Chapter 4
RFID Indoor Localization Techniques

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ABSTRACT

Radio frequency identification (RFID) is a technique using two-way radio transmission pattern to transmit information through the device of interrogator (also called reader) and tag. It is considered to be one of the most popular techniques for internet of things (IOT). In this chapter, the authors study indoor localization techniques based on passive UHF RFID, which works around the frequency of 900MHz. Passive RFID has the advantage of reasonable reading distance, non-contact, easy deployment, and low cost. The tags do not need battery and it can harvest power through wireless charging. Due to those advantages, passive UHF RFID positioning has always been an active research area in the past few decades. This chapter discusses the key techniques in passive UHF RFID positioning, which include range-based, range-free, tag-based (device-based), tag-free (device-free), and improved positioning methods. All the techniques studied are suited to be implemented in RFID systems, each of which can be accommodated to a specific application scenario.

INTRODUCTION

With the rapid development of Internet of Things (IOT) technology, radio frequency identification (RFID) localization has attracted wide attention. RFID positioning system consists of reader, antenna and tag. RFID localization technology has many advantages such as non-contact, easy deployment, and low cost, hence it has been widely used in logistics, medicine, library management, and so on. RFID tags are divided into active tags and passive tags. The primary difference between an active tag and a

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passive tag is whether or not a power supply (i.e. battery) is included. The active tag has a power supply so that it has a long read distance, but it requires periodic battery replacement. The passive tag does not have a power supply so it harvests power typically through electromagnetic induction when a reader is within the radio range of the tag. Comparatively, a passive tag is cheaper and has a smaller size, however, it has a shorter read distance.

This chapter introduces the main positioning techniques based on passive ultra-high frequency (UHF) RFID. After briefly reviewing the various RFID positioning approaches in the introduction section, five different techniques for passive RFID positioning are described in detail in five separate sections, which are LANDMARC, range-based method, improved range-based method, optimization based localization, and device free localization.

BACKGROUND

The signal transmission characteristics for wireless indoor localization have been investigated for many years, resulting in some useful conclusions and experiences which have a positive effect on the advances in UHF RFID localization. The UHF RFID has a backscattering channel, so one research focus is on the effect of channel characteristics, link budgets, and modeling methods on positioning performance. Griffin and Durgin (2009) studied the link budgets for RFID backscattering channel. They analyzed the budgets for passive tag's power-up link, backscatter radio link, and antenna configuration. Lázaro *et al*. presented a method to estimate the read range of a tag in multipath environments and analyzed the different effects on read range. A RFID system simulator was also presented using the ray tracing method (Lázaro, Girbau & Salinas, 2009). Arnitz *et al*. proposed a method to calculate wideband channel parameters of backscatter channels based on the parameters of the constituent one-way channels and studied characteristics that are vital for narrowband and wideband ranging, such as the K-factor w.r.t. the direct (line-of-sight) path and the root mean square (RMS) delay spread (Arnitz, Muehlmann & Witrisal, 2012a). They also conducted a comprehensive investigation on ranging and localization with UHF RFID, using measurements made inside a warehouse portal (Arnitz, Muehlmann & Witrisal, 2012b). The influence of reflecting/absorbing backplanes as well as the effects of a reflective pallet on the channel was discussed in detail. Furthermore, the developed channel model was analyzed for deterministic components and compared to a number of channel models. Faseth *et al*. studied the effect of multipath propagation on phase-based positioning methods based on UHF RFID and a channel model was derived (Faseth, Winkler & Arthaber, 2011). Simulations were conducted to understand the effect of the channel parameters on the narrowband phase-based localization methods.

In recent years, new algorithms especially related to optimization have been proposed. Many are based on the LANDMARC (Ni et al. 2004) and VIRE (Zhao, Liu & Ni, 2007). LANDMARC is a kind of range-free localization which uses reference tags to position. LANDMARC will be discussed in detail later. VIRE is a positioning method using virtual reference elimination. Zhang *et al*. analyzed how tag interaction affects a tag antenna radiation pattern and RSSI to improve the RSSI-based localization algorithms such as the k-nearest neighbor (k-NN) algorithm and the Simplex algorithm (Zhang et al. 2014). Experimental results show that the performance of the modfied k-NN and the modified Simplex algorithms is improved significantly and they are more robust against variations in the number, distribution density, and material type of target objects. DiGiampaolo and Martinelli (2012) studied a global localization problem for a mobile robot that was able to detect the presence of passive RFID tags. Kal-