

Can You See Me Now? A Citywide Mixed-Reality Gaming Experience

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Abstract. Can You See Me Now? was a mobile mixed reality game that took place on-line and on the streets of a city. On-line *players* moved across a map of the city that they accessed over the Internet. *Runners* equipped with wireless handheld computers with GPS receivers chased them by running through the city streets. Players communicated with one another using text messages and also received walkie-talkie communication from the runners as an audio stream. Can You See Me Now? was staged publicly. Evaluation based on ethnography, discussion with participants and analysis of system logs, revealed a number of design issues for future citywide mixed reality games. Gameplay issues focus on the tactics of the runners and players, the need to enhance local knowledge for the players, the role of audio, and designing entry into and exit from the game. Orchestration focus on improving monitoring interfaces in the game control room and better supporting participants on the streets.

1 Introduction

Can You See Me Now? was a mobile mixed reality game in which up to twenty on-line players were chased across a map of a city by three performers who were running through its streets. The game was staged as public event over a weekend in late 2001, providing a valuable opportunity to study issues surrounding the design, deployment, and experience of mobile games and related experiences.

Can You See Me Now? was a collaboration between the EPSRC-funded Equator Interdisciplinary Research Collaboration and the artists group Blast Theory. Equator is a six-year research programme investigating the interweaving of physical and digital interaction [21]. It began in 2001 and involves researchers from computer science, electronics, social science, psychology and art and design, spread across eight academic organisations in the UK. Blast Theory is a group of artists based in London who make live events for theatres, clubs, galleries, and the street [22]. The four members of Blast Theory have developed cross platform projects since 1991 and have a history of creating performances that involve computing technologies.

The motivation behind this collaboration is to take emerging technologies out of research laboratories and to quickly create professional quality applications that are then deployed and studied in public. We believe that the discipline of working in public enables us to more fully appreciate the often subtle issues involved in creating successful experiences and also to gauge the future potential of new ideas. Our study techniques involve a combination of ethnography and discussions with audiences and design teams, backed up with statistical analysis of system logs, an approach that has been honed through a number of previous public experiences [11,13].

In this paper, we apply this approach to the study of a mixed reality experience that involved deploying mobile technologies outdoors.

2 The research challenge

Technologies such as mobile phones and handheld devices have an established role in gaming history. The most notable examples include the Nintendo Gameboy and the abundance of interactive arcade-style games on today's mobile phones. We believe, however, that such games do not even begin to exploit the huge potential of ubiquitous gaming, especially the possibility to combine the world of the game with the physical world in novel and engaging ways. This idea has been explored in a range of previous projects.

Several projects have focused on the use of commodity technologies such as mobile phones and handheld computers to create games:

Majestic from the computer game company Electronic Arts is a conspiracy theory-inspired game, which communicates with its players via email, fax and terrestrial and mobile phones.

Pirates! [4] integrates some of the social aspects of traditional game play into computer games. Set indoors, it utilises handheld devices connected to an 802.11b wireless network to engage participants in a variety of activities such as exploring islands and taking part in sea battles.

Bot-Fighters [5] utilises standard features of mobile phone technology such as cellular positioning and SMS to provide an indoor and outdoor location based combat game. While moving around in a city the players receive SMS messages regarding who is in their direct vicinity and their attack status. By replying to these messages they can select to retaliate or flee from an attack.

Geo-caching [9] is a web-based treasure hunt that utilises GPS as its chief underpinning technology. Players hide items of treasure in different real world locations and then register these items with the geo caching website. Other players then hunt out the treasure by downloading hints and riddles, together with GPS position data and a short description of the treasure from the site.

Unearthing Virtual History is a museum experience in which participants use wireless handheld devices with GPS to locate buried virtual artifacts outdoors. They then take them back indoors in order to view them on a virtual reality display [3].

Other projects have begun to explore the potential of augmented reality interfaces for gaming. Conventional augmented reality employs physical or video see-through displays to overlay a virtual world on the physical world [1]. Recent projects have

begun to move augmented reality outdoors, for example exploiting handheld devices and wearable computers with see-through head-mounted displays [2]. Projects in this vein include:

arQuake [19], an extension to the desktop game *Quake*, that creates an outdoor and indoor mobile augmented reality gaming environment, based upon moderately accurate six degrees of freedom tracking that combines GPS, digital compass, and vision-based tracking.

AR2 Hockey and *RV-Border Guards* from the Mixed Reality Systems Laboratory [18] employ high-precision body tracking and see-through head-worn displays to superimpose virtual game elements onto the player's worldview.

MIND-WARPING [16] has explored issues in wearable computing and augmented reality through games.

PingPongPlus [12] used a sound-based tracking system and a ceiling-mounted projector to throw graphics onto a ping pong table.

The focus of our research is on the social nature of mixed reality games. In particular, we believe that there is great potential for games to draw upon relationships between online players and players on-the-ground. Exciting new games can be created in which these different kinds of participants collaborate and compete in different ways, exploiting their different perspectives, different capabilities and access to different kinds of information. *Can You See Me Now?* was intended to support an initial exploration of the challenges arising from this kind of game. Specifically, we wanted to address two key questions:

- What kinds of relationships are possible between on-line participants and those on the streets? In *Can You See Me Now?*, the public players would access the game over the Internet and a key issue would then be what kind of relationship could they have with professional performers on the streets.
- What activities are required in order to stage and successfully manage such a mobile game? In particular, what work is involved for professional performers and behind the scenes production crew and how do the technologies support or hinder this.

