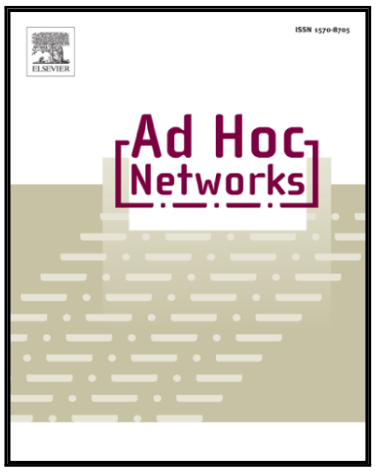

TrackT: Accurate Tracking of RFID Tags with mm-level Accuracy Using First-order Taylor Series Approximation

Zhongqin Wang , Ning Ye , Reza Malekian , Fu Xiao , Ruchuan Wang

PII: S1570-8705(16)30273-6
DOI: 10.1016/j.adhoc.2016.09.026
Reference: ADHOC 1468

To appear in: *Ad Hoc Networks*

Received date: 4 August 2016
Revised date: 18 September 2016
Accepted date: 30 September 2016

Please cite this article as: Zhongqin Wang , Ning Ye , Reza Malekian , Fu Xiao , Ruchuan Wang , TrackT: Accurate Tracking of RFID Tags with mm-level Accuracy Using First-order Taylor Series Approximation, *Ad Hoc Networks* (2016), doi: 10.1016/j.adhoc.2016.09.026

TrackT: Accurate Tracking of RFID Tags with mm-level Accuracy Using First-order Taylor Series Approximation

Zhongqin Wang, Ning Ye, Reza Malekian, Fu Xiao, Ruchuan Wang

***Abstract*—Radio Frequency Identification (RFID) technology is widely used to achieve indoor object tracking and positioning. Currently, many methods need to deploy a large number of reference tags beforehand and some are limited by antennas' spacing. Further, the signal propagation along Non-Line of Sight introduces multipath effects which will challenge the accuracy of RFID localization system. In this work, we propose a method based on measured phase to track mobile RFID tags with millimeter level (mm-level) accuracy. We first partition the surveillance region into square grids at mm-level and suppose that there is a virtual tag as the same as the tracked one in each grid. On this basis, for the case where the tags move along a known track with constant speed, we only need to locate the tag's initial position. We leverage phase periodicity to obtain some candidates and then eliminate position ambiguity by double difference true phase. And for the case where the tag's moving track is unknown to the system, we adopt a first-order Taylor series expansion to calculate the relative displacements of the tracked tag and then locate the initial position as the same process as tracking the known trajectory. In our experiment, our solution can achieve a mean error distance of 0.26cm and 0.55cm for known and unknown movement tracks respectively.**

***Index Terms*—Phase detection, Radio frequency identification, RFID tags, RF signals**

The research is support by National Natural Science Foundation of P. R. China (No.61572260), Major Program of Jiangsu Higher Education Institutions (No.14KJA520002), the Key Research and Development Program of Jiangsu Province (Social Development Program) (No.BE2015702), Jiangsu Planned Projects for Postdoctoral Research Funds (No.1302055C), China Postdoctoral Science Foundation (No.2014M560440), and National Research Foundation, South Africa (AOX220).

Zhongqin Wang is with the College of Internet of things, Nanjing University of Posts and Telecommunications, Nanjing, 210003, China (e-mail: zhongqin.wang.CN@ieee.org).

Ning Ye is with the College of Computer, Nanjing University of Posts and Telecommunications, Nanjing, 210003, China, and also with the Jiangsu High Technology Research Key Laboratory for Wireless Sensor Networks, Nanjing 210003, China (e-mail: yening @njupt.edu.cn).

Reza Malekian is with the Department of Electrical, Electronic and Computer Engineering, University of Pretoria, Pretoria, South Africa (e-mail: reza.malekian@up.ac.za).

Fu Xiao and Ruchuan Wang are with the College of Computer, Nanjing University of Posts and Telecommunications, Nanjing, 210003, China, and also with the Jiangsu High Technology Research Key Laboratory for Wireless Sensor Networks, Nanjing 210003, China. He is also with Key Lab of Broadband Wireless Communication and Sensor Network Technology of Ministry of Education, Nanjing University of Posts and Telecommunications, Nanjing, 210003, China (e-mail: {xiaof, wangrc} @njupt.edu.cn).

I. INTRODUCTION

RADIO Frequency Identification (RFID) technology is increasingly used in various applications such as assisted tracking of robots [1], product identification[2], asset assessment, indoor positioning and so on. Currently, the common method to locate passive tags in practice is described as follows. People often deploy many RFID readers in different monitoring areas to continuously read RFID tags. The tags are assigned with the unique Electronic Product Code (EPC) and given position information beforehand in the database. Once a reader captures a new tag's EPC, people consider that the tag has been moved to the reader's surveillance area. However, there are many disadvantages in this coarse method: (i) Low positioning resolution. The reading range of an RFID reader antenna is generally about 3~10 meters, and RFID readers can only provide "absence and presence" results, so the system is far from meeting the high accuracy requirements. (ii) False negative reads [3], [4] and false positive reads [5], [6]. The former means that a reader fails to read a tag in the reading zone and the latter means that a tag in some other areas outside the intended read zone is read. These two problems can also affect the positioning accuracy.

Many applications will benefit from millimeter level (mm-level) localization accuracy. For example, false positive reads will be avoided by setting the intended reading zone beforehand. If the RFID tag is within the area, the RFID reader will record and report events related to this tracked tag. If not, the reader will ignore it. As another example, in a large-scale clothes shop a retailer could use the RFID location system to visually track clothes with RFID tags, making sure that sales representatives could easily find matching clothes which may have gone astray and customers could easily know the locations of wanted clothes.

At present, the two key approaches for RFID localization are based on received signal strength indication (RSSI) and radio frequency (RF) phase.

(i) RSSI. The RSSI methods [7]-[11] need to deploy many reference tags since the absolute calibration for RSSI measurements is rather difficult, and positioning accuracy is greatly affected by antenna design, impedance matching, and the changes in reflection coefficient [12]. The distance error is about 60cm. At present, many commercial-off-the-shelf (COTS) RFID readers can report RF phase once an RFID tag is