Gaming on the Edge: Using Seams in Ubicomp Games

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ABSTRACT

Outdoor multi-player games are an increasingly popular application area for ubiquitous computing, supporting experimentation both with new technologies and new user experiences. This paper presents an outdoor ubicomp game that exploits the gaps or seams that exist in complex computer systems. *Treasure* is designed so that players move in and out of areas of wireless network coverage, taking advantage not only of the connectivity within a wireless 'hotspot' but of the lack of connectivity outside it. More broadly, this paper discusses how the notion of *seamful design* can be a source of design ideas for ubicomp games.

Categories and Subject Descriptors
H.5.1. Multimedia: Augmented and virtual realities, H.5.3 [Information Interfaces and Presentation]: Group and Organization Interfaces—collaborative computing

General Terms
Experimentation, Human Factors.

Keywords
Ubiquitous computing, mobile games, seamful design.

1. INTRODUCTION
In this paper we describe our experiences with an outdoor mobile game. Games have long been one of the most popular applications of technology, both in terms of their impact on culture and their significant financial success [8]. Games have also been a key motivator in the development of many new technologies and techniques, particularly in the areas of computer graphics and artificial intelligence [3]. One avenue of recent investigation has been *mobile* and *ubiquitous* games [1, 6, 10] through which a number of broader research themes have been investigated, such as how one can combine new digital media with the older media that make up our everyday environment. Games such as 'Can You See Me Now?' [6] explore the incorporation of urban environments and digital systems, forming games to support unusual yet enjoyable connections between online players and players on the street.

We describe our experiences with an outdoor mobile game that explores an approach to ubicomp system design based around the notion of *seams*. A seam is break, gap or 'loss in translation' in a number of tools or media designed for use together as a uniformly and unproblematically experienced whole. Our designs draw upon the concept of 'seamful design' put forward by Mark Weiser [2, 11], but echoing established media theory, in which designers take advantage of the physical gaps, limits and similar characteristics that constitute a design medium—rather than smoothing them out or ignoring them. For example, many applications for mobile computers may be built as if they could be used along with the features of the environment one travels through, e.g. to display web pages about nearby buildings and people. Such applications often assume constant network connectivity, and yet this is not always the case when mobile systems are truly mobile; as one walks away from an access point, such systems may crash or become unusable as the wireless connectivity drops off and then disappears. Applications may be built to be uniform and 'seamless', but the seams of their infrastructure often show through in interaction.

Inspired by the seamful design idea, we designed a game, *Treasure,* in which each player uses a handheld PDA equipped with GPS and 802.11. Players collect virtual 'coins' from outside the wireless network, and then run back into network range to 'upload' the coins and gain points. Game strategy is based on observing, understanding and taking advantage of where coins and players are, hotspots of network coverage and the 'cold spots' out beyond them, and the urban setting of the game. We ran 14 observed trials of Treasure, involving 46 players in all, and experimented with a number of different game features. Overall, we suggest that the 'seam' concept can be a productive resource not just for game design but potentially for ubicomp systems design in general.

2. MOTIVATION AND RELATED WORK
While games offer considerable value and enjoyment for players, they also have the potential to be used by designers and researchers as experimental platforms for new technologies and design concepts [4]. Along with our desire to create a successful game, we were also interested in using a game to experiment with Weiser's concept of seamful system design. In particular, we were interested in how the use of infrastructure such as 802.11 wireless networks can be very apparent in people's interaction with mobile computers. What may be 'infrastructure' to a system designer may be something that users have to understand, handle or react to—which perhaps then should be designed for in the interface and interaction design, rather than ignored or suppressed.

Wireless networks have distinct physical characteristics such as a tendency to be absorbed by metal, water and other conductive materials. These variable features lead to a limited area of usable network connectivity that can be hard to precisely predict or model in advance of use. Usable network coverage, therefore, rarely covers all the areas one moves through and spends time in during a day of work or leisure. Indeed the dynamic nature of many deployment environments makes coverage subject to change over time. Furthermore, when one takes a mobile computer into network coverage, one can receive and transmit information to other machines and other players but one might also be tracked, recorded or spied upon electronically. Out of network coverage one can, then, be more private or 'safe' from these negative aspects of network use, and focus on work or leisure that does not rely on network access—deferring or avoiding activity that does rely on network access, of course. Depending on one's context, one might wish to be in a network hotspot—but at other times one might prefer to be outside the network.

