An RFID-based game to encourage social interaction

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Abstract. Radio Frequency IDentification (RFID) is an emerging and increasingly popular technology. Though the majority of applications deployed thus far have been utilitarian ones, in this work, we present an RFID-based game that encourages social interaction. Throughout the design process we have paid close attention to issues of privacy and the logistics of deploying a building-scale RFID system.

1 Introduction

Radio Frequency IDentification (RFID) is an emerging and increasingly popular technology with many applications. The majority of applications deployed thus far have been utilitarian ones, mainly in supply-chain management [11]. In this work, we present an RFID-based game.

This application differs in that people and objects are tagged, in a space where people work. By bringing RFID explicitly into the public sphere, it may help create a dialog with the audience for this technology and its many possible users. We hope that an easy-to-understand game will provide future users with more of a background on which to base their understanding of RFID and kick-start their imagination about future applications. Our goal is to encourage RFID-applications research and to view the issues of RFID deployment and use from different perspectives.

The major goals of the design of our game were:

- To encourage social interaction in the community of students, faculty, and staff that make up our department - approximately 1000 individuals,
- To start gaining an understanding of the privacy mechanisms that will be needed in any consumer-scale deployment of RFID, and
- To spur use of the extensive system of RFID readers being deployed in our building (the Allen Center at the University of Washington).

We based our work on a building-scale RFID reader deployment, called the *RFID ecosystem*, described in Section 3.1. We are installing readers at key intersections of hallways in a 7-story 8,000 square meter facility. Of course, one of the design considerations in building our game is that it not depend on 100% accuracy (tags near readers will occasionally not be read) or on 100% coverage (the readers will be installed only at key intersections, open areas, and hallways in our building).

We use the RFID ecosystem to track users' movements (while keeping their privacy in mind) and determine interactions between players. The more interactions with other players a user has, and the more meaningful the interactions, the more points that user scores in the game. As this is a continuously running long-lived game, we use a global interface to keep players aware of the game state and keep them motivated to interact with other players while considering their current position in terms of total score.

In Section 2, we discuss the game as it applies to the players, and the privacy issues involved in the game. Section 3 describes the RFID system on which our game is based, and as the game architecture. We discuss related work in Section 4 and future work in Section 5.

2 The Game

A strong sense of community is important to the culture of our department. Because of this, the main purpose of this game is to encourage new and continued social interaction among the regular denizens of our CSE building. Scoring is based on meaningful interactions with other players, as well as casual or less frequent interactions. Since the game brings a constant reminder of the RFID system developed by the department, it also encourages attention to and pride in departmental projects. Moreover, it causes a larger group of people to think about the issues, in terms of privacy and utility, of creating RFID-based applications for consumers.

The game is to be played over a long period of time, and simultaneously with everyday activities. Individual interactions are cooperative, though players accumulate scores and will be able to see their ranking versus other players.

2.1 Game basics

Figure 1 shows the game board and basic moves (described in the next section). The game board is entirely virtual. It consists of a unit circle, with a rainbow of colors around the edge, blending in to each other and fading to white in the center. (The colors are to make the display more engaging, and to make it easier to name locations on the board.) Players' avatars start out at a random point on the edge of the circle, and drift towards the center at a constant rate. The primary goal is to stay out of the center, with sub-goals associated with bonus areas of the board, and other bonuses discussed in Section 2.5.

