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Integration of Cognitive Radio Networks in RFID system for identification of Missing Tags

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ABSTRACT

Radio-Frequency Identification (RFID) is a rapidly growing technology that has the potential to make great economic impacts on many industries. RFID is the use of radio waves to read and capture information stored on a tag attached to an object. In this paper, we propose a system model for tag detection in large-scale RFID systems. This is achieved by using the cognitive radio (CR) network technology. The main advantage of using cognitive radio is that it senses the environment through spectrum sensing and adjusts the frequency of reader in Radio frequency system to enable the detection of tag. Combination of Cognitive Radio with RFID improves the performance of the system. The overall communication quality in a radio frequency environment is enhanced by minimization of data losses.

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INTRODUCTION

Radio Frequency Identification (RFID) is a wireless technology which uses radio waves as the key to determine the objects that has been lost or that has to be tracked. An RFID system is an advancement of Barcode technology which uses horizontal and vertical lines with the gaps in between. The disadvantage of the barcode is that if there is any damage on the lines of the barcode the object could not be detected. This could be overcome by RFID. RFID systems use tags (transponders), readers (interrogators) and the antenna to carry out its functionality. Tags are embedded in the object that has to be tracked. Tags contain unique id that distinguishes one from another. Readers are used to detect the tags that fall under its coverage area. Antenna is used by both the reader and a tag to transmit the radio waves. Thus Radio Frequency Identification Device (RFID) is the wireless, radio wave technology that uses a small RFID chip to be embedded in any physical object and to be uniquely identified by an RFID reader. RFID is considered as a non specific short range device. It can use frequency bands without a license. Nevertheless, RFID has to be compliant with local regulations (ETSI, FCC etc.) Reader queries the tags on different frequencies. The frequencies depend on the type of application that is executed. Proximity (short range) and Vicinity (long range) are two major application areas where RFID technology is used. Applications based on tracking and tracing the tags varies on either long range or vicinity types. This technology provides additional functionality and benefits for product authentication.

Cognitive Radio (CR); a radio with an intelligence layer of awareness and learning is necessary to achieve optimal performance under dynamic and unpredictable situations. It is used to configure the radio system parameters. It senses the environment and fine tunes the radio system parameters in order to provide a better quality of service to the users.

Many research challenges in RFID exist; one of the attractive and most promising challenges among them is the missing tag identification from a given set of tags. In this paper cognitive radio technology is used to sense the RFID environment and paves the

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Australian Journal of Basic and Applied Sciences, 9(23) July 2015, Pages: 227-232

way for detection of tags which provides a healthier solution to missing tag problem. The rest of the paper is organized as follows: Part 2 surveys the related work; Part 3 presents the proposed method, the detailed system model is presented in Part 4, Part 5 details the simulation conducted, Part 6 discusses the results and discussions. Finally Part 7 concludes this paper and Part 8 the future work.

Related Work:

During the infancy stage of RFID, the solution to tag detection was categorized based on two types of protocols: Aloha based protocols and Tree based protocols.

In Aloha based protocols the reader sends a frame size *f* and a random number *R* to the tags in its coverage area. Each and every tag uses the values of *f*, *R* and its own ID to select a slot in a frame by using the hash function *h(ID,R) mod f*. During this process if a single tag fits into a slot, that particular tag can be easily identified. If two or more tags fit into a same slot, it results in collision and thus the tags could not be identified properly. So this process is repeated until all the tags are collected.

A binary tree is being created using the tag Ids by tree based protocol. The left branch of the tree is marked by ‘0’ and the right branch by ‘1’. The tree is searched depending upon the value queried by the tag. The reader sends a sequence of either ‘1’s or ‘0’s and the required tag is identified. The process is repeated until all the tags have been identified.

Different techniques for sensing and detecting tags have been proposed in the recent years. WeiXie.A et.al proposed a novel type of RFID application called RFID seeking and this is the first secure RFID seeking protocol which is designed to meet all the given requirements. Kai Bu et.al proposed series of protocols to detect the misplaced tags using reader positions in order to guarantee the efficiency and scalability of the system. D. Zhang et.al proposed a Tag-free Activity Sensing (TASA) and frequent route detection using RFID tag arrays for sensing the location.

Data losses can be incurred in the above mentioned techniques to tag detection problem. Some protocols only detect the number of tags missed in a RFID environment rather than determining exactly which tag has been missed. Also collision among the tags exists during the tag determination process. Hence the proposed method is used to overcome all the above mentioned disadvantages.