This tension between the good and bad aspects of being either in or out of a network appears, to us, to be a seam in the sense that Weiser discussed. Whether there is coverage, and the context–specific choice about whether to be in network coverage or out of it, are aspects of network use that are common in use but under–represented in the design of ubicomp systems and user experiences. Instead, most such systems are built on the assumption that all use of the system happens within network coverage. In contrast, *Treasure's* design assumes interaction both in and out of network coverage. It uses this seam as a starting point for its design. The setting of a mobile multiplayer game let us experiment without requiring long–term commitment from users (i.e. players), or demanding that they have any conceptual understanding of the notions of seams and seamful design. Instead, players would be using game limitations or constraints in a way that is commonplace in games, in the form of limits, boundaries and rules [9].

There are several research projects that have used outdoor gaming as a means of exploring new research ideas, and a number of games that work with similar design features and techniques. 'Can You See Me Now?' (CYSMN) [6] linked on-line and street players in a chase game. Street players *(runners)* moved around the game area covered by a game–specific wireless network, and had their positions tracked by GPS. On-line players used arrow keys to move themselves around a 3D view of the same streets, with icons showing the locations of runners. Similarly, online players' positions were shown on the mobile computers carried by runners. Runners chased on-line players through the city, making their GPS positions match the on–line players' positions i.e. 'catching' them. In playing CYSMN, the variable accuracy of GPS caused problems for street players when trying to catch players in areas of bad GPS coverage. However, as the game progressed, street players became more skilled at using their knowledge of good and bad GPS areas, luring online players into areas of good GPS where catching them was easier. In this way the players took advantage a limitation—a seam—of the game's construction to their advantage, but the game was not designed to make explicit use of this.

Another game influential in the design of Treasure was NodeRunner (www.noderunner.com), which made use of the wireless network infrastructure existing in a city. Each team had a PDA equipped with 802.11 and a camera. Teams of players raced against time, logging as many wireless access points as they could and uploading photographic proof of each find to a central server. While NodeRunner made original use of the existing invisible wireless infrastructure, it made no use of the signal beyond the existence of access points.

The 'Pirates!' game [1, 5] used RF technology to determine the proximity of players to one another and specific resources. The game mapped an ocean environment on to the real world and players took the role of a ship's commander travelling from island to island trading and fighting in order to gain wealth. The underlying RF infrastructure was mapped to specific game events so that when a player came close to a RF beacon representing an island, a game event was triggered. In particular, face–to–face interaction was a key part of the game, encouraging some of the social aspects of gaming that can be lost in some computer game designs.

3. OVERVIEW OF *TREASURE*

The main aim of a Treasure player is to collect 'coins' placed in areas of poor network coverage, and then bring these coins back into an area of good network coverage to gain points. By moving in and out of areas of network coverage, players also survey the wireless network they are playing in, building up a changing map of network coverage that they all share.

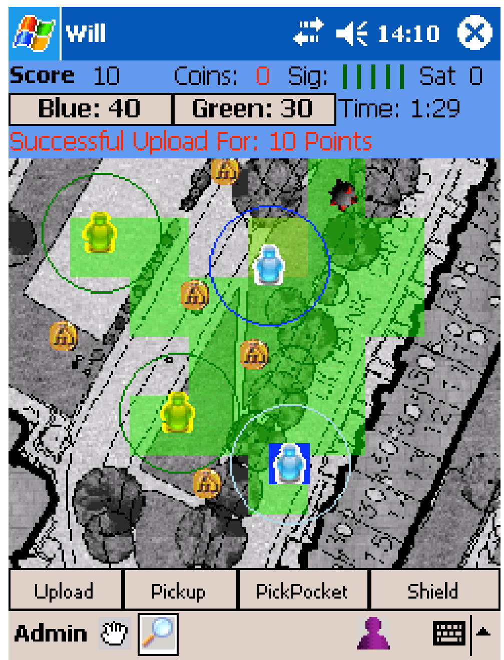

Figure 1: The *Treasure* interface. The map shows player positions along with coins, typically positioned outside the game's wireless network coverage. As players move around, a map layer of coloured squares builds up, revealing the network's coverage and serving as a resource for game tactics.