Basic move The basic move is accomplished by being seen interacting with another player. An interaction consists of the tags associated with each player being seen by an RFID reader within a short window of time (short enough that the users can be considered to have been in the same location – within sight of each other). Any interaction pulls both players outwards from the center of the circle, and pulls them angularly towards each other, that is, not in a straight line, but along the arc between them. Such an interaction is illustrated in Figure

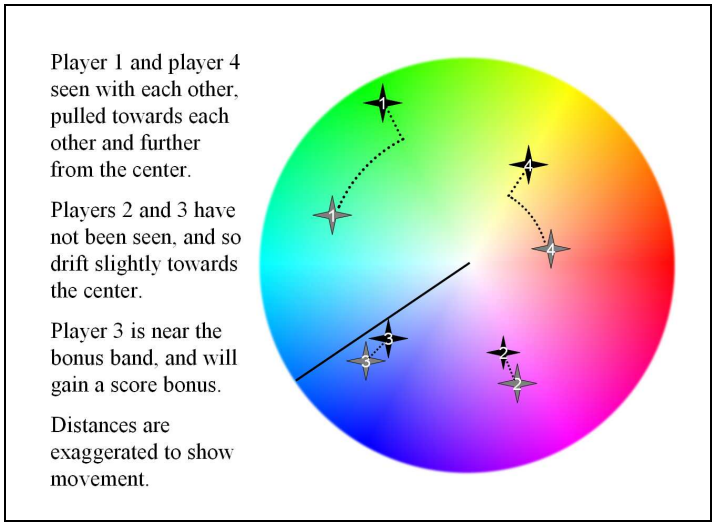

Fig. 1. The game board, with a sample interaction between players. The board is colored with red at the right, sweeping to blue in the lower left and green at the top left. The dotted lines indicate the path of movement on the game board by players 1 and 4, who have just been seen interacting with each other in the real world. Players 2 and 3 have not been seen, so they drift towards the center, but player 3 is close to the bonus band, and so will be receiving a score bonus.

1. The strength of the attraction in the board depends on the literal *length* and metaphorical *depth* of the interaction. An interaction that lasts longer causes a stronger pull, but so does one that *means* more. Walking down the hall together is a more meaningful interaction than happening to be in the same conference room during a colloquium, for instance, and so it pulls players in the field more strongly. We can detect a walk by a sequence of co-locations at topologically-close RFID readers, e.g., two users' tags seen by one reader at one end of a hallway and a short time later by another reader at the other end implying that the two individuals are walking together. Spending substantial time with another player one is not normally seen with should also be considered more meaningful, because it indicates the user is making new connections. There are many variations of interactions and we have only just begun to explore this space.

Due to the constant drift towards the center, when a player is not seen interacting with others frequently enough, that player drifts towards the center.

A player's score is dependent primarily on their distance from the center of the board, taking into account the distance at the moment, as well as the distances in the past month or two. Since the installation is ongoing and the game continues indefinitely, scores are computed as a weighted average of the points accumulated during each day that the user has been playing, with more recent days weighted more heavily. This way, a new player will be able to eventually

catch up to someone who's been playing a long time.

The other major effect on the players' score is their proximity to bonus locations on the board. Without this factor, players would only be motivated to be seen with any arbitrary other player, and so could just stick to their cliques and habits. If they want to get to a particular place on the board, though, they need to figure out who to interact with, to pull them both towards the bonus. This encourages interaction with others with whom the player may not normally interact without the incentive provided by the game.