3 An overview of Can You See Me Now?

Central to *Can You See Me Now?* was a relationship between up to twenty on-line *players* (members of the public using the Internet) who were moving across a map of Sheffield, and three *runners* (members of Blast Theory) who were moving through the streets of Sheffield. The runners chased the players. The players avoided being 'seen'.

Everyone, runners and players, saw the position of everyone else on a shared map. Players sent text messages to each other, which were also received by the runners. In turn, runners talked to one another over a shared radio channel, which was also overheard by the players. The performance took place over an area of Sheffield that was roughly half a mile square and that consisted of a mixture of open spaces and narrow streets lined with tall buildings.

3.1. The player interface

A player's experience began at the Can You See Me Now? homepage [21] where they entered a name for themselves in response to the prompt "is there some one you haven't seen for a long time?" They then joined the game queue, and from there were eventually dropped into the map of Sheffield. They used the arrow keys on their keyboard to move around this map. They were unable to enter solid buildings and other restricted areas.

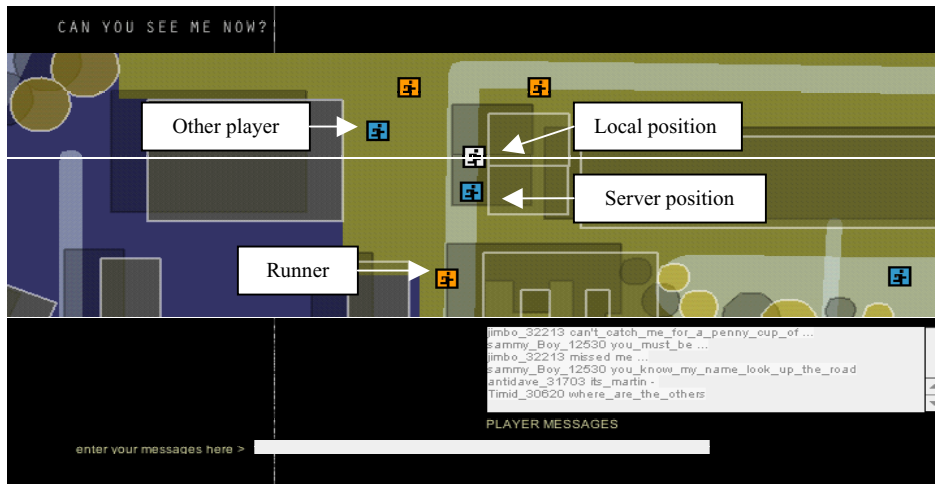


Fig. 1. The player interface

Figure 1 shows an example of the player interface. A player was represented as a pair of icons on the map. A simple white icon showed their current position according to their local client, providing immediate feedback as to their movement. A blue icon showed their position according to the game server, and this would trail closely behind the white icon with a lag of a few seconds (due to the communication delay between the client and the server over the Internet and the time taken to process players' movements at the server). Other players were represented as blue icons. The runners were shown as orange icons.

Each player was able to exchange text messages with other players. In addition, audio from the runners' walkie-talkies was streamed to the players over the Internet so that they could listen in to their communications (which in part, were a deliberately staged dialogue created as part of the performance). The players continued to move and text until a runner got sufficiently close to them that they were 'viewed'. At this point they were removed from the game and offered a chance to re-enter the queue.

3.2. The runner interface

The runners also saw the map of Sheffield showing their positions as well as the players' positions and text messages. Unlike the players, their map allowed them to

zoom between a global view and a close-up local view centred on their current position. This interface was delivered to them on a Compaq iPAQ from a server in a nearby building over a 802.11b local area network. A GPS receiver plugged into the serial port of the iPAQ registered the runner's position as they moved through the streets and this was sent back to the server over the wireless network. The iPAQ and GPS receiver combination was attached to a wooden board that could be placed in a plastic bag to improve ruggedness, ease of carrying, and to provide some basic weatherproofing. The runners also used walkie-talkies with earpieces and a head-mounted microphone. Finally, they carried digital cameras so that they could take a picture of the physical location where each player was caught. These pictures appeared on an archive web site after the event [20]. Figure 2 shows one of the runners kitted up and ready to go (left) and the equipment that they carried (right).

