

The Drop: Pragmatic Problems in the Design of a Compelling, Pervasive Game

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We are developing a new multiplayer pervasive game, called *The Drop*, designed to be compelling to play and yet practical to deploy in real-world settings. In *The Drop*, two teams use mobile phones to play a version of “capture the flag,” where one team hides a virtual “briefcase” in a public place and the other team attempts to find it within a specified amount of time. If the team that is searching for the briefcase finds it within the game’s time limit, they win; otherwise, the team that hid the briefcase wins. In this article we explain how the game is played, then discuss the technical, social, and business challenges we have faced while creating and implementing it.

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1. INTRODUCTION: THE DROP SCENARIO

It is 7pm on a Saturday evening at an espresso bar on the periphery of Westlake Mall in downtown Seattle. A somewhat dejected conversation among six young men is taking place at a table. On the table is a mobile speakerphone so they can talk to a remote team member. These six men¹ are part of a seven-person Drop gaming team who refer to themselves as “the Alphas.” The six men are AJ, Benjamin, Charlie, Donald, Edward, and Frank—the seventh team member, George, is on the other end of the mobile phone.

A similar, yet more jovial, conversation is taking place in the food court *inside* the mall among seven young women. This Drop team is called “the Omegas,” and its members are Quinn, Rachel, Stephanie, Teresa, Ursula, Valerie, and Wendy. They are basking in their success at the just completed game (round) of *The Drop* with the Alphas. It is currently the brief intermission before the next round starts. Wendy, the Omega’s leader for the evening, is reviewing the sequence of play of the last game on her laptop.

At the espresso bar, the Alphas are plotting their next move (while enduring taunting SMS messages from the Omegas). Their team leader, George, who is talking to the team via the mobile phone from his home, suggests that in the next game the team should try to

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¹ The use of single gendered teams in this article is for ease of exposition—and pronoun selection—only. It is not a feature of *The Drop*’s design.

protect some of its *sweepers*, rather than employing all six players as fairly weak sweepers, as unsuccessfully tried in the last game. Moans ensue, as no Alpha wants to be “the protection;” everyone wants the glory of being a sweeper. After some debate, it is decided that Edward and Frank will be used as “muscle” to protect two very weak sweepers, and the other two players, AJ and Benjamin, will be “hybrids” who have a decent ability to defend themselves, mobility, and a faint chance of meeting the objective: *finding the briefcase* in time. The Alphas hope that the two guarded sweeper pairs can slowly and methodically try to find the briefcase, and the two hybrids can be scouts to try to figure out where to search. The Alphas are playing the role of law enforcement in The Drop: their only task is to find the briefcase, hidden somewhere in the mall by the Omegas.

Meanwhile in the food court, a debate has arisen among the victors about their upcoming strategy. Several members of the team are making a simple argument: “if it ain’t broke, don’t fix it.” Wendy is trying to play peacemaker between the two factions of spies, one advocating a strategy identical to the last game and the other suggesting that the Alphas will devise counter-measures to defeat the Omegas’ *closed ranks* strategy. Everyone agrees that the closed ranks strategy—one that simply marshals most or all of the forces near the briefcase and hopes to hold on for the time limit—is vulnerable to a brute-force, frontal attack by the law-enforcement team.

With five minutes remaining before the next round begins, a consensus emerges. Most of the Omegas will feign using the closed ranks strategy while a lone spy, Quinn, will guard the briefcase and attempt to remain unnoticed. There is a quick scramble through the assembled backpacks, and a different jacket, hat, and glasses are arranged as a disguise for Quinn to help avoid recognition by the Alphas. She is sternly told by Wendy to “under no circumstances move from this part of the food court once the game starts—I’m going to set your speed to zero. Buy a burger and fries, sit in a crowded part of the court, and eat it *really* slowly. Don’t do anything to attract attention. Keep your phone on the table where you can see it, but try to not to mess with it too much. If you get discovered, message us and we’ll try to bring the team to you...but you are basically on your own and you can’t move. If you can, find a single person and ask to sit down at their table, maybe even make some small talk. That’ll make you less noticeable.”

