Paranoia Syndrome – A Pervasive Multiplayer Game using PDAs, RFID, and Tangible Objects

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Abstract. In this paper we present Paranoia Syndrome as a novel hybrid game approach. Paranoia Syndrome combines classic multiplayer strategy game elements using 2D computer graphics on PDAs with location-based interaction paradigms in physical space using RFID technology and tangible objects. The combination of virtual and physical reality interaction in addition to a rule system, that encourages player cooperation, provides a powerful approach for social gaming experiences.

1 Introduction

With pervasive gaming, novel types of games have recently emerged. The general idea is to apply pervasive computing technology - which embeds computing and interfacing capabilities in real-world, everyday objects - to games. By bringing gaming back to natural, social interaction spaces, pervasive gaming aims to overcome some restrictions of conventional computer games: Players are no longer tied to computer screens and human-computer interaction is not constrained by graphical user interfaces (GUIs), which is a crucial aspect of traditional non-computer games.

A specific enhancement of pervasive game design is given by the usage of tangible user interfaces (TUI) [10][12]. TUIs support the use of graspable – not just pervasive – real-world objects as intuitive interfaces that follow familiar metaphors and allow for conveniently combining real and virtual worlds.

Recently, several pervasive games using advanced technology have been proposed. Cheok et al. [2] and Ulbricht and Schmalstieg [12] proposed augmented reality games using tangible interfaces. In the EyeToy system [11], a camera is used to track the movements of the user. The Nokia Xpress-on™ Fun Shells [9] have inbuilt accelerometer sensors and RFID readers, which can be used to control games on the phone display. A comprehensive discussion of tangible user interfaces in game design has been provided by Ullmer and Ishii [13]. In the EU project IPerG [5], board games have been analyzed for the potential of computer augmentation with a special focus on socially adaptable games. Board games and table-top games have been presented in a number of research projects, since classical board games show an explicit level of sociability [8].

Our previous work on pervasive gaming has focused on the aspect of tangible interfaces [6]: Guardian Angel [4] as a single-player game focused mainly on the tangible interface and Fruit Salad [3] as a multi-player game focused on the combination of graphics and tangible interfaces in a table-top game.

In this paper we propose *Paranoia Syndrome* as a new pervasive game approach; combining tangible interfaces in the form of physical objects, with mobile, context-aware functionality using Portable Computers (PDAs) and Radio Frequency Identification (RFID) to create a novel pervasive game experience. Social collaboration is strongly supported, since players work as a team by sharing tangible objects, game space and strategies while competing against a common opponent.

2 Game Concept

Paranoia Syndrome is a science fiction strategy game about the battle between players and an invisible alien race. The playing field is part of the real world. Players must physically move between locations to achieve their goals. Coordinating their efforts is crucial, with communication also taking place by real world means, e.g., real voice, telephones or other telecommunication infrastructure.

The game features two types of interfaces, which are used simultaneously:

- The *Virtual Interface* is realized as graphical user interface on the PDA of each player with functions for querying information about the game state and for invoking actions. The PDA interface is the only channel to the otherwise invisible aliens.
- The *Tangible Interface* is realized by integrating specially prepared real world objects. These objects can be bought, used and sold (for game money) by all participants during game play. Equipped with RFID labels, these *Tangible Object*s can be identified and operated by the user using the RFID scanner on the PDA.

2.1 Story

The story of Paranoia Syndrome revolves around a race of extraterrestrial beings, invading planet earth. These beings live in another phase of time-space and hence are invisible and untouchable to humans by normal means. Although they can only be detected with specialized scanner equipment, the aliens are nevertheless harmful to humans, as they feed on people's mental energies and can eventually drain them to the point of death. Since the number of these alien beings is ever increasing and their hunger for human energies is insatiable, they pose a deadly threat to humanity, which can only be countered by a band of bold heroes. Equipped with the newest developments in technology, the players set out to neutralize this alien threat.

