Place Sticker: Energy Harvesting Approach for Low Cost Wi-Fi AP Positioning Infrastructure

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Abstract. In order to realize a feasible and low-cost indoor positioning, we implemented prototypes of energy-harvesting Wi-Fi AP's and conducted evaluation experiments at the underground shopping mall in Osaka. Solar panel driven access points only transmit a unique beacon but do not perform any other functionality in order to conserve energy. The unique beacon can be used for Wi-Fi positioning from ordinary Wi-Fi devices. We controlled beacon transmitting power to adapt positioning precision and obtained average 0.4m at most and 3.2m at 10m-pitch layout for both stationary status and walking status in the underground mall.

Keywords: indoor positioning, energy harvesting.

1 Introduction

Indoor positioning technology is investigated these days [1]. However, many approaches require newly constructed infrastructure and/or mobile or wearable devices. For example, indoor GPS technology, which is called IMES [2] in Japan, requires many signal-sending devices act as landmarks as well as rewrite the firmware of the receivers already on the market. Infrared [3], ultrasonic [4], visible light [5] and so forth also require new devices that should be equipped both in the mobiles and infrastructure.

Among the conventional positioning technologies, only the Wi-Fi AP positioning method [6] is good for feasibility and availability both of the mobiles and infrastructure. Currently, many people already carry Wi-Fi capable mobiles, and Wi-Fi positioning services have already been usable. On the other hand, indoor use of the Wi-Fi positioning service seems far from ideal performance for ubiquitous usage. Wi-Fi positioning requires access point (AP) survey war-driving beforehand. Our survey reports no AP can be heard at nearly half of the 1079 sample points in the biggest underground shopping mall of Osaka in Japan. Therefore, we have to prepare Wi-Fi

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AP's proactively and these should be optimized for positioning. In this approach, normal Wi-Fi equipped mobile devices can be used, so that low-cost AP should be designed for optimization of positioning services.

In this article, we introduce our prototype implementation of an energy harvesting Wi-Fi access point, which is optimized only for Wi-Fi positioning by omitting other communication functionality. In addition to this, we controlled beacon-transmitting power so as to obtain more precise positioning compared with conventional outdoor Wi-Fi positioning, according to the precision requirements of the location-based services.

2 Prototyping Place Sticker

Our prototype implementation, named "Place Sticker" (Fig 1), uses the low-power Wi-Fi chip from GainSpan[1] Inc. and we developed the firmware for the device to only perform transmission of a unique beacon, which means we support passive scan from mobile devices, not active scanning. We utilized sleep mode to the full where only 5.3mA average energy is consumed, while beacon submission requires 100~120mA at its peak consumption.

Solar panels usually produce the best electricity in solar light. However, we use the under fluorescent lights where only 1/5~1/10 energy would be produced. Therefore, we adopted a dye sensitized type solar cell (DSC) which has peak performance under the light frequency of fluorescent lights. A 1-cell DSC module (Fig 2) has dimensions of 105mm×35mm×2.3mm, weights 19g, and produces up to 0.46V in fluorescent light. We prepare an energy harvesting module with a series of 4 DSC cells and a power stabilizing circuit, which upgrade the power to 3.3V.

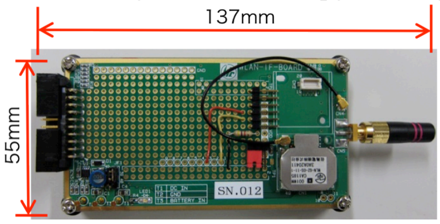

Fig 1. Place Sticker

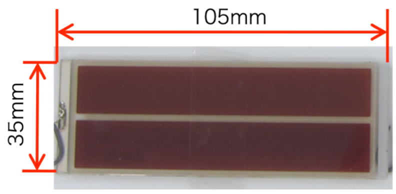

Fig 2. DSC (Dye sensitized type Solar Cell)

3 Positioning Precision Control

We try to put Place Sticker prototype in the best positions as well as known positions. We assume they are placed next to fluorescent light tubes in the ceiling with their antennae facing straight toward the ground. This is because only straight waves with little reflective waves would improve positioning precision. Normal Wi-Fi

