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SAND2003-3865
Unlimited Release
Printed November 2003

Multipurpose Locator Tag System LDRD 65145 Final Report

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Abstract

This report summarizes work performed to determine the capability of the Pinpoint Locator system, a commercial system designed and manufactured by RF Technologies. It is intended for use in finding people with locator badges in multi-story buildings. The Pinpoint system evaluated is a cell-based system, meaning it can only locate badges within an area bordered by its antennas.

Contents

Introduction

There are a multitude of applications for RFID (Radio Frequency Identification) material and personnel tracking and locating tags. These range from first responder and EMT (Emergency Medical Team) personnel in burning buildings, to keeping track of inventory and sensitive materials in a warehouse.

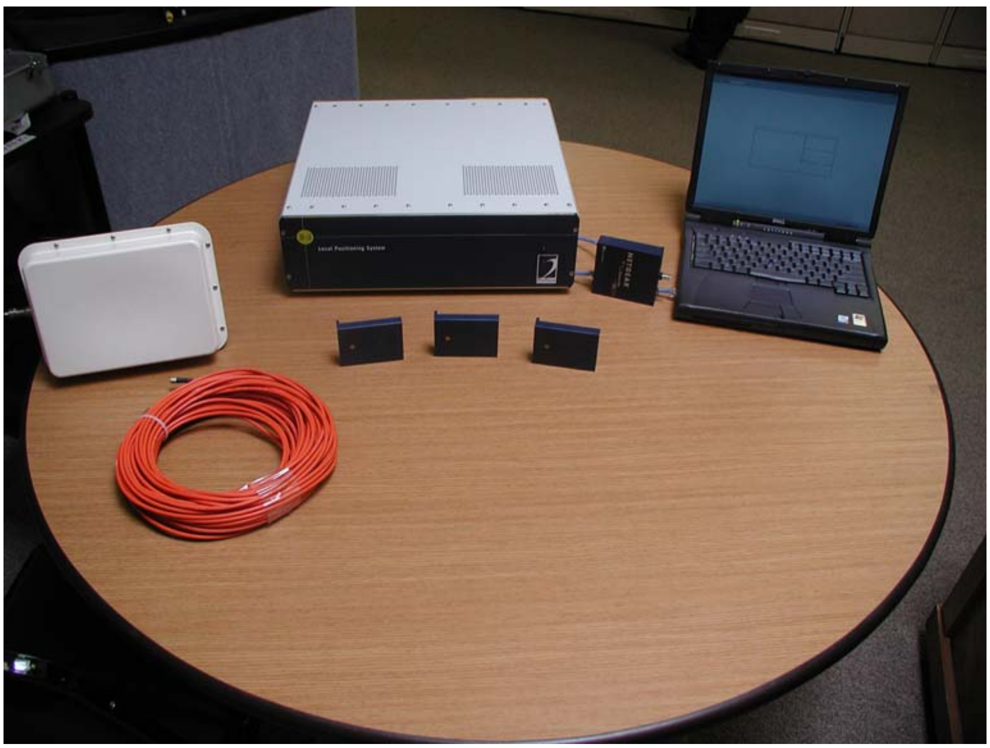
An investigation of marketed RFID systems for EMT personnel turned up several commercial products. One of these systems, "Pinpoint" by RF Technologies, actually had a demo system they were willing to ship, proving their actual existence in the market place (not vapor ware). Most other companies didn't have hardware, much less a functional system, but they still advertised that they were in this business.

The Pinpoint system is a tracking system, which locates and updates the position of tags, attached to personnel and or objects. The system uses microwave signals between the cell controller and the Tags. Their software application, which comes with the system, enables you to gather, manage and display the location of the tag units. When using a personnel computer monitor, the tags appear on a building map indicating where personnel, material, and equipment are located.

Description

The Pinpoint system is made up of the following pieces of equipment 1) Cell controller, 2) Antennas and RF cable, 3) Individual tags, 4) Computer and LAN, and 5) MRM application system software.

The system is setup with four antennas positioned in the corners of the building or areas to be monitored. These antennas are connected with equal lengths of RF cable to the cell controller. Use of equal lengths of RF cable is necessary to equalize the signal delays between the antennas. The cell controller is then connected through a network system to the controller/server computer. In our test system the controller/server was a laptop computer serving as system controller and display unit.