2.2 Gameplay

In Paranoia Syndrome, players work together to fight a common artificial opponent, simulated by a central game server. Each player carries a PDA, serving as the main interface to the game world. Part of the gameplay takes place virtually on the PDA

and the other part, such as moving around, communicating with team members, etc., takes place physically in the real world. The location of players is tracked (at room granularity) as players actively scan RFID tags, which are attached to each doorway. Players use their PDAs to perform scans of the rooms they are in, giving them a hint of the level of alien presence in that room. The PDAs are in contact with the central game server, which continually progresses the simulation, even if the players are idle, creating real-time pressure for the players.

Each player chooses one of three roles, which provides him or her specials skills that the other roles do not possess (see section 2.3). This feature intends to foster human-to-human interactions and helps players feel individual achievement through contributing their individual skills to the overall group in order to win the game. These simulated skills add to real skills, that players contribute, such as leadership skills, tactical skills, being a fast runner etc.

The player's means for fighting the aliens are tangible objects that act as weapons or tools in the virtual world (see section 2.4). These objects can be bought from a special shop room, using limited monetary resources. The mental energy of each player (player health) is monitored and displayed on the PDA. It is decreased by various forms of alien attacks and when it drops too low the player dies in the game. The game ends with a victory for the players when they have killed or trapped all aliens. Conversely the game is lost the moment the last player dies.

An ever increasing number of aliens of different types (see section 2.5), makes it increasingly difficult for the players to control their opponent, unless they take the right actions. Basically it is more effective for the players to aim for weak points in the alien strategy, instead of just blindly trying to kill them all. Additionally, as soon as the game starts, aliens start to build certain alien structures in the rooms, which aid them and hinder the players in the long term.

Overall, players have to think and act quickly and cooperatively in order to defeat the aliens and win the game. Players are facing an opponent that never rests and is only visible through their equipment, which creates a sense of pressure and paranoia.

2.3 Player Roles

At the beginning of the game, each player chooses one of three roles, which he or she retains during the course of the entire game. These roles determine the various skills and possibilities that a player has during the game. All these roles complement each other, thus players must communicate and coordinate their strategy to benefit from each available skill. Only in this way will they have all of the information about the current situation and the required means to win the game. The different roles are:

- *Scientist* – Of all roles, the scientist is able to collect the most detailed information from PDA scans. Scientist scans provide the exact numbers and – with the right equipment – the types of aliens in a room. In contrast the other roles only get a rough indication of the level of alien presence. Furthermore scientists can detect alien eggs, which are undetectable to the other roles.
- *Technician* – Technicians can install and use the most complex equipment, which is not available to the other roles, such as Toxin Emitters and Snare Traps (see section 2.4). Additionally, they are capable of checking the exact condition of equip-

ment and to perform quick fixes on damaged items. With special equipment a technician can also detect the presence of alien structures, which then can be destroyed.
– *Doctor* – A doctor is significantly less vulnerable to alien attacks, which makes him or her predestined to act in heavily infested areas and to back up the other team members. A Doctor's most significant ability, however, is to perform first aid on other players, restoring their lost health up to a certain degree.

2.4 Equipment

Players can buy or sell equipment at the shop, which is a specially set up room (see Fig.1). This equipment acts as weapons or tools in the virtual world and is the only means of fighting the aliens. Players are provided with a certain amount of starting money and are awarded more by certain achievements in the game. If a player's funds are low, and a specific type of equipment is needed, he or she can also sell owned equipment at a lower price, which is based on the condition of the equipment.

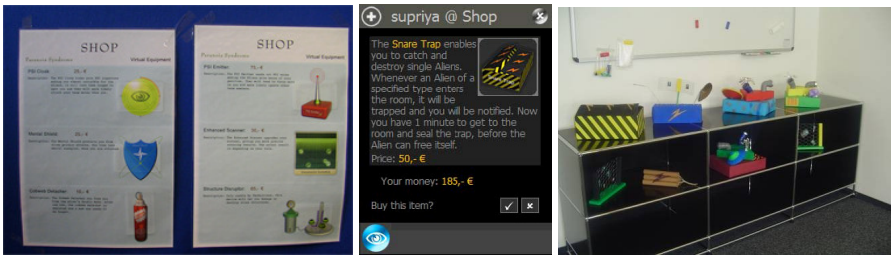

Fig.1. The Shop: posters (left), shopping interface on the PDA (middle), tangible equipment in shop (right)

