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RFID-Enabled Location Determination:
Within Indoor Environments

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ABSTRACT

The ability to track the real-time location and movement of items or people offers a broad range of useful applications in areas such as safety, security and the supply chain. Current location determination technologies, however, have limitations that heavily restrict how and where these applications are implemented, including the cost, accuracy of the location calculation and the inherent properties of the system. The Global Positioning System (GPS), for example, cannot function indoors and is useful only over large-scaled areas such as an entire city. Radio Frequency Identification (RFID) is an automatic identification technology which has seen increasingly prominent use over the last few decades. The technology uses modulated Radio Frequency signals to transfer data between its two main components, the reader and the transponder. Its many applications include supply chain management, asset tracking, security clearance and automatic toll collection. In recent years, advancements in the technology have allowed the location of transponders to be calculated while interfacing with the reader. This article documents an investigation into using an active RFID based solution for tracking.

Keywords: *Location Determination, RFID, Security Clearance, Supply Chain*

INTRODUCTION

Accurate location determination systems have been a luxury for large scientific institutions and military installations for some time, but such systems are much too complex and expensive for use in smaller areas such as schools, clinics and even the common household. Similar systems, available commercially, have limitations that make it difficult to accurately determine the location of an object or person in these areas.

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Many systems that track subjects in real time have severe limitations when tracking individuals in a smaller area, such as a room, building or garden. GPS devices require line of sight with satellites in order to be tracked correctly, meaning devices cannot be tracked indoors or in some areas surrounded by tall buildings. The degree of accuracy to which GPS provides location information is also inadequate for applications that monitor areas with specific boundaries between where an individual is allowed and where they are not. Mobile phone tracking is expensive and works only in more

developed areas in range of multiple cell towers. Position estimation, to within an average of fifty metres, is much too inaccurate to track subjects over a small area. Implementing a location determination system using ZigBee received-signal-strength (RSS) has the advantage that the system can work indoors, however the cost of implementation is rather high and the complex network infrastructure may need constant maintenance. Place Lab is an open source solution but since it relies on a centralised list of "landmarks" to work correctly, it would not be suited to smaller areas such as inside buildings (at room level).

Hence, a system that could deliver quick and accurate position information (i.e. to within half a metre) at minimal cost could have many extremely useful applications, such as monitoring the safety of children in school, the whereabouts of patients in a hospital or even tracking inmates in a prison. Radio Frequency Identification (RFID) is an automatic identification technology that is widely used across a multitude of applications, including security, safety and asset tracking. A modulated radio frequency signal is used to transfer data from transponders, attached to people, animals or objects, to a reader in the vicinity. Recently, systems have been developed that can calculate the location of a tag, as well as read the data it contains. This major development in RFID technology could allow for the installation of cheap, accurate and reliable location tracking systems to greatly improve safety in schools, clinics and many other areas.

Technologies that determine the current location of a person or object have very useful applications in many areas, including security, safety systems, location-based information services, mapping and the tracking of people, animals and goods. The first highly successful location determination technology was Radio Detection and Ranging, more commonly known as radar. Many engineers and scientists, including Nikola Tesla, had worked on the principles of radar in the early part of the twentieth century. Several systems were patented in the 1930s in the United States, Germany and France. However, the British were the first to use radar as a defence from enemy aircraft attacks, with Robert Watson-Watt's 1935 patent GB593017. The Second World War brought about a large push in radar research on both the allied and axis sides. Radar systems work by transmitting a very short, high-intensity burst of radio waves at a high frequency. After transmission, the transmitter is disabled and the receiver is turned on. The receiver listens for an echo created by any object (e.g. an aeroplane) within range of the transmitter. The distance of the object from the transmitter can be estimated by measuring the time taken for the echo to arrive. Modern radar systems can also measure the Doppler shift of the echo to estimate the speed of the object. Figure 1 shows the components of a typical radar system.

This article outlines the use of RFID-radar technology to track the location of items or people indoors. The RFID based tracking system allows items/people to be tagged with long-range and short-range RFID tags. An RFID-radar system is used to provide 2D position location with identity, range and tracking information, thus keeping the user informed of each person's location. The user may define areas within the monitored zone as "unsanctioned," and the system alerts the user if any tracked individual enters any of these unsanctioned areas.

LOCATION DETERMINATION TECHNOLOGIES

There are a number of popular, accessible and versatile technologies available, each with their own advantages and disadvantages for particular applications.

GPS

The Global Positioning System (GPS) is a Global Navigation Satellite System (GNSS), employing a network of twenty-four satellites launched by the United States Department of Defence. Originally intended for military use,