Design in the Absence of Practice: Breaching Experiments

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Abstract
IT research is often informed by studies of the practices that new technologies are to be embedded in and which they transform in their use. The development of mixed reality, tangible, ambient, ubiquitous, mobile, and wearable computing have seen the emergence of a range of technological innovations that have little or no grounding in current practices, however. Such developments create new practices where none existed before and the challenge for multi-disciplinary research is to adapt to this situation. This paper articulates a novel methodology that treats technological innovations as 'breaching experiments', whose situated use beyond the confines of the research lab may be studied ethnographically to support innovation.

Categories & Subject Descriptors: J.4. **[Computer Applications]**: Social and Behavioral Sciences - *sociology*; D2.10. **[Software Engineering]**: Design - *methodology*.

General Terms: Experimentation

Keywords: Multidisciplinary design, ethnography, breaching experiments.

INTRODUCTION

Understanding practice has long been a chief concern of IT research and systems design, and one that has seen the widespread emergence of multi-disciplinary work. Today a wide range of social science disciplines, the humanities, and the arts are involved in foundational research. The inclusion of these disciplines has been encouraged by funding agencies and research councils across Europe and the US and been promoted by international conferences such as *CHI*, *CSCW*, and *DIS*. Multi-disciplinary participation has been accompanied by the development of a diverse corpus of design methodologies, which in the various technical ways of their founding disciplines, seek to understand practice and bring these understandings to bear on the creative process of design.

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The diversification and development of new fields of computing raises a new challenge for multi-disciplinary work, however. Mixed reality, tangible and ambient computing, ubiquitous, mobile and wearable computing, etc., have seen the emergence of a range of technological innovations that have little or no grounding in existing practice. Instead, these technologies create entirely new possibilities, and practices for their use have yet to emerge. How, then, are disciplines that take practice as their object of inquiry and study to proceed in the *absence* of practice and, furthermore, to support innovation in design?

In this paper we articulate a solution we have developed over the course of our own research to address how we might incorporate ethnography into an innovative process of research and development at the Mixed Reality Laboratory. By ethnography it should be said that we refer here and throughout this paper to ethnomethodologically-informed ethnography [10, 11]. While the approach has been of considerable utility in work-oriented research, being notably pioneered by colleagues at Xerox and Lancaster University, it has been a longstanding problem as to how to incorporate the approach into processes of innovation and the "invention of the future" [4].

In the absence of practice, our solution to the problem consists of treating technological innovations in an experimental fashion. The rationale at work here is similar to that employed by Ed Hutchins, who sees experiments as socially organized events which may be studied ethnographically to explicate the interactional practices involved in their production [18]. While Hutchins' 'ethnographically-natural experiments' are confined to the laboratory, however, our approach is based on conducting experiments 'in the wild' where technological innovations might be confronted by a host of socially organized contingencies that both shape their use and inform their continued development [e.g. 5, 13, 19, 6].

We employ ethnography to explicate the sociality of use by treating technological innovations deployed in the wild as 'breaching experiments' [15] that illuminate the interactional practices organizing use. We briefly outline the notion of breaching experiments below before moving on to elaborate the approach through a series of practical examples describing the interactional practices involved in the production of a mixed reality game and their relevance to design [14]. These examples articulate how the approach may be put to work to support innovation in design.

BREACHING EXPERIMENTS

The ethnomethodological notion of breaching experiments has recently been employed by Steve Mann [20] in his remarkable exploration of computer wearables and surveillance technologies. Mann employs breaching experiments to actively create situations of uncertainty, bewilderment, anxiety and confusion in order to bring into question everyday structures of surveillance, governance, and control. Mann wants technology to empower users and he seeks to employ breaching experiments to make visible and so invert the power structure of networked surveillance.

Mann's notion of a breaching experiment reflects a common reading of Garfinkel's work, where the breaching experiment is construed of as a research procedure that necessarily disrupts ordinary action in order that the sociological analyst might "detect some expectancies that lend commonplace scenes their familiar, life-as-usual character, and to relate these to the stable social structures of everyday activities" [15]. It was no part of Garfinkel's program to use such experiments as political devices, however, to invert the power structure of surveillance or whatever else, but rather, to make the taken for granted ways in which "the structures of everyday life are ordinarily and routinely produced" visible and available to sociological reflection. "Making trouble" – or breaching everyday activities – was conceived of as one way in which the empirical study of social organization might proceed.

The emphasis placed on disrupting everyday activities is overstated, however, and even misleading if taken too literally. If we consider the breaching experiments reported by Garfinkel, for example, then it is clear that "bewilderment, consternation, and confusion … anxiety, shame, guilt, and indignation" are not essential features of the breaching experiment. While his students often reported these effects when carrying out breaching experiments, it is also clear that they were not *always* present on the occasions when the experiments were carried out.

When medical students were asked to assess a "boorish candidate" at interview, for example, Garfinkel reports that 7 out of 28 subjects (25% of the experiment's population) did not realise they were the victims of a well-contrived deception until after the fact. Or again, when sociology students were asked to bargain for goods in shops, they reported that:

> *… they were enjoying the assignment [and that] they had learned to their 'surprise' that one could bargain in standard priced settings with some realistic chance of an advantageous outcome, and planned to do so in the future, particularly for costly merchandise.*

Hardly an occasion defined by bewilderment, consternation, confusion, and the rest. What is being suggested then, is that disruption is not a *necessary* criterion of the breaching experiment, though it may be sufficient.

