Automatic Generation of Radio Maps for Localization Systems

Ahmed Eleryan[1], Mohamed Elsabagh[1], and Moustafa Youssef[1,2]

[1] Dept. of Computer Engineering, Alexandria University, Egypt
{ahmed.eleryan,mohamed.elsabagh}@alex.edu.eg
[2] Dept. of Computer and Systems Eng., Alexandria University and E-JUST, Egypt
moustafa.youssef@ejust.edu.eg

Abstract. In this paper, we present the design and evaluation of a system that automatically constructs accurate radio maps for both device-based and device-free WLAN localization systems. The system uses 3D ray tracing enhanced with the uniform theory of diffraction (UTD) to model the electric field behavior and the **human shadowing effect**.

1 Introduction

Both device-based and device-free localization systems usually require the construction of a radio map where collected signal strengths from different streams at different selected locations in the area of interest are tabulated. Using manual calibration, current methods of radio maps construction are therefore tedious and time-consuming, which emphasizes the need for a method to automatically construct the radio maps for an area of interest.

In this paper we present a system which can automatically construct an accurate radio map for a given 3D area of interest. It is unique in supporting automatic radio map generation for **both device-based and device-free** localization systems, which require high accuracy. To our knowledge, this system is the first to consider radio map generation for device-free systems and the first to consider **human body effect** on the generated radio map.

2 System Architecture and Evaluation

The system combines ray tracing with UTD[2] to model both the RF propagation and human shadowing effect. Fig. 1 shows the architecture of the system. Previous work in human modeling has shown a strong correlation between the RF characteristics of the human body and a metallic circular cylinder [1] in indoor radio channels. Therefore, we use a metallic cylinder to model the human body with radius 0.15 m, and height 2 m [1]. For the device-free case, due to the lack of a perfect 3D model, the predicted RSS deviates from the measured ones by a constant offset. To make up for this, the system can optionally be fed with only a *single* sample representing the measured signal in the absence of humans in the environment. This sample is used to compensate for any deviation.

We present only our evaluation of the device-free radio map generation. The experiment was conducted in a typical apartment with an area of $700ft^2$. 44 locations were chosen and are illustrated in Fig. 2. We collected 60 samples for

P. Sénac, M. Ott, and A. Seneviratne (Eds.): MobiQuitous 2010, LNICST 73, pp. 372–373, 2012.

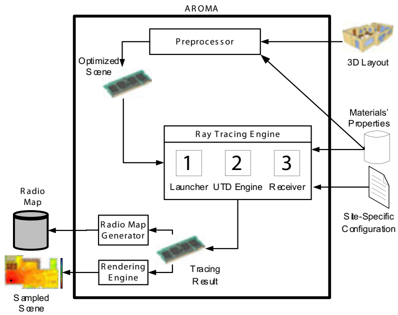

Fig. 1. System architecture

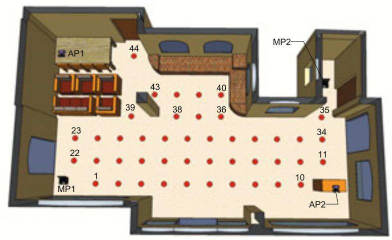

Fig. 2. Device-free experiment layout. The figure highlights the locations of APs, MPs, and radio map locations.

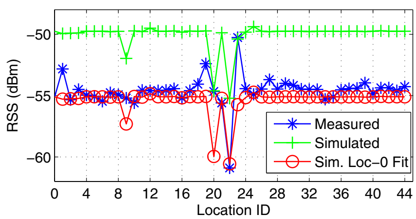

Fig. 3. RSS from AP1 by MP1

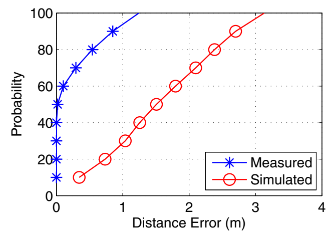

Fig. 4. Performance of the MED classifier

each location. A new location is introduced, namely location-0, which represents the environment in the absence of humans. Fig. 3 shows the simulated versus measured RSS for AP1/MP1. We show only one stream due to space limitations. The results show that simulated values are close to the measured values with a maximum average absolute error of 2.77 dBm for all streams. The accuracy of the generated radio map (Fig. 4) is then judged by comparing the average distance error (in meters) of a Mean Euclidean Distance classifier when trained by the manually measured radio map and the automatically generated one. The average distance errors are found to be 1.24 m and 3.13 m, respectively.

3 Conclusion

This paper introduced a system capable of generating site-specific radio maps for device-based and device-free localization systems. Our experience showed that it achieves its goals of: high accuracy, and minimal user overhead.

References

1. Ghaddar, M., Talbi, L., Denid, T., Charbonneau, A.: Modeling Human Body Effects for Indoor Radio Channel using UTD. In: Canadian Conference on Electrical and Computer Engineering. IEEE, Los Alamitos (2004)
2. Mcnamara, D.A., Pistorius, C.W.I., Malherbe, J.A.G.: Introduction to the Uniform Geometrical Theory of Diffraction. Artech House Publishers, Boston (1990)