At the beginning of the game, each player is given a PDA with GPS and 802.11 wireless capabilities. The PDA interface (Figure 1) consists of a map supporting panning and zooming, on which the player's location, the location of coins, and the location of other players are displayed. To pick up a coin, a player must walk or run to the physical location of the coin as indicated on the map, so that his or her GPS–tracked location is close to the coin's location, and then press the *Pickup* button. For the player to gain points for this coin he or she must then walk or run to an area of sufficiently high network signal strength and click *Upload* so as to send the coins he or she has collected to the game server. The chances of a successful coin upload increase the deeper a player is inside wireless network coverage. To be successful in the game, players must therefore learn which areas are covered by wireless network and which are not. In other words, they have to learn and use the 'seams' of the game infrastructure.

A key competitive game feature is 'pickpocketing'. When players are close to each other they can use the *Pickpocket* button to steal coins that are being carried by other players. However, for a pickpocket to work, both players need to be within network range i.e. one can gain safety by staying out of the network. Players can also protect themselves from such attacks by deploying a *Shield*, preventing other players from stealing coins that they have collected. Those players bringing coins into network coverage have to be aware of where their opponents are, keeping a distance or shielding themselves so as upload coins before they are stolen.

In addition to coins, mines are occasionally placed in random locations on the map. When a player walks over a mine their PDA vibrates and is disabled for twenty seconds. This also causes the player to drop all coins he or she was carrying, and prevents the player from participating in or observing what is going on in the game via the game interface. A player who has walked over a mine can still see other players in the 'real' world, and can thus get into a good position to wait for their PDA to become active again. This was a strategy we observed on many occasions during our trials.

In our development of the game we have used two distinct versions. The first version was a two–player game in which one player competed 'head to head' with an opponent. Feedback from this early pilot led us to increase the team size from one to two, and to add more features to encourage social interaction between players. We maintained the essential competition between players in different teams, but we also added a feature involving collaboration between players of the same team: *collaborative uploads*. If teammates upload their coins to the same access point within two seconds of each other, they gain double the normal point allocation. Additionally the latter version allowed players to see cumulative team scores for each team.

In the first version of the game, players' PDAs collected data on the distribution of wi–fi signal strength as they moved around. At the end of the game, the server made a map from the data collected from all the players, which could be shown to players after their game. Forcing each player to discover network coverage individually, and to build up their own mental model of coverage without system assistance, proved frustrating to players. In the second version of the game we made this data available during game play. A wireless coverage map was constructed dynamically by the server, and was regularly broadcast as part of the game state for display as a semi–transparent map layer on users' PDAs (see figure 1). Green squares show areas of high sampled signal strength, and yellow squares show areas of weak coverage. These collaboratively constructed maps provide players with additional awareness of the network strength in the game environment, and also reveal where players have been and can be used to select suitable places to upload coins and areas where pickpocketing is likely to work.

4. ARCHITECTURE & DEPLOYMENT

Treasure was initially designed for play over our own wireless network set up at the University of Glasgow's campus. The Treasure network consisted of five VPN-connected fixed position wireless access points, arranged to create three distinct areas of network coverage. We also trialled the team version of Treasure (under the name *Seamful Game*) in the course of demonstrations at the MobileHCI 2004 and Ubicomp 2004 conferences. At Mobile HCI we set up our own temporary wireless network that spanned much of a park–like area outside the conference venue. At Ubicomp we made use of the network set up by the conference organisers, one node of which was kindly set up in a window of the conference centre; the game was played in an area of grass and trees just outside this window. Each player in the game was provided with an HP 5550 iPAQ with built–in 802.11b wireless and a compact flash GPS unit.

Designing a system that would work reliably across the seams of the wireless network proved challenging. We needed an appropriate networking system that could handle disconnection and reconnection, and would also work in areas of patchy signal strength. To this end, we developed a custom wireless driver and messaging system. The standard iPAQ PocketPC wireless driver automatically connects to the strongest network signal if it is not currently connected to a network. Unfortunately, this meant that the iPAQ would connect to non-game wireless networks when outside the range of our network. Our replacement wireless driver allowed us to lock the iPAQ onto one network, disconnecting and reconnecting to that one network as needed without user intervention. Additionally we implemented a simple UDP based messaging system. Since connections to the network are constantly being made and broken, TCP would have added considerable setup overhead. UDP allows us to use a 'one shot' messaging system without a guaranteed transaction mechanism. A central server periodically 'heartbeats' notifications of all new game events (new coins and mines, scores, player positions) accoss the network and all clients who are within range receive these updates. Player's PDAs in turn send information over UDP to the server about their position and player events. While this introduced a time issue in that events were only periodically updated, it removed the need for guaranteed messages.

