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Survey on UHF RFID portals

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August 2010

Abstract

An overview of academic and industry solutions to UHF RFID portals.

1 Introduction

In this document, we analyze UHF RFID systems in portal scenarios. Two major problems exist for UHF RFID portal systems: one is read accuracy, which is when reader cannot read the tag in its confined area or the reader reads the tag outside of confined area and two is interference and cross-reading of tags, which refers to several portal readers interfering with each other and readers reading the tag that did not pass through their dock door. In order to simplify the system complexity, this paper will analyze the problem in a single portal scenario and then extend it to cross the reading problem.

2 Read accuracy

For the ideal RFID portal system, the reader should achieve 100% read accuracy when tags pass through the confined area, and the reader should not read the tag when tags are not present in the confined area. The performance of read accuracy is the most important factor for RFID portal systems. With the RFID passive tag, the read accuracy depends on the amount of power the reader is able to deliver to the passive tag. Since the RFID reader power is limited into 6 dBi, in North America under FCC regulations, several researchers proposed different solution to increase read accuracy. Tao and al. demonstrated the reader antenna deployment can help increase the read accuracy [1]. By installing a reader antenna in proper position, it would help the reader achieve better read accuracy. Oberli, et. al. presented an experiment that showed more antennas also increase the read accuracy [2]. Those configurations not only increase read accuracy in confined areas, but also increase the reader range. Due to RF characteristic, if we tried to increase the read accuracy, we could not limit the range in a confined area; it will affect cross reading problem in multi portal systems.

3 Cross Reading

When several several dock doors operate at the same time, RFID readers will interfere with each other and may read the tag that is in the confined area of the other portal. Extensive experimentations with RFID portal systems, in order to analyze cross reading problems, are sparse. There have been several research papers that deal with read accuracy of RFID portal systems. They focus on a single portal system. To avoid multi-reader collision problems, the most simple solution is that reader should operate in a different time slot, a method called TDMA (Time Division Multiple Access). Soylemezoglu, et. al. proposed a RFID portal system, where the portals are equipped with RFID antennas, light stacks, and motion sensors to fully use the benefits of RFID technology for shipping and receiving operations in a warehouse, shown in Figure 1.

This system adapted "read it when you need it" concept, which is implemented using an on/off power control protocol. The protocol enables turning on and of RFID antennas intelligently to avoid communi- cation signal interference depending on the status of the motion sensors on the portals. The antennas are turned on and off whenever needed by

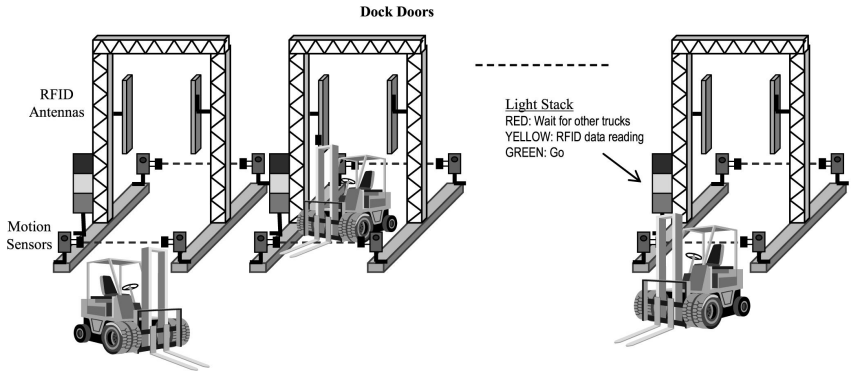

Figure 1: RFID data-based forklift traffic management system[3]

making sure that only one dock door is active at any one time, so that the cross-reading problem is avoided. The power control on antennas and management of forklifts are synchronized by the use of light stacks. Another solution involves setting simple time thresholds to ignore intermittent appearances and disappearances that are deemed to be aberrations from physics rather than from real physical removal of objects[4]. For example, the user could tell the software to ignore tags that appear for only a second before disappearing.These simple rules would reduce the rate of false-positive and false-negative reads. These thresholds must be set with care, however, because they are obviously preemptive in the sense that they cause data to be rejected from the system. Sirit Technologies company proposed a RFID system using Stray-Tag Elimination Technology to increase confidence that tags read by portal readers have actually passed through the system portal gates and are not near by straytags[5]. Figure 2 shows the system view. The tag needs to be triggered first, if the tag did not trigger, the portal reader will ignore the stray tag.