The Omegas now set off for their positions. Wendy moves to a café near the main entrance. Since she is the Omegas’ commander, it does not matter if the Alphas see her or know her position—she is not playing in the game physically. Her only job during the game is to monitor the progress of the total game on her laptop and communicate information on strategy to her team. She knows that the café near the main entrance has excellent WiFi bandwidth, so she always uses it as her post. This is also so that no “extra information” is given to law enforcement by virtue of where she is sitting. She brings up a map of the mall on her laptop using The Drop’s management application. She tells The Drop that her team is ready, enters the statistics (explained in Section 1.1 below) for each of her team members, takes a deep breath, and using her mouse makes the critical decision: *she places the briefcase*. Wendy puts it in the food court near the place she knows Quinn will sit. The briefcase does not exist in the physical world, only in the computing system that manages the game.

Wendy also uses The Drop’s map application to place both of her *flash mines*. A flash mine is a charge that is activated by law-enforcement personnel looking for the briefcase. Before this session started, the two teams agreed that the Omegas would get two flash mines to compensate for the fact that the Alphas have a shared audio channel between their mobile phones, whereas the Omegas must use SMS. If a law-enforcement

officer is actively searching for the briefcase (“sweeping”) and walks within a few meters of the location defined as a flash mine, that player is put out of the game. Wendy uses her map to place the flash mines near the entrances of a department store. As with the briefcase, the flash mines exist only in the The Drop’s computing system; they are virtual, not physical, objects.

The department store is a critical element of the Omegas’ ruse, and a key component in the cat-and-mouse strategy in any game of The Drop. The remaining five Omegas have spread themselves evenly along a 20-30m perimeter, creating a blockade at a corner of the women’s shoe section of the department store. At first glance, they appear to be shopping, but closer examination reveals that they are all roughly stationary and carry mobile phones as they appear to go through the racks of merchandise. The Omegas’ plot to convince the Alphas that the briefcase is in the ladies’ shoe section of the department store hinges not only on the Alphas *discovering* the closed-ranks formation, but also being *convinced* that they need to bring their forces to bear on that location. Via their closed-ranks maneuver the Omegas intend to postpone discovery for as long as possible. Hence the Omegas have left the briefcase only lightly guarded, and hope that the Alphas spend their time trying to break through the blockade at the store’s shoe section.

Outside the mall, the Alphas are getting into their positions. All the physical participants in the Alpha team (i.e., everyone except George) are wearing headset/microphone devices connected to their mobile phones. Using push-to-talk, Alphas can easily communicate with each other (including George); Alphas use the mobile phones primarily as displays to “sweep” the mall for information about the spies and the briefcase. The display on the mobile phone shows only a small region of the mall that contains the phone. Only the commander, with his large TV and game console at home, can see the entire playing space and Alpha team members.

George is busy at home, using the same application as his counterpart Wendy. The Drop’s application shows different displays and offers different options to the two leaders. George says to the other Alphas, “I’ve just placed the spawn point for this game. It’s just outside the North entrance to the department store. If you are coming from the inside of the department store, it’s past hardware.” The other Alphas make a mental note of this, as it is not on their displays, and if they are disqualified or killed in the course of the next 15 minute session, they can re-enter the game by returning to the spawn point. Spies cannot re-enter the game, as they have the natural advantage of being defenders.

George says “T-minus 3 minutes. Everybody get into position.” All the Alphas and Omegas can see the countdown on their mobile phones via The Drop application, so his first comment is not strictly necessary. However, he wants his four teams (two two-man, two one-man) to be posted near the mall entrances as planned. George and Wendy can see their team members only when they (the team members) are near or inside the mall. At the start of a game, neither can see any of the opposition.

The location system that The Drop uses to determine the location of phones (and thus players) is only calibrated inside the mall and immediately outside the mall entrances. Only in the calibrated area can the game track the players and communicate that information via The Drop’s application to team leaders. All the Alphas take up positions near entrances, being careful not to get too close to the building or entrance. The players understand that the location system has a typical error of about 2 meters inside the mall, but an error that can reach 15-20m outside the mall. “Entering” the building (even inadvertently due to error in the location system) before the beginning of the game will cause automatic disqualification by The Drop and necessitate a time-consuming *respawn trek* to rejoin the action.

1.1 Player Statistics

George makes a few final tweaks to his teammates' statistics or "stats." Each team leader has a budget of 10 points per player that can be allocated in any amount to three stats: strength, speed, and stealth. The *strength* stat is used by The Drop to decide the outcome of confrontations. If two players come in close proximity (less than 5 meters), the player with the higher strength stat is likely to emerge from the encounter; the weaker player is likely to be killed, although this is statistical in nature. Combat takes place entirely in the game's software. The players do not touch physically, and may not even be aware that they are close to each other until one of their mobile phone screens goes dead and says: "You've been eliminated by [name]." For a spy, the game is over at this point; for a law-enforcement player, there is the possibility of going back to the respawn point.

