Chapter 4
The WiMap: A Dynamic Indoor WLAN Localization System

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ABSTRACT

As positioning technology is an important foundation of the Internet of Things, a dynamic indoor WLAN localization system is proposed in this paper. This paper mainly concentrates on the design and implementation of the WiMap—a dynamic indoor WLAN localization system, which employs grid-based localization method using RSS (received signal strength). To achieve high localization accuracy and low computational complexity, Gaussian mixture model is applied to approximate the signal distribution and a ROI (region of interest) is defined to limit the search region. The authors also discuss other techniques like AP selection and threshold control, which affects the localization accuracy. The experimental results indicate that an accuracy of 3m with 73.8% probability can be obtained in WiMap. Moreover, the running time is reduced greatly with limited ROI method.

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1. INTRODUCTION

From the Internet of Things architecture it can be seen that people utilize RFID and sensors to access to a wide variety of information from the physical world; the information has spread through the network to the end user or server, providing users with a variety of services. Meanwhile, all collected information must be associated with the specific location information of sensors; otherwise the information will not make any sense. So it can be said that the positioning technology is an important foundation of the Internet of Things.

The WiMap system is implemented in the context of 802.11 wireless LANs (IEEE Computer Society, 2009) and devoted to achieve high accuracy indoor localization with light computational complexity. Nowadays most commonly used methods to calculate the unknown position of a target includes Proximity Sensing, Lateration, Angulation and Dead Reckoning; and many of these methods when used alone give levels of accuracy which are insufficient for most users (Curran, Furey, Lunney, Santos, & Woods, 2009). WiMap uses RSS (Received Signal Strength) to locate the mobile target.

Like most researches on localization systems (Bahl & Padmanabhan, 2000; Bahl, Padmanabhan, & Balachandran, 2000; Youssef & Agrawala, 2005; Kushi, Plataniotis, & Venetsanopoulos, 2010; Ngyuen, Jordan, & Sinopoli, 2005; Addesso, Bruno, & Restaino, 2010; Ji, Biaz, Pandey, & Agrawal, 2006; Chiou, Wang, Yeh, & Su, 2009), WiMap works in two phases: offline training phase and online positioning phase. During the offline phase, a radio map associating RSS with the selected known grid locations is established. During the online phase, WiMap tries to find the grid location in the radio map with the most “similar” signal characteristics.

The WiMap system locates the target by calculating the probability under the Bayesian framework. During the process of building the radio map, we assume the signal characteristic satisfies the GMM (Gaussian mixture model), instead of single Gaussian model. And the EM (expectation-maximization) algorithm is used to calculate the parameters of GMM. And the state estimation of the mobile target is assumed to satisfy the Markov model. To lower the computational complexity, a ROI (region of interest) center with the last estimated grid location is outlined as the target searching area for the next localization. Moreover, AP selection is implemented to achieve both higher accuracy and less computational complexity by discriminating grid locations better and reducing the likelihood probability calculation range as a subset of all APs. However, these methods work well only in the premise that the last estimated results are reliable enough. Otherwise it just returns worse estimated results. So to solve this problem, we propose the threshold control technique that let the system carry out a global search in a larger ROI than the former one when the biggest posterior probability is less than some threshold value, which can be inferred from the experimental statistics. In this paper, we present the details of localization techniques and show how they work together to achieve its goal.

The rest of the paper is organized as follows: Section 2 provides an overview of the WLAN localization and related researches in the area. In Section 3 we present an overview of the WiMap system and introduce the models and the techniques used to achieve the goal. Section 4 shows the experimental results of our system and compares its accuracy to the accuracy without these techniques. Finally, Section 5 concludes the main findings of the paper and gives the future work to improve the WiMap system.

2. RELATED WORK

WLAN localization, based on whether using the trained dataset, can mainly be categorized into parameter-estimation-based technique or pattern-mapping technique. Parameter-estimation-based
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