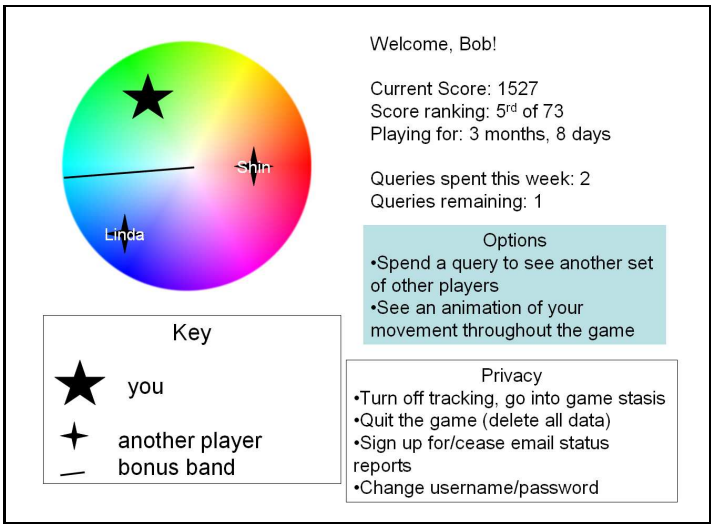

Fig. 2. Mock-up of the game interface as seen by a sample user "Bob", through the on-line interface. He sees his location, score and rank, and is offered the options to leave the game temporarily or permanently. He sees two other players with whom he can decide to interact. Though there are many other players, to help enforce privacy, only a small subset is presented at any time to a given player. Bob must choose to "spend" some of his queries for the week if he wishes to see the game locations of more other players.

2.2 Game play and interface

It is possible for users to "play" this game just by going about their daily activities, and interacting with others as they would normally, allowing the system to see them and update their game location in whatever uncontrolled way it happens to. (Indeed, it was an intentional design goal that players should be able to participate in the game at a basic level with a minimum of effort.)

However, players can also keep themselves up to date on their score and ranking, using the individual on-line interface as seen in the mock-up shown in Figure 2. This interface is accessed through a secure website using a user name

and password of the player's choosing. In order to help players reach a specific location on the board (whether just to stay out of the center, or to reach a bonus location), the interface will offer to show them a small number of other players with whom it would be in their interest to interact (the selection of which players to show is discussed in Section 2.3.1).

Since this game is meant to be played in the department, players will all know each other, or be able to find out easily enough who other players are. By suggesting interactions that wouldn't happen on their own, we hope that the game will foster greater interaction and with it an even stronger sense of community.

In addition to the individual interface, we intend to have a global interface visible on the web or on a public kiosk. A mock-up of the global interface is shown in Figure 3. We hope that the global interface will encourage discussion and awareness of the game, and collaboration between players.

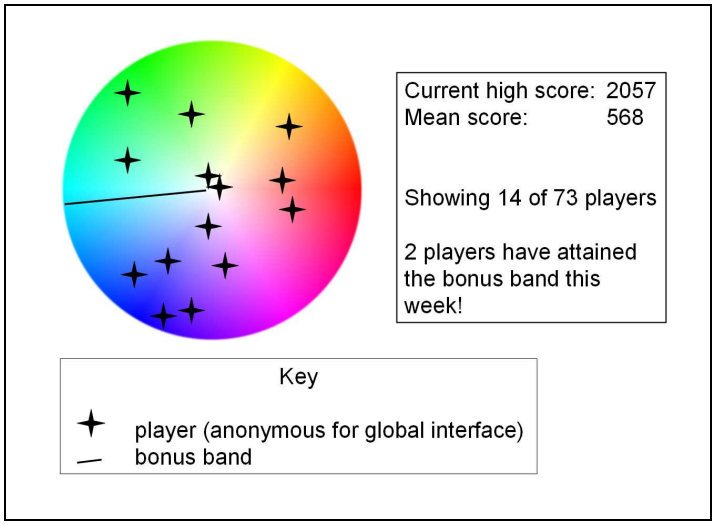

Fig. 3. Mock-up of the global game interface to be shown on a public kiosk or web page, updating at regular intervals. To protect the privacy of the players, only a random subset of the players are shown, with no names. To give players an idea of their rank or the competition they face, it shows global score statistics. To keep players up to date on the potential bonuses to be had, it shows the bonus bands.

2.3 Privacy in the game

Users may have different privacy expectations in a game than they would in other aspects of their daily life. Here it is understood that they are playing for fun, and that if they decide not to continue playing, it will have no adverse affect

on them. However, privacy is an important issue to address head-on with any technology that tracks people's movements. In this application, we protect not only the location information itself, but also the game information generated from that location information. In other words, we also consider how a player could be tracked *indirectly* (or have other information about their interactions inferred) by other players observing their avatar's movement on the game board. In this section, we discuss the threats to privacy in the game, and the steps we take to alleviate them.