Instead of construing of breaching experiments in narrow terms of sufficiency, however, the absence of necessity provides grounds to acknowledge the broader scope of the breaching experiment, one which goes beyond the "making of trouble" yet nevertheless respects the *spirit* of the procedure as conceived of by Garfinkel:

> *[Breaching experiments] are demonstrations, designed, in Herbert Spiegelberg's phrase, as 'aids to a sluggish imagination'. I have found that they produce reflections through which the strangeness of an obstinately familiar world can be detected.*

For Garfinkel, breaching experiments are essentially "aids to a sluggish imagination", whether that be the sociological imagination, or design imagination, or, in a multi-disciplinary context, both.

Accordingly, we suggest that in the absence of practice with which to inform design, novel technological innovations might be deployed in the wild in order to confront them with novel situations and ad hoc practices devised on the fly to make the technology work 'here and now'. Novel technological innovations may be treated as breaching experiments then, in that they *provoke* (in the etymological sense of 'call forth') practice and make it visible and available design reasoning. Construed of as a provocational rather than a disruptive procedure, breaching experiments have clear parallels with provotyping, where technological innovations 'trigger' cooperative analysis of practice and elaborate the design space [21]. Breaching experiments do not make existing practice available to analysis however – as none exists – but make visible the contingent ways in which the technology is made to work and the interactional practices providing for and organizing that work. Knowledge of these novel practices may, in turn, be employed to support innovation, as we articulate by practical example in the following section.

CAN YOU SEE ME NOW?

Can You See Me Now? (CYSMN) is a mobile mixed reality game where runners situated in the physical streets of a city chase and catch online players [14]. Winner of the 2003 Prix Ars Electronica award for Interactive Art [16], CYSMN is a multi-disciplinary collaboration between the performing arts group Blast Theory [2] and the Mixed Reality Laboratory. The game was first staged as a public event in Sheffield over one weekend in December 2001 as part of the BBC's groundbreaking event, Shooting Live Artists [24].

The Technology

CYSMN allowed up to 10 online 'players' to log into the game on the Internet simultaneously and be chased through a virtual model of a circumscribed area of Sheffield by 4 'runners', professional performers, who were located on the actual city streets and interacted with the players via handheld computers. The runners' interface was delivered to them on a Compaq iPAQ from a server located in a nearby building over an 802.11b wireless 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.

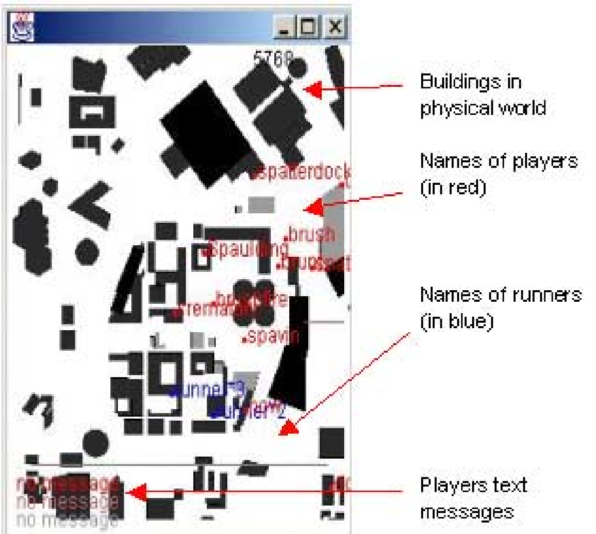

Figure 1. Runners' interface (global view)

Given the small screen size of the iPAQ, the runners' interface allowed them to zoom between a global view of the gameplay area (Figure 1) and a close-up local view centered on their current position. In either view, player's positions were indicated by their online names displayed in red text. Runner's positions were indicated by their online names in blue text. The runners could also see the latest text messages sent by players. The runners communicated with one another and support staff via walkie-talkies with earpieces and a head-mounted microphone. The runners' talk was also broadcast to the players and 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 [8].

Players had a local view of the gameplay area (Figure 2) and moved through a 2D virtual model of the city streets at a fixed maximum speed.

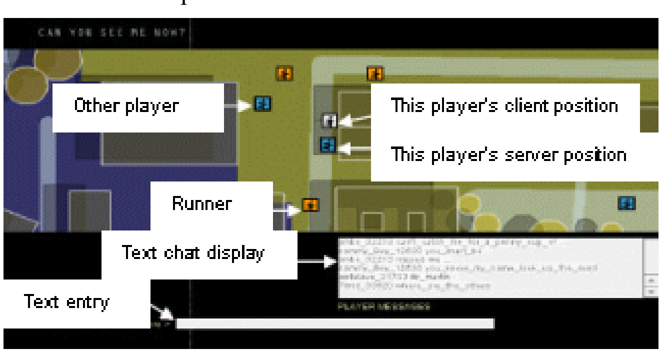

Figure 2. Players' interface

A white player icon showed their current position according to their local client, providing immediate feedback as to their movement whenever they pressed a key. A blue icon showed their position according to the game server. This would trail behind the white icon with a lag of about one second due to the communication delay between client and server and the time taken to process players' movements at the server. Other players were represented as blue icons. Runners were shown as orange icons. Players communicated with one another and the runners via text messaging. When a runner got within 5 metres of a player, the player was caught, removed from the game, and offered a chance to re-enter the game queue.