The *speed* stat controls how fast a player can move in the physical world—a kind of speed limit for the game. The Drop system can sense the velocity of a player's movements (by virtue of tracking the player's location); players who move faster than the speed limit are disqualified from the game. A player with a 0 speed statistic must be stationary, as discussed with Quinn above. A player with 10 speed stat is limited to a quick walk, perhaps 1.3 or 1.4 meters/sec.² If a player wants to be able to walk at a normal pace, a speed statistic of 5 is necessary. Law-enforcement personnel who are disqualified from the game must obey this speed limit even when returning to the spawn point; failure to do so will result in permanent elimination from the game.



Fig. 1. Early mock-up of the interface seen by players of The Drop on their mobile phone screens. Green dots represent two teammates; the red arc is an area containing an enemy.

² A quick walk is 55-65 strides/min; a typical walk is 45-55 strides/min; and a slow walk is 35-45 strides/min. Our experiments at a local mall on a typical shopping day show that a pace of 65 strides/min requires players to spend significant effort to maneuver around slower patrons.

The *stealth* stat is interpreted differently for the two opposing teams. For spies, the stat determines the ability to remain “virtually” undetected. When a law-enforcement player virtually scans his or her environment, the likelihood of detecting a spy decreases when the spy’s stealth stat is high; for law enforcement, this is reversed. Thus, a player on the side of law enforcement with a high stealth value is more likely to detect spies.

Returning to George’s allocation of points to his team-mates: George ensures that his two-man subteams have the same speed value (4 in this case), otherwise there would be wasted speed points when pairs travel together. However, the “muscle” members of his pairs have all their remaining points allocated to strength, while the sweepers have all remaining points allocated to stealth. This makes each pair a formidable opponent, able to both detect and defeat opponents, but unable to move quickly. Further, the pair must travel together, and thus fewer areas of the mall can be searched in the allotted time.

George decides that his scouts, the one-man teams, need excellent mobility. These players will rely on clues in the physical environment, rather than the game’s application, to find (and, with luck, avoid) opponents. George sets the stats for these players to 1, 1, and 8 for strength, stealth, and speed respectively.

2. GAME-USER INTERFACE (UI)

As the countdown completes, the forces of the law head into the mall. Every spy knows her role and wants to either be as inconspicuous as possible, or give the appearance of being as inconspicuous as possible! All the players inside the mall use their mobile phones as local information displays, while the two leaders use their laptops or home gaming consoles to get an overview of the action.

2.1 Mobile Phone UI

On the mobile phone display, players can see a local map and three key types of information.

- **Timer.** The timer displays the time elapsed and the time remaining in the round. If a law-enforcement player is disqualified or killed, an additional countdown timer is displayed on the player’s personal display, i.e., the time until that player can respawn. Thus ensuring that there is at least some penalty for players who have been killed. Typically, the time to return to the respawn point is greater than the penalty.
- **Health points remaining.** This displays the number of health points the player has—e.g., how much damage he or she can withstand in future confrontations with an enemy. All players start with 5 health points. As an example, if a player with a strength stat of 4 comes near a player with a strength stat of 2, one would expect the player with strength 2 to be killed and the player with 4 to lose 2-3 health points. Since confrontations only occur at close range, players with few remaining health points may change their strategy and actively avoid the enemy.
- **Other players’ status.** Number of active players on each team.

Both teams use a simple interaction phone model; it can be in one of three modes (controlled by the keypad): safe, scan, or sweep mode. These three modes are progressively better at detecting the presence of enemies and the briefcase (in terms of range and accuracy), but have increasing drawbacks. A user employing any of these modes gets more accurate information when they move more slowly or (even better) are stationary. (This leads to “The Drop Shuffle,” where people walk then stop and look at their mobile phones, then walk a bit more, etc.) However, the better the detection mode,

the greater the penalty the user incurs against his strength statistic in a confrontation. Thus, players who are able to see a great distance are actually quite vulnerable to opponents, since they are likely to both move slowly and use scan or sweeping mode, thereby reducing their ability to fight.