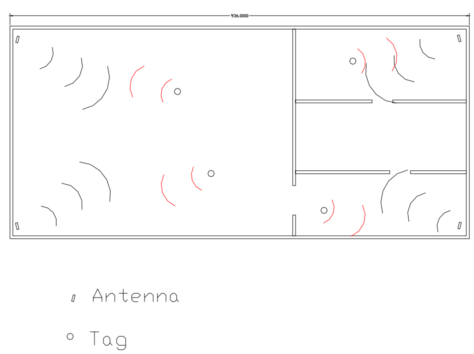


PinPoint System Hardware
(Back row left to right: Antenna, Cell controller, Network hub, PC running MRM software. Front row left to right: antenna cable, tags)

Principle of Operation

The cell controller communicates with the Tags via the 4 antennas. The antennas send out a 2.4 GHz ISM (Industrial, Scientific, and Medical) band signal at less than 1 watt. The Tags receive this signal, encode their serial number on the signal and re-transmit the signal on 5.8 GHz at less than 0.5 watts, in another ISM band. Upon receiving the signals from the tags, the cell controller processes the signals and determines 1) which tags responded, 2) which antennas received the signals, 3) calculates the distance between the tag and each antenna, and 4) which antennas received the strongest signal. Based on these results the system determines the tag location. The system divides the location, such as the floor of a building, into zones and then displays the tag in one of those zones. Although its name implies pinpoint accuracy, the tag is only displayed as being in one of the zones and not its exact position in that zone.

The four corner antennas define the multiple rooms as an cell, By software we split the cell into 4 zones corresponding to the four rooms.



Test Layout

Evaluation

The demo system evaluated was comprised of a basic set of hardware components. The system consisted of the cell controller, 4 antennas, RF cable, 7 tags, and the controller computer running their "Mobile Resources Management" software. The physical setup of the equipment did not take much time. Placing the 4 antennas and running the cable to the cell controller took roughly 1 to 2 hours. However, the software and computer side was a lengthy process. The software installation and setup took approximately 12 hours. The software and instructions were not straightforward and an eight-hour conference call with tech support was required to get the system up and operational. To be practical in the field, automatic set up will be needed.

The software setup included several tasks. Some of these tasks were:

- Make a floor plan and graphically enter into computer
- Define the zones within the floor plan
- Indicate antenna placement within the zone
- Set individual antenna gain, power levels, and signal thresholds (these adjustments are made with within the software with sliding bars)
- Input the tag serial numbers.

Our floor plan had been drawn up previously as a computer file in Autocad, so that was not part of the 12-hour setup time.

The "Alert Builder" option lets the user define a rule set for the tags associated with specific locations. Alerts can be set to audio message or text message display in the Alert Viewer.

Alerts can be activated for 7 different conditions to trigger. The alert rules are:

- Entry or Exit (when a tag enters or exits a location).
- Stationary (when a tag is stationary for a specific time).
- Timeout (when the signal from a tag has not been detected for a specified interval of time).
- Transition (when a tag moves from one location to a second location).
- Foe (when a tag enters a location occupied by another tag, and both these tags should not be in the same location at the same time).
- Friend (when a pair of tags should always be in the same location and one of the tags is detected in different locations).
- When a tag is part of a pair of tags enters a location without the other.

The system has several setup options available to accommodate various operating environments. For example, environments with other ISM RF signals present to those with a lot of metal cabinets and metal building materials causing RF reflections. These issues are handled by using different detection algorithms intended to optimize the performance to the environment. Additional setup options include the transmitter attenuation and the receiver threshold. Rooms with a lot of metal objects will cause reflections of the RF signals and may lead to some error in the tags location. Some building environments may take considerable time to get the system settings optimized.

The test location we used to perform the testing is shown in the Test Layout diagram. In the smaller rooms the equipment and metal cabinets were against the wall, and so movement within these zones was easy to track. The large room, however, had equipment racks in the middle of the room as well as against the walls, so tracking movement here was more difficult. Once the system settings were tailored for the environment it was very effective in keeping track of the tags setup in the software. The different alert modes were tried for functionality. That is, alerts to tag movement into an area that was restricted for that tag, and tag movement from an area that the tag was not to be removed from. There are several symbols available to associate with the tags, such as a figure for a person, a forklift, and even a bomb. The system response time is very short, in the milliseconds. Tag movement is displayed instantaneously upon movement between rooms or zones.