The types of equipment can be classified in two broad categories:

PDA Equipment. This type of equipment can only be virtually installed on the PDA and has no physical representation. These items can be thought of as extension modules in hard- or software, which are built into the PDA. They are bought at the shop by scanning a poster, which is equipped with RFID tags (see Fig.1, left). The number of extension slots in the PDA is limited, forcing a player to make decisions about what items are most useful in the current game situation. PDA equipment is activated via a menu in the GUI on the PDA.
Among the various types of PDA equipment available are items like the *Enhanced Scanner* for more detailed scans, a *Mental Shield*, for protection against alien attacks, etc.

Tangible Equipment. In order to integrate tangible interfaces into the game, various physical objects have been designed. These objects act as physical representations of virtual weapons, which can be moved around game space. The six different types of tangible objects have been designed using materials like cardboard boxes, plastic

pipes, wire mesh, thermacole balls, jute strings, drink cans, etc. The idea was to make the objects look abstract as well as match the name and purpose of the weapon.

Fig. 2. Tangible Equipment

As depicted in Fig. 2, these items are (from left to right):
- *Toxin Emitter* – emits different types of toxin, having a harmful effect on aliens.
- *Alarm Trap* – sounds alarm when the number of aliens nearby exceeds a threshold.
- *Snare Trap* – will trap a specified type of alien for a certain time period.
- *Energy Trap* – is placed near the door to restrict alien access to and from rooms.
- *Bomb* – explodes and destroys everything in a room after the set time expires.
- *Energy Drink* – is consumed by players to temporarily increase their health value.

Tangible Equipment is physically present in the shop, thus it is limited in number. The number of simultaneously usable items is also limited by the physical carrying capacity of the player. Items are bought by a player by going to the shop and scanning an RFID tag on the object. After purchase, players can physically carry the objects between rooms, set functional parameters and activate the objects using a graphical user interface. This interface is displayed on the PDA after scanning the attached RFID tag, after the object has been bought. Objects can also be sold at the shop, where they are repaired, if previously damaged by the aliens.

2.5 Aliens – the Opponent

The aliens are the invisible opponents of the players, simulated by the game server. Their goal to win the game is to (virtually) kill all the players, by reducing their simulated mental health. There are several different types of aliens, each with a specific function for the collective of the alien race, which is organized similar to an insect state. The alien race consists of eggs, terror flies, crawlers, workers and breeders (see Fig. 3), each with an individual simulated behavior:
- *Egg* **–** All aliens hatch from immobile eggs. The hatching time varies for different alien types. Eggs are very hard to detect and immune to traps.
- *Breeder* – The only type of alien that creates offspring. Breeders walk from room to room, laying eggs. They flee most threats and do not attack unless badly hurt.
- *Worker* **–** Builds alien structures with the intention of assisting and fortifying the alien spreading. Workers can also damage and destroy player equipment but cannot harm players themselves.
- *Terror Fly* **–** Small and fast moving soldier type which patrols in search of players. If a player is encountered, it tries to chase him while slowly feeding on the player's mental energy. A player can escape by changing rooms quickly.
- *Crawler* **-** Slow moving but powerful soldier type which can place cobwebs in rooms to ensnare players. The main objective of the Crawler is to protect weaker

aliens and alien structures. If a player enters a room with a Crawler, it will attack after a short time.

Fig. 3. Alien Types: Egg, Breeder, Worker, Terror Fly, and Crawler (left to right)

2.6 Alien AI

The artificial intelligence system used in Paranoia Syndrome is based on probabilities for certain actions, which are determined by the current game state. This creates a balanced, but not strictly deterministic game flow. Each possible action for a given type of alien, in a given situation, has a certain a priori probability of being chosen. This base probability is modified according to certain events or conditions during game play. E.g., the probability of a breeder alien laying an egg is higher than moving to another room or attacking a player. This situation changes, however, when there are many players in the room. In this case the probability of laying an egg decreases and the probabilities of moving to another room (fleeing) or attacking a player (defending the brood) increases. Similar rules are defined for all actions of the other alien types.

