A CASE STUDY OF AUTOMATED INVENTORY MANAGEMENT

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Abstract: Maintaining a knowledgebase the location and condition of IT assets in large organisation is a problem. Knowledge of exact number of these assets is important for a number of reasons, which include controlling or eliminating procuring multiple assets for the same job or task; cost savings on maintenance contracts in accordance with the exact number of assets to be maintained; reduction in man hours spent in locating these assets; and checking theft. This paper presents a case study of a large sized Australian utility that is grappling with the same problems. In addition to these issues the company is also looking for looking for improved security of fixed/removable/mobile IT assets used by staff, integration of IT asset movement information with the staff access card and associated systems currently in use. This paper, therefore, presents a set of options available to the company to track the movement of their assets, and using the same technical architecture to integrate asset information with the information of the staff moving the asset.

1 INTRODUCTION

With improvements in computer power and miniaturisation of the components of microchip technology, automated identification technologies are now being used in various applications in governments, business, supply-chain management, logistics and retail. Since early days of the current decade numerous applications have been developed using automated identification technologies. Among these are applications like luggage tracking, tracking individual parts along the production line; tagging and tracking of patients; smart shelves for pharmaceutical products, and smart toolbox etc. Even though these identification technologies have been used in a variety of settings, however, the fundamental feature of tracking and traceability of these technologies continues to hold great promise.

IT assets that get lost or misplaced add to the total cost of ownership of these IT assets and thus contribute to the costs of managing business operations. Organisations generally use passive technologies such as barcodes, which makes it extremely difficult to track the IT assets and almost impossible to maintain a history of the movements of these assets. It is expected that the implementation of the Radio frequency identification (RFID) technology for asset tracking will help to keep this cost in check. Using RFID technology, it will be possible to not only track assets but also maintain a history for every asset which will prove to be a useful aid if an asset turns put to be lost or misplaced. With integration of the identification/access cards, the history could also contain the details of personnel last responsible for moving the asset. It will be possible not only to monitor assets using RFID technology but also keep track of the status of the assets which could be viewed by anyone across the organisation through related computer systems who would want access to that asset. The adoption of RFID technology in Australia is only recently escalating due to the new standards that have emerged which have worldwide acceptance as opposed to the previous ones which were highly region-specific. This paper presents a case study where RFID technology is applied to track movement of IT assets in a large sized public sector organisation, and the same architecture integrates information of the asset with that of the staff that moves or is responsible for the asset.

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2 CASE BACKGROUND

This case involves a major utility in one of the largest state in Australia. This organisation has major problem in tracking the location of all of its IT and related assets as well as finding out the exact number of working IT assets. As a result not only that the organisation keeps on procuring redundant assets, but it also uses a rounded figure in signing support and software licensing agreements. With exact information on the number of assets, it will be easy to manage resources effectively and to develop maintenance contacts in accordance with the exact number of assets to be maintained. For example, if the current IT asset inventory states 5000 assets then the support and licensing agreements are signed for the same number regardless of the condition of the assets. Information of exact number of assets, their condition, and their location will help in reduction of costs of support and licensing agreements, as well as the man hours spent in locating these assets. In addition, it will also eliminate the chance of redundant purchase of IT assets. The company is now looking for improved security of fixed/removable/mobile IT assets used by staff, integration of IT asset movement information with the staff access card and associated systems currently in use. It should be noted that the IT assets include laptops, desktop computers, printers, servers, hubs, scanners, plotters, data loggers, UPS units, switches, routers, projectors, and smart boards.

