cuvinte cheie: interior, pozitonare, puterea semnalului receptionat.

ABSTRACT. Nowadays, the positioning systems based on Wi-Fi technologies gain popularity, being studied by many researchers. A technique for finding the position in such a system is based on RSS. This makes the system very sensitive to changes in the environment. Therefore, in order to increase the system performance, in this paper we present few experiments for recording the signal strength of Wi-Fi signals, by using some proposed parameters.

Keywords: indoor, positioning, RSS.

1. INTRODUCTION

Recent development of wireless technology have enabled the proliferation of mobile devices and the interest on using them in an increasingly number of applications becoming higher and higher. A common topic where this technology is widely used is positioning or more specifically, the indoor positioning. Most of the techniques involved in positioning make use of the Received Signal Strength Indicator (RSSI) in distance estimation and therefore localization. RSS is a standard feature in most wireless-enabled devices and has attracted a lot of attention for obvious reasons: removed the need for additional hardware in small wireless devices and have favorable properties in terms of power consumption, size and cost [1]. The main advantage of this method is its low cost. However, this method is very unstable being affected by the changes in the environment, obstacles or people. Propagation effects such as reflection of the signal against walls, floor and ceiling, diffraction and scattering [2] produces signal fluctuations and interferences. In [3] is stated that the received signal is the result between the combinations of two effects: large-scale fading and small-scale fading. The first one describes the signal attenuation, while the second one explains the signal fluctuations.

Hence, in this paper, we focus on studying the sources of signal strength variability. Therefore, we proposed few experiments for recording a large number of signal strength values. During measurements we studied how some proposed parameters affect the signal strength. The tool used to perform the measurements and to record the signal strength values is called OwlPS (Open Wireless Positioning System).

The remainder of this paper is organized as follows. Section 2 provides a short description of the OwlPS. Section 3 presents the experiments conducted for the measurements. Section 4 reports the comparison among the experimental results in terms of RSS Mean Value. Finally, in Section 6 we conclude the paper.

2. OWLPS SYSTEM OVERVIEW

Open Wireless Positioning System (OwlPS) [4] is a Wi-Fi-based, infrastructure centered indoor positioning system developed at the University of Franche-Comté, which implements several positioning algorithms and techniques, all based on the analysis of the Wi-Fi received signal strength.

The OwlPS architecture, presented in Fig.1, is composed of several elements: **Mobile terminals** (laptops, phones, PDAs, etc.) equipped with Wi-Fi cards. **Access Points (APs)**, which capture the

frames of the Wi-Fi network in order to receive any positioning request transmitted by the mobiles. **The aggregation server**, to which the APs forward the captured positioning requests; its task is to gather and format these requests. **The positioning server**, which computes the position of each mobile using the information forwarded by the aggregation server, thanks to the *owlps-positioner* software.

In order to determine the position of the mobile terminal which made a positioning request, the system needs four steps:

– positioning request
– signal strength measurement
– aggregate the positioning requests
– computing the mobile's position

First, the mobile submits a positioning request to the infrastructure. This request consists of a group of identical UDP packets containing the type of the request (positioning request or calibration request), the local time on the mobile terminal. Each AP capturing the positioning request extracts the corresponding SS. Then it transmits to the aggregation server a UDP packet containing the received mobile information, the received SS, the timestamp of reception on the AP and the mobile and AP MAC addresses. The aggregation server receives the positioning requests forwarded by the APs. It gathers those corresponding to the same couple {mobile MAC address, request timestamp} and forwards them to the positioning server. The positioning server analyses the information received from the aggregation server and computes the mobile's position; the result is then sent to the mobile, or processed in another way.

3. EXPERIMENTS

The measurements were done with the Owlps system in which each hardware unit of the system runs a software module. As mobile terminals we can use any kind of device endowed with Wi-Fi capabilities: Android Smartphone, iPhone, laptop, access points, etc. For our experiments we chose an Asus EeePC 1001-PX laptop equipped with Atheros AR2427 Wi-Fi chipset and Fonera 2.0g which is a small access point equipped with an Atheros chipset. These mobile terminals runs OwlPS Client module. Four access points Fonera 2.0 are used as listeners, hence they are running OwlPS Listener module. A laptop computer Asus EEE-PC 701 4G with an Atheros AR 500 Wi-Fi interface is running the aggregation server and, therefore, the OwlPS Aggregator module.