Due to the limits in wireless networks, UDP packets are often (or even usually) not received by all devices. The game was designed to work with these technical problems and dropouts, using them as features of the game. So, for example, if one is outside network range then one will not be given updates on other player's positions. This could be seen as a disadvantage to our system; but instead we see this as part of the game. For example, one can ambush other players by 'hiding' out of network range and then running into the network and pickpocketing other players.

There was concern about the interaction between the game and the urban environment, in particular about whether players would be too distracted from cars, roads, walls and so forth, we found this not to be the case. We suggest that this may be due to the way that the game already involves continual comparison and relating between features of the game interface on the PDA and features of the wider environment.

In the first set of trials, while the participants reported a good game, from our analysis and observations we could see that there was very limited social interaction between players. Indeed, in the post–game interviews a number of players commented that Treasure could have been played as a single player game: there was hardly any interaction between players. At times players almost bumped into each other as they concentrated on playing the game and their iPAQs. Players reported that they found the experience of playing the game enjoyable and engaging, to the point of returning from playing the game physically exhausted. As one trial participant commented: "That was fun […] least I don't need to go to the gym now". The main forum for social interaction was competition: the game was designed so that players would compete for a higher score. While there was evidence that players did put effort into competing for a higher score, this generated little social interaction during the game. The only specific game feature that required physical proximity between players was the Pickpocket, which allowed a player to steal coins from another. While players attempted to pickpocket a considerable number of times—in the first trial six times per player per trial, on average—there was only *one* successful pickpocket in the whole complete first trial. It appeared that there was insufficient support for awareness of the network coverage.

To address this, in the second version of the game we introduced the collaborative production and sharing of a network coverage map. We also changed the game to involve two teams of two players each, with visible total team scores, and we added collaborative uploading of coins between members of the same team to receive points. The second set of trials certainly shows more evidence of collaborative events, such as pickpockets. Successful pickpockets jumped from negligible to an average of 1.6 per player per game, and there was considerably more interaction between players recorded in our videos and observations. Collaborative uploading—only available in the second set of trials—proved to be a focus for interaction, in that players would call each other over to both attempt to upload in the same spot, and verbally synchronise and confirm the success of the upload. Indeed, nearly half of all successful uploads were such collaborative uploads.

More broadly, these experiences show some of the value in supporting collaboration in outdoor games as well as competition. Our move to team games, and implementation of new features such as collaborative uploading, produced an improved version of the game with more social interaction. While game designs often emphasise the importance of competition between players, our experience suggests the value of also supporting collaboration between players. Indeed, our game even supported a limited form of collaboration between competing players, through the way in which the shared map of wireless network coverage was built up during play.

5. CONCLUSION

Treasure was a successful attempt to apply the concept of seamful design to an urban ubicomp game. Infrastructure becomes a central feature of the game, rather than the peripheral technical context. The deliberate exposing of selected aspects of the infrastructure suggests something of how users could develop their own ways to take advantage of the limits, gaps and seams in technology.

The trials of Treasure show it to be both an enjoyable and provoking game for players. In particular, our redesign of the game had some success in encouraging more social interaction—competition and collaboration—between players. Although there was a concern about players' ability to safely move through and interact with the urban environment while playing the game, this appears to have been unwarranted, because of the players' ongoing interrelation of game system interface and the game arena. Indeed this interrelation may in fact be one of the defining features of ubicomp games, since the design area of ubicomp centres on ways to richly interweave digital media with the other older media that make up our everyday environment.

Making seamful systems can be a challenge. Indeed, much of our implementation work involved dealing with the ways in which systems are generally designed to fail on encountering seams, rather than to continue and to communicate those seams to users. Most systems (e.g. TCP) either succeed or fail when used on the boundary. However, as Treasure shows, these boundaries can have value as positive design features, rather than simply as points of failure.

We emphasise that we do not see seamlessness as always bad and seamfulness as always good. More traditional and familiar system design approaches, which remove or overcome limits, gaps and 'losses in translation' between media, may of course lead to engaging and useful designs too. However, we see seamful design as a far less–explored area. Seams shown in an interface have to be chosen and designed well. While design techniques and lessons from such research may be applicable to areas beyond games, we intend to continue using mobile games both as a design area to work in, understand and contribute to, and as a vehicle for developing new technologies, tools for analysis and design concepts.

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