3 CHOOSING APPROPRIATE TECHNICAL FOUNDATION

Barcodes have traditionally been used for the purpose of item tracking and warehouse management. However, barcodes only identify a class of items and cannot identity particular items. For example, a barcode identifies a 500 ml of a coke bottle but it is insufficient to identify the exact location of that bottle. Similarly, information on origin and manufacturing of an item could be related to its barcode, but barcodes cannot provide information regarding its movement after manufacturing or commissioning, and current condition. Another of their drawback is that barcode technology is only effective in line of sight with the reader, such that each item has to be scanned individually. Hence for the purpose of item location and tracking, Radio Frequency Identification (RFID) is a suitable alternative. This technology has been successfully deployed in different parts of the world for various applications using its tracking and identification allowance. The significant level of interest in RFID technology's development and uptake has made it cost-effective and scalable (Wyld 2006). RFID technology falls under the classification of Automatic Identification and Data Capture technologies (Wamba *et al.* 2006). It consists of three components, an RFID tag, a reader, and a Tag/Reader management systems or a middleware. RFID tags are made up of a small microcontroller and antenna available in many different packages. They provide a contact free form of identification through the use of radio frequencies. Each tag has an electronic product code (EPC) or an identification number embedded into the tag microcontroller that is used to uniquely identify each tag, which can also be termed as the RFID's version of a bar code. When an RFID tag is placed close enough to the reader it is powered up through a magnetic field emitted by the reader thus powering the microcontroller of the tag, such that it transmits the EPC to the reader. RFID tags do not require line of sight between tags and readers for them to be detected and therefore make it possible for tags attached to items to be identified from a single point. Therefore it makes RFID a viable option to address the issues at hand. The following sections provide an analysis of how this technology could be used to resolve the problems posed to the case organisation.

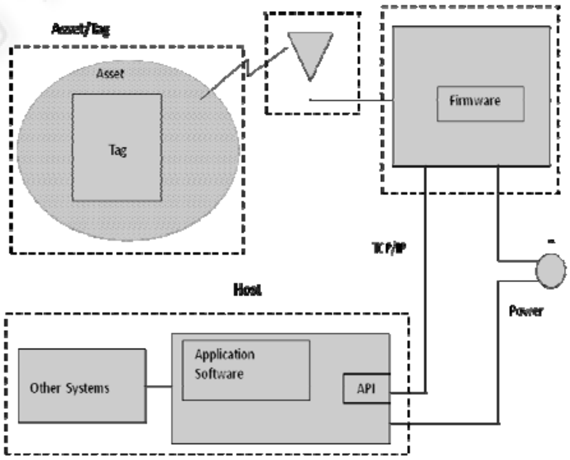

Figure 1: RFID System Components.

4 AUSTRALIAN TECHNICAL ENVIRONMENT

The International Telecommunication Union has developed the ITU Radio Regulations. These regulations form the basis of the Australian Radiofrequency Spectrum Plan.

Figure 2: Automatic scanning using HF Tags.

The Radio Regulations divide the different radio frequencies into bands and allocates services to each band according to three geographic regions. These regions are defined as Region 1, 2 and 3 (Australian Communications Authority 2005). Region 1 is composed of most of Europe, Africa and the Middle East. Region 2 is composed of the Americas. Region 3 is made up of the Asia-Pacific region. Thus, Australia is located in Region 3 (Australian Communications Authority 2005). ISO/IEC 15693 is a global standard for 13.56 MHz HF RFID tags (Class 1) and reader electronics. The ISO/IE C 15693 protocol conforms to FCC (USA), ETSI (Europe) and MPT (Japan) regulations worldwide. The standard allows tags to travel around the world under optimal conditions for operation with region specific RFID readers (Attaran 2007). Hence the standards for HF radiolocation are accepted all over the world. However, for UHF radiolocation, although, the frequency band assigned is from 860 to 960 MHz, not all the frequencies in this band are usable. Both U.S. and Europe have different frequencies in this band for radiolocation. In Australia (Region 3), most of the frequencies in this UHF band are used by mobile phone service providers. Hence, the available frequency band that may be used is from 915 to 928 MHz so that the operation does not interfere with other applications (Australian Communications Authority 2005). The EPC has developed two standards, Class 0 and Class 1 for the UHF RFID tags. In December 2004, in order to promote interoperability, they introduced the Generation 2 standard to replace Class 0 and Class 1. These Gen 2 tags are now being promoted world-wide for their interoperability and their higher memory capacity (Li *et al.* 2006).

The other regulation in Australia has to do with the power output of the RFID readers. Current Australian RFID services are governed by the ACMA through the class of license for Low Interference Potential Devices (LIPD). These regulations limit the RFID services operating in the 915 to 928 MHz frequency band to a maximum power of 1 watt EIRP (effective isotropic radiated power). No licenses are required for applications up to 1 Watt but anything between 1 and 4 Watts requires a scientific license from GS1 Australia (GS1 Australia 2008). Read range for RFID tags depends on the power output of the RFID readers, and the difference between 1 Watt and 4 Watt is approximately a 300% improvement in read distance and efficiency (i.e. improving the average read range from 1 metre to 3 metres). Much of the World now uses 4 Watt (GS1 Australia 2008). However, this means that services operating at 4 Watts EIRP may interfere with other services like mobile communications which also operate in the same area and around the RFID UHF frequency band. Both 1 Watt and up to 4 Watt have been used by GS1 Australia in various RFID pilots; with 1 Watt suitable for shorter range applications, such as hand held devices, and up to 4 Watt more suited to RFID gateways or other applications where accurate reads at a distance are needed (GS1 Australia 2008).