Proposed Method:

The proposed system uses cognitive Radio technique to overcome the existing problems. For RFID spectrum, the CR can dynamically adapt its behavior to monitor the radio environment and RFID spectrum policy. CR solves the problem of data losses in radio frequency environment that exists among tags. Spectrum sensing is the important functionality of CR to sense the surrounding environment.

In the general course, a tag moves from one coverage area of the reader to another. The assumption made is that the reader’s contain the information of the tags in its coverage area in the cache. To determine the tag that is mislocated, CR enables all the reader’s in the RF environment to search for the particular tag that is being declared as missed by the actual reader. Thus the tag is never considered as missing through the CR technique in RF environment.

As the tag information is collected by CR no data losses will be incurred which improves the performance of the system.

System Model:

In our model, the RFID system consists of a number of RFID readers (reads identification database) and a large number of RFID tags as shown in the Figure 1. The reader’s database coordinates the RFID readers and has powerful computation capability. When multiple readers are synchronized, we may logically consider them as a whole. For the tags, the RFID system may use battery-powered active ones that have larger transmission range, or use light-weight passive ones that are energized by radio waves transmitted by the readers and communicate with the reader by backscattering the RF carrier according to the application requirement.

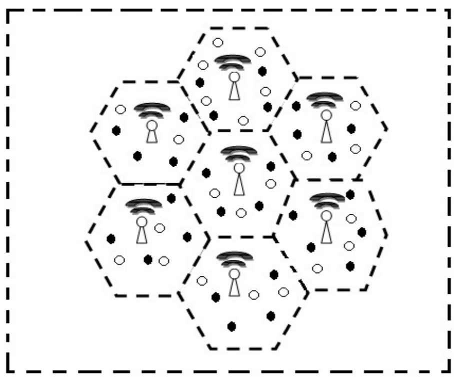

Fig. 1: RF environment with readers and tags within the range and outside the range.

When the problem comes to tracking of a particular tag, two scenarios have to be considered which is whether the tag is in the reader's coverage area or outside the reader's coverage area. The two scenarios are explained below:

Case i: For a Tag within the Reader's coverage area :

For the tags within the vicinity of the reader, data from the tags is transmitted to the reader through the Baseline protocol. The reader sends a message that contains the random number along with the frame size from which the information has to be retrieved. All the tags upon receiving the frame size uses its own ID to calculate the slot number it has to fit in. Tags in the coverage area of the reader easily respond to the readers' request by filling into a particular slot. In this manner the tags could be identified easily by the reader.

Case ii: For a Tag outside the Reader's coverage area:

If a particular tag is away from the reader's coverage area, tracking is done through CR technique.

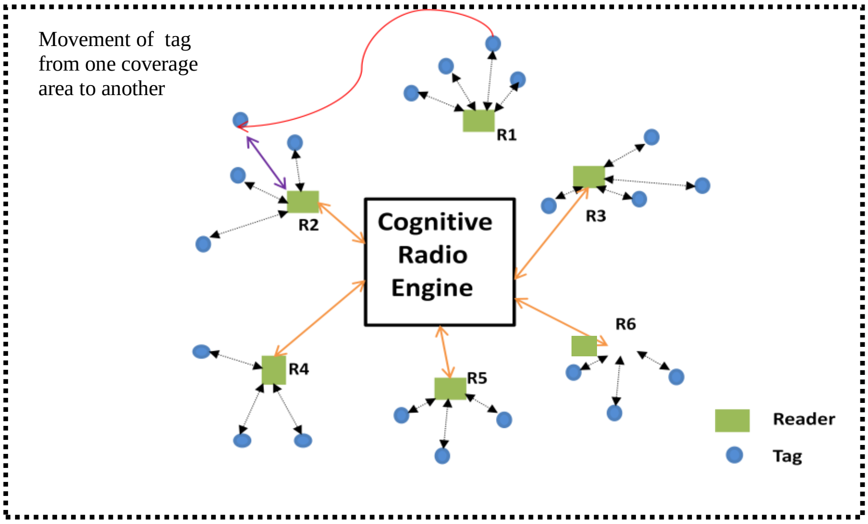

Fig. 2: Tag detection using Cognitive radio technique in RF environment.