Control of information It would be a clear violation of privacy to make any user's physical location data available to other users. More subtly, though, *disclosing a player's game location* too much of the time is also a threat to privacy. If a malicious party were to track the game location of one or multiple players at all times, it might be possible to determine what the players' physical location had been at particular times, or to tell who each player tends to interact with. For example, say that Cindy knows where Bob and Alice both are on the game board. If she can watch them move on the board towards each other, she can tell that they've interacted in real life.

We alleviate this problem by selecting only a small subset of the other players to show on a player's individual interface. The system ensures that no single player shows up on another player's interface for too long. To both limit the amount of information and allow players some amount of control over how much information about other players they get, players have an allotment of requests for other players' information which they can "spend" during a week. In Figure 2, Bob has used up two of his queries this week, the most recent of which showed him Shin and Linda. (This idea of protecting privacy by limiting the number of queries a user can make is an emerging privacy technique in databases research [6].)

In order to help players reach bonus bands (and in order to nudge them towards interacting with people they don't normally interact with) the game chooses with somewhat higher probability to show users who are in game locations that will help the user requesting the information.

Similarly to the individual interface, if the global interface (Figure 3) showed all of the players at once, even anonymized, it would be possible to infer, for instance by consulting an individual interface, which player was which, and gather all of their game data that way. We solve this by only showing a small random subset of the players at a time. The players in the global interface are anonymized so that non-players will not be able to know who players are.

On both the global and individual interfaces, we only show updates to players' locations at random intervals, rather than continuously. This helps prevent users from getting real-time knowledge of other users' actions.

In addition to privacy safeguards within the RFID ecosystem itself (discussed in Section 3.1, users can simply decide not to carry their ID tag with them. In a pinch, they can also hide tags under metallic or water-heavy objects when they wish to avoid the tag being seen by a particular reader.

2.4 Strategy

Interestingly, the limited information about other players and the small allotment of requests for information allocated to each player introduce an element of strategy to the game: should I spend my requests for information now, or save them for later in the week when they might matter more? Should I go ahead and go chat and walk with my friend, not knowing where he is on the board, since at least it will pull us both out from the center?

Other elements of strategy are unrelated to the limited information about other players. For instance, I need to get to the printer – should I go the long way around to get the bonus for the long path, even though the long way takes me by a location that will pull me a different direction than I want to go? Of course, the longer path may increase socialization with people in another hallway that the player traverses more rarely. And so on.

We expect that players may develop their own coordinated strategies to cooperate in the game, being seen together at the same location for mutual benefit. In variations of the game with more complicated rules and tagged game objects (as discussed in the next section), scheming may develop. If rules only apply under particular circumstances (particular users at a particular read) and if they benefit one player more than others, that player may exert effort to bring about those circumstances. In some configurations, an adversarial element may even emerge.

2.5 Game extensions

An immediate concern about the basic game rules is this: if players are attracted to each other in the game space, how do we prevent them from becoming clumped together all at one point in the space? To vary mobility in the game field, we add special non-ID tags, here called *tokens*. To facilitate a player's movement around the circle, there may be a selection of tokens which cause an attraction in the game similar to that of another player, but which do not themselves move in the game board. Along these lines, being seen at a particular location could exert a constant force on the player, such as pulling them towards the red part of the board, or exerting a constant clockwise force, etc. Tokens or locations, or combinations thereof, might also influence the ease and speed with which players move on the board - generally increasing mobility would make interactions to other players have greater effect, but would also mean drifting towards the center faster.

Scoring can be made more complex by providing more opportunities for bonus points. These bonus locations may be the bonus bands already discussed, or may be particular spots in the board, (a harder goal, since the player has to control their radial distance from the center). To encourage physical activity, players receive a bonus for being seen taking the stairs, or walking all the way around the floor in a short amount of time.

