Radio Frequency Identification for Educational Gaming using Mobile Devices

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***Abstract*—Radio Frequency Identification (RFID) is a location determination technology that has been receiving a lot of commercial attention in recent times, especially in the areas of asset tracking and supply chain management. The technology makes use of radio frequency communication to transfer data between the two key components of an RFID system, the tag and the reader. Location based gaming, also known as urban gaming, combines the physical activity and social interaction of classic games with the modern age digital games. These games incorporate the services of location determination technologies and mobile devices to offer the user an exciting and unique game play experience. It is emerging as an increasingly popular form of gaming. However, current technologies employed for many location based games incur limitations that could hinder the success and growth of the area. RFID is a possible solution to this problem. Matching Shapes is a mobile based game for a PDA based on scanning a matching pair of tags in sequence. The objective is to demonstrate the viability of using RFID as a location determination technology for location based games.**

***Index Terms*—RFID, location based gaming, Gaming**

I. INTRODUCTION

Radio Frequency Identification (RFID) is a flexible and versatile technology that has become prominent in the areas of supply chain management and security [1]. The technology uses radio frequency communication to transfer data between the RFID tag and the reader. It has many advantages over other similar technologies, including the ability to communicate at high speeds and the ability to track objects on which a tag is attached. It is these characteristics that make it an ideal candidate to be used in conjunction with location based games and this is the concept that the project aims to investigate. Location based gaming is a new form of entertainment for the next generation. It incorporates the services of location determination technologies, wireless networks and mobile devices to offer the user an exciting and unique game play experience. Location based games have the potential to burst into the mainstream entertainment market as one of the defining games of the next generation. They combine physical activity with the social interaction of classic board games or traditional PC games. It is also known as urban gaming, as most of the games take place in urban areas, like city streets or parks. Various determination localisation technologies have been employed to create these location based games, including Global Positioning System (GPS) and Cell ID. But there are some major issues with the deployment of these technologies. The slight inaccuracies in exact locations are an obstruction for many location based games. The lack of coverage in certain areas, especially urban areas, is another problem. This type of gaming is still relatively new, and these limitations could hinder the success and growth of this area.

The paper documents the creation of a location based game named *Matching Shapes* that utilises RFID as the location determination technology. Matching Shapes involves users attempting to find matching shapes linked to the RFID tags by reading in information from the tags via an RFID reader. If the shapes corresponding to the tags are the same, the user has successfully found a matching pair of tags. It combines this game play with the physical activity of finding the various tags. The game is developed for a PDA and works via WiFi.

II. RADIO FREQUENCY IDENTIFICATION (RFID)

RFID is an automatic identification technology. The two key components of an RFID system are the reader (or interrogator) and the tag (transponder). Each tag contains a unique identification that allows RFID readers to identify the tag via radio frequency communication [2]. RFID is part of a family of technologies that make up the Automatic and Identification and Data Collection (AIDC). Other similar technologies include optical character recognition, magnetic strips and barcodes, but each technology has its own capabilities and limitations. RFID is one of the most exciting modern technologies and its potential uses apply to a wide range of sectors, including supply chain management, security and authentication. One of the most prominent applications is to identify and track the movement of items through the supply chain [3]. The number of tags in circulation across a varied range of sectors demonstrates the current popularity of RFID. The amount is approaching one billion RFID tags with the world moving fast towards ubiquitous computing and the creation of an "internet of things", whereby every object has its own unique ID and its movement can be traced from location to location. RFID is seen as one of the pivotal components in the creation of this "internet of things" [4, 5].