Intermec proposed a solution on the software level. Intermec uses Received Signal Strength indicator(RSSi) data, along with the phase angle of the received RF wave, which changes over time and can be used to compute a tag's speed[6]. The system uses the data to calculate whether a tag is in motion and whether it is near a reader, in a particular zone, or in a portal. By tracking the history of tag movement, the system will decide whether the tag data should be forwarded to the user.

4 Wearable body antennas

A popular application for portals is tracking people, for example at conferences. The tag used is of high importance to the performance of the system. At ultra high and microwave frequencies body-worn antenna can suffer from reduced efficiency due to electromagnetic absorption in tissue, radiation pattern fragmentation and variation in feed-point impedance [7, 8, 9], the RFID tag placed on human body should be carefully considered. Almainy, et. al. analyzed printed dipoles, printed monopoles, printed circular loops, inverted Ls, parasitic Ls and wiggle antennas at 2.44 GHz. The analysis demonstrated the suitability of ground place based antenna for wireless body network application since

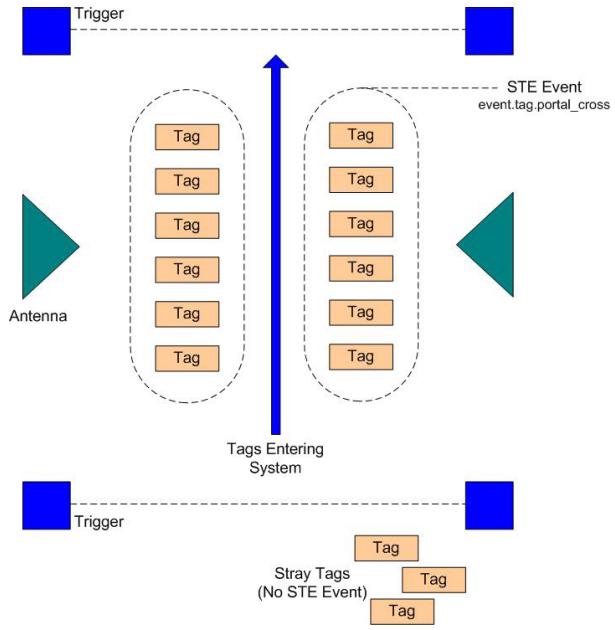

Figure 2: Example system using stray-tag elimination technology[5]

they are less affected by varying distance from the body [10]. In order to increase the read accuracy, the position where the antenna is placed on the human body will highly affect the overall performance. Oberli, et. al. did the read accuracy experiment by placing a RFID tag in hand held, Wallet-Backpack, Waller-Pocket and Loose-Pocket[2]. The result shows the hand held tag had the best read accuracy result in multi-antenna configurations. Hall, et. al. demonstrated that the patched antenna is suitable for wearable applications [11]. However, the size of the patched antenna would be a problem. For 900 MHz, the patch antenna size should be greater than 13X13 cm to have good reflection coefficient. Park, et. al. proposed a microstrip line monopole antenna for wearable applications [12]. The gain of the antenna is around -7.5 dBi.

5 Commercial UHF RFID portals

UHF RFID portals are gaining widespread popularity. They find uses in conference rooms, to track the attendance, warehouses, to follow the incoming merchandize, storage rooms, to view the incoming and outgoing items, and many other applications. In this document we show the state-of-art commercial portal technologies.