For both teams, the phone displays a map of the immediate vicinity around the phone, with a range that varies from 10 to 50 meters, based on the scanning mode. (The display is similar to the sonar displays in many movies with the moving ring and the “boing” of pulses (see Figure 2). It is also similar to the motion detector in Halo.) Teammates are shown with green dots. As enemies are detected—based on proximity and the stealth ratings of both parties—they are added to the map as red dots, and remembered such that if the same enemy moves away and returns, it is still “detected.” Friends and enemies are superimposed on a map showing the interior of the mall.

As in sonar, but unlike the Halo motion sensor, enemies are not automatically localized to a point. It may take several scans to actually pinpoint the location of any enemy. At first, a player may only know the general direction of the enemy, and it may take more “sweeps” with the mobile phone to provide the specific location. Figure 1 shows a mock-up of the user interface for a mobile device. The central green dot represents the holder of the mobile phone; the other green dot is a teammate; and the red area contains a not yet pinpointed enemy.

Since different players are assigned different stealth scores and may be in different sweep modes, it is possible that two nearby teammates will see different data about the same enemy on their displays. This allows the use of verbal communication or gestures in addition to the technology, e.g:

- C: *“Hey, Donald, it’s Charlie. My phone says there is an enemy in the back of La Boutique... near you. Do you see her?”*
- D: *“No ... er... ok...yeah, I see her now, even though my phone didn’t spot her. It’s Stephanie. She’s changed into a green windbreaker in this game.”*
- C: *“See any other Omegas near her? Is it a trap?” ...*

In addition to encouraging visual or gestural communication, the ability to “back down” the scanning level of the player’s mobile phone (thus increasing defense capabilities) is another side effect of the way sweeping works. Once an enemy is known to be nearby, a player may switch to a less accurate sweep setting to prepare for confrontation.

2.2 The Briefcase

The goals of The Drop game are for the spies to hide and protect the briefcase while the law-enforcement players attempt to locate it. The spies’ team leader can always see the location of the briefcase, and the spies who are physically near the virtual location of the briefcase (e.g., it is in their scanning range) can also see it. The briefcase is not visible to the law-enforcement players until the game is won because finding its location is their objective.

A key element in the interaction in The Drop game is that the spies cast a “shadow” when being scanned. If two spies are near each other, or at least one spy is near the briefcase, the law-enforcement players with their scans cannot see beyond the first spy (the location system computes a region “behind” the spy that the spy cannot see into; see Fig. 2). The shadow extends for a few meters, and the Omega team exploit this feature via their new formation. By blocking off a corner of the store, the Omegas know that

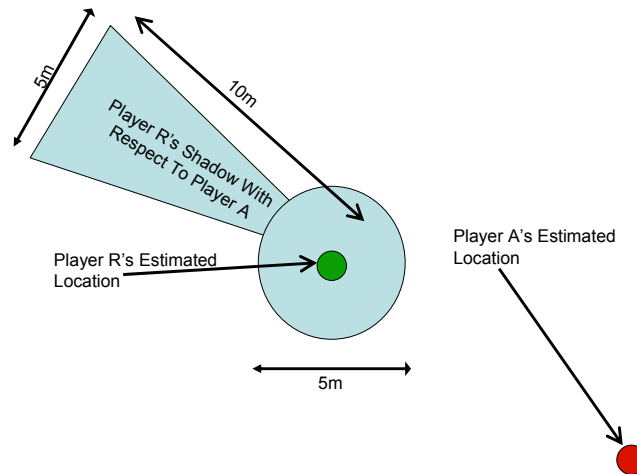


Fig. 2. *Shadows*: The shadow of player R when player A is scanning in player R's region. Note that other players on the same team as R are not visible to A's scan when they are "behind" R (in the triangular area).

there is no way for a scan to penetrate their ranks and the law-enforcement players (the Alphas) cannot go outside the building to scan from the other direction. (Of course, this is a feint, since in our scenario the Omegas are using their formation to suggest a bogus location for the briefcase.) If the spies concentrate their forces, and thus shadows, they have an excellent chance of concealing their numbers from their opponents' scans—although making them (the spies) easier to see visually.

2.3 Team Leader UI

The team leaders use a large display and are likely to have communication channels that allow them to coordinate the activities of all of their team members. This may be as simple as a web page that allows the leader to type broadcast SMS (used by the Omegas) or it may be the most advanced in mobile-telephony (used by Alphas).