The purpose of an RFID system is to enable data to be transmitted by a mobile device, called a tag via radio frequency that is read by an RFID reader and processed

according to the needs of a particular application [6]. The antennas and choice of radio characteristics include decisions regarding the energy source of the tags, the frequency and the memory. The network connects the reader to the application using it to determine what to do with the information. The tag is made up of a small integrated circuit (or silicon chip) that allows for the unique identification of the tag, and an antenna that can send and receive radio waves [3]. The chip can be wired or printed using conductive ink. Tags come in a variety of shapes, sizes and protective casings depending on the use and application. Animal tracking tags are inserted underneath the skin and can be as small as 10mm in length. Other examples are credit card shaped tags used for access control applications. Passive tags do not have a dedicated internal power supply. They derive their operating power from the electrical field generated from the reader in order to power the circuit and rely on this energy to provide a response to the reader. They do not operate unless they are within very close proximity to the reader. The practical read distance ranges form approximately 10cm up to a few metres depending on the chosen frequency and the power supplied by the reader. One benefit of this limited operating distance prevents the tag from inadvertently being read. Other benefits include the lack of an onboard battery means passive tags have an unlimited operational life span. The onboard chip is usually very small and easy to install or embed into packaging. The small size and lack of battery also mean passive tags are cheap to produce. Passive tags are usually used when large numbers of tags are required for the success of the application or when the tag must be placed close to the reader, e.g. a fuel dispenser application. Active tag systems have an internal battery to power the chip and to communicate with the reader. They have an active radio frequency transmitter, and thus are capable of peer-to-peer communication [3]. The internal power source allows for significantly greater read ranges, upwards of 100 metres, and improved readability. Tags can be read at a speed of up to 100mph, e.g. at automatic toll-road payment systems, and are capable of quick reads of multiple tags. It also allows for better noise immunity and higher data transmission rates. They are much larger and are more secure. They conduct a session with the reader, thus meaning fewer errors. Active tags, like semi-passive tags, can be used to integrate sensing technologies like GPS and cellular connections as well as sensors and a host of other features.

The reader can be a fixed unit, a special handheld unit, or can be incorporated into a mobile device like a Smartphone or PDA. The reader performs various functions including powering the tag, identifying it, reading data from it and communicating information back to the network or database associated with the system. There are also read/write readers that can write new data to a suitably designed read/write memory tag, as well as read the information from it. The modern readers are becoming much more intelligent and versatile, becoming an integral part of the communication systems of modern businesses as well as supporting various communication protocols and network technologies [3]. The reader, an antenna packaged with a transceiver and decoder, constantly emits radio waves to activate nearby tags. When the tag enters the reader's effective reading range (the electromagnetic zone), it becomes aware of the reader's activation signal. The reader can then interrogate the tag to read its data and this data can then be passed to any associated host computer. RFID tags and readers operate within several distinct frequency ranges, each of which is intended for specific application characteristics. The four main frequency ranges are low, high, ultra high and microwave. These frequencies differ in the approximate read range. High frequency allows successful reads up to approximately 1.5 metres, and is the frequency employed by many variations of passive tags. Ultra high frequency is used for active tags and has a greater read range of up to 100 metres. These frequency ranges transfer the data at different rates, with low frequency rates typically less than 1 kbit/s and microwave up to 100 kbit/s. The main characteristics and uses of the frequencies are also described. The low frequency band is used for applications that can facilitate short read ranges. For applications requiring the larger read ranges or a high level of concurrent reads, the higher band frequencies would be employed.

The different characteristics of the various frequency bands mean that the choice of carried wave frequency is of primary importance in determining data transfer rates. Generally speaking the higher the frequency the higher the data transfer or throughput rates that can be achieved, e.g. noise interference, metal, or moisture can affect reading. There are two types of RFID system using different physical properties in the communication process that determine the operating range of the systems. Backscattering is the process of reflecting the communication signal from the tag back to the original reader. The antenna on the tag is designed to gather the power transmitted from the reader and use this to transfer the information back to the reader. Inductive Coupling communication is carried out when the reader creates a magnetic field around the tag that induces an electric current in the tag's antenna [3]. This powers the integrated circuit to carry out the communication. RFID tags are replacing barcodes for the use of animal identification and tracking. The RFID tags can store much more information on the origin and the movement of the animals, which will prove very beneficial in times of diseases such as bird-flu or BSE. Hospitals also use this technique to tag patients, ensuring they do not leave the hospital without the proper authorisation. These tags or wristbands can contain the medical status and requirements of the patient, improving hospital efficiency. Other advantageous uses of RFID in this area include equipment tracking and document tracking. Concerned parents are turning towards RFID to track the movements of their children. The tags can be embedded into wristbands and contain monetary amounts, removing the need for the child to carry money. They can also be used to track the child down if they get lost, e.g. in an amusement park. Many governments are introducing the