The measurements for each of the experiments have been conducted on a room of the Numérica building within the University of Franche-Comté, Montbéliard. This room is 10.60 m long by 5.80 m wide and includes a partition wall made of metal, plastic and wood which can be extended to separate the room into two approximately equal parts. Also, the room includes electricity, water and network cables columns, four air conditioners, two light metal and wood tables and two plastic and metal chairs. Fig. 2 shows the room plan where the experiments took place and the location of the APs. The origin of the room is set to the South-West corner of the room.

The analysis of RSS data is made during seven experiments. All measurements were performed at well known fixed locations which we call measurement points (MPs).

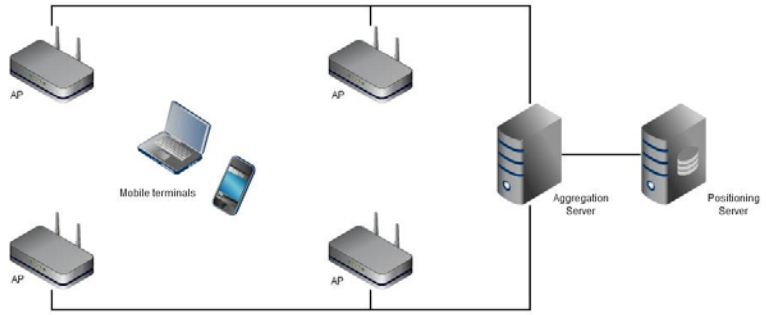


Fig. 1. System architecture.

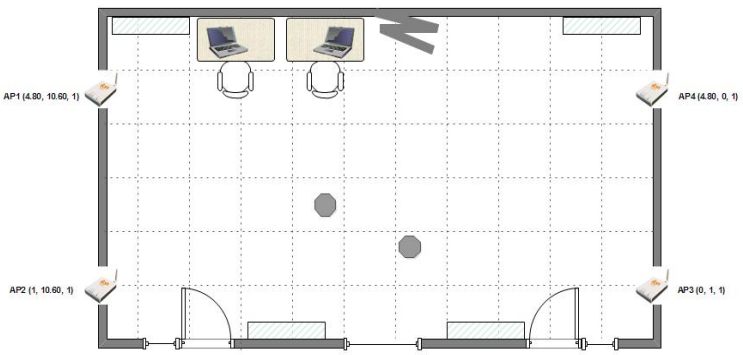


Fig. 2. The environment of the experiments.

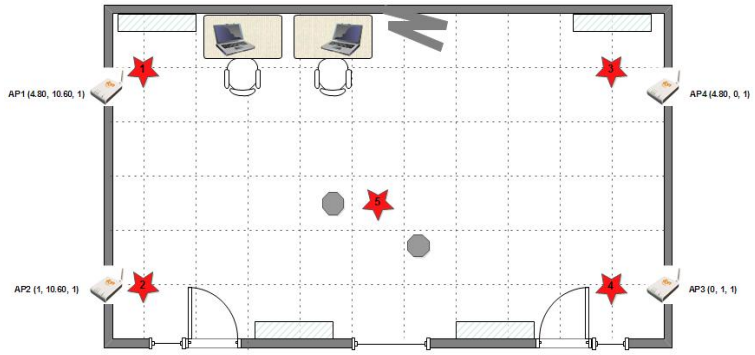


Fig. 3. The plan for experiment 1.

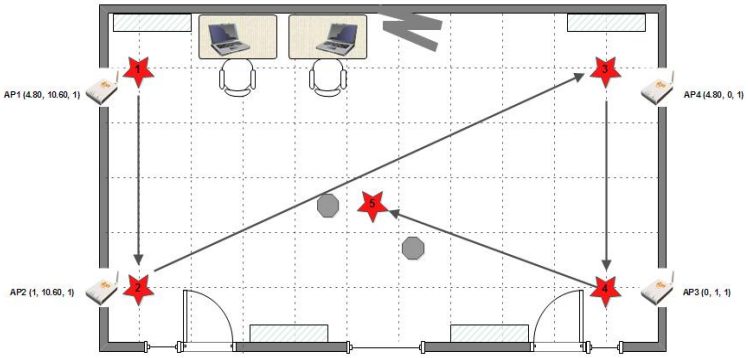


Fig. 4. The plan for experiment 3.

