People Effects on WLAN-Based IPS' Accuracy Experimental Preliminary Results

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***Abstract*—In order to enable Location Based Service (LBS) closed environment, many technologies have been investigated to replace the Global Positioning System (GPS) in the localization process in these indoor environments. WLAN occurs as the most suitable and powerful technology for Indoor Positioning System (IPS) due to its widespread and low cost. WLAN received signal strength (RSS) fingerprinting can be considered as the most accurate IPS method, but this accuracy can be decline due to WLAN RSS fluctuation. WLAN RSS fluctuates due to multipath influenced by obstacles presence. People presence under WLAN coverage can be considered as one of the main obstacles which can affect the WLAN-IPS accuracy. This research presents experimental results to show that the presence of one person between (Access Point) AP and (Mobile Device) MD decreases the Received Signal Strength (RSS) by -5dBm. This RSS decline can lead to big distance error more than 2m. Hence, any accurate IPS must consider the presence of the people in the indoor environment.**

Keywords—People presence; Signal attenuation; Indoor Positioning; Fingerprinting; Radio Map

I. INTRODUCTION

In the recent days there is a high demand for applying Location Based Services (LBS) in indoor environments as well as in outdoor environments. LBS can be defined as services that integrate the mobile user's location with other information in order to provide valuable information to the user [1]. LBS can be involved in several important systems in our daily life such as: Emergency services, healthcare, manufacturing, retailing, logistics and many other industries. Indoor positioning systems (IPS) gained in importance after the Global Positioning System (GPS) fails in determining a location accurately inside buildings due to the lack of line-of-sight (LOS) between the GPS receiver and the satellites. Hence, a lot of researches have been conducted to find other techniques to enable the LBS to provide its services in the indoor environment. Although Wireless Local Area Network (WLAN) technology is a valuable technology to be used for IPS due to its low cost and simple configuration, achieving high accuracy still needs more investigation because the WLAN's has two main weaknesses. These weaknesses are multipath influenced by presence of obstacles and signal strength fluctuation during the day time [2, 3]. These obstacles can be wall, ceilings and/or people [3, 4]. The walls and ceilings have been investigated deeply in [5-9]. This research presents experimental results to show that the people presence under the coverage of WLAN will decline the received signal strength (RSS), hence the positioning accuracy will be decline also. The experimental results shows that the presence of one person in the WALN coverage will decline the RSS by -5dBm which means that the accuracy of IPS will decline too.

II. BACKGROUND

In 1973 the GPS has been developed for military use, then it has been allowed freely for civilian use but with a degraded performance [10]. The widespread usage of the GPS shows LBS as a significant part of the people daily life [11]. LBS can be defined as services that integrate the mobile user's location with other information in order to provide valuable information to the user [1]. These services vary according the characteristics of the targeted domain such as: Military to track/determine target location, Civil defense to determine the appeal location, Marketing to helping possible customers, Healthcare to find the current location of a doctor for emergency cases; and Management to follow up the employees or object locations. Since LOS between the GPS satellite and the GPS receiver could not be achieved in the indoor environment, a need for alternative technology has been raised. Many technologies have been proposed for IPS such as: Radio Frequency Identification (RFID), Infrared Radiation (IR), Ultra Wide Band (UWB), Wireless LAN (WLAN), Ultrasound, and Bluetooth [3, 4, 11-13]. WLAN has been showed as the most valuable technology for IPS (due to its low cost, simple configuration, and widespread). Although WLAN RSS fingerprinting is the most accurate positioning method achieving high accuracy still needs more investigation because the WLAN's has two main weaknesses: multipath influenced by obstacles presence (Walls, furniture, people presence), and signal strength fluctuation during the day time [2, 3].

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III. Related Work

A lot of researches such as [4,13-22] list the presence of people in the indoor as signal attenuation factors, rarely found researches investigate this attenuation factor.

In 2000, RADAR [22] authors noticed that RSS in any location varied based on the orientation of the person calibrating it with respect to the access point. In order to overcome this problem, they built four orientations RM (0o, 90o, 180o, and 270o), as a result of this action accuracy enhanced by more 70%. Unfortunately the proposed solution, four orientations RM, increases the calibration effort four times and it is not applicable for the dynamic environments.