use of RFID into passports, with varying degrees of success. The RFID tags on the passports can include various features including digital photographs, fingerprints and other potentially useful information [7].

III. LOCATION BASED GAMING

Location based services extend digital media out into the physical world, freeing users from the confines of their PC and creating digital applications that incorporate the real world and the users' position in it. The popularity of these services is growing rapidly with the current research and development and increasing operator commitment [8]. Location based games are at the forefront of these industries and are ready to explode into the mainstream mobile market. Location based services utilise various current technologies to create a wide range of applications across many different areas. These include emergency services, information services and guides, navigation/routing and games [9].

- Emergency Services: Tracing emergency requests in order to obtain exact locations and speed up the response times.
- Information Services and Guides: Some applications respond to their current location in order to provide information of local facilities, e.g. details of the nearest library or video-rental store. Other applications are designed to act as guides, providing tourist information on the current area or information on certain exhibits at a museum.
- Navigation/Routing: Navigational aids such as route finders are very popular and have replaced the traditional map for many vehicle drivers. Exact directions and alternate routes can be easily provided.
- Location Based Games: Games are one of the most exciting applications of location based services. A location based game is one in which the game play changes and evolves according to the player's current position. This area is also known as urban gaming and has attracted its own unique band of followers, who embrace the opportunity to expand the gaming experience to the real world and leave behind the constraints and confines of the traditional table-top PC games. These games are highly interactive and have created a new entertainment genre.

The deployment of localisation technologies into mobile devices along with the increase in popularity of mobile gaming has lead to the ability to create location based games. The combination of these two areas – games played on mobile devices using localisation technology – can generate the pervasive game experiences and is called location-based gaming [10]. Location based gaming is a thriving market and there are already some successful location based games, ranging from adaptations of classic arcade games like Tron to mixed reality games like Can You See Me Now? These games incorporate both physical activity and strategic game play, and are highly interactive. Botfighters is regarded as the first location based mobile phone game [11], it was launched in 2000 by the game company It's Alive. It was a search and destroy combat game using cell ID, with players simply sending SMS messages to each other in order to track their location, destroying each other by sending destroy messages when they are within a certain distance of their opponent. The sequel, Botfighters 2 (Figure 1) was released in 2004 but with limited success.

Geocaching is one of the oldest and best-known location based games where players use geographic coordinates and handheld GPS receivers to track down hidden treasures, or caches as shown in Figure 3. Players then trade one item in the cache with an item they have brought along with them. Due to the inaccuracies of GPS, this is not just as simple as navigating to the exact location, but often involves a detailed search of the surrounding areas. The search can be interactive with the Geocaching website[1] offering various events like GPS powered corporate team building activities.

Figure 1: Botfighters 2

Figure 2: Tron

A modern version of the arcade classic game Tron has players moving in the real world leaving an imaginary trail in the game world. The aim of the game is to locate opponents and block their path with your trail. This is a highly interactive multiplayer game, played with mobiles and GPS receivers (Figure 2).