While the technology was clearly designed to meet a use-purpose (playing a game), it is worth pointing out that the design was of a planful character. That is, it was designed to work according to a plan of use – that players would act in 'this' way, and runners 'that' way, and the technology would support projected forms of interaction. The technology was not designed for the actual circumstances whereby the plan (the game) was *realised* however, [25] as those circumstances were not yet known. In the following section we elaborate the unknown by examining ethnographic vignettes of the technology-in-use [3]. These vignettes are used to articulate the main findings to emerge from situating the technology in the wild and provoking practice.

Breaching Experiment #1. Sheffield

Previous attempts to migrate augmented reality outdoors have highlighted GPS inaccuracy as a primary research issue [1]. While GPS is a versatile positioning technology for outdoor applications it can also be problematic, particularly with regard to inaccuracies that vary according to location on the Earth's surface, time of day, proximity to buildings, and weather. GPS accuracy ranges from a few centimetres up to tens of meters, and is often worse in urban environments and when using budget GPS receivers, both of which were significant factors in CYSMN.

Analysis of the system logs showed that from a technical perspective the GPS set-up employed in the game was highly inaccurate. Estimated errors ranged from 4 metres to 106 metres with a mean of 12.4 metres and a standard deviation of 5.8 metres. Error varied according to location in the game area, with some of the more open spaces typically exhibiting only a few metres error while the more narrow built up streets suffered considerably more. Consequently, the GPS situated runners in different locations on the map compared to their actual physical locations on the streets. They also resulted in the runners' avatars making sudden unfeasible jumps across the map. Such extreme errors were due to multi-path reflections or temporary losses of satellite visibility. Despite a wide variation of errors the runners still managed to capture players and to do so routinely without recourse for complaint or concern. GPS error was *not* a significant problem for the runners then, but how was this so?

Runner 1 (on walkie-talkie): I've taken a photograph of Sammy Boy.
Runner 1 (on walkie-talkie): The time is 7:16 pm.
Runner 1 puts the camera back in his bag and then looks at the iPAQ interface.
Runner 1 (on walkie-talkie): *Laughs* - 2 down!
He changes his view on the iPAQ (from local to global) and looks to see who is where on the map.
Runner 1 to other runners (on walkie-talkie): OK, I'm going to see if I can come and help you with Jimbo (another player).
Runner 1 to other runners (on walkie-talkie): See if you can get above Jimbo and drive him down towards the roundabout; I'll try and cut him of at the roundabout.

Technically, location is furnished by GPS, which articulates the runner's geographical relation to one another and their virtual relation to online players. Interactionally, and as the above vignette shows us, locating runners and players consists in the doing of *locational work*. The vignette instructs us that locational work consists of the contingent conversational formulation of collaborative game-play strategies, within which the technology is embedded and used. The contingency of the matter revolves around who is playing the game and where they are. Thus, the runners might formulate the following collaborative strategy: "get above Jimbo and drive him towards the roundabout where I'll try to cut him off". Whatever the particular case, it was through the formulation of collaborative game-play strategies that the runners came to manage GPS inaccuracies and make use of an apparent deficiency in the technology to actually enhance gameplay:

Ethnographer: 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.
Ethnographer: Ambush!
Runner: Yeah, ambush.
Ethnographer: What defines a good place to catch them?
Runner: A big open space, with good GPS coverage, where you can get quick updates 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.

GPS accuracy was not construed of as a problem by the runners then, but, through hands-on experience, as something to be exploited to inform the contingent formulation of collaborative gameplay strategies. In other words, the contingent formulation of gameplay strategies was directly informed by the runner' *working knowledge* of GPS accuracy. As the above vignette instructs us, that knowledge was used to inform decisions as to what 'what makes a good place to catch players' (and what doesn't) and what strategies it was therefore appropriate to formulate. Thus, and for example, trying to 'drive a player down towards the roundabout' was a good place to catch a player because there was a high level of GPS accuracy at that location.

Further examination of locational work also instructed us that the contingent formulation of collaborative game-play strategies relied on another distinct type of knowledge:

Runner 1 (on walkie-talkie): I need a runner at the glowing mushrooms! I need a runner at the glowing mushrooms!
Runner 2 (on walkie-talkie): I'm thirty seconds away.
Runner 1 (on walkie-talkie): I need another runner to meet me at the glowing mushroom.
Runner 2 (on walkie-talkie): I'm ten seconds away.
Runner 1(on walkie-talkie): Where are you?
Runner 2 (on walkie-talkie): I'm going round to your right.
Runner 1looks to his right and sees Runner 2.
Runner 1 (on walkie-talkie): OK.