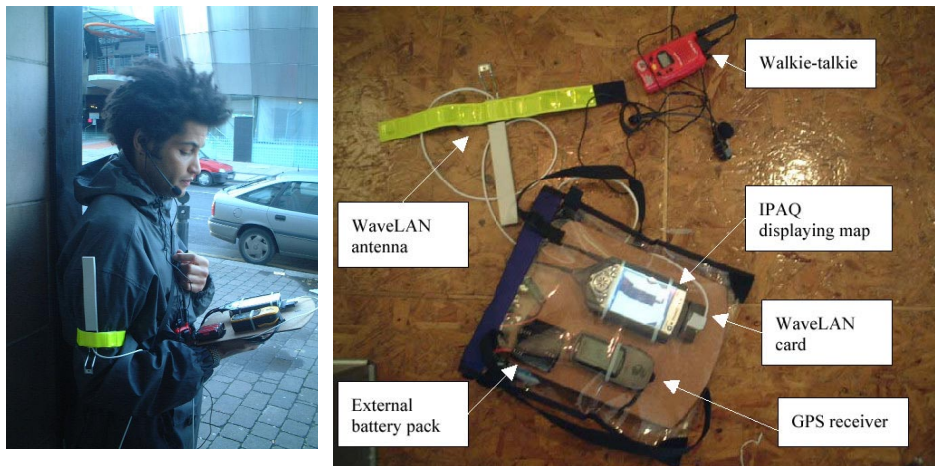


Fig. 2. A runner and their equipment

3.3. System architecture

Can You See Me Now? required position updates to be exchanged between players and runners; text messages to be exchanged between the players and also transmitted to the runners; and audio information (from walkie-talkies) to be exchanged between the runners and also transmitted to the players. This was achieved by two separate subsystems, one dealing with position updates and text messages and the other dealing with audio. These subsystems were spread over four locations: the streets of Sheffield, a temporary control room that was established in Sheffield, our laboratory back in Nottingham, and the Internet at large (connecting to the players' locations).

Position and text subsystem. Figure 3 shows the position and text subsystem. Players initially contacted a public HTTP server from which they downloaded their game web client (a Macromedia Shockwave program) and were placed into a queue.

A Fuselight multiuser server, hosted at Nottingham, managed admission to the game, ensuring that no more than twenty players would be playing at a time. Once admitted to the game, a player's client contacted the main game server (implemented using Macromedia Director) that was hosted in the control room in Sheffield. The client's game events (position updates and text messages) were sent to the game server. In return, this sent back game events from the other players, as well as the positions of the runners.

Each runner on the streets transmitted position updates from their GPS receiver via their iPAQ to a proxy server that was running in the control room in Sheffield. These updates were unicast over an 802.11b network using UDP. The proxy server converted the GPS coordinates from latitude and longitude to metric units based upon a known reference point in Sheffield. It then transmitted them to the main game server (via TCP). In return, the players' positions and text messages were transmitted from the game server to a second proxy server which then sent them on to the runners' iPAQs over the 802.11b network as (multicast) UDP messages.

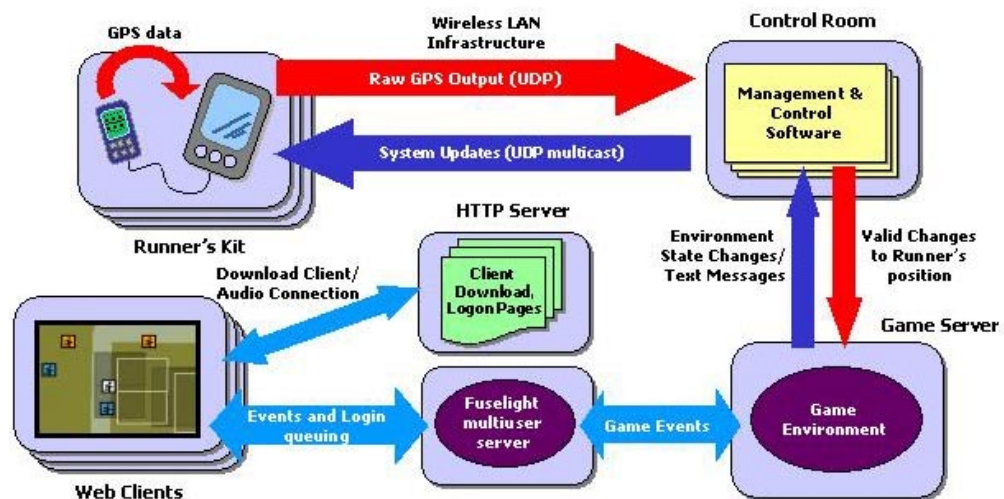


Fig. 3. Position and text subsystem

Audio subsystem. Figure 4 summarises the audio subsystem. The runners communicated using radio walkie-talkies. An additional walkie-talkie in the control room also received this communication. This was wired into a local computer, enabling the audio to be encoded into a digital audio stream (using Sorenson Broadcaster). From here it was transmitted to a Darwin audio streamer that was hosted in Nottingham and then made available to the players over the Internet. A useful feature of this set-up was that the walkie-talkie in the control room could also be used to talk back to the runners (e.g., to give them guidance and instructions) without being overheard on the on the public audio stream

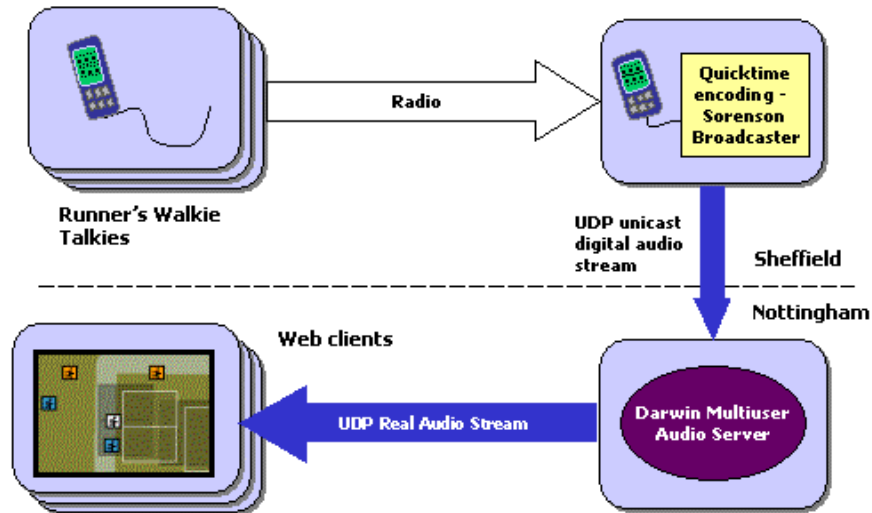


Fig. 4. Audio subsystem

Wireless network. We invested considerable effort in establishing an 802.11b network with sufficient range. Two advance trips to Sheffield were undertaken in order to test out 802.11b and GPS coverage. These enabled us to establish a sense of the area within which the game would be playable (determined by a combination of physical accessibility, 802.11b signal strength and GPS accuracy).