Combinations of the tokens and meaningful locations can be arbitrarily complex. For instance, a token might be defined to only have an effect when there

are three or more players present, or a particular other token present, or when in a particular location. In a different kind of complexity, a "transfer" token could cause a delayed player-interaction when it's seen first with one player and later with a different one. The transfer of the object implying that the two players exchanged the object in a place not covered by and RFID reader.

Adjusting the game All of the rules discussed so far (the basic rules, and all of the rules involving bonuses, tokens and special locations) have multiple parameters associated with them. For the basic rules, which kinds of interaction are more meaningful than which others? How quickly should players move on the board? At a higher level, which rules should even be included? More rules make the game more interesting, but too many may make it frustratingly complex.

We are designing the game to be easily modifiable, both so that parameters to rules, and the set of rules themselves, can be easily changed. To test the changes to these parameters, we will use simulated data about player and token movements. We will collect and generate this based on observations of people around the department (with their permission). Later runs may use real data from the ecosystem, recorded, anonymized, and replayed, for similar tweaking of parameters.

3 Game Implementation

3.1 RFID Ecosystem

We are taking advantage of the *RFID ecosystem* which is being deployed in the Allen Center, (home of our Computer Science and Engineering department). This system is a collection of stationary long-range RFID readers, small mobile tags, and a database and information management system which records data and filters it for applications. It also includes an API by which applications receive more abstract events of interest than just simple tag read (tag seen at a specific reader antenna at a specific time), e.g., two tags seen by a reader at nearly the same time. The game will eventually be one of several applications using the system. Users of the RFID ecosystem specify which applications should be allowed to see their data.

Between the RFID ecosystem and the player interface is the game engine. This engine stores all of the game state and the rules of interaction between players and objects. It receives *events* from the ecosystem layer which alert it to what is happening in the world. Using these, it builds up its own higher-level understanding of the world state (such as is needed to detect when a token has changed hands from one player to another) and applies the rules as appropriate to the players locations, scores, and meta-data.

Practical issues with tags In the implementation of the game, players will receive individual ID badges, which will be small enough (about the size of a credit card) that they can be carried a number of ways, whether in a pocket, on

a lanyard, or pinned to clothing. Since we want to encourage players to keep the game in mind and remind each other, we will provide customizable lanyards or pins, which keep the tags visible.

Tokens can be attached to colorful objects of shape and style depending on their purpose and meaning. For instance, a token that attracts players universally towards red might have a red case. If tokens were to go missing, game administrators would be able to locate them or view their last known location and the last player they were seen with.

Privacy in the RFID ecosystem The RFID ecosystem is explicitly built with privacy controls. Its features include

- Tag IDs are never transmitted in the clear
- Data is stored on secure servers
- Users specify which applications are allowed to see their data.
- Users can at any time instruct the system to stop tracking them (ignore reads of their tags), or erase all of their stored data.

When the user asks not to be tracked by the RFID ecosystem, it alerts the game engine, which will take the player out of the game.

4 Related Work

There is a large body of work on RFID-based games, location-based games and other pervasive gaming. Though much of it is relevant to our work, here we point out what we hope is a representative subset.

There has been other work in RFID-based games which puts tags in small game objects and readers in the game table. Examples are the smart jigsaw puzzle assistant [3], and smart playing cards [10], both of which track the identities and locations of the playing pieces, and offer advice and scorekeeping.

Using wearable tags and fast readers that provide feedback when tags are scanned, fast-paced sports games are possible. Tagaboo [8] is one example of such a game - tagged objects which are associated with points or behaviors are worn in a vest by one child, while the other wears a glove containing a reader and processor.

Location-based games have also been explored, mostly on a city level rather than in buildings. Can You See Me Now [2] and Spacerace [5] are two examples, both using GPS. The first users wireless internet (802.11b) and GPS readers on separate devices, while the second uses GPS enhanced mobile phones. In location aware computing, the distinction between the physical world and the game board becomes blurred. Though we have drawn a distinction between them, other work has tied the two together. Pirates! [1] is such a game, where players carry handheld wireless devices, and their physical location triggers game events.