Figure 3. The "glowing mushrooms" – 2 distinctive structures

This vignette shows us that the contingent formulation of collaborative game-play strategy also relied on *local knowledge of the physical environment* in which gameplay was situated. Like working knowledge of the technology, local knowledge of the environment was developed over the unfolding course of the game and exploited to coordinate the runner's actions in the accomplishment of locational work. Coordination relied on the runners' familiarity with the physical terrain features of the environment. Through experience, the runners came to know the location of structures that made up the built environment and became aware of the spatial relationship that buildings had with other structures (pavements, roads, walls, cul-de-sacs, etc.), together with the contours of the landscape (inclines, slopes, and hills). This knowledge was articulated in locally formulated names (e.g. 'the glowing mushrooms'), which provided *shared points of reference* in the physical terrain that the runners employed and oriented to, to coordinate their actions and track down players.

Local knowledge was essential to the runners' concerted efforts to 'make the technology work'. It was not that the two forms of knowledge – local knowledge of the environment and working knowledge of the technology – were separate phenomena, however. While distinctions may be drawn for analytic purposes (such as writing up reports), in practice the two were thoroughly intertwined and combined to form a *common stock of knowledge* [23] for playing the game. Observably, working knowledge of the technology (e.g. knowing 'where a good place to catch a player is') informed the formulation of collaborative game-play strategy in terms of local knowledge of the environment (e.g. 'drive him towards the roundabout' or 'meet me at the glowing mushrooms') and so it was through the combination of the two that the game came to be played in the real world.

It was a notable feature of gameplay that the player's were unable to exploit the common stock of knowledge built up by the runners over the course of the game. The knowledge upon which gameplay relied was not reflected in the digital domain and so the players did not share the same 'picture' of the game as the runners. Consequently, players were often unaware that they were being targeted, they did not know and could not tell how far off the runners were until they emerged in their immediate sector, they could not tell which direction runners were approaching from, and consequently, players often failed to take evasive action until it was too late or alternately, took evasive action when none was required. In short, players could not *assess and respond* to the current state of play: Just how many runners are chasing me? Where are they? What does their talk mean? These were relevant questions that player's could not ask let alone answer given their restricted view and the unavailability of the common stock of knowledge.

Breaching Experiment #2. Rotterdam

The phenomena seen in the breach – seen, that is, in the provocation of practice brought about by confronting the technology with real world circumstances of use – provide concrete resources for thinking about innovation. The practices that the use of CYSMN 'turns upon' – the exploitation of a common stock of knowledge – informed the redesign of the players' interface.

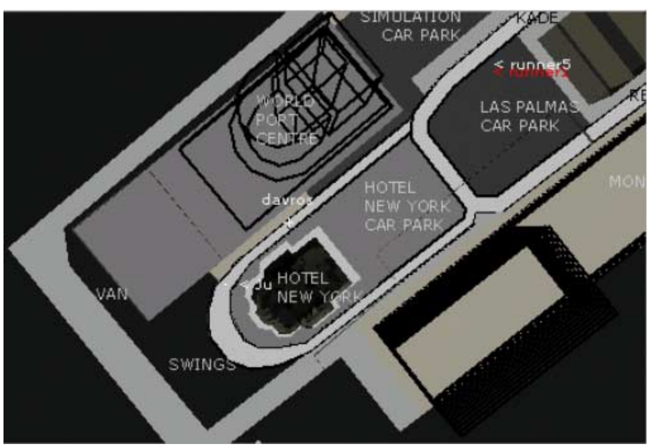

Figure 4. New player interface - exploiting local knowledge

Buildings and topographical features were labeled to reflect the runners' local knowledge of the gameplay environment and provide a shared frame of reference for all parties to the game (Figure 4). The redesigned version of the game also exploited a 3D model of the gameplay area and provided zoom-in/zoom out global, local and ground level views for players and was subsequently deployed in Rotterdam [9]. These changes provided a much richer interactional context for players, enabling them to orient one another to runners, to help each other avoid runners, to take evasive action, to organize collaborative gameplay, and to both find and meet one another, as the following edited text log extracts make visible.

Orienting other players to runners

#1. WILLEM: Where are the runners?
MARTIN: They're all around Las Palmas car park

#2. JOHN DOE: Runner 4 near cafe Rotterdam
TOBY: Heading up by Las Palmas
JOHN DOE: Runner 4 headed for Las Palmas

Helping other players to avoid runners

#3. DANI: Runner 3 at Las Palmas
PHIL: Runner 2 is nearby
CLAUDIA: Shit!!! Runner 3's on our ass
D.BOT: He's still on us - look out Catherine
DANI: Watch out Catherine

#4. SAAB: Mike meet me at cafe Rotterdam
MIKE: Sorry, stalking Anna
ANNA: That's okay Mike
SAAB: Stop stalking her then
MIKE: Anna has a nice butt
ANNA: How do you know?
MIKE: Big imagination
ANNA: Well you're right
SAAB: Mike watch the runner!