Our final 802.11b network involved deploying a high-power omni-directional antenna mounted on an eight meter mast on the roof of the building where the control room was located to give longer-range coverage. This was supplemented with a smaller lower power omni aerial to fill in coverage on the street immediately below the control room. Figure 5 shows the mast as deployed on the roof of the Workstation.



Fig. 5. Eight-meter high-power omni mast

3.4. The control room

Our previous experience of staging public performances involving mixed reality technologies had taught us the importance of orchestration, that is of providing adequate support for monitoring and intervening in an event from behind the scenes in order to ensure a smooth experience for the participants [13]. With this in mind, we introduced several monitoring tools into the control room in Sheffield:

- An application that monitored the signal quality of the wireless 802.11b connectivity for each of the runners.
- An application that monitored the GPS data feeding back from each runner so as to provide an indication of tracking accuracy.
- A management interface that gave an overview of all participants' positions on the map (both runners and players), displayed all transmitted text messages, and supported management functions such as removing particular players.
- A laptop running a player's online interface so that staff in the control room could join in as a player to carry out live testing of the game.
- An application that tested connections to the main servers at Nottingham and to the 802.11b router the roof of the building.

Figure 6 shows the monitoring tools as deployed in the control room.

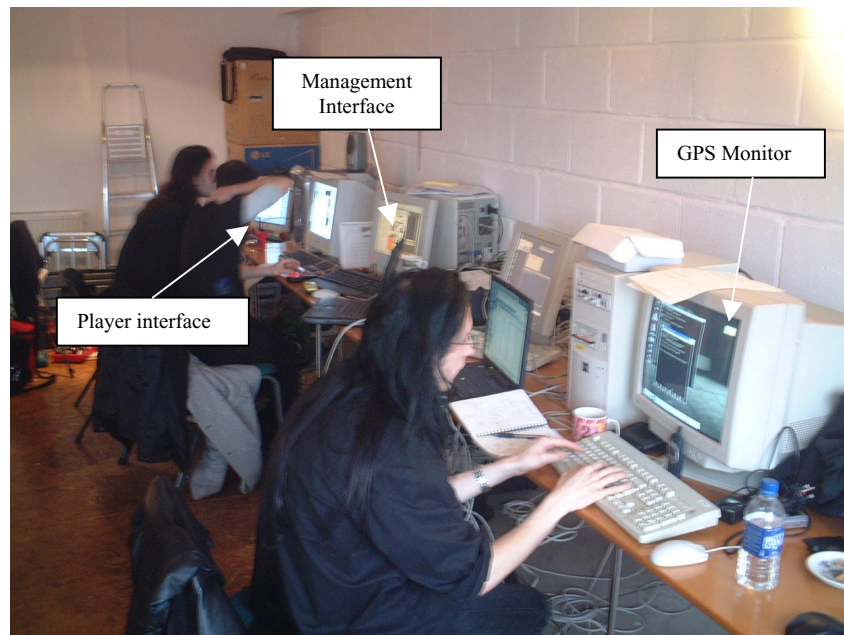


Fig. 6. Monitoring interfaces in the control room

Having established an overview of the design of Can You See Me Now? we now turn our attention to what happened when the game went live and the lessons that were learned as a result

4. Evaluating Can You See me Now?

Can You See Me Now? was live for 6.5 hours during the weekend of Friday 30th November and Saturday 1st December 2001. 214 players took part over the Internet. 135 of these were caught, 76 logged off and 3 were never caught. The best 'score' (time without being caught) was 50 minutes. The worst was 13 seconds.

Can You See Me Now? was commissioned by the Arts Council of England, BBC Online, and b.tv as part of Shooting Live Artists, a programme of new media performances, installations and an associated conference that was taking place in Sheffield's National Centre for Popular Music. This commission provided a production budget to top up our core research from the Engineering and Physical Sciences Research Council through the Equator project. It also provided us with publicity and hence a pool of interested players, including delegates at the conference (who used a suite of public machines) and others who saw the publicity on the BBC website.

4.1. Approach to evaluation

As with our previous experiments that involved using emerging technologies to stage public events [11, 13], our evaluation draws on several sources of information.

We gathered offline feedback from players via email and our web-site and also held debriefing meetings with the project team in order to solicit the opinions of different participants. This provided us with an initial high-level view of how the event had unfolded and framed issues for deeper exploration.