Based on these experiments, first, we want to study if the signal strength is affected by the level where the mobile terminal is located. Second, is examined the effect of the human operator's presence. Third, we consider the measurement direction and antenna orientation of the mobile terminal. Because the signal encounters various obstacles in its way, we want to see if changes occur upon it due to the partition wall inside the room. We also analyze the fluctuations of RSS when a human operator moves from one point to another within the room. Because we have the possibility to use several types of mobile devices, we want to compare the differences in terms of RSS between mobile terminals used for our experiments.

For the first experiment we chose five measurement points as shown in Figure 3. The mobile terminal is placed, without human operator, at hip altitude. The measurement of the signal is performed from all four APs during one minute at each position.

The second experiment kept the same measurement points as in the first one, the only difference being the level of mobile terminal which now is placed on the floor.

Within the third experiment, a human operator holds the mobile terminal. The operator moves along a path following the measurement points 1 to 5 as shown in Figure 4. In each point the operator waits for 10 seconds and then he start walking to reach the next point.

The forth experiment study the effect of various measurement directions and antenna orientations of the mobile terminals on RSS. The measurements are performed at the measurement point 2 and 5 as can be seen in Figure 5. During measurements, a human operator held the mobile terminal. For the MP 2 the directions are East and South-East and for the MP 5, the directions are North-West and North. For each direction, the orientation of the antenna is horizontal, diagonal and vertical. Each measurement lasts one minute.

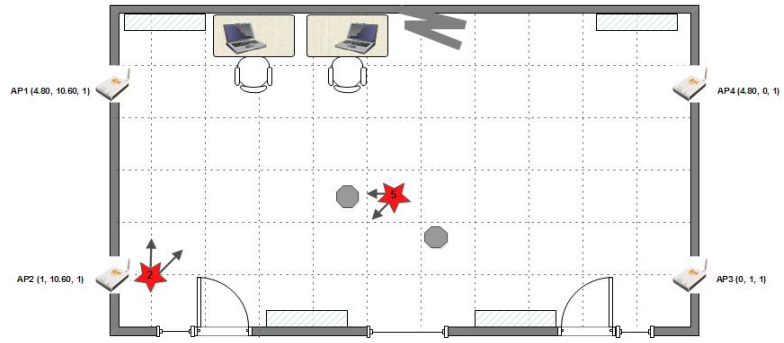


Fig. 5. The plan for experiment 4.

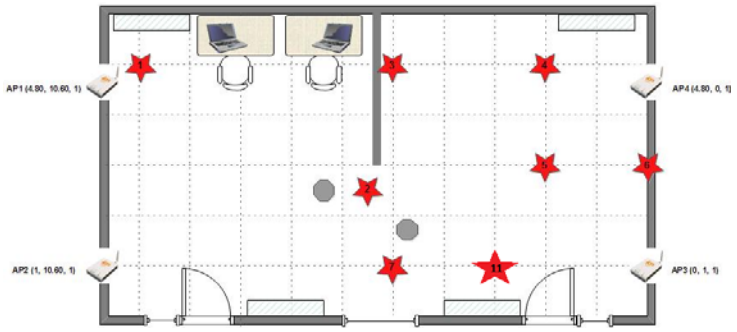


Fig. 6. The plan for experiment 5, 6, 7.

For the next experiment were introduced new measurement points as is shown in Figure 6. For each measurement point, three levels of the mobile terminal are considered: floor, hip and ear. The partition wall is unfolded and there is no human operator in the room. For each point, the measurement for each altitude is measured for one minute.

The above experiment will be repeated twice but only for the hip altitude of the mobile terminal. In the first case the human operator is standing 0.5 m at the West of the terminal resulting experiment 6. In the second case (experiment 7) the human operator is always standing at the MP 11.