Taking evasive action

#5. DAVE: I'm in the south
ANDREW: Runner 4 is in the hotel car park
DAVE: Action
TOMMIE: Christine look right
ANDREW: Run for your lives!
JULES: Run baby run!
CHRISTINE: Thanks!
ANDREW: Runner 4 is west of the swings

#6. TAMA: Runner 1 at Las Palmas car park
ROBERT: North and east is clear
TAMA: Look out Ed! Runners 1 and 2 at Las Palmas

Organizing collaborative gameplay

#7. PAUL: No sign of the runners?
5000: I don't think so
NOBODY: They are in the car parks
5000: What are they doing there?
NOBODY: Chasing nobody
PAUL: It's probably a long way to get over here
PAUL: Lets run
5000: Where to?
PAUL: Lets meet the runners

#8. D.BOT: Runner 3 is still by Koolhaas I think
LANDO: Runner 4
SAN: Near Phil now
LANDO: He is heading to the car park
D.BOT: Bring Runner 3 over this way
CHRIS: I'm feeling suicidal

Finding other players

#9. AMMA: Running around to find Anna. Does anybody see her?
ROBERT: Anna is moving towards Hotel New York

#10. PENNY: Hello Steve we're looking for you
STEVE: I'm near Las Palmas - avoiding Runner 1

#11. VESPER: Jasper where are you?
JASPER: Behind Las Palmas

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#12. MARCEL: Ali I'm somewhere around Las Palmas
ALI: How do I find Las Palmas?
MARCEL: Look at the map, right corner
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Meeting other players

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#13. VESPER: Let's all gather - makes things more exciting
ANNICK: Where?
VESPER: And when the runners come we scatter
PHIL: This could be interesting when they come running for us
VESPER: Between Las Palmas and Sumatra
ANNICK: OK

#14. JASPER: Hi Vesper
VESPER: Runner 2 is ahead
JASPER: Runner 2 on the move
VESPER: Better get moving
JASPER: I'm outta here
LANDO: Where are the runners?
VESPER: Wait for me!!
JASPER: All right
VESPER: Gather at Las Palmas everyone
```

Exploiting local knowledge of the gameplay environment provided a valuable resource for players' collaborations, though this is not to say that the game was trouble free. Players often encountered technical problems and collaborated to make sense of them as the following extracts indicate.

```
#15. MARCEL: Attention. Runner 1 is cheating by using his invisible coat
HBAB: What's an invisible coat?
MARCEL: Never mind what the coat is - he can pop out of nowhere

#16. STEVE: Runner 4 keeps seeing me, but I don't always see them
TOBY: Runner 1 you're moving very fast
TRACY: Sure you're not roller-skating?
ADAM: Ah! Where did Runner 2 come from?

#17. MARJOLEIN: Anyone seen the runners?
MELISSA: I think they can turn off their signal
HANNE: I only see two runners - are the rest taking a coffee?
BLASTER: Runner 1 is just a lazy joke
HANNE: If they can turn off their signal that's pretty scary and not really fair
MELISSA: Tell me about it
MARJOLEIN: Well maybe the satellites don't work properly
```

The problems players encountered were a product of GPS variability and slow network updates [14] and in the absence of working knowledge of technology, this produced situations of uncertainty for players [6]. Were the runners cheating? Did they have invisible coats? Were they on roller-skates? Where did come from? Could they turn their signals off? Are they lazy? Or having a joke? Ethnographic studies of the runners' work on the streets of Rotterdam provided further resources for thinking about how we might augment working knowledge of the technology and develop support for collaboration between runners and players alike [12].

The study revealed that working of knowledge of the technology is in significant respects tied to dealing with interruptions to the game. Working with 'constant interruption' [22] is an irremediable feature of using the technology for two main reasons. Firstly, 802.11b networking has limited coverage. Even though seven wireless access points were distributed across the physical gameplay area (which was roughly 400 metres by 800 metres), the narrow and built up nature of the city streets resulted in many network blackspots where runners could not connect to the game. Secondly, GPS is subject to the contingencies of satellite availability. If too few satellites are visible from a runner's current location (perhaps due to being in the shadow of a building or there being only a few satellites passing overhead at that moment) a runner will not be able to get a GPS 'fix' and will be unable to play the game. Managing such interruptions is, therefore, an essential feature of gameplay for the runners insofar as they must be handled and repaired if interaction is to proceed. The following vignettes elaborate the situated ways in which managing interruptions is tied to the production and use of working knowledge of the technology.

```
Runner 2 on walkie-talkie. Runner 2. I've just lost all players; I've lost all players!
Runner 2: Looking at Jornada. I've got a disconnection here.
```

Figure 5. Seeing a disconnection: losing players

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The runner can do no other than abandon the chase, and he informs his colleagues and players alike that he has a specific problem and just where that problem is located.
Runner 2 on walkie-talkie: Runner 2. Heading seawards on Otto. I am currently disconnected.
He turns around and starts walking back down the street to the last known point at which he had connectivity. He arrives at the carpark where he last checked the Jornada.
Runner 2 on walkie-talkie: Runner 2. I've connectivity again. I'm in Vern.
```