We made ethnographic observations (utilising video and field notes) of the activities of the different participants, including runners, players and the behind-the-scenes production crew. Ethnography is a natural observational method that seeks to provide rich descriptions of the social organization of work-in-context. It is one of the oldest methods in the social research armory and has been found to be of considerable utility to the designers of interactive technologies [7]. This follows from the recognition by designers that successful research and development increasingly relies upon an appreciation of the social circumstances in which systems are deployed and used [10]. The method is particularly good at identifying the social demands that may be placed on new technologies in their use.

We instrumented the underlying system to log all movements and text messages. Subsequent statistical and manual analysis of this data revealed broad patterns of user activity (frequencies, distributions and correlation of movements and communication) in order to support or contradict other observations.

We have previously employed these methods to study interaction within collaborative virtual environments and mixed reality (see, [8,11,13,14,15] for examples). Our aim in applying them to Can You See Me Now? was to build a rich picture of participants' experiences that would lead to new design insights. We now summarise some of the key issues that have emerged from our analysis, illustrating them with examples of participants' interactions and collaboration. We group these issues under two broad headings: gameplay and orchestration.

4.2. Gameplay issues

Gameplay issues focus on the players' and runners' experiences of the game, their tactics, and ways in which the game could be improved or extended. We begin with general descriptions of 'tactics' before narrowing down on specific design issues.

4.2.1. Runners' tactics

The runners tactics changed significantly over the course of the event. The first session on the Friday saw them running frantically through the streets. Following a debriefing meeting on the Friday night, it was agreed that the players needed to be slowed down. However, this technical fix turned out to be impossible to implement in time, and so the Saturday sessions began with the players at the same speed. However, the runners then changed their tactics in several significant ways. First, they slowed down in order to lure the players in, and then suddenly sprinted to catch them. Second, they learned to exploit areas of good GPS coverage where having accurate updates would make it easier to catch the players. Third, and perhaps most importantly, they collaborated more closely, essentially hunting as a pack, and cornering chosen victims. This tactical approach is perhaps best summarised by the following fragment of conversation that was observed in control room during a rest period:

Steve: So your tactics: slow down, reel them in, and get them?
Runner: If they're in a place that I know it's really hard to catch them, I walk around a little bit and wait till they're heading somewhere where I can catch them.
Steve: Ambush!
Runner: Yeah, ambush.
Steve: What defines a good place to catch them?
Runner: A big open space, with good GPS coverage, where you can get quick update because then every move you make is updated when you're heading towards them; because one of the problems is if you're running towards them and you're in a place where it slowly updates, you jump past them, and that's really frustrating. So you've got to worry about the GPS as much as catching them.

These observations are backed up by analysis of system logs of the runners' movements. Plots of the normal distribution of runner speeds showed that the runners went from running at a relatively fixed speed (2 meters per second) at the beginning of the event, to utilizing a broader distribution of speeds at the end. Also, as the game progressed, the distribution of distances from one another was broader, yet the mean distance decreased to around 75 meters.

The main implication of these observations is to realise that creating a successful experience relies as much on participants' tactics as it does on the underlying technology. We believe that early public experiments such as *Can You See Me Now?* can play an important role in understanding what kinds of strategies and tactics might form the basis of future games.

4.2.2. Players' tactics

The overall picture of the players' tactics is less clear, probably due to the lack of long-term and repeated exposure to the game that would have enabled them to develop coherent strategies (in contrast to the runners). However, some general trends can be observed.

There were many examples of the players using text messages to taunt the runners and goad them into action (an example of player-runner coordination). Some typical (and printable) examples include:

```
lee      they_are_useless
adam     they_need_exercise
unfit_tel_ come_and_get_me_coppers
graham   come_and_get_me_suckaz!!
```

These hint at why the runners' tactic of slowing down was effective; as there was little else to do in the game, the players seemed to be naturally drawn into flirting with danger. Due to technical and topographical constraints, however, there was no guarantee that such 'goaded' strategies would always work. A player might goad the runners but poor GPS reception or physical terrain characteristics often resulted in the runners ignoring the player's taunts. Interaction between runners and players therefore relied as much on the runners' adaptation to conditions on the ground (manifest in discrete practical strategies as noted above) as it did on direct communication.

The players also used text messages to coordinate with one another. The introductory web page and interface provided hardly any instruction as to how to play. Engagement with the game thus relied upon players' familiarity with and expectations about the technology (e.g. that one may move around by using the arrows keys, that the avatar in my view is mine, that one may communicate with others via text messages, etc.). This working knowledge was often not sufficient for establishing a specific sense of the game's workings, and so a significant coordinational feature of player interaction was to instruct each other as to how to play (as in the following example involving the players Perry and '0000'):

```
0000      what is going on? Ive no idea
Perry     avoid_the_runners -
0000      what_do_the_runners_look_like?
Perry     orange figures -
```

Text messaging not only provided instructions to players as to how to understand the game and engage in it, but also supported the coordination of collaboration between players, where players would explore the game-play environment and interact with the runners together. Examples included trying to meet at a common location, reporting when they were being chased or were about to be caught, and exchanging encouragements and tips.

The work of collaborating in game play required the players to establish recognizable identities. However, all the players had undistinguished blue avatars. In order to collaborate it was therefore necessary for the players to distinguish between the avatars in the shared environment. The work of 'distinguishing' avatars consisted of sending text messages querying the shared view (e.g., "is that you on the right?"), and

responding to queries both textually and through taking action in the environment (e.g. “that’s me moving up and down”).