Consider the reader's R1, R2, R3, R4, R5 and R6 as shown in the Fig.2. These readers contain the information of the tags in its vicinity at its own cache. If suppose a tag moves from reader R1 to reader R2. Henceforth R1 will not be able to identify the moved tag as it is not in its coverage area. Since reader R1 reports the tag to be missing, the proposed method is to make use of the cognitive radio engine to identify the particular tag. The cognitive engine senses the spectrum of the surrounding environment and enables all the other remaining readers to check for the tag. The cognitive engine technique used is a cooperative spectrum sensing method which has a master node and sub nodes connected to each reader. The sub nodes retrieve the information from the reader's cache as the tag are being tracked and updates the master node. If the tag ID is tracked by any reader the master node is updated and the process is terminated. Through this integration technique the data losses are minimized thereby increasing the performance of the system.

RESULTS AND DISCUSSIONS

Simulation was conducted through spectrum sensing test bed in Matlab along with RF transceiver. The following results show the retrieval of tag using cognitive engine.

Australian Journal of Basic and Applied Sciences, 9(23) July 2015, Pages: 227-232

Fig. 3: Sectioning the readers and the tags; the reader in each subsection contains the information of the tag in its cache.

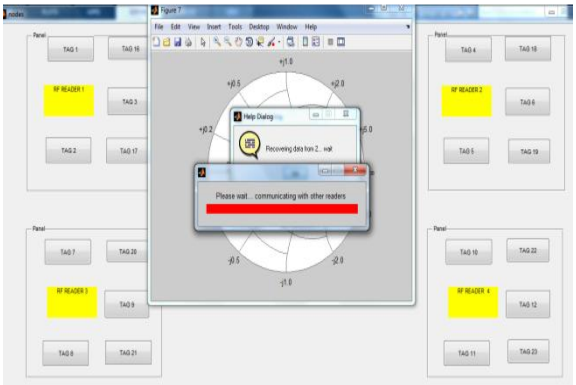

Fig. 4: CR communicates with the readers of the subsections to track the missing tag.

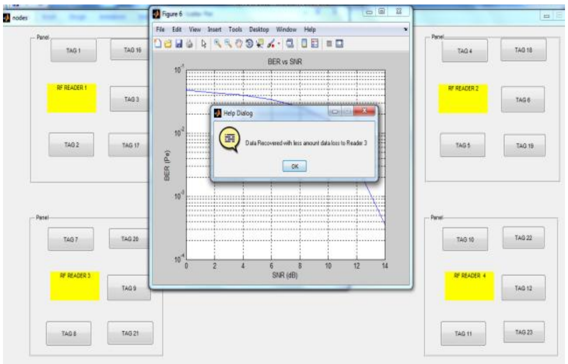

Fig: 5: Tag recovery

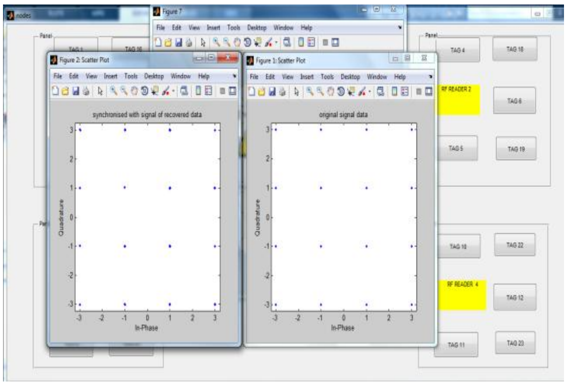

Fig. 6: Scatter plot of original data and recovered data; signifies that the data has been recovered correctly and there is no data loss.

Australian Journal of Basic and Applied Sciences, 9(23) July 2015, Pages: 227-232

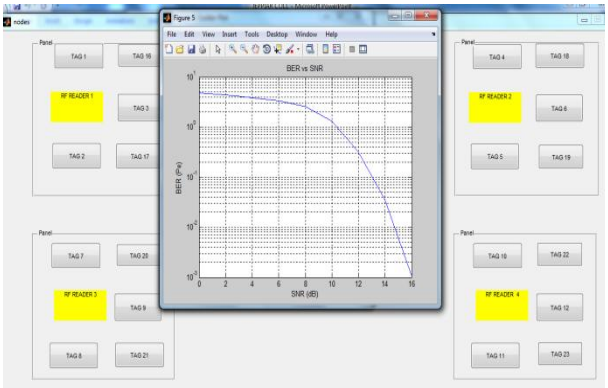

Fig. 7: SNR Vs BER

Conclusion And Future Work:

The system model proposed here is time efficient which means data could be retrieved at a faster rate with less data losses. The error rate decreases considerably through the integration of CR. Collision among tags may exist during the tag tracking process. Thus the future work is determination of collision and its avoidance.

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Australian Journal of Basic and Applied Sciences, 9(23) July 2015, Pages: 227-232

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