4. RESULTS

In each of the above experiments the data were collected from all APs. The measurement process is as follows: the OwlPS Listener program is launched and runs continuously. OwlPS Aggregator is running in the same time. During the measurement process, the mobile terminal continuously sends positioning requests. One request is transmitted approximately each second and consists of 20 packets. Each AP captures the request, extracts the corresponding SS and forwards the information to the aggregation server where, the received data is gathered in a CSV file. For our analysis, we took data from those files and mean values of RSSs were computed for each AP and for each point of the experiment. To compute the mean values, we chose the RSSs corresponding only to a single request during measurements.

To observe the influence of the mobile terminal (MT) altitude on RSS, we study the measurement results obtained for experiment 1 (E1) and experiment 2 (E2). The results are shown in Figure 8 in which can be observed how mean value varies with the altitude of MT. For some points the difference is around 1dBm, for other points is bigger, while for most of the points the mean value differ by about 5 dBm.

In Figure 8 are also presented the results for E1 and E3. A comparison between these results is made in order to see the effect of human's presence on RSS. There is a difference in RSS values between the two experiments but we can't talk about signal attenuation when the human operator is present and carries the mobile terminal. Studying the results for E5 and E6 in Figure 9 we observed that the RSS is attenuated when the human operator is involved in the experiment. Going further and comparing the results from the E6 with the results from the E7, the RSS values were attenuated when the user stayed fixed on MP11. Certainly, there is a connection between the RSS values and human operator presence. Hence, it is essential to take into account the influence of human for application where the RSS measurements are performed in its presence.

To study if the signal is absorbed by wall, we take a look at the RSS Mean values for E1 and E5 in Figure 9. In MP1 case the signal is not attenuated but there exist a maximum variation of 15.65 dBm for AP4. In case of MP5 the RSS is attenuated, the maximum attenuation of 11 dBm being obtained for the same AP.

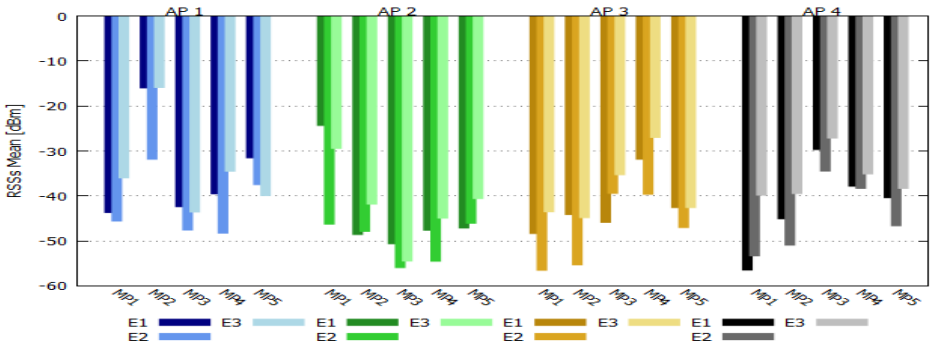


Fig. 8. RSS variability for different altitudes of the MT.

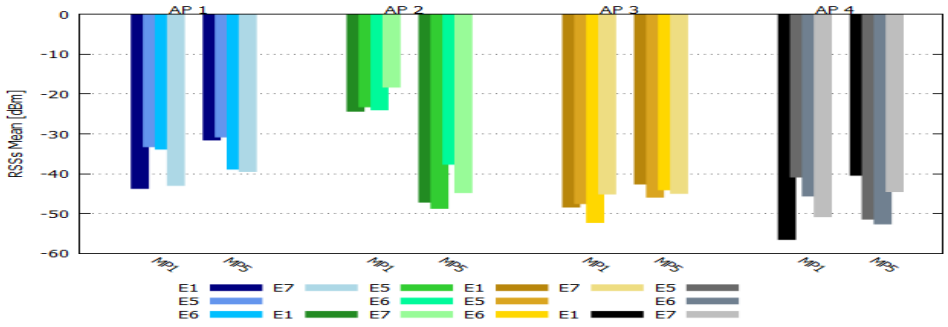


Fig. 9. Effect of human presence on RSS values.