Figure 3: Geocaching

Developed by Blast Theories Studios, Can You See Me Now (CYSMN) is a mixed reality location based game where street players chase online players in a highly interactive game of tag. It pits traditional computers against PDA's connected with GPS receivers in a WiFi network. The online players watch the projections of the street players on their computer screen, while street players use the map on their PDA's to track down online players' positions. This was a significant development in the history of the games. When the

[1] http://www.geocaching.com

position of the street player is equal to the coordinates of the online player, the street player has caught his opponent and wins the game. Uncle Roy All Around You allows street players to work in tandem with online players in order to find Uncle Roy (**Error! Reference source not found.**). The online players aid the street players by setting puzzles and leaving clues for the street player in order to lead them towards Uncle Roy within the time limit. Actors following the street players complicate the challenge, adding to the game play. Various location based games set around Pacman were developed using alternative technologies. PacManhattan[2] simply uses mobile phones to relay players positions to other players, whereas Virtual PacMan uses a myriad of technologies including GPS, wearable computers, Wi-Fi and Bluetooth for location determination.

The future for location based games appears very exciting. This new gaming experience has already attracted much attention, with many new games entering the market. The development of the Nintendo Wii has shown there is substantial potential in the entertainment market for games that will combine physical activity with the classic storyline of traditional games. The major challenge is in the limitation of many of the current location determination technologies. The lack of accuracy, line of sight requirements, deterioration of performance and accuracy indoors or in urban environments are all hindering the progress of location based games. If a solution to these problems can be developed, then the future is bright. One technology that has potential in the location based games industry is Radio Frequency Identification. This automatic identification technology can be used to overcome these issues. The characteristics of RFID make it an ideal technology to be used for determining the location of an object. This could be applied to location based games in order to determine the location of the player or a game object. There has been some work done in RFID based games that puts tags in small game objects and readers in the game table. Examples include the "Smart Jigsaw Puzzle Assistant" [12] and "Smart Playing Cards" [13], both of which track the identities and locations of the playing pieces and offer advice and game keeping. PacLan is a location based game utilising RFID. It is based on the classic PACMAN video game. Human players play the game in a maze based on Lancaster University campus. The characters (Pacman and Ghosts) have RFID tags embedded in their clothing. Pacman moves around the maze collecting pills (discs also containing RFID tags). The ghosts try to catch Pacman by reading the pills to track his last known position. The game runs on a mobile phone that connects the players to a central game server using their mobile phone data connection [11].

[2] http://www.pacmanhattan.com

IV. LOCATION BASED GAMING PROTOTYPE

The objective is to demonstrate the potential capabilities and advantages of using RFID in the areas of location based gaming. The prototype is a location based game utilising RFID as the location determination technology called "Matching Shapes". Location based games are essentially games that in some way involve the location of the user. Many current games also involve some physical activity. Thus the main aims of the game are:

- To demonstrate that when the user is reading a tag, they can be identified at an exact location at a particular time.
- To create an entertaining game that can facilitate a wide audience.
- To involve some sort of physical activity.
- To eliminate cheating by having all the tasks handled by the application.

The Matching Shapes game exhibits these properties. It is a variation on the card game Matching Pairs where all the cards are placed face down and a player turns over any two cards in an attempt to reveal two matching cards. The game is played across a large area (determined by the range and set up of the wireless network). The user is equipped with an RFID reader attached to a PDA. The RFID tags correspond to a shape and are spread across the game play area. The aim of the game is to read in two tags containing the same object in sequence in the quickest time possible. The user scans the tag with the RFID reader and the application determines if the tag matches the target. This is then used to establish the precise user location at an exact time, as when they are scanning the tag, they must be in the vicinity of the tag. The tags used are passive tags which allows for accurate location determination as the user will have to be within very close proximity to the tag in order to read it. The game caters for a wide audience. The RFID tags are identical to each other and have no distinguishing features. This means that there is no way of knowing what tag corresponds to what shape. For younger audiences, the tag is attached to a card cut out of the corresponding shape and colour. Shapes are chosen to add an educational aspect to the game. It will help the younger children identify and recognise shapes, while the use of colours will improve their colour coordination and recognition. The game involves physical activity, as the user must quickly move around the game area to find the shapes. The game also improves memory, as the user may remember where they have seen the location of a certain shape while searching for another shape. This enables them to return to that spot quickly when they have to find that shape. For older audiences, the tags can be removed from the card shapes, incorporating a greater memory aspect into the game. This also allows for the game to be replayed many times if the tags are mixed up and replaced throughout the game area. All the game logic and score tasks are carried out by the system application

in order to eliminate cheating, e.g. the user could pretend that they had found a match, when in fact they had scanned in a square and a triangle.