Research

During the process of investigating the current market, we found a number of companies in the RFID business. For the large part these products are cell based. This means they can tell you when an item moves from one cell (that is through a portal) to another cell. The actual location in that cell is unknown. Most tag systems operate in the 2.4 GHz and 5.8 GHz ISM bands for multiple reasons: 1) No need for FCC licenses; 2) at high frequencies the wavelength is small (2 - 5 cm on an electronic board for these 2 ISM bands) so the antennas and electronics can be fabricated making the tag physically small; and 3) a plethora of commercially available wireless chips are already designed and fabricated for these frequencies.

The tags use batteries and have a lifetime of approximately one year. Naturally the more features a tag contains, the more complex the construction of the tag, and physically larger the physical unit will be. Increased tag activity will lead to a shortened battery life. The antenna units contain RF circuitry as well as the actual antennas. These circuits obtain DC power from the cell controller through the interconnecting cables.

Studies of wireless LAN (802.11a, b) show that indoor propagation is more complex than outdoor free space. Indoor propagation complexity is attributed to numerous metallic objects in the signal environment, resulting in signal scattering, diffraction, reflection, and absorption of the RF signals. Measurements show 5 to 25 dB local fading is not unusual with little distinction between 2.5 and 5.8 GHz signal frequencies. Floor losses (that is for a multi story building) range from 3 to 12 dB. Pinpoint would work reliably in a multi story building if 4 antennas defined as a cell were installed on each floor because of the floor loss and ambiguity of which floor the tag is on. These results are attributed to the presence of metal furnishings and building materials. The use of spread spectrum signal processing is useful in reducing the effects of these complexities of signal propagation. The pinpoint system does not use spread spectrum signal processing.

Conclusion

The name "PinPoint" was misleading as it give the impression you can track items with pinpoint accuracy. In reality the system only indicated the presence of the tag in a room or zone. With sufficient equipment a large room could be divided up in to zones of 10 ft x 10 ft size. This is the best resolution possible with this product. The equipment in our demo was adequate to monitor an area approximately 200 ft by 200 ft split into at most 4 zones, but with longer cables the area could be increased to about 500 ft by 500 ft. The 500 ft is based on the signal detection range of the standard antennas of 250 ft, so with 4 antennas a space of 500 ft by 500 ft could be covered. The "long-range antennas" have a range of 500 ft. The other problem is the losses encountered in the RF cables used between the cell controller and the antennas. Cable extenders and wireless items are a part of the product line. However, we do not have data or information on these items at this time. The cables shipped have a spec sheet loss of 20 dB/100 ft so cables of 500 ft would inflect a loss of 100 dB (10^9 X).

Due to the principles under which this system operates, modified or new software could take advantage of the hardware and give almost pinpoint accuracy. Instead of taking only the signal from the strongest antenna to determine distance and zone location one could use the signal from 2 antennas. In addition, they should incorporate some software routines using triangulation. Added to the distance already calculated by the system, one could have exact location.

The current tags are large, about the size of a Palm PDA with a battery life of one year. The use of SAW correlator technology, currently in development in Department 1751, could reduce the size of the tag by a factor of 3 and extend the battery life by a factor of 2 or 3. There is the option of designing such a system with passive tags so no batteries are needed. The use of the SAW correlator also has the advantage of greater accuracy in locating a tag by using elevation information.

The other issue is the need for pre-implementation for dealing with location of First Responders and EMT personnel. A system like this would have to be incorporated into a building infrastructure because it is needed the instant an emergency starts. This way the emergency team could plug into the system and have immediate access. Since systems like this have not been incorporated into building infrastructures it is unlikely that First Responders or EMT personnel will be able to use this type of system, because: 1) the time to deploy the system at the time of a disaster is too lengthy, 2) the signal attenuation through the building structure is too large for only a few antennas, and 3) multi-story building would have no floor or elevation information available.

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