Hamida and Chelius [23], provided an experimental approach which investigated the impact of the human activity on the performance of the indoor WLAN in order to answer question "Is RSS a robust indicator for the WLAN link quality?". They observed relation between presence of periodic fluctuations in RSS and the presence of people activity within WLAN coverage that means during the day time the people activity has a significant impact on the WLAN performance in line-of- sight (LOS) and none line-of- sight (NLOS) paths. This observation depends on the value of the standard deviation values the collected RSS which are 10 and 1 for 8:00 am to 6:00 pm and for 6:00 pm to 8:00 am respectively. Unfortunately, the researchers did not mention about the number of people in the environment during the day time.

Karadimas, et al. in [24] statistically proved that the signal strength can vary over the time based on the human activity in the short-range wireless network, 60GHz. The experimental results showed that there is a Gaussian distribution of the effect of the human body when it obstructed the LOS path. In addition of that, it showed that effect can be increased by the number of people. Although this research has a valuable indication about the effect of the people presence or activity, from other point of view it considered only the case in which the human body obstructed the LOS and it did not provide any indication about RSS decline, in dBm, as effect of single human body. Turner, et al. [25] studied the human movement in 2.4GHz Wireless Sensor Network (WSN). They proved experimentally that there is significant impact of the number of people and their movement speed on the WSN signal strength. More specifically they found that the RSS can be decline 6 dBm and 3 dBm for one person movement in slow speed and fast speed respectively, and these values doubled when the number of movement people increased. Here also the researchers focused on the LOS obstruction only, and they considered only the effect of moving people only while in the dynamic indoor environment such as banks people presence in different states which need to pay more attention.

Fet, et al. [26] mentioned that the manual RM building required orientation-dependent RSS calibrating to overcome the signal attenuation by the human body. This orientation-dependent calibrating needs four times effort. The researchers showed that WLAN signal distribution with distance takes ellipse shape due to people presence. Then based on the ellipse properties and some empirical measurement they proposed RSS distribution model to generate multiple orientations RM depending on the 0o direction – access point facing – calibration. The proposed a model reduced the calibrating effort by 75% and the analytical correlation between the generated RM and calibrated one is greater than 0.9. In order to measure the effects of the generated RM on IPS performance, KNN algorithm has been used and the result showed a small decline in the accuracy less than 7% depending on the multi orientations RM. This work have multi defects; firstly, the authors mentioned that the difference of RSS values between the facing AP and the facing the opposite direction of the AP is -38dBm, this value is too large in comparison with the measurement from [23, 25] and this research preliminary results; secondly, using multi orientations RM means extra computational cost for the whole IPS. Thirdly, the 0^{o} direction RM calibration performed manually which is not suitable for the dynamic environments.

Finally, all the previous related works tried even to involve people presence to enhance the IPS accuracy by creating multi-direction RM (as sign for the huge effect of people presence) or tried to measure the effects of the presence of people using WSN not the usual WLAN. In this research we present experimental preliminary results to show that people presence under the coverage of WALN affects the RSS, hence the IPS accuracy will decline.

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IV. Preliminary Results

In order to show the effects of people presence under WLAN coverage on the accuracy of WLAN-based indoor positioning system (WIPS) five experiments have been conducted. All of these experiments have been done under the same full control conditions in the Graduate Assistant Room, which reside in Level 3 of Menara Razak; Universiti Teknologi Malaysia (UTM) Kuala Lumpur. In these control conditions: there is no mobile phone or any other wireless devices; the air conditioning unit and the lights had been turned off; WAP4410N Wireless-N Access Point and the mobile device (SONY VAIO, MS Windows 7) have been put in fixed locations, 3m of distance and on the same height 0.75m, in LOS to each other as shown in Fig. 1. MD equipped with Atheros AR9285Wireless Network Adaptor as hardware and Wifiscanner home-developed application aims to collect RSS from the WLAN as software.

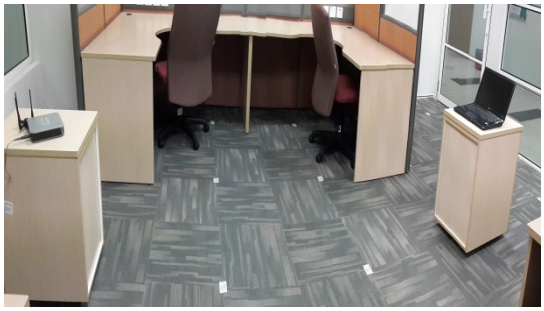

Fig. 1 One person effects in different scenarios

Firstly, The Wifiscanner has been configured to scan and store the RSS of AP beacon frames for 10 minutes without people presence (Sc0). After removing the duplicated frames, simple statistical values have been computed as shown in Table I.