Ethnographic study of runners' work shows how working knowledge of the technology emerges and evolves. We can see, for example, how in experiencing a disconnection the runner makes the kind of interruption he is experiencing public knowledge. An interruption is *announced* to the other runners over the walkie-talkie, making others *aware* of the nature of the interruption and the location at which it occurs. The runner repairs the interruption by retracing his steps and moving to a location where he last had connectivity. This strategy trades on and exploits working knowledge of the technology – of knowing that disconnections are transient technical phenomena that may be resolved by moving to a better location – and at the same instructs us how such forms of knowledge are developed: through hands on experience of using the technology *in situ* and through making others aware of and *sharing* knowledge of the interruptions encountered as they occur. Accordingly, over the duration of gameplay, a corpus of working knowledge of 'good' and 'bad' areas of technology use emerges and evolves. The following vignettes sheds light on the use of working knowledge to manage interruptions.

```
Runner 2 on walkie-talkie: Runner 2. I'm in pursuit of Dave.
He runs along a side-street, consulting the iPAQ as he goes, turning left at the end of the street and going down Wilamena before slowing to a walk.
Runner 2 on walkie-talkie: Runner 2. I'm heading seawards on Wilamena, waiting for a server update.
He continues walking down the street, looking at the iPAQ and his place on the street, seeing the incongruity between his virtual and real positions.
Runner 2 on walkie-talkie: My GPS is currently 35 metres. My server position is about 50 metres out.
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Figure 6. A visible incongruence between virtual and real

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Runner on walkie-talkie: This is Runner 2. Can Runner 1 and Runner 4 hear me, or Runner 3 please? Come in.
Runner 2 switches to the technical channel.
Runner 2 on walkie-talkie: This is runner 2 on 4 Zero. I can't get any response from anyone else on 238 (gameplay channel). Can you please confirm that the other runners are on 238?
Runner 2 on walkie-talkie: And who else is on 4 Zero (technical channel) please?
Runner 2: Runners 1 and 3 are having technical trouble. 4's in.
Runner 2 notices Runner 3 on the other side of the street and goes over to him.
Runner 3: Are you on 238?
Runner 2: I'm on 238, yeah.
Runner 3: OK.
Runner 2: I just switched back.
Runner 2: Looking at Runner 3's iPAQ. What's the problem?
Runner 3: Just not moving.
Runner 2: Yeah, I'm having the same. Looks like we have a bit of a server screw up.
Runner 3: All right.
Runner 2 starts walking away from Runner 3.
Runner 2 on walkie-talkie: This is Runner 2. I've had no GPS update in 2 or 3 minutes.
Runner 2 walks towards the seafront, where he knows there is usually good GPS coverage when it's available.
```

This vignette makes it visible that working with constant interruption consists of exploiting working knowledge of the technology to conduct *diagnostic work*. While the nature of an interruption might be readily apparent – that the runner is 'stuck' as can be seen in the visible incongruity between the runner's virtual and the real positions – the source and/or the extent of such interruptions is not always clear. Runners do not know whether being stuck is a result of server problems, poor satellite availability or some other technical matter such as the disconnection of their GPS armband antenna or receiver from the rest of their equipment (which occasionally happened as they were running for hours at a time, placing the equipment under considerable stress). Similarly, a runner does not know if it is an interruption only they themselves are experiencing or that others are experiencing too. And knowing such things is important because it informs the runner's decision-making – i.e. helps them establish a sense of what it might be appropriate to do next in order to manage the interruption that is currently to-hand.

So runners need to diagnose interruptions in order to handle them. Diagnosis is a collaborative achievement and the vignette instructs us as to some of the ways in which that achievement is collaborative. On experiencing an interruption that is not quickly repaired runners consult one another via the walkie-talkies to establish which *channel* they are on (gameplay or technical) and to determine the gameplay *status* of others (whether others are playing the game or experiencing some interruption). The absence of a response from other runners in this case suggests that the interruption may be *widespread* and so the runner next consults control room staff via the walkie-talkie to establish whether or not that is the case.

Runners also collaborate with one another directly (face-to-face) as they meet through happenstance on the streets. Although serendipitous in nature, this form of collaboration is nonetheless important. It allows runners not only to see for themselves the interruptions others are experiencing but also, as with indirect collaboration (via the walkie-talkie) with control room staff, to establish the *generality* of the interruptions. And therein lies the nub of the matter: diagnostic work is concerned to establish the generality of interruptions, which in turn informs their decision-making. Diagnostic work enables a runner to determine whether or not the interruption he is encountering is his alone, and related to his *personal kit*, or being experienced by others as well and related to the *game's technical infrastructure*. This, in turn, suggests the next move in managing the interruption: moving off to a better location and waiting for a GPS update as more satellites become available, for example, or restarting the Jornada, or even restarting the game if needs be.