Furthermore, alien behavior also depends on their health condition. When badly hurt, they tend to act more defensively and try to reach a safe location (lair). When in good health and in bigger numbers, they act more aggressively putting pressure on the players to control alien spreading.

2.7 Alien Structures

In a way similar to players using their equipment, aliens can place immobile structures in rooms in order to assist their spreading, to harm players and to protect themselves. Most structures are constructed by workers, except traps, which are placed by crawlers. The construction process of structures is rather long (several minutes), which allows players a chance to stop it in time, e.g., by killing the worker. Finished structures can only be destroyed by a Technician with special equipment.

- *Hatchery* – Makes eggs hatch faster. Breeders only hatch in rooms with hatcheries.
- *Alien lair* – A place where aliens can retreat to heal. All aliens (except eggs) flee to the closest lair when seriously hurt. Aliens in a lair are more resistant to toxins.
- *PSI beacon* – A small beacon which gives false scanner readings to the players. Players can scan a room repeatedly in order to detect the random results or ask assistance from a technician with a scanner extension who can detect the beacon.
- *Cobwebs* – Traps which are placed by Crawlers. A player entering a room with a cobweb is ensnared and immobilized until freed by another player. While trapped, the player can still scan the room, but cannot operate tangible equipment.

3 Graphical User Interface

The graphical user interface on the players PDA is a central control entity of the game. It is used for presenting game status, for operating the virtual and tangible devices, to register the player at certain locations and to attack the aliens. The upper part of the screen presents the name and role of the player and provides means for leaving the game. In the bottom of the screen, control elements can be used to activate equipment, to check the budget, to scan for aliens and to monitor the health status. The main display area in the middle changes depending on the respective action during the game play. The device location is tracked (at room-level granularity) by scanning RFID tags placed on the door plates of rooms. Inside rooms the PDAs can be used to scan the tangible objects. In every case, the display will reflect the context change and present a corresponding interface (Fig. 5).

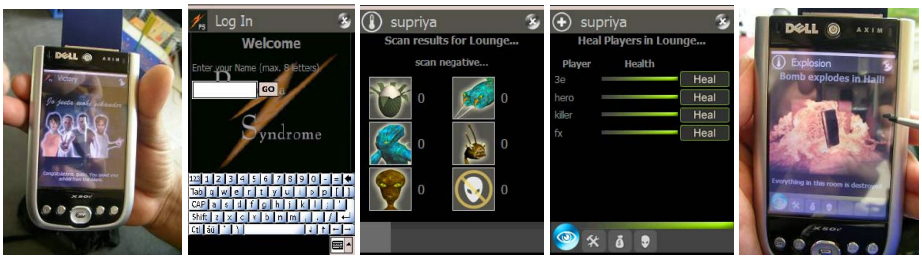

Fig. 4. Welcome Screen, Login, Scanner, Health Status, Bomb Explosion

The interface was constructed as web pages which incorporate various media items; like photos, computer graphics, sound, videos, etc. Several media production tools, like Adobe Photoshop©, Macromedia Flash©, Autodesk 3ds Max© and Combustion© have been used for content development.

4 Technical Infrastructure

Paranoia Syndrome's technical infrastructure of consists of five basic entities (Fig. 6):

- A MySQL database, maintaining the actual state of the game.
- The game simulation engine, which continuously monitors the game state, generates events and writes updates back into the database.
- The web server, which dynamically generates web pages (using PHP), that form the graphical user interface. These are transmitted wirelessly to the PDAs of the players. The pages can also influence the game state, by passing intended player actions as commands in form of HTML variables. The PHP code running on the server checks for these variables on execution and applies changes to the database.
- PDAs (Dell Axim x50v) equipped with RFID Readers in CompactFlash Slots.
- The Aladin platform [1] running on the PDAs. This ubiquitous computing framework is responsible for handling input events from the RFID reader. Detected RFID tag information is passed to the web server via URL parameters. Appropriate

web pages are