As we have designed our game with the awareness that reader coverage will be less than 100%, the "seamful games" work in [4] explicitly make use of these gaps in coverage. In that work, the ubiquitous technology in question is wireless 802.11.

5 Future work

Though we will undoubtedly learn substantially more between now and the end of our actual deployment, we are aware of further expansions we could apply to this game. Many of the changes and extensions discussed in Section 2.5 will effectively be future work. Additionally, the parameters to the basic rules can be changed and their effect observed. We can also make the game arbitrarily intelligent, with more sophisticated ways of deciding which other players to show.

Our RFID system uses writable tags. In future work we may make use of this feature, for example by causing certain locations to write information on tokens, which will become meaningful upon visiting that location again.

Further in the future, we can consider incorporating more information about what the players are doing. There is ongoing research in our department using multiple sensors in a single board to identify social interactions [7, 9]. In expanding the RFID technology, we can also make use of motion-sensitive RFID tags, for example to tell if a user is moving a token or other tagged game object. Taking the same problem from an entirely different perspective, we could potentially do the same game with a completely disparate technology underneath, such as WiFi localization or other techniques in activity recognition.

Lastly, we can also look into expanding to larger populations and areas. Though privacy issues will have to be addressed, offering game tags to users could be an engaging way to make new or visiting members of the department feel at home and part of the community. We hope that our system design will prove to be extensible enough to be applicable to other departments and workplaces elsewhere.

References

1. Björk, S., Falk, J., Hansson, R., Ljungstrand, P.: Pirates! - Using the physical world as a game board. In Proceedings of Interact 2001, IFIP TC. 13 Conference on Human-Computer Interaction (Tokyo) (2001).
2. Benford, S., Fraser, M., Reynard, G., Koleva, B.: Staging and evaluating public performances as an approach to CVE research. Proceedings of the 4th international conference on Collaborative virtual environments Bonn (2002).
3. Bohn, J., The smart jigsaw puzzle assistant: Using RFID technology for building augmented real-world games, In Workshop on Gaming Applications in Pervasive Computing Environments at Pervasive 2004 (Vienna), http://www.pergames.de, 2004.
4. Chalmers, M., Barkhuus, L., Bell, M., Brown, B., Hall, M., Sherwood, S., Tennent, P.: Gaming on the edge: Using seams in pervasive games. In The Second International Workshop on Gaming Applications in Pervasive Computing Environmnets at Pervasive 2005 (Munich), http://www.pergames.de (2005)
5. Drab, S., Binder, G.: Spacerace - A Location Based game for mobile phones using Assisted GPS. In The Second International Workshop on Gaming Applications in Pervasive Computing Environmnets at Pervasive 2005 (Munich), http://www.pergames.de, (2005)

6. Blum, A., Dwork, C., Mcsherry, F., Nissim, K.: Practical privacy: the SuLQ framework. Proceedings of the twenty-fourth ACM SIGMOD-SIGACT-SIGART symposium on Principles of database systems (Baltimore) (2005)
7. Kautz, H.: Sensing and Modeling Dynamic Social Networks, http://www.cs.washington.edu/ai/socialnetworks/
8. Konkel, M., Leung, V., Ulmer, B.: Tagaboo: a collaborative children's game based upon wearable RFID technology. Personal and Ubiquitous Computing (September 2004).
9. Pentland, A., Choudhury, T., Eagle, N., Singh, P.: Human Dynamics: Computation for Organization, in: Pattern Recognition Letters, Volume 26, Issue 4, Pages 503-511, (March 2005)
10. Römer, K., Domnitcheva, S.: Smart Playing Cards: A Ubiquitous Computing Game, in: Personal and Ubiquitous Computing. (December 2002)
11. Want, R.: RFID: A key to automating everything. Scientific American (January 2004) 56–65

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