This game demonstrates the capabilities of RFID in this environment and its advantages over other current technologies. There are various levels to the game that allow the user to progress to more difficult challenges, as they get more experienced with the game. The hardware used in the implementation of the prototypes include a laptop to host the server, a router to create the wireless network, a PDA to host the applications, RFID tags and an RFID reader to carry out the RFID communication. Passive tags functioning at 13.56MHz are utilised for the RFID tags due to their limited read range. Thus, when the user is reading the tag, the RFID communication that occurs can locate the user at a precise point at an exact time. A Compact Flash RFID Reader manufactured by ACG is used to read the tags which functions at 13.56 MHz, which is a suitable frequency for the prototypes. It can be attached to the PDA as a backpack attachment and communicate via the compact flash port. The database is an important component of the systems. It is used to store the current player and game information for the Matching Shapes Application along with the tag information. It is also used in conjunction with the web service to read and manipulate the data. The database is stored on the central server and can be accessed at any time. There are various levels and variations of the initial game idea considered, however the game developed provides two main levels.

- The first level involves the system specifying a shape to discover. The user must find a tag that matches this shape in the quickest time possible. The score attained will be based on the time taken to retrieve a matching tag. This round provides the user with the necessary experience to play the second level.
- The second level involves the system specifying all the matching tags to find in a specific order. The user must read subsequent matching tags in the correct order and in the quickest time possible. Again, the score attained is based on the time taken to retrieve the matching tags.

The RFID tag holds a unique identifier that is used by the Matching Shapes game to correspond to a shape. The RFID reader is attached to the PDA and is used to read the RFID tags. The PDA stores the Matching Shapes game, which uses the Reader Control class to interact with the RFID Reader. The PDA and laptop are connected to the network via the wireless router. The laptop acts as the web server to host the web services used by the game and also hosts the database. There are ten tags. These tags contain a unique ID that is associated with a shape. There are five shapes to find: a circle, a triangle, a square, a pentagon and a hexagon (Figure 4).

Figure 4: Five shapes

Therefore each shape has two corresponding tags. These tags can be attached onto a card cut out of their corresponding shapes in order to help identify the tags for younger players of the game. A harder version of the game would incorporate a greater memory aspect where the tags are not attached to their related shape. The aim of the game is to match all the shapes in the quickest time possible. This involves scanning in a tag with an RFID-enabled PDA and then trying to match the shape of this tag by reading in another tag that represents the same corresponding shape. The final score is determined by calculating the length of time taken to complete the game.

To set up the game, spread the tags a large distance apart around the game play area. The player is presented with the introduction page. There are three menu options available, Start, Help and Exit. To start a new game, the player chooses New Game from the Start menu on the bottom right of the screen. The player is required to enter a player name to start the game. The focus is automatically set to the player name textbox. An error message will alert the user if no name is entered. This player name is sent to the database and a message appears informing the user that the name is being processed.

Figure 5: Target shape

Level 1 Instructions are displayed on the screen. The time will start when the player presses ok. The timer on screen begins and runs until the game is complete or the player ends the game manually. The number of completed matches and the score are also displayed. The correct buttons become enabled and available to be pressed by the player. A random shape is selected as the first target and is displayed on screen for two seconds (Figure 5). The first level requires the player to find one of the two tags that corresponds to the target shape shown on screen. When the player has found a tag, they need to scan it using the reader. In order to scan a tag, the player must press the Scan button and hold the reader within a few centimetres of the tag. This shape is then displayed on screen for one second. A Message Box displayed on screen gives the player feedback as to the success of the read. If the tag was not a match for the target shape, then an unsuccessful match message is displayed to the player.