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1 http://www.gainspan.com/

transmission covers a distance of 100m and is too strong to realize ideal positioning; this gives many reflective waves, and therefore the variety of signal strength would become wide, even at the same distance from the access point. As the power control for each transmitting beacon, we packaged the module with an antenna in a box of aluminum with a 3.2 cm square hole (Fig 3). Packaging in such a metallic box would effectively decrease reflection of the beacon waves. This approach results in the sharper figure of RSSI distribution. (Fig 4)

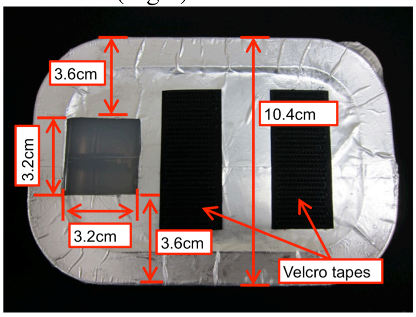

Fig 3. Packaged Place Sticker

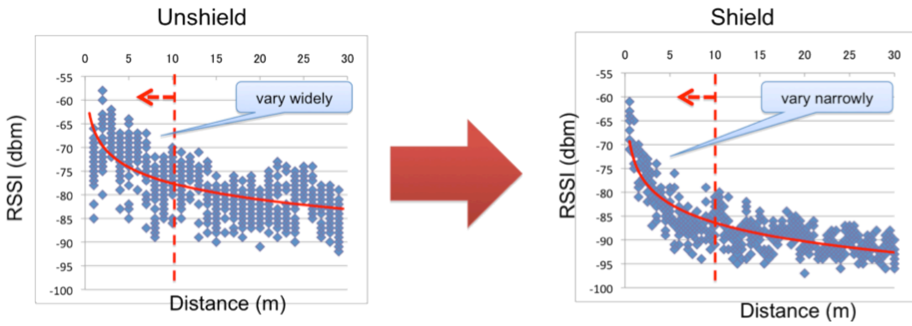

Fig 4. The effect of the aluminum shield

4 Evaluation Experiment

We conducted an evaluation experiment at an underground shopping mall in Osaka. The site is shown in the Fig 5. 10 prototypes of Place Sticker are prepared and put in fluorescent light fixtures attached to the ceiling. We evaluated two types of positioning, stationary performance (132 times evaluation at the 10m-pitch layout for store-wise location and 16 times evaluation at the 2m-pitch layout in quest for the best precision), and walking performance (10m-pitch layout, one tracking). To evaluate the stationary performance, we tapped the correct position on the map of our own Android application and measured the average error of positioning. In evaluations of walking performance, we obtained 29 samples of positioning and their correct locations from the log data of tracking the straight way at 1.33m/s. We obtained stationary performances of 3.2m and 1.2m at the 10m-pitch layout and the 2m-pitch layout, respectively. Also, we obtained a walking performance of 3.3m average positioning error when server communication delay is eliminated.

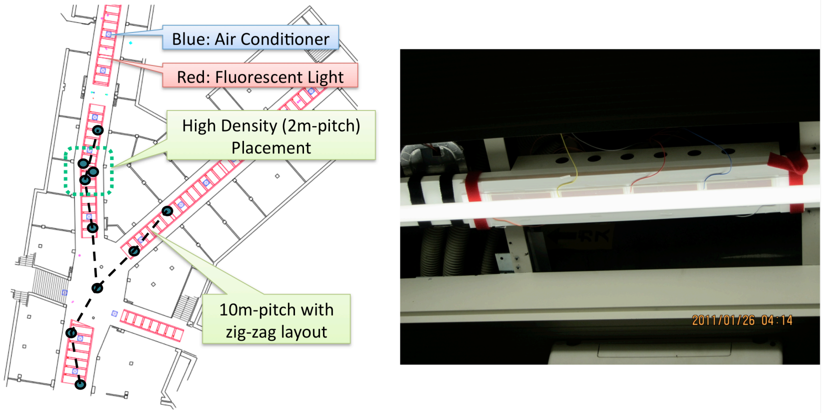

Fig 5. Experimental Field

5 Conclusion

In order to realize a feasible and low-cost indoor positioning infrastructure, we developed a DSC-based energy harvesting approach for positioning optimized Wi-Fi AP. A prototype AP device was developed and we conducted the evaluation experiment at the underground shopping mall in Osaka. Normal fluorescent light tubes produced enough power to send Wi-Fi beacons that were used by ordinary Wi-Fi equipped mobile device for positioning.

In the future, we plan more compact packaging and energy conservation in order to manufacture Place Sticker for actual markets.

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