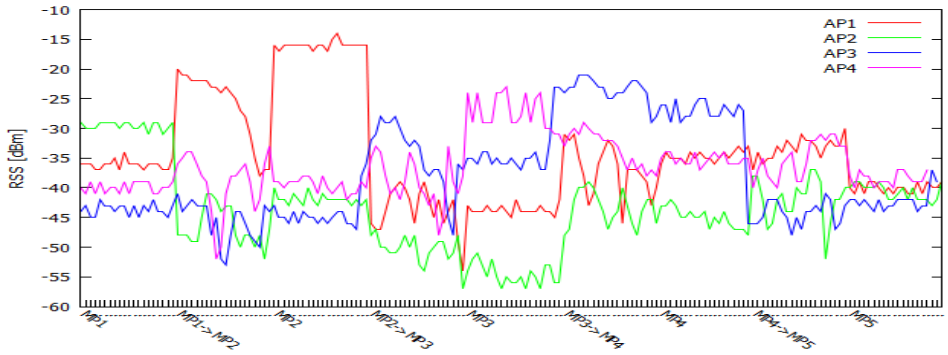


Fig. 10. RSS variability during movement.

Figure 10 depicts the behavior of RSS values measured from the four APs while experiment 3 (E3) is realized. Observe that the RSS abruptly changes its value when the human operator starts moving to the next measurement point while, the variation of RSS is less than 5 dBm when the operator stands still at the measurement point.

Table 1. **RSS (dBm) for MP 5 with different direction and orientation**

Measurement point		MEAN			
		AP 1	AP 2	AP 3	AP 4
MP 5 N - W	H	-30.75	-49.2	-35.65	-47.6
	D	-32.8	-47.5	-42.9	-42.65
	V	-42.5	-42.8	-48.3	-52.3
MP 5 N	H	-39.4	-47.1	-43.6	-42.85
	D	-39.8	-42.6	-39.9	-42.3
	V	-42.5	-50.45	-51.8	-49.75

To study the effect of MT's measurement direction and orientation, we realized the experiment 4 (E4) in which we performed measurements at MP2 and MP5. Herein, we chose to examine only the situation of MP5 since this point is placed approximately at the same distance by each AP. The results of the mean RSS values from the four APs are shown in Table 1. The higher value for RSS mean was -30.75 dBm when the MT direction is North–West and the antenna's orientation is horizontal. The lower value for RSS mean was -52.3 dBm when the MT direction is north. The biggest difference between RSS mean values is 16.12 dBm and is obtained for AP 3.

Table 2. **RSS (dBm) for MP 5 with different mobile terminals**

Experiment No.	Mobile Terminal	MEAN			
		AP 1	AP 2	AP 3	AP 4
1	Fonera AP	-31.65	-42.7	-47.25	-40.5
	EEE-PC	-45.35	-47.05	-48.6	-47.75
2	Fonera AP	-37.6	-47.15	-46.2	-46.75
	EEE-PC	-41.05	-46.15	-43.95	-42.95

Examining the RSS mean values within Table 2, we can conclude that the RSS may vary function of the mobile terminal used. Hence, we should choose carefully the device so that it best suits the application requirements.

5. CONCLUSIONS

In this paper we analyzed the behavior of the RSS values using real data collected from seven experiments conducted in indoor environment. We point out that the altitude where the mobile terminal is, brings significant variations in RSS values. The best case is when the mobile's terminal altitude is hip. An explanation for these results may be the fact that the mobile has the same altitude as the APs.

Regardless the effect of human's presence, is better to take it into account, especially when the collected RSSs are used for applications which involve human's presence. Usually the human operator holds the mobile device and moves inside the closed environment. During movement the variation of RSSs is roughly. Therefore, the effect of human's presence is important during RSSs measurements.

The direction and the orientation of the mobile terminal in analysis of RSS variation are important even more because the mobile terminal is carried by a user. Because the RSSs are collected from many APs, the user's body can obstruct the signal path between the AP and the mobile terminal.

An indoor environment is full of obstacles like furniture, walls and so on, and because these obstacles may lead to signal attenuation we analyzed the situation and we find that the wall inside our room influence the values of RSS.

We have more and more devices equipped with Wi-Fi technology and for some applications are more suitable small devices while for other applications this is not a requirement. Hence, we analyzed if there exist any difference in term of RSS values between two mobile devices when no change occurs in the infrastructure.

In conclusion, when is about an application which make use of RSS it is essential to take into account a set of parameters which can affect the RSS values and are particular for application's purpose. Choosing these parameters based on the application and making a good study of them, the performance is reached and the application will be a success.

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