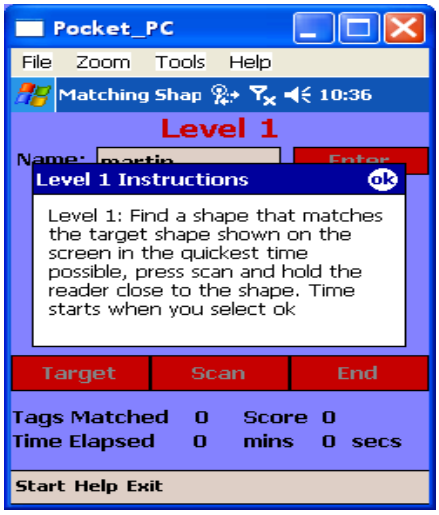

Figure 6: Level 1 Instructions

The player cannot progress to match the next shape until the current target has been matched. If the read was successful then the tag corresponded to a matching shape and level 1 is completed (Figure 6). The time is stopped. Instructions for level 2 are displayed to the player. The time continues when the player selects ok. Level 2 requires the player to find the two tags that match the five target shapes in sequence. The system randomly generates the list of shapes to find and displays the first target shape. The player has to find the tags and scan them in the same way as done in level 1 (Figure 7). The system checks if the corresponding shape matches the target shape. If the two tags relating to that shape have been found, then the next shape in the list becomes the target shape. The player cannot move onto the next shape until the two tags have been found for the current target shape.

Figure 7: Successful match

The user cannot scan the same tag twice in order to make a matching. The game ends when the five shapes have been found and matched in the correct order. The final score is calculated and displayed to the user and the game ends (Figure 8). The current time and time taken are logged in the database. The RFID reader is closed and the screen returns to its initial state.

Figure 8: Game over

The target shape can be viewed at any time by pressing the Target button. This displays the target shape for 2 seconds. At any time the player can view Instructions by selecting the appropriate option form the Help menu. The highest score achieved by any player can also be viewed at any time by selecting the Highest score option from the Start menu. The player can end the game at any time by pressing the End Game button. A Dialog Box appears to confirm whether or not the player wishes to exit the game. If ok is selected, the game is ended and the final score is calculated. The game then resets to the initial set-up. If the Cancel button is selected, the game returns to its previous state. A player may also exit the application at any time by selecting the Exit menu. A Dialog Box is displayed as for the end game option and if a game is currently being played, the final score is calculated and the application exits.

One of the main issues for creating smart device applications is dealing with the limitations of the .NET Compact Framework. The first issue encountered is the screen size and the inability to create multiple forms. Therefore, every stage of the interface had to be implemented within a single form. Many of the items had to overlap and be placed directly over other items. This involved extensive use of the visibility property as most of the labels, buttons and textboxes had to be hidden when not being used. The input methods of the PDA are another consideration in the implementation of the game. The keyboard is available by clicking the icon at the bottom of the screen. This displays a small keyboard on screen and the player can enter their name by tapping on the keyboard. The keyboard display takes up a portion of the screen and hides the underlying form. Thus input from the keyboard was kept to a minimum. When the name is entered, the player can hide the keyboard again to avail of the full screen. The remaining input is done via

the touch screen, where the player taps a button to activate the click event associated with that button. The GUI minimises the input from the player. The only text input needed from the player is at the start of the application to set the player name. The text input was as limited as possible as this takes time and the game is very much based on speed. The colour scheme is consistent and the buttons appear in the same position throughout the application. Setting a button disabled and greying it out when the button is unavailable is done to facilitate error prevention. The textbox is set to read only as soon as the player enters their name. The font is set at a readable size and is appropriate for the size of the buttons.