5.1 Industrial solutions

Industrial solutions for RFID portals widely range in cost, performance, configurations. The applications for the portals include: warehouses, storage rooms, retial stores, conveyor belts, and people tracking. Based on the application, a different approach is taken the architecture of the reader and to the solution of crossread problems. In most cases,

the enclosure and the readers, antennas and other accessories, are sold separately, and must be assembled on-site. Only few fully integrated solutions exist on the market. Today on the market, the following portals exist:

- Impinj xPortal
- Alvin portal
- Autocrib Intelliport
- Intellident UHF RFID portal
- BlueBean Simple Conveyor RFID Portal (enclosure)
- GAO Tek Inc portals
- Symbol DC600 RFID portal
- Alien ALX-9010 portal

5.2 Cost

Basic types of portals start at the price range of about $1000. For sophisticated portals, the price range of the enclosure alone is in the range of $2000-$3000, like in the case of MOD2/MOD3 Guardian portals and the BlueBean Simple Conveyor RFID Portal. The Impinj xPortal has a price tag of $2,495 and the Autocrib Intelliport $929 per month[1].

5.3 Antenna Configurations

Most solutions use two free-standing portals at opposite sides of the door, directed towards each other. Each of these portals would house two to four antennas. Another implementation is having an enclosed space, protected by metal shielding.

- **Impinj xPortal**
  The xPortal uses Dual-Linear Phased Array (DLPA) antennas which continuously alternate between vertical and horizontal polarizations. The readers low duty cycle function limits operation to only times when tags are detected within the field of view[13].
- **Intellident UHF RFID portal**
  Places antennas on various angles at the portal, as shown in Figure 4.
- **BlueBean Simple Conveyor RFID Portal**
  Framed with RF reflective mesh panels to contain RF field.
- **GAOTEK 216006 and ALR-9814**
  Two to four circular antennas per portal. The portals are faced towards each other.

[1] All prices displayed are as of May 2010

Figure 3: Intellident UHF RFID reader[14]

5.4 Direction of movement

Direction of movement estimates the direction the tag is moving in. The most widespread solution consists of installing photo eyes or electric eye sensors. Another solution is installing another set of antennas, further down the portal. Some implementation rely solely on RSSi and angle of arrival to estimate the direction.

- **Impinj xPortal**
  The xPortal has a Speedway Revolution reader with Octane 3.0 firmware. On all readers with this firmware, there is a tag direction estimate option. This option requires two or four antennas.

- **Autocrib Intelliport**
  There are photo beam sensors installed at the entrance to the portal.

- **Alvin RFID Portal Controller**
  Photoelectric motion sensors find the direction of travel.

- **Portals with Intermec readers**
  Estimates based on RSSi data along with the phase angle of the received RF wave. Another option includes installing two motion sensors, as shown in Figure 2.

- **Gaotek RFID portals**
  Photo eye turns on RFID reader. Two photo eyes determine directionality.

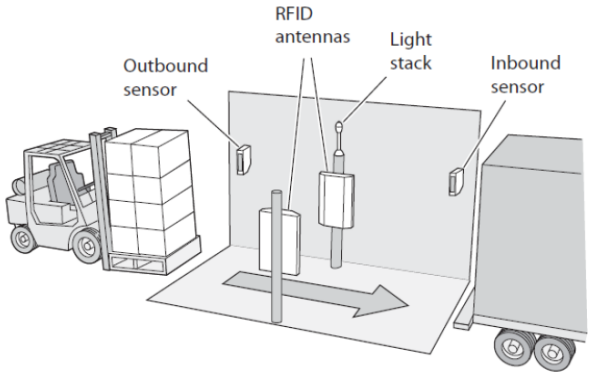

Figure 4: Tag direction estimation[15]

5.5 Setup

Most portals require assembly, only a handful come as fully integrated finished solutions. The readers and antennas must be installed appropriately, the wiring has to be managed and the portal alignment must be done. Some solutions requiring assembly claim it takes only 30 minutes to do so. Another factor is the mobility and weight of the portal. Impinj xPortal has all the devices integrated, and requires no assembly. It is small and mobile. The Power over Ethernet (PoE) offers easy setup. GAOTEK 216006 and ALR-9814 Require setup, wiring, assembly. Can take 30 minutes[16].

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