The team leaders can always see all their team players' true locations superimposed on a map of the playing area. The team leaders are also fed aggregate information about the players' scans. In the simple case, by using their mobile phones to scan the environment, finding, for example, that a scan has detected an enemy in some general area, the leaders will have the same information as the players. However, since the leaders get *all* this information from their teams, the leaders may be able to pinpoint an enemy with more accuracy than any of their individual players.

The leaders participate in the game by suggesting where their team players should move in the physical environment. In the case of the law-enforcement players, it is to search various areas and find the spies; in the case of the spy team, it is to remain undiscovered. However, both leaders need to direct their players when a confrontation is foreseeable. *For law-enforcement players, this is so that spies can be killed, their shadows eliminated, and the briefcase located.* In the case of spies, it is to distract the opponent or to prevent all the spies from being killed and the briefcase found.

3. PRAGMATIC ISSUES

In the previous two sections, we outlined the basic game play and user interface for the pervasive game, The Drop. The Drop is currently still in development; it is not fully

implemented and has not, as described above, been played by anyone. However, we have been investigating the problems (and to some extent potential solutions) in the design and deployment of a game like *The Drop*, in the real world. We have also done initial field experiments in public spaces, such as malls, to test these ideas and collect data about the parameter settings that will make the game viable. In this section we discuss the issues, design features, and pragmatic problems that we have faced thus far in the development of *The Drop*.

Almost every design element of *The Drop* described in the previous sections is impacted by the issues explored below. There are features that are not impacted such as the nomenclature, story design, and general feel of the game: namely, the spies vs. law-enforcement officers scenario, the briefcase located in a public place with hundreds or thousands of (real) people around, and confrontations that result in “deaths.” We could have easily designed this game with a less grave theme. (Perhaps by using two sets of happy farm animals, one set trying to hide the tasty, healthy apple and the other set trying to find it?) We, however, chose our thematic elements by building on games that are already popular.

3.1 Game Objectives

The objectives in *The Drop* are broadly similar to games like hide-and-seek, treasure hunt, geocaching, or capture the flag. Yet, a couple of broad goals are at work in the design of *The Drop*, both of which attempt to differentiate it from its relatives. First, for success, the goal stresses communication and coordination among the team members.³ This is intentional, especially the “command bunker mentality” that is created in team leaders because they are the only members of the team that have an overview of the entire playing area. It can be seen from the huge popularity of online gaming technologies, such as the successful Xbox Live service from Microsoft, that many people enjoy collaboration and communication in gaming. Second, the goal to “find the virtual briefcase” was crafted to be challenging—the briefcase can be in any part of the public space, yet concealed from view—while causing minimal or no disturbance to others in the physical space who are not involved in the game.

There are alternate proposals broadly similar to ours for the design of the goal. For instance, it was proposed that the goal should be for law-enforcement players to try and locate a physical, not virtual, object, such as a mobile phone or other networked device, which could be tracked by the location infrastructure. This would allow the device to be moved physically during the game, while retaining much of the character of the existing virtual game. This idea seems compelling, but has some small problems that the “purely virtual” scheme does not. For the physical object to be tracked by the location system, it must be a significant computing device, which implies additional cost. Although there are business models (see below) that allow game devices to be supplied by non-players, it seems an undue burden to require that to play the game players take on the *extra* expense of a mobile phone (or PDA). Further, this reduces flexibility in terms of briefcase placement and player options for its concealment, as there is a fear that the briefcase could be stolen by others in the physical space.

Another suggestion is that the briefcase be associated with a person (a “mule”) rather than with a geographic spot on the map. This offers the option for spies to move the

³ Careful readers will note that the design of *The Drop* presented here does not discuss inter-team communication, an idea that is likely to occur to many players. We are still exploring this issue; it is discussed briefly later in this article.

briefcase, perhaps even exchange it (particularly if the briefcase is a physical object). Due to fears about the movement of the players in the physical space, this option has not been chosen (see below).

As an aside, a strategy that can be employed by spies in the existing design of The Drop is to leave the briefcase absolutely unguarded and use all spy forces as decoys. This strategy is risky, particularly since any member of the law-enforcement team who is simply passing through the general vicinity of the (unguarded) briefcase will spot it and the game will be over. Both the object design schemes above do not allow this strategy to be easily employed.