5 AVAILABLE OPTIONS

There following section discusses the options available to address the issues at hand in this paper.

5.1 First Option

High frequency tags can be used for asset tracking in the company. The tags operating at the frequency of 13.56 MHz are very cost effective and flexible. They are available in paper as well as filmic inlays which makes embedding with the assets very convenient. The ISO/IEC 15693 standard for 13.56 MHz is accepted worldwide and the protocols conform to FCC (USA), ETSI (Europe) and MPT (Japan) regulations which constitute the three Regions determined by the International Telecommunications Union (ITU). The standard allows tags to travel around the world under optimal conditions for operation with region specific RFID readers (Attaran

2007). Australia being in Region 3, according to the Australian Communications Authority, the HF frequency band can be used for radiolocation (Australian Communications Authority, 2005). The tracking of assets using HF tags may be done in two different ways:

In this case, there are two RFID tags. One attached to the IT asset and the other enabled on the staff access/identity card. In this scenario, HF readers are either mounted on the doorways or at convenient locations similar to the ones present in the anti-theft systems at supermarkets may be installed before of after doorways (see figure 3). Since the access/identity cards assigned to staff are also equipped with HF tags, details like IT assets assigned to them, asset configuration, maintenance history, special operating requirements, and other details can also be stored on the tags. In this scenario, when staff enter or leave the room equipped with RFID readers, the readers will automatically read staff as well as IT asset tag. The information captured will be compared against the existing record to see if the IT asset being carried by the staff members actually belongs to them or has been issued to them. Upon confirmation, it will be considered a valid 'check-out' event and relevant information will be entered in the 'asset movement database'.

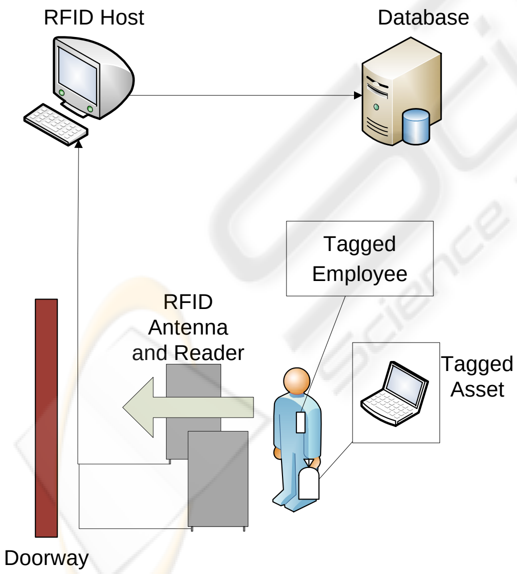

Figure 3: Automatic scanning.

This database will obviously be related to employee/staff database and IT asset inventory database. In case, the asset does not belong to the staff member who is trying to take it out of the room. They will need to make appropriate changes to IT inventory database before leaving the room. In case these changes are not made, the system will generate an alarm and inform the security system. When the employee returns with the asset to the room, the same reader will be read the staff as well as the asset tag, and the relevant 'check-in' event will be recorded in the 'asset movement database'.

The other option available is that of manual scanning. This option is similar to the self-service counters available at supermarket check-out or the check-out systems available in many libraries. In this case, the access/identity cards may not be equipped with RFID tags, however, the assets are to be tagged with HF tags. However, an RFID station consisting of a reader and an access card scanner needs to be present next to the door on the way out of the room. When a staff member wishes to leave the room with an asset, he/she will need to swipe his card through the card scanner so as to invoke an instance of the check-out event. Once his card has been read, he will present the asset to the reader which will read the HF tag and transmit this information to the computer system. The system will tie the employee data to the asset tag data and create a 'check-out' entry in the 'asset movement database'. At the same time, the HF asset tag will be deactivated and the employee can then leave the room after the asset is 'issued' to him. If the employee decides to leave without deactivating the tag at the RFID station, an alarm will be raised and the security system will be notified. The employee can leave the room at anytime without going through any scanning procedure if he is not carrying any asset.