The button size is quite large. This is done because the game will be played on the move and at a fast tempo. The interface was designed to be easy to find the main controls. The picture box displaying the shape is big enough to ensure that the player can determine which shape is associated with each tag. The shapes are colour coded to further distinguish them from each other and allow the player to become familiar with them, as they get more experienced at the game. The first level of the game is a simple task to find one tag matching the target shape and makes up only a small proportion of the score. This allows the player to become familiar with the aim of the game and the interface, as well as gaining experience in reading in the tags and using the application. The standard menu strip complies with player's expectations and the labels attempt to be self-explanatory. The dialog box is used to confirm an end game or exit the application request to ensure that the player did not accidentally press these buttons. Continuous and informative feedback is given at all times. The player is always informed of the success of the tag read. Visual clarity is maintained throughout with a consistent interface and the controls are limited to only those necessary at any time to avoid cluttering of the screen.

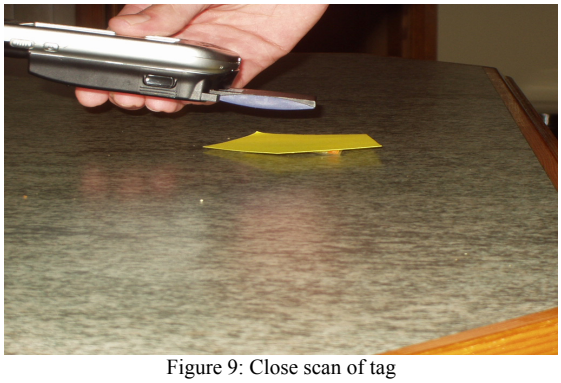

Figure 9: Close scan of tag

The performance of the RFID reader was tested to ensure its functionality was as expected. The reader was tested reading tags at various orientations to ensure that it read the tags correctly. This is necessary to ensure that the tag ID can be read in correctly and interpreted by the client application. The read distance of the tags was tested to validate that the tags could only be read whilst in very close vicinity to the reader. Figure 9 shows a close scan of the tag and this successfully reads the tag.

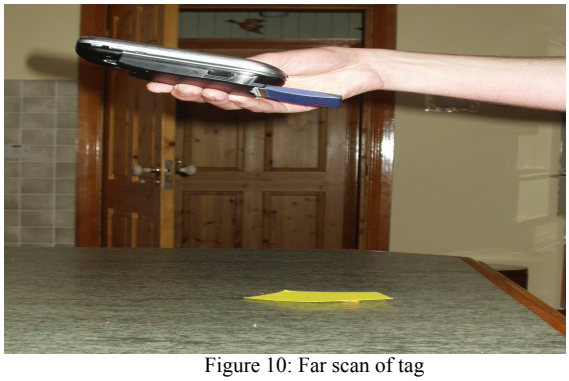

Figure 10: Far scan of tag

Figure 10 shows a far scan of the tag. This does not read the tag because the distance is too large. This allows for very precise location determination. This read distance is consistent and ensures that the user can be accurately located to a definite place in time when reading the tag. Therefore RFID can be used to provide accurate location determination for location based games. This is a crucial property with regards to the location based game and proves one of the main aims of the project.

V. EVALUATION

The system was aimed primarily aimed at a younger audience but also catered for a wide range of audiences. The system was first presented to young children aged 5-10 (Figure 11 and Figure 12). The number of children which took part was 8 (5 boys and 3 girls). They enjoyed the game and the main feedback was that the game was fun and easy to use. 5 adults also evaluated the system. They commented on the interface and noted that it achieved good cosmetic effect. The game was evaluated as simple to use and entertaining. The game was also perceived as having good educational potential. The system was designed primarily at younger children so it was designed to be as easy to use as possible. The shape scanned in is displayed on the screen to reinforce that the tag has been scanned correctly. The limitations of the PDA also prevented the use of short keys or any expert options.

Figure 11: Scanning in circle

RFID is a flexible technology and has many attractive attributes that can be integrated into different systems. It can uniquely identify any object on which a tag is attached. The tag can be read in any orientation. The RFID reader does not a require line of sight of the tag and can be read through most materials.