3.2 Player Movement

The biggest challenge in the design of The Drop is preventing its disruption by non-players in the physical space where the game is being played; for example, The Drop should prevent physical collisions between people. We argue that the game must at a minimum achieve the three following goals:

- *Goal 1.* Prevent players from moving through the physical space at inappropriate speeds. All physical interactions among people in the physical space should be at a normal speed for that space.
- *Goal 2.* Reward players for playing “heads up” versus “heads down” (i.e., looking at their mobile devices while moving through the space).
- *Goal 3.* Discourage players from assembling too closely together. Players who form large, densely-packed clumps disrupt the typical traffic flow of non-players in the physical space and increase the risk of collisions.

There are a number of design features in The Drop that may seem arbitrary at first, yet support one or more goals. First, the speed stat is intended as a speed limit (in response to Goal 1). This statistic and the penalties for violating it are designed to ensure that players will move at an appropriate pace. Second, the fact that “sweeping” is more effective when stationary discourages a fast pace (and it is hoped increases the players’ tension).

These two features of the game, and the simple experiments conducted by us, quickly led us to the idea that players would adopt the The Drop Shuffle, mentioned above. The strange looks we got from other patrons of the mall while doing the “shuffle” convinced us that it would be easily recognizable, whether this is desirable or not remains unclear.

As mentioned above, there have been proposals to associate the briefcase with a particular spy, and thus allow the player’s movements to move the briefcase. We have not adopted this design due to the fear that, in the heat of the moment, players may run to evade discovery by the enemy--although we have conclusive evidence to prove that this would happen. Players of compelling games often shriek, lean, or jerk in their chairs, or knock over objects with cables because they are so “into” the game that at the time they remain unaware of the consequences of these disruptive actions.

To address Goal 2, audio could be used to keep players playing “heads up.” Audio feedback provided by headsets such as those used by the Alphas, could be used to alert players about scans that detect enemies, player deaths or respawns, and perhaps current speed. We have not yet explored this issue in depth.

We have had difficulty finding a good solution to address Goal 3. In The Drop, the law-enforcement players are motivated to spread out so they can search a larger area. They are unlikely to clump together, except in trying to confront a group of spies. The “shadow” cast by spies is intended to increase the “stealth” elements and make the game

more challenging for law-enforcement players (see Figure 2). Unfortunately, this may give spies more reason to clump together (as in the scenario), since they may hope to conceal their numbers with the shadow feature. We have chosen the sizes of the shadows shown in Figure 2 on the basis of simple field experiments in a local mall. Our intent was to make the shadow sufficiently large to encourage the spies to not clump too tightly as well as force the law-enforcement players to move around in the physical space and look for different scan angles. As a point of comparison, Westlake Mall in central Seattle is approximately 30,000 square meters (10,000 sq meters per floor) and the shadow shown in Figure 1 is approximately 50 square meters, or about .015% of the total area of the mall. Only actual deployments will reveal whether the visual detriment of clumping, which makes them easier to spot, outweighs the benefit of the concealment offered by the shadow.

All of the efforts we have made to slow the players' speed will fail if players can hide from the location system. A simple method is to leave the phone with a teammate, run somewhere, and then run back. Currently, a location has no way to prevent this. Another "attack" on the speed limit can be made via "faraday backpacks," which prevent the phone signal from reaching the location system, thus blinding the location system to the location of the phone. Such an attack would almost certainly have to be prevented by mechanisms outside the current location system, if the player who wanted to cheat were clever. The location *could* detect this effort if the player's location changed radically and was "visible" to the location system at each end. The system could compute the average velocity needed to "jump" the distance, in a way similar to the way average velocities are used to give speeding tickets on toll roads.

3.3 Location System

The design of The Drop is based on the assumption that there is a location system that can track mobile phones (or other small, handheld computing devices) in the playing area. For our design, we assumed a beacon-based location scheme such as Place Lab [LaMarca et al. 2005.]. Place Lab is a software system for a computing device that enables that device to locate itself (while the details of Place Lab are beyond the scope of this article, they can reasonably be approximated as "software GPS that works both indoors and out").

Some readers or designers may question our choice of playing area (as discussed above): Why be restricted to a mall? Why not play the game on the scale of a city with hundreds of players? There is a pragmatic motivation for placing The Drop in a constrained physical space. The accuracy of location needed for a game like The Drop is simply not technically feasible on a larger scale. All the currently available technologies for computing highly accurate locations require significant instrumentation of the space [Ward et al. 1997; Priyantha et al. 2000.] or calibration [Krumm and Horovitz 2004]. In some cases these schemes are also very expensive to deploy, making the games impractical to play.