The next vignette elaborates other important features of the runners' diagnostic work.

```
Runner 1 is walking around the Los Palmas carpark looking at her Jornada. She crosses the road on Wilamena, going towards the seafront. She walks across Simulation Carpark and then stops suddenly, holding the Jornada up in front of her.
Runner 1 on walkie-talkie: Runner 1. I've got locations on players but I'm stuck in New York.
Runner 1 turns around and starts to walk back towards Los Palmas carpark. She stops at the roadside, looking closely at the Jornada. She turns around again and walks back towards the seafront.
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Figure 7. Diagnostic work: moving from place-to-place

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Runner 1 then heads back towards the road. She turns left and walks up Wilamena, crosses the road, turns down the first alley she comes to on her right and then turns right again at the end of that, heading towards Los Palmas. Halfway down the street she comes across John, one of the control room staff who also monitors the status of work on the streets as and when technical troubles arise.
Runner 1: John, my position's gone really bizarre as in its not saying where I am. And I know that it takes a while but I seem to be getting stuck in really bizarre places. Like, I am not in Simulation carpark at the moment.
John: Looking at Jornada. No. The best thing to do is to stand out in the middle of the carpark and just do a reset.
They both go to Los Palmas carpark and John resets the Jornada.
Runner 1: Brilliant, are we in the right place?
John: We've not got GPS yet. But, I think there's only about 3 satellites or something.
Runner 1: Runner 4's just dropped out of GPS.
They look up from the Jornada and see Runner 4 across the road, standing beneath a waveLAN base station (where there should be good connectivity).
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Figure 8. Seeing that others are interrupted too

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John: Looking across road. Runner 4 seems to be waiting.
Runner 1: Looking at Jornada. Yeah he is. He's just disappeared off here.
Runner 1 on walkie-talkie: Runner 1. Runner 4 can you here me?
John: Are any runners running?
Runner 1: No.
John: Everybody's down?
Runner 1: I think so.
Runner 1 on walkie-talkie: Runner 2 what is your current situation?
Runner 1: He's got GPS.
Runner 1: Hup, I've got GPS.
```

This vignette extends our understanding of diagnostic work. It first draws attention to a strategy for recognizing the *seriousness* of an interruption: moving from place-to-place. The strategy establishes that the interruption is more than a matter of a slow update in that it provides for its repair and, in failing to effect a repair, brings to light a technical gremlin that results in the runner 'getting stuck in really bizarre places'. The situation is repaired through serendipitous collaboration with a member of the control room staff, who resets the Jornada to eliminate one possible source of trouble. The sequence also makes it visible that runners consult one another when encountering serious interruptions, not only collaborating indirectly via the walkie-talkies, but also through *surreptitious monitoring* [11] of the streets to see what others are doing and to establish whether or not the interruptions to-hand are local (i.e., of this kit) or general (of the technological infrastructure). The interruption in this case transpires to be general, which affects all the runners.

Breaching Experiment #3. Here and Now

Once again, the phenomena seen in the breach – the troubles players' encounter and runners management of interruptions – provides a concrete resource driving innovation. Having successfully augmented local knowledge of the gameplay environment, providing players with a key resource for collaboration, we now consider augmenting working knowledge of the technology to support collaboration between runners and players alike. This work is ongoing and below we present design prototypes that will, in turn, be deployed in the wild and treated as breaching experiments.

Development work here involves giving the runners and players access to information about the expected spatial availability of GPS and WiFi by colouring the gameplay map to show 'good' and 'bad' areas of coverage. This allows the runners to supplement their personal experience and shared knowledge with timely infrastructure-derived data so that they know where to go in order to rejoin the game, and provides a resource for players to make sense of the troubles they encounter and to orchestrate their actions accordingly (avoiding 'blackspots', for example, where sudden 'jumps' may occur).

Augmentation builds on an existing mechanism in CYSMN where artists configure the game by colouring maps. At present, they colour in possible start positions for online players (the game engine chooses one of these each time an online player is introduced into the game) and also areas such as buildings and water where runners are not allowed to appear (if a GPS update places a runner inside one of these regions, the system moves their visible position to be the nearest location that is just outside of it). Our proposed extension involves creating *dynamic* colour maps that are updated from a mixture of logged, live and predicted information. We have developed two prototype visualisations as first steps towards this.

Our first design prototype visualises the history of GPS availability and error as reported by GPS receivers in order to build up a picture of 'good' and 'bad' locations. Figure 9 shows a visualisation of GPS error over a two-hour game session that has been overlaid onto the map of the game zone. The solid black areas within the game zone are buildings and the surrounding area is water. Coloured areas are locations where a GPS reading was successfully transmitted to the game server over Wifi and logged. Green blooms signify readings with larger errors (5 meters or above) and blue blooms signify readings with smaller errors (approaching 1 meter). Larger errors also produce larger blooms of colour due to the uncertainty in the reported position. Grey areas with no color show locations where no readings were obtained, either because there was no GPS or WiFi coverage, because they were inaccessible to runners (some areas were fenced off), or because runners simply never ventured there. This serves a dual purpose of revealing areas of expected WiFi connectivity and also giving historical clues to the generally quality of GPS accuracy that might be anticipated in different places.