In summary, providing a communication channel among the players, in this case through text chat, supported several aspects of playing the game through interaction with both runners and other players. Supporting the easy identification of other players would have enhanced this channel.

4.2.3. Exploiting local knowledge

The runners made extensive use of local knowledge of Sheffield to coordinate their actions. Collaboration between runners was primarily achieved through the use of the walkie-talkies. The following sequence shows the work involved in coordinating runner-runner interaction.

Runner 1 on walkie-talkie: I need a runner at the glowing mushroom. I need a runner at the glowing mushroom.
Runner 2 on walkie-talkie: I’m thirty seconds away.
Runner 1: I need another runner to meet me at the glowing mushroom.
Runner 2: I’m ten seconds away.
Runner 1: Where are you?
Runner 2: I’m going round to your right.
Runner 1: Okay.

As the sequence makes clear, the use of the walkie-talkie in the coordination of the actions of the runners relied on, and was accomplished through, the use of local reference points. The runners were familiar with the topographical features of the built environment in which the game took place. Runners knew the location of structures that made up the built environment and were aware of the spatial relationship that buildings had to other structures (pavements, roads, walls, etc) together with the contours of the landscape (incline, slopes, and hills). This meant that the runners shared common knowledge of the physical landscape, which was embodied in locally formulated names (e.g. ‘the glowing mushrooms’). These names provided shared points of reference in the physical terrain that the runners oriented to and employed to coordinate their actions.

However, these named landmarks were not reflected in the digital domain (e.g., as labels on the shared map) and so, on the whole, the players did not share the same knowledge of the game environment as the runners. Consequently, a particular player might not be aware that he was being targeted, or how far off a particular runner was, or what direction the runner was approaching from, or where blind spots were in the game, etc., and so might not take evasive action until it was too late, or alternatively might take evasive action when none was required.

One solution would be to label common landmarks and key locations on the map. This might be done in advance of the game. More interestingly however, the game might also allow participants to create and share their own annotations (after all, the label “glowing mushroom” does not appear on any conventional map of Sheffield).

Local knowledge also extends beyond labels, to include other features of the environment. For example, there was a relatively large hill in one part of the playing area.

Repeatedly running up this hill was tiring for the runners (and hence would have been a good tactic for the players). Similarly, traffic on busy roads would have hindered the runners and so could have been exploited by the players had they been more aware of it. A few players did figure out such tactics. As one put it in an email sent after the event:

“I figured out pretty quickly what was uphill and downhill. I also figured out which was the main road to cross”

However, many players apparently did not and might have benefited from techniques to enrich their local knowledge. Features such as hills, traffic and other obstacles might be represented on the map. They might also be more subtly incorporated into the gameplay. For example, players might be slowed down when moving uphill. Finally, video cameras might be used to provide live views of the city streets to the players, a feasible idea given the growth of traffic and other cameras in public spaces and their increasing availability over the web. Feedback from one of the players after the game clearly identified the potential of such views. This player revealed that they had been playing from a machine in the National Center for Popular Music next to a window that enabled them to look out onto the game area. They reported thoroughly enjoying moving across the online map only to see a runner physically chasing past a few seconds later.

4.2.4 The importance of audio

Although often of poor quality, it appears that the real-time audio stream from the runners' walkie-talkies could have a significant impact on a player's experience. In particular, hearing their name mentioned by the runners could be an exciting moment for a player. As our previous player put it in the same email:

“I only managed to get on to the map once for about 15 minutes. I can't remember the name I used, but it was pretty un-nerving first hearing my name said”

In addition, the audio stream did provide a further mechanism for conveying local knowledge. The runners would often make references in their talk to local features including landmarks (as already mentioned), traffic conditions (e.g., “I'm waiting for a Green Man” meaning I'm waiting at a road crossing), being tired, or the state of the technology (e.g., references to batteries being low and GPS accuracy). Although many players may have failed to pick up on these cues (possibly due to some problems receiving the audio stream over the Internet), this seems like a potentially useful approach for future games. In short, real-time audio can play an important role in building tension and in revealing local conditions by having participants describe them to one another.

4.2.5. Entering and exiting the game

Entering and exiting were two key points in the game. On entering the game players were dropped directly into main the game area at one of ten randomly chosen

locations. At this point, many of them were still confused. It might have been better to initially drop the players into a safe zone away from the main game play. Here they could become familiar with the game, orientate themselves and form relationships with other players before progressing to the main play area to deal with the runners. Another possibility would have been to allow players in the game queue to watch the game being played by others in advance of their turn (an idea that we toyed with before the event, but didn't have time to realise).

Exiting the game also raised issues. The runners had established a common ritual for when a player was caught: they would take a digital photograph of the site of capture (to appear on the web archive after the event) and would then report the player's name and time and location of viewing over the walkie-talkie. The game server would also generate a text notification that was sent to all participants. It was common for players to use text messages to notify others of imminent capture or to support others in trouble as in the following exchange between Nanny and Scott:

```
nanny      they've_got_me_in_a_pincer_movement
scott      nanny_good_luck
nanny      am_doomed
scott      no_way_to_fight_them
scott      bye_nanny
scott      come_back_reincarnated
```

There were even some reports of players coming back just to say goodbye to others. However, there was no ritual that allowed players to mark the moment of being viewed. The game could have been extended to allow players to mark the moment of their passing, perhaps with a final text message that would have been sent to other players and posted to the archive web site.