There are few systems available that are both cheap to deploy and allow both indoor and outdoor play. GPS (particularly some forms of assisted GPS that are less error-prone) is an option for outdoor-only game-play, along the lines of The Drop. However, the typical GPS 8-10 meter error may necessitate the use of the (more expensive) forms of GPS. Further, players are not likely to have these expensive GPS devices in the foreseeable future, making acceptance of the game by a large user population unlikely. For this design, we assume that in the future mobile phones will have WiFi hardware, allowing the use of algorithmic techniques (e.g., Place Lab, Radar) that depend on

sensing the WiFi network. Mobile phones already on the market with WiFi hardware are the T-Mobile MDA III and the Motorola E680.

To get the accuracy needed for The Drop, we are working with a scheme that is a hybrid of Place Lab's beacon-based location sensing and the Locadio scheme [Krumm and Horovitz 2004]. Via its calibration of the playing space, Locadio offers sufficient accuracy for The Drop by sensing the (now nearly ubiquitous) WiFi network. We are experimenting with using Place Lab for the (larger) outdoor spaces near the playing space—where the law-enforcement players must start the game—and using Locadio for the interior of the playing space. This hybrid design minimizes the amount of calibration needed by only calibrating in areas where enhanced accuracy would be valuable. Calibration can consume a significant amount of time, perhaps tens of man-hours to get good calibration for the interior of a typical mall.

It seems likely that there are game designs that exploit less accurate location techniques, perhaps at the 100m granularity that is typical for GSM-based location systems today, or the short range yet inaccurate Bluetooth network found on many mobile phones. Despite some effort, we have not found a compelling design that uses a lower resolution type of location-sensing. We hope that our work encourages other designers to investigate compelling games using these popular, cheap, and already deployed systems.

3.3.1 Boundaries and Maps. An additional difficulty with the location system of a game like The Drop is the human players' notion of physical space. Frequently, location systems like the ones we use do not have any notion of interior versus exterior spaces, walls, doors, art displays, or other parts of the physical environment that may be important to players, as the players will "expect" the game to know about them. At the most basic level, The Drop's application must be supplied with highly accurate, registered, and up-to-date maps (e.g., "as built" floor plans) of the interior space to be utilized by the game.

The need for maps suggests that the space chosen should be one where the maps already exist for other reasons. Maps of this quality are costly and difficult to produce, probably prohibitively so if they need to be developed just for the game. Even good maps will likely require some processing to be useful for a Drop application; for example by providing explicit models of walls rather than "pictures" of the mapped space. In other words, computational models of where walls are will need to be created, not just a set of pixels for the map.

The issue of boundaries also raises concerns about game-play. The location system needs to calculate and understand boundaries to ensure that players cannot do things like hide in places restricted by gender, such as dressing rooms, access closets or storage rooms, which might cause a problem for others in the space, or exploit permissions to go to places in the playing space that are usually *verboten*. This again suggests that the creation of maps that have explicit models of these areas is important to a successful design.

In the area of maps and boundaries, there is a final, more subtle, game-play concern. Throughout the discussion of our design, we have assumed that the mobile devices are strongly bound with a one-to-one ratio to players. What if a player abandons his or her phone? What if a player carries someone else's phone? Clearly, there may be cases where a strategic advantage can be gained by "decoupling" the player from the mobile phone. In The Drop, a law-enforcement player may abandon his mobile phone outside the mall in an effort to go on a "scouting mission" inside the mall during intermission. We have

not yet found a solution to this problem that can be enforced by The Drop game system itself. Players can, of course, spot cheaters and refuse to play with them. A clever team might also use counter-measures to deceive cheaters engaged in activities such as the scouting mission.

3.4 Organizational Issues and the Business Model

The business model and organizational structure of the gaming industry is generally fairly clear: sell cardboard boxes containing games on discs to players. A few new business models are emerging, such as game rentals, buying games over the Internet, etc., but these are more evolutionary than revolutionary. The business and organizational problems for a game like The Drop are fairly challenging.