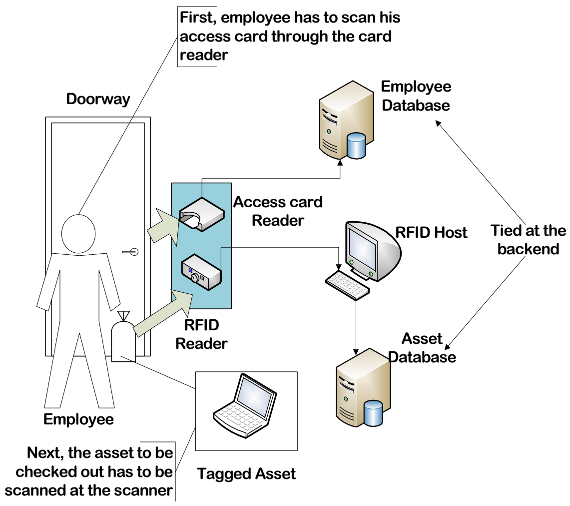

Figure 4: Manual scanning.

When the employee wishes to return the asset, he will have to scan his card which will bring up the existing record and when the asset is presented to the reader, the 'check-out' entry will be cleared as part of the 'check-in' process. Also the tag will be reactivated and ready for its next check-out event. It should be noted that the HF tags and readers have low read ranges and hence the automatic scanning method might not be feasible unless the placement of the antennas and readers is tested and the optimum position is determined.

5.2 Second Option

Due to the read ranges provided by UHF (EPC Gen 2) tags, the automatic scanning method is feasible when these tags are used for asset tracking. The tags operate between the frequencies of 918 and 926 MHz in Australia and are available in many different formats like paper, film, hard tags, discs and even tamper-proof tags. Although these tags are designed to operate in the frequency band of 860-960 MHz, the Australian frequency spectrum plan only allows operation in the 918 to 926 MHz range as the remaining frequencies on either side of this band are utilised by mobile service operators (Australian Communications Authority, 2005). Various pilots have been carried out in Australia to test the Gen 2 tags by GS1 Australia. One such pilot entailed the implementation of EPC Gen 2 tags in the supply chain of Patties Foods in Victoria along with their logistics partners, Montague Cold Storage (GS1 Australia, 2008).

These tags only have provision for storing the EPC which can be used as an identifier for the asset to which the tag is attached. The EPC has been designed to enumerate all objects and accommodate all current naming methods. The EPC serves as a reference to information on the computer network. In order to describe the physical objects that the tags are connected to, a language called the Product Data Markup Language (PDML) is used. PDML is based on XML and it uses a schema describing the common aspects of physical objects. Using PDML, data about the assets like configuration details, service or maintenance history, physical attributes, special operating requirements and so on can be stored in a database. In this scenario (Figure 5), tags attached to each IT asset are read by a reader fixed at the convenient location, which passes the EPC information to the middleware or savant. A savant acts as buffer between the reader and other organisational information systems, and consists of various modules or sub programs with each module performing specific functions. The savant remains connected to the readers and act as a router of the RFID network with the primary functions of EPC related data smoothing, data forwarding and data storage; along with reader coordination, and task and event management. Savant need to be based on open standards so as to provide for easy information interoperability. Since the EPC is the only information stored on the tag, it has to be used in such a way that it provides additional information about the IT asset that EPC is attached to. Data exclusive to IT asset could be stored on a server located on a connected local area network or the Internet, by an application of the concept of domain name service (DNS).

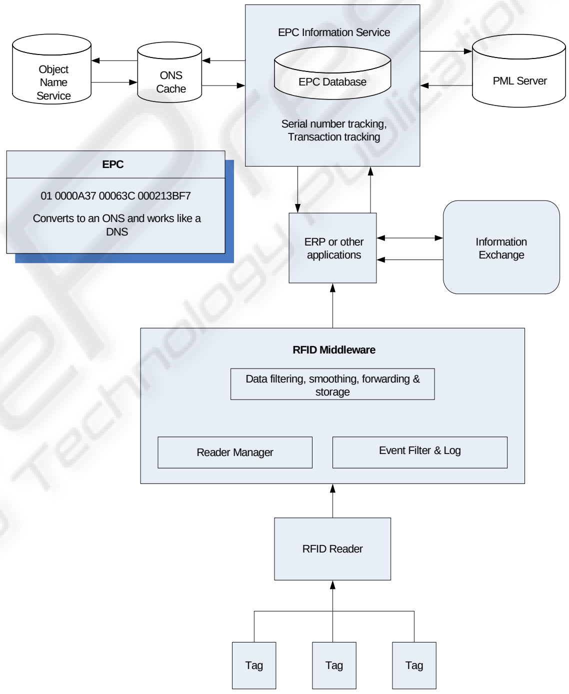

Figure 5: EPC framework (Adopted from Brock 2001).