4.3. Orchestration issues

Orchestration issues focus on the management of the game by the production crew from behind the scenes, and how the technology supported and hindered this.

4.3.1. Interfaces for monitoring the state of play

As noted previously the control room housed a number of tools for monitoring different aspects of the state of the game. Control room staff spent a great deal of their time monitoring the game and working together as shown by the following example of shoptalk:

```
Steve is playing the game: How many players have we got?
Martin is looking at the global view: 21 players so far.
Steve: Altogether or at the moment?
Martin looks at the global view.
Martin: You've got 21.
Steve: Is it just two at the moment?
```

Martin: What, players or runners?

Steve: Runners.

Martin: All three are out there. Dave's joined.

Steve: Just two players?

Martin: Two players.

This fragment illustrates an important issue. In the first instance, the crew was interested in establishing an overall picture of the status of the game. What was being asked for when querying the population and its make up (of runners and players) was not so much a head count, but whether or not the game was working properly? Being able to 'see', via the global monitor, that players were engaged in the game 'told' the controllers that the online system was working. Similarly, being able to see that a number of runners were actively engaged in the game told the controllers that the runners' gear was working. And, taken together, the global view on the game told the controllers that there were no prima facie technical problems.

However, our monitoring tools were not ideal for this purpose. There were several problems with both their content and style:

- the GPS and 802.11b monitors provided very low level information that was difficult to read at a glance and that required expert interpretation.
- the information was spread across several monitors in the control room.
- some vital information was not available. Dead batteries turned out to be a particular problem for Can You See me Now? A combination of the power management system and battery status reporting on the iPAQs made it difficult to predict when the runners' devices would fail and, as a result, they tended to fail mid-game. Orchestration would have benefited from accurate telemetry data concerning battery status.
- another class of missing information concerned the status of the players. For example, there was no visible indication of the length of the queue and no easy way of detecting problems with specific players (such as the frequent failure to receive the audio stream).
- monitoring information was associated with a particular device (i.e., iPAQ). However, a scheduled change over of runners (the runners worked in overlapping shifts with three on and one off at any time) or the complete failure of a device (necessitating the introduction of a spare) meant that a runner would swap devices. It proved difficult to keep track of which runner was using which device (a problem when talking to the runners over the walkie-talkies).

We propose that more sophisticated monitoring interfaces are required for future events. These should make it easy to get a quick overall sense of the status of the game or of particular participants. At the same time they should support drilling down to obtain more complete detailed information on a particular participant (including battery status and runner name).

4.3.2. Intervening outside the control room

An important feature of Can You See me Now? was that orchestration spilled out of the control room and onto the streets. The following sequence of shoptalk elaborates what this work was about and the ways in which it was coordinated.

Jamie on walkie-talkie: Okay, I'm coming in. I need batteries for my GPS.
Steve: Is the GPS down? Did he have any (batteries) before?
Martin: Yeah.
Steve: So he's had two sets.
Martin picks walkie-talkie up: Jamie, what's the problem?
Jamie: Me batteries gave up.
One of the control room staff comes into the room.
Martin: Can you get some batteries and take them out to Jamie, some GPS batteries. Staff gets and takes batteries.
Steve is looking at the management overview monitor: Three runners are there?
Martin: Yeah. Jamie's changing his batteries. [Inaudible].
Steve: He's just?
Martin: His GPS is working again, he's just waiting for satellite.
Jamie: Satellite, I've got two satellites.
Martin looking at GPS monitor: Jamie's been down for eight minutes - ooo, he's back.

Coordination between controllers and runners over such practical matters as getting new batteries and establishing whether or not this or that was the 'problem', was facilitated via the mechanisms described previously: the walkie-talkies, the game overview, the GPS monitor and the 802.11b monitor. However, resolving these problems required us to deploy a full time member of the production crew outside of the control room, at street level, so that they could directly service the runners (e.g., changing batteries or trouble shooting with the iPAQs and GPS receivers). In turn, this raised the issue of how this person monitored the game (what kind of interface was available to them) and how they communicated with the runners and the other crew in the control room. A further problem was that it still took the runners approximately five minutes to reach this person whenever they needed help – a major disruption to the game. Perhaps this crew-member should themselves have been mobile?

Such problems will become more acute as the scale of mobile games increases. What if the game had been taking place across the entirety of Sheffield? Runners might then have been up to an hour away from the control room? Future large-scale events will need to consider a combination of more robust technologies for mobile participants combined with mobile control centers (i.e., based suitable vehicles).

5. Summary

Can You See me Now? was an experimental mobile mixed reality game in which on-line players were chased across a map of a city by three runners on its streets. The runners were equipped with handheld computers that displayed a live map of the game environment (showing the positions of all runners and players) and that also

transmitted position updates from an attached GPS receiver back to the game server over an extended 802.11b network. The runners' movements, along with a digital encoding of walkie-talkie audio communication between them, was then transmitted over the Internet to the online players, who in return were generating their own position updates as well as text messages.