The most basic question is this: Why would a space (like the Westlake Mall) *want* to allow a game like The Drop to be played on its premises? Put more negatively, wouldn't any sensible mall administrator simply ban all The Drop players, jam their wireless networks, and threaten players with trespass charges if they return? Unless the people who own and/or operate the game's playing space at least tacitly agree to have the game played there, it cannot be played successfully on a large scale.

A number of proposals have been made to make The Drop (and its genre) more acceptable to the owners of playing spaces. The simplest is to play the game in spaces such as parks, wilderness areas, or campuses, which have little formal or actual oversight, thus requiring a much lower bar of agreement with the owners and operators. Although this is certainly workable, we have not proceeded in this direction for two reasons. First, the issues of maps (raised before) suggest that areas that have excellent maps (for their own reasons) are more suitable as playing areas for The Drop. Second, a very successful game in the style of The Drop will eventually encounter the same problems of agreement with the owners or operators. For example, the national park service can, if it chooses, ban activities in public parks. Rather than simply side-step the problem, we have chosen to explore designs that make it *desirable* to host a game like Splinter Cell.

There are a number of ways that the owners of a space could monetize a game like The Drop, which may motivate them to at least accept, and perhaps even promote, the game. Charging the players of the game a fee seems reasonable, and could be modeled on either a pay-per-game or a pay-per-hour approach; the payments could be made by-player or by-team. Since The Drop's computing system is needed for the game itself, it seems quite reasonable to use it to also enforce payment by the players and allow easy billing and payment to the owner of the space. Automating payment means that even tacit acceptance by the owner of a space could lead to checks that show payments for play at the space.

Monetization can be achieved by more indirect means as well. Perhaps a drink, for example, "The Drop's Stealth Mochachino" could be offered at a café. By purchasing the product the buyer receives a receipt with a code that is entered into The Drop's application and gives the player bonus points on the stealth statistic for the next 60 minutes. If popular products could be created along this line, perhaps the money could flow from the café to the mall's owner or operator to both quantify the benefits of hosting games and offer the game at a lower price (maybe zero) to players.

The choice of mobile platforms in the design of games similar to The Drop is another serious business issue. In our experiments, we used Compaq iPaqs due to their reasonably small size, WiFi interface, and ability to run fairly powerful software (such as a location system). However, these and similar devices have a price point that makes them unlikely choices for a more significant trial, especially if game players are expected

to buy their own devices for the specific purpose of game-play. An interesting question is whether mobile phone (or PDA) companies would be willing to supply devices for such a game, in the hopes of convincing players (who otherwise would not be exposed to them) that such devices are worth owning.

Along these same lines, mobile telephony providers, who typically sell mobile phones tied to their networks, might be interested in supporting games like The Drop to promote new communication products such as push-to-talk (in our example game above). This feature is currently not available on GSM networks in the United States, hence marketing this feature to game players via games like The Drop might be a positive way to raise awareness. Using mobile gaming as a marketing strategy has already been done in the ConQwest mobile game [<http://www.conqwest2004.com>].

At present, the design of The Drop does not encourage players on opposite teams to talk to one another. If the design were extended to allow for, or even encourage, cross-team communication, roles such as moles, double agents, secret payoffs, and other interplayer communication would make the game-play deeper as well as encourage the consumption of more telecommunications products. It seems likely that clever players would discover the benefits of crossteam collaboration quite quickly anyway, so the game should profit from it rather than rely on the “honor system” to prevent players from talking amongst themselves.

A final question about The Drop’s cost structure and business model is one of referees or moderators. Some physical games—such as paintball—often have referees to keep the game safe and playable. This seems like a useful and positive thing for The Drop, yet in our design we do not provide for such a position. Because higher costs make adoption of a game, and therefore its success, less likely, we strongly prefer a game that is self-regulating; and so avoid the costs of employing one or more referees to keep the game safe. A semi-serious proposal was made to allow already existing mall security personnel some type of interface to The Drop that would, at least, allow them to stop all game play in their space for some amount of time. Fear of this “nuclear option” may help to keep rambunctious players in check.

4. CONCLUSIONS

In this article we have outlined a new game design, The Drop, which mixes the physical and virtual worlds to create compelling game-play. The Drop can be implemented today by using commercially available hardware like the top-of-the-line mobile phones from major vendors. The game’s design accounts for a number of pragmatic problems we encountered while preparing to implement the game. We have contributed pragmatic design solutions to challenges that arise when creating games that are both compelling and workable, to other—hopefully better—game designers.

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