TABLE I
STATISTICAL FUNCTION FOR THE COLLECTED RSS

Statistical Function	RSS Value
Minimum	-43
Maximum	-40
Mean (Average)	-41.6
Median	-42
Standard Deviation	0.91

Secondly, with the presence of one person the RSS of the beacon frames have been collected in four different scenarios. These scenarios are: Sc1 where the person setting down nears the mobile device, Sc2 where the person standing between the AP and the mobile device, Sc3 where the person moving between the AP and the mobile device, and Sc4 where the person moving randomly in the experiment's room. Some of the main statistical values have been computed for each scenario, these values are Minimum; Maximum; Mean; Median; and Standard Deviation. These values have been summarized in Fig. 2 which shows that the presence of one person acts as signal attenuation factor. This attenuation can decline the RSS value by -5dBm if the person obstructed the LOS between AP and the mobile device. These experiments indicate that this attenuation, which case by one person, will be increased as people count in the WLAN coverage increased.

Finally, radio map for 27 different points in three neighbored rooms, bold number as in shown in Fig. 3, has been built. After computing the RSS mean value on each point, we can easily note that -5dBm (the effect of one person) will lead to location estimation error.

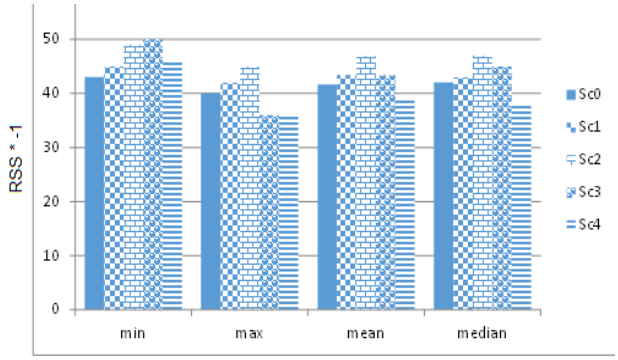

Fig. 2 Experimental Environment configuration

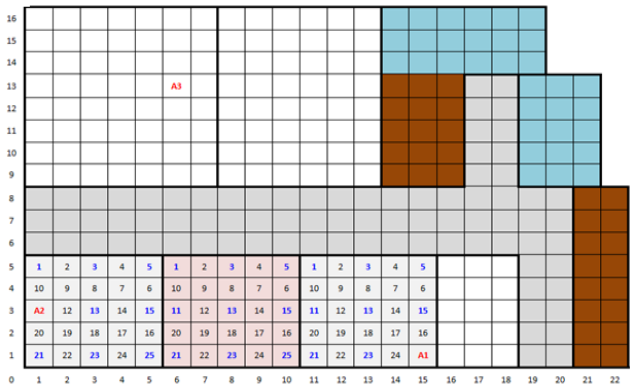

Fig. 2 Radio Map points in the site layout

Table II shows the averaged RSS values for nine points in the ASL1 room, which is the middle room in Fig. 3. The differences between the averaged values in Table II indicate that the positioning process distance error can be more than 2m or it can lead to location in different room.

TABLE II
RM FOR THE ASL1 ROOM, AVERAGED VALUES

Point	AP1	AP2	AP3
1	-54	-52	-68
3	-56	-50	-56
5	-52	-56	-68
11	-53	-52	-62
13	-50	-53	-63
15	-48	-53	-58
21	-57	-51	-58
23	-53	-50	-57
25	-50	-53	-62

V. CONCLUSIONS

Many technologies have been proposed to be used in IPS in order to activate the LBS in the indoor environments. WLAN occurs as the most suitable technology for IPS due to its widespread and low cost. WLAN RSS fingerprinting can be consider as the most accurate IPS method, but WLAN RSS fluctuates due to multipath influenced by obstacles presence. People presence under WLAN coverage can be considered as one of the main obstacles presence which can affect the WLAN-IPS accuracy. This research presents experimental results to show that the presence of one person between AP and MD can decrease the RSS by -5dBm. This RSS decline can lead to big distance error more than 2m. Hence, any accurate IPS must consider the presence of the people in the indoor environment.

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