The EPC stored in the savant is interpreted into a unique address of an object naming service (ONS), which is basically an automated network service which when given an EPC number, returns a server address where the corresponding PDML file is located. The ONS service thus behaves similarly to the DNS used in IP networks, in the way that DNS converts the IP address of a computer connected to a network into a domain name for communication with other computers on the network (Brock, 2001). The PDML file corresponding to the EPC can contain any type and length of information about IT asset.

For automatic scanning, the staff access card needs to be equipped with RFID tags as well as the IT asset. In this scenario (figure 6), when an employee leaves a room with an asset, the UHF reader will scan the staff as well as the asset tag. This data will be sent to the middleware and onwards to the PDML files and 'asset movement database'. The data from staff will then be related to the data from the asset and a 'check-out' entry will be created in a database that can be interfaced with other existing systems so that this information is available to all the related systems. As mentioned in the earlier scenario, the identity of the staff will be matched with the IT asset and if they don't match then alarms will be raised and relevant procedures invoked. When the employee enters the room with the asset, the staff and asset tags will be scanned again and a 'check-in' entry will be made. The UHF paper and filmic inlays are very thin and their compact nature makes their application very flexible. These tags have been used successfully for baggage identification in the airline industry. As mentioned earlier, due to their compact nature, it is possible to enclose the tags in the barcode labels such the tags are concealed and the barcode is visible. This will prevent possible tampering of tags.

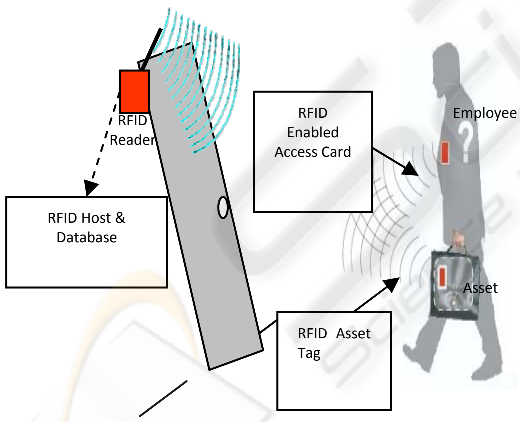

Figure 6: Automatic Scanning with UHF Tags.

If manual scanning option is south then as explained in the manual scanning option for HF tags, there need to be a RFID reader and an access card scanner available at the exit door. When a staff member exist the room with an IT asset, he/she will have to manually scan the access card and the RFID reader will automatically read the card. The data thus captured will be matched to see if the person carrying the IT assets is the one whom the asset has been assigned. If not, an alarm will be raised. Therefore, anybody who wants to take the asset out of the room will have to ensure that the asset is 'issued' to them.

Apart form these options there is a third option available under this category, which uses microwave tags. The UHF range microwave tags operating at the frequency of 2.45 GHz can also be used for asset tracking. They have longer read ranges than the UHF 860-960 MHz range tags. The use of the 2.45 GHz frequency for the purpose of radiolocation is permitted in Australia according to the Australian Communications Authority. Due to the long range nature of tags, the tags may be read in multiple positions. Using this feature of the long-range tags and with multiple antennas connected to readers at appropriate positions, tracking of assets on the entire floor is possible. This will result in real-time tracking of assets and staff who take those assets. These tags also employ the EPC standard and so, all the information about the personnel and assets has to be stored in a database separately and identified using the EPC. Hyper-X and Balogh RFID solutions offered by Electro-com in Australia use these long range tags.