Figure 12: Scanning in square

The limitations incurred by present location based games using GPS and other similar technologies were identified. GPS is the main technology currently used but it requires a line of sight with the satellites in order to determine an exact location. This hinders the use of location based games in urban areas that include high-rise buildings that block this line of sight. This also makes it inadequate for indoor games. The degree of accuracy provided by GPS does not meet the requirements of some location based games. These issues are stifling the growth of this area. This project identified the current popularity and future potential of these games. Therefore an accurate and reliable location determination technology is essential in order to fulfil this potential. The first aim of the project was to address these issues by developing a location based game for a mobile device using RFID in order to determine the viability of using RFID as the location determination technology.

The game developed was Matching Shapes. This game exhibits all the properties of a location based game including the need to know the location of the tags and the physical activity aspect. It is a variation on the card game Matching Pairs. The game is primarily targeted at young children but also incorporates a more difficult version that can be enjoyed by older children and adults. The game involved finding and subsequently scanning in two tags attached to matching shapes that corresponded to a target shape. The tags could also be detached from the shapes to cater for an older audience.

The conclusion drawn from the development of this prototype and the feedback received is that RFID can be successfully integrated into location based games. It overcomes the deficiencies of other similar technologies. It is able to uniquely identify the location of a person at an exact point in time when the tags reside at a fixed known position, i.e. when they are scanning in the tag. This alleviates the problems associated with GPS and is a major benefit for location based games. The Matching Shapes game itself was deemed an entertaining game and provided educational value to younger children in relation to learning shapes and colours. It also included physical activity in moving around the game play area to find the shapes and read them in the quickest time possible. There are still some issues related to RFID and location based games. The read range of the passive tags used in this prototype requires that the person reading the tag has to place the RFID reader extremely close to the tag, i.e. within a few centimetres. But there are different types of tags, including active tags, with various read ranges that can be used to suit the specific nature and requirements of the individual game. For the purpose of this game, the passive tags were sufficient and they provide the ability to locate a player to within centimetres. Another issue is that the position of the tags must be fixed. The tags should remain permanent in order to maintain the accuracy of the system. The final issue encountered was that the tag ID of the tags had to be assigned to the shapes prior to the implementation of the game and had to remain consistent. But these issues are minor in comparison to the major benefits that RFID can bring to location based games. The Matching Shapes game proved that RFID can be successfully incorporated into a location based game and it provides many advantages over other similar technologies. RFID could be easily utilised by other location based games to achieve satisfactory results.

VI. CONCLUSION

The aim of the project set out to determine the feasibility of incorporating RFID technology into location based games. The deficiencies of the current technologies used in these areas have presented a problem. RFID has the potential to solve this problem. RFID is a location determination technology that can be used to track any object on which a tag is attached. The main components of an RFID system are the reader and the tags. Passive and Active tags are the two main types of tags. They differ in the read range and type of frequency they communicate with the reader. Passive tags are used in this project. The characteristics they exhibit mean that the reader must be extremely close to the tag in order for the tag to be correctly scanned. Each frequency has its own advantages and disadvantages. The main benefits of RFID are that the reader can read the tags in any orientation, without a line of sight, through many surfaces, at varying distances and multiple tags at a time. The main challenges facing RFID in the future surround privacy and security concerns of the customers. But RFID has great potential and can continue to gain momentum in a wide variety of areas due to its great flexibility. The fall in the price of the tag will lead to a great increase in the amount of items tagged, creating a ubiquitous world or “internet of things”. The development and evaluation of the Matching Shapes game has successfully demonstrated that RFID is a flexible technology that can be integrated into location based games. Location based games have an exciting future as long as the current limitations of existing technologies can be overcome. RFID technology

could be the key to its future success. It can accurately determine the position of an object at a specific point in time, which is a key concept in location based gaming. The Matching Shapes game utilised RFID and successfully verified the power and benefits of using RFID as the location determination technology.

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