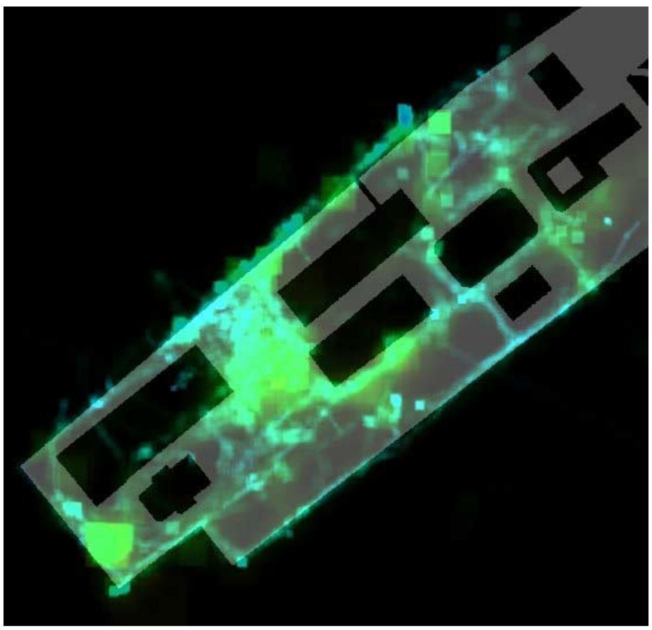

Figure 9: Visualization of GPS history from CYSMN

We know that GPS exhibits considerable variation over time as the GPS satellites move across the sky overhead. Our second design prototype predicts the likely availability of GPS at different locations on the streets at *specific times,* rather than the broader historical trends revealed by the first visualisation. This visualisation takes the 3D model of the game zone and information about the positions of GPS satellites at a given moment in time and for each location on the ground, calculates how many satellites are in its direct line of sight.

The output is a map of expected 'good' and 'bad' areas of GPS availability as shown in Figure 10. In this example (which is an area of central London), buildings are shaded black, areas of likely good GPS (with line or sight to three or more satellites) are shaded white, and areas of poor GPS (line of sight to less than three satellites) are shaded grey. Following trials in the wild we are also considering providing runners with a self-reporting mechanism that logs positions where interruptions are experienced [6], which may also be used to augment the gameplay map with working knowledge of the technology. Access to such information, would give the runners much more timely and fine-grained hints to resolving GPS problems than might easily be acquired through first-hand experience, and provide players with definite insights into the troubles at-hand and so inform their sense-making and decision-taking.

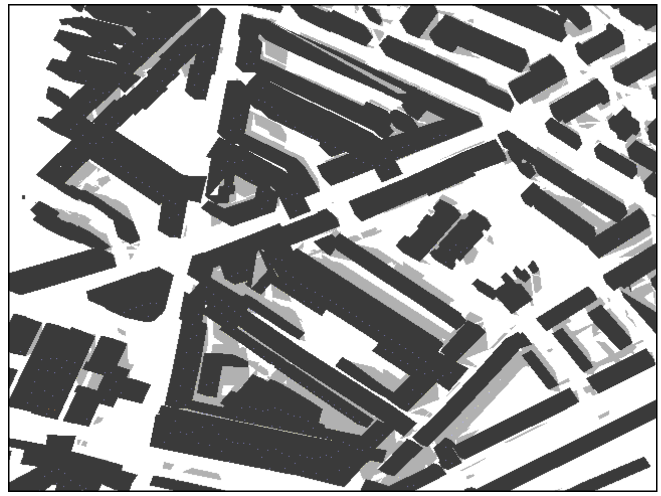

Figure 10: Visualisation of predicted GPS availability

Ongoing work is exploring how these visualizations can be combined and integrated with the runners' and players' interfaces to provide effective support.

PROVOCATION AS METHOD AND RESOURCE

This paper has raised the problem of innovation and design in the absence of practice. IT research and systems design is often based on or informed by studies of existing practice, which has seen the widespread emergence of multi-disciplinary work. Rapid developments in computing have brought with them a range of innovations which have little or no grounding in practice, however. Instead, these technologies create entirely new possibilities, and practices for their use have yet to emerge. In our own research we have been concerned to develop ways of incorporating (ethnomethodologically-informed) ethnography – an approach that is firmly oriented to studies of existing practices and often criticized for its inability to be responsive to design intervention and innovation – in an innovative process of research and development. Our solution to the problem has been to deploy innovative technologies in the wild and treat them as breaching experiments that provoke or 'call forth' practice when confronted by users and the socially organized contingencies they encounter in the attempt to make the technology work.

We have articulated this approach by practical example, describing the ad hoc interactional practices involved in the production of a mixed reality game that takes place online and on the streets. Studies of the technology-in-use in the wild have drawn particular attention to the importance of the production and use of a common stock of knowledge. This consists of local knowledge of the environment in which the technology is used and working knowledge of GPS technology. These studies have, in turn, provided concrete resources driving innovation and we have, accordingly, augmented the gameplay environment with local knowledge to promote and support collaboration amongst online players. This has proved to be highly successful, though technical problems caused troubles for players in the absence of working knowledge of the technology. Studies of the situated ways in which runners on the streets produce and exploit working knowledge to manage technical interruptions have subsequently informed the development of an augmented gameplay map that supports diagnostic work on the streets and at same time provides online players with a concrete resource with which to make sense of runners' actions.

Breaching experiments elaborate the social circumstances that innovative technologies turn upon or rely and, in this case, have informed the development of mobile, wireless, and GPS applications for real world use. This configuration of the relationship between ethnography and design leads to a research and development model where technology becomes a vehicle for social research and the results of that research in turn, and demonstrably, propel innovation and design.

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