5.3 Third Option

The third option includes active tags. These tags are powered by batteries and can be automatically activated at control points in a building. They can broadcast non line-of-sight to small receivers networked on the existing corporate LAN/WAN, VPN or Internet over IP. They operate on dual frequencies, one to activate the tag and the other for transmission of data. They can be used for real-time tracking of assets in the building. The read points can also be grouped into zones to locate an asset or person within a specific zone, as well as monitor movement between zones. The memory on these tags allows storage of a unique code and other information like location, status information, etc. In this scenario (figure 7a&b) a tagged personnel enter the premises, access may be granted without swiping a card or entering a code using active tags embedded on their access/identity cards. The active tags, using their battery power, transmit data at every control point like a beacon, which is forwarded to the reader. So when an employee enters a room, the tracking system will detect him based on the data transmitted by his access card.

Using the asset tracking system, assets can be assigned to authorised staff. A work-request system may be employed for this purpose. As that employee moves with his asset in or out of the room, the access card as well as the tag on the asset is read by the control point and the data is sent to the system. The system compares the data with the records created by the work-request and when a match is found, confirms that the employee is an authorised user of the asset. Tamper-proof tags are available which raise an alarm if removal of the tags is attempted. If an employee other than the authorised user attempts to take the asset, the system senses the mismatch between the personnel tag data and asset tag data and an alarm is raised. Also, if an employee leaves his personnel tag behind (say in his cabin) and attempts to take the asset, he has to go through the coverage area of many different control points. The control points relay the movement of the asset to the system and the system senses that the asset is being moved without its authorised user. So an alarm is raised in this event as well.

The active tags can also be used for populating automatic inventory. The tags broadcast their data periodically at predetermined intervals to the control points like beacons. This allows the system to maintain an inventory of all the assets currently available. In this way, employees can check on availability of assets in real-time and if an asset has been checked-out, the status can be displayed on the system. Active tags however are the most expensive and cost in the range of 30 Australian dollars to 75 Australian dollars each.

6 CONCLUSIONS

This paper has presented options for tracking IT asset using RFID technology and using the same architecture to integrate asset information with the information of the staff moving the asset or responsible for the asset. One of the biggest risks in the project would be trying to manage all the expectations from the technology. It is necessary to understand the drawbacks of the technology and challenges that other organisations have encountered while implementing this technology. Most important among these are the privacy concerns, since the same technology could be used to track employees as well. One of the major risks in the project is system and application integration. Seamless integration of the RFID system with existing systems with few changes is vital. If such integration proves to be infeasible, the fate of this project might be uncertain as the costs and efforts involved to bridge the gap would be enormous.

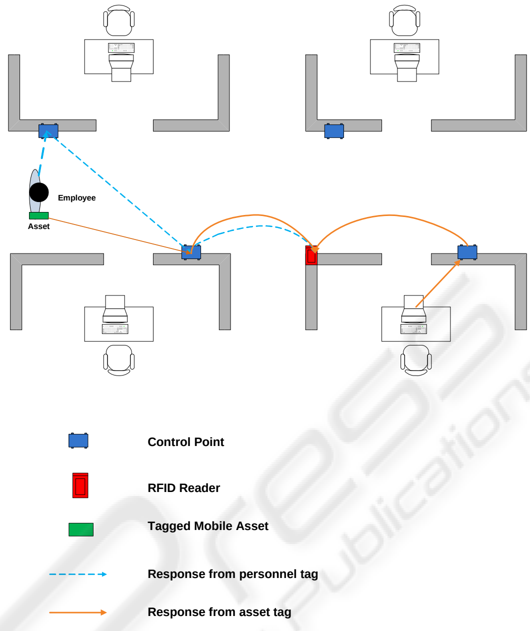

Figure 7a: Active tags for automatic access.

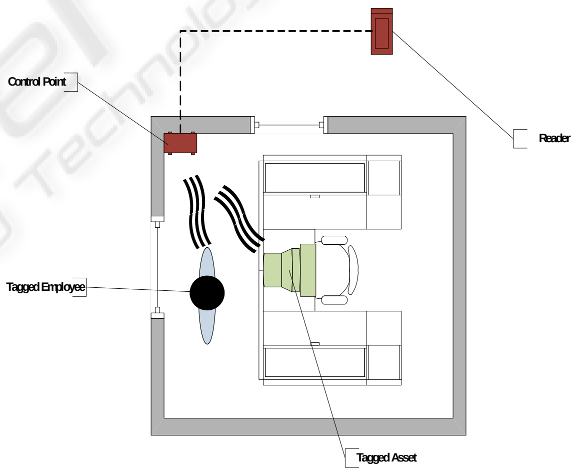

Figure 7b: Active tags for automatic access.

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