Can You See Me Now? was staged as a public event over two days, during which period over two hundred players took part. This provided a valuable opportunity to learn about the issues involved staging mobile mixed reality games. A combination of ethnography, discussions with key participants and analysis of system logs, highlighted a variety of design issues including:

- The ways in which the runners could change the experience by varying their tactics (rather than changing the technology);
- The different uses that the players made of a shared communication channel, including goading the runners, explaining the game to one another, and commentating on key moments (such as their own capture).
- The importance of local knowledge to playing the game, and the need to make this more available to players through better labeling, shared annotations, extensions to gameplay or remote video views.
- The role of the runners' audio stream in creating tension for the players and in revealing conditions on the ground.
- The need to carefully design the players' entry to and exit from the game.
- The need for more powerful monitoring displays that convey the overall status of the game while also allowing crew to drill down into richer information about specific participants (including battery status and who currently has which device).
- The need to provide support for the runners on the streets, which might require mobile control units in future larger-scale experiences.

We plan to carry these issues forward into further public trials. With this in mind, we have recently secured funding to stage a larger-scale event in London in 2003. Our goal is to create a richer, more narrative-based experience that spans several locations across the city and that also involves public players on the streets as well as online. We hope that this event will enable us to further explore the potential of mixed reality gaming and to shed light on the combination social and technical issues that it raises.

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References

1. Azuma, R. T., "A Survey of Augmented Reality", *Presence: Teleoperators and Virtual Environments*, 6(4): 355-385, Aug. 1997.
2. Azuma, R., "The Challenge of Making Augmented Reality Work Outdoors", In *Mixed Reality: Merging Real and Virtual Worlds*, 1999, Springer-Verlag.
3. Benford, S., Bowers, J., Chandler, P., Ciolfi, L., *et al.*, "Unearthing virtual history: using diverse interfaces to reveal hidden virtual worlds", in *Proc. Ubicomp 2001*, Atlanta, 2001.
4. Bjork, S., Falk, J., Hansson, R., Ljungstrand, P. (2001). "Pirates! Using the Physical World as a Game Board". *Proceedings of Interact 2001*.
5. BotFighters web site (In Swedish) <http://www.teliamobile.se/botfighters/>, News article on BotFighters http://on.magazine.se/pdf/6_2000/Games1.On_6_2000.pdf
6. Bowers, J., O'Brien, J., and Pycock, J. (1996) "Practically accomplishing immersion: cooperation in and for virtual environments", *Proc. CSCW '96*, 380-389, Boston: ACM Press.
7. Crabtree, A., Nichols, D.M., O'Brien, J., Rouncefield, M., and Twidale, M. (2000) "Ethnomethodologically informed ethnography in information systems design", *Journal of the American Society for Information Science*, vol. 51 (7), pp. 666-682.
8. Crabtree, A., Rodden, T. and Mariani, J., "Designing virtual environments for cooperation in the real world", *Journal of the Virtual Reality Society*, London: Springer-Verlag.
9. Geocaching web site <http://www.geocaching.com/>
10. Goguen, J. (1993) "Social issues in requirements engineering", *Proc. 1993 IEEE International Symposium on Requirements Engineering*, pp. 194-195, San Diego: IEEE Press.
11. Greenhalgh, C. M., Benford, S. D., Taylor, I. M., Bowers, J. M., Walker, G. & Wyver, J., "Creating a Live Broadcast from a Virtual Environment", *SIGGRAPH '99*, 375-384, 1999.
12. Ishii, H., Wisneski, C., Orbanes, J., Chun, B., & Paradiso, J. (1999). "PingPongPlus: Design of an Athletic-Tangible Interface for Computer-Supported Cooperative Play". *Proceedings of CHI '99*, pp. 394-401, ACM Press.
13. Koleva, B., Taylor, I., Benford, S., Fraser, M., Greenhalgh, C., Schnadelbach, H., vom Lehn, D., Heath, C., Row-Farr, J. and Adams, M., "Orchestrating a Mixed Reality Performance", in *Proc. of ACM CHI 2001*, Seattle, USA, pp. 38-45, ACM Press.
14. Pettifer, S., Cook, J., West, A., Murray, C., Trevor, J., Mariani, J., Coleborne, A. and Crabtree, A. (2000) "Exploring electronic landscapes: technology and methodology", *The Society for Imaging Science and Technology & International Society for Optical Engineering's 12th International Symposium*, vol. 3960, pp. 2-13, San Jose: IS&T/SPIE Press.
15. Schnädelbach, H. *et al.*, "The augurscope: a mixed reality interface for outdoors", *CHI 2002*, ACM Press.
16. Starner, T., Leibe, B., Singletary, B., & Pair, J (2000b), "MIND-WARPING: Towards Creating a Compelling Collaborative Augmented Reality Game", *Proceedings of Intelligent User Interfaces (IUI) 2000*, pp. 256-259, ACM Press.
17. Starner, T., Leibe, B., Singletary, B., Lyons, K., Gandy, M. & Pair, J. (2000a). "Towards Augmented Reality Gaming", *Proceedings of IMAGINA 2000*.
18. Tamura, H. (2000). "Real-time interaction in mixed reality space: Entertaining real and virtual worlds", *Proceedings of IMAGINA 2000*.
19. Thomas, B.H., Close, B., Donoghue, J., Squires, J., De Bondi, P., and Piekarski, W., "ARQuake: A First Person Indoor/Outdoor Augmented Reality Application", *Journal of Personal and Ubiquitous Computing*. To Appear.
20. [www.canyouseemenow](http://www.canyouseemenow.com/), verified 12 April 2002
21. www.equator.ac.uk, verified 12 April 2002
22. www.blasttheory.co.uk, verified 12 April 2002