Journal of Network and Computer Applications 34 (2011) 902–913

Contents lists available at ScienceDirect

Journal of Network and Computer Applications

journal homepage: www.elsevier.com/locate/jnca

RFID-assisted indoor localization and the impact of interference on its performance

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ARTICLE INFO

Article history:
Received 31 October 2009
Received in revised form
27 March 2010
Accepted 28 April 2010
Available online 7 May 2010

Keywords:
RFID interference
RFID localization

ABSTRACT

Radio Frequency IDentification (RFID) is a rapidly developing wireless technology with key features which anticipate its outstanding position in the upcoming era of pervasive computing. Even though object identification is its primary objective, it is generally accepted that RFID systems can revolutionize various commercial applications. Despite its promising benefits, however, there are some technological challenges that should be addressed in order to exploit the full potential of RFID. Admittedly, the interference problem among its components and from non-conductive materials is the main shortcoming of RFID. The main goal of this paper is exploring its applicability for indoor location sensing, an important feature for the realization of ubiquitous computing applications. To that end, we study the impact of several interference types on its performance. Focusing on the case of determining the location of mobile terminals with reader extension by relying on a deployment of tags, we consider three RFID positioning schemes which are easily implemented but differ in their memory and computation requirements. Mathematical models are derived for describing the main interference types and their influence on the accuracy and time response of these schemes. Finally, extensive simulation analysis is conducted for exploring the practicality and efficacy of RFID for the localization of single or multiple users under different levels of environmental harshness. Numerical results validate the potential of RFID in location sensing but also the requirement for careful design of RFID-based positioning systems.

1. Introduction

Over the last few decades, we have been witnessing great advances in the field of wireless communications and mobile computing. RFID has a relatively long history of more than 50 years in the field of wireless communications, but only the last decade it has received a considerable attention for becoming a useful general purpose technology. Actually, RFID was initially developed as an automatic identification system consisting of three basic component types, readers, tags, and servers (Want, 2006). RFID tags are simple devices with main purposes storing their ID and transmitting it to a reader. Many types of RFID tags exist, but at the highest level, they can be divided into two classes: active and passive. Active tags require a power source such as an integrated battery. Passive tags do not need a battery to operate, they just backscatter the carrier signal received from a reader. This makes their lifetime large and cost negligible. Readers are responsible for communicating with tags and an application. To that end, they have two interfaces. The first one is a RF interface enabling them to read the IDs of tags with their vicinity by running a simple link-layer protocol over the wireless channel. The second one is a communication interface, such as IEEE 802.11, for enabling communication with servers. Servers are back-end entities responsible for receiving and processing the information sent from the readers.

Key benefits of RFID, such as low cost and indefinite lifetime of passive tags, non-line of sight requirement, simultaneous and fast reading of multiple tag IDs, resilience to environmental changes, reduced sensitivity regarding user orientation, inspired the academia and industry for exploring its potentials in more intelligent applications, such as supply chain management, object or people tracking, real-time inventory, retail, anti-counterfeiting, baggage handling, and health-care (Baudin, 2005).

Nevertheless, applying RFID for indoor localization is one of the main active research domains. The localization problem has received considerable attention in the areas of pervasive computing and wireless networks as many applications need to know where objects are, and hence various location-based services (LBS), such as E911 emergency services, are being created. Furthermore, location awareness is useful for enhancing the network functionality, such as mobility management (Papapostolou and Chaouchi, 2010), quality of service support, network planning, load balancing, etc.

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doi:10.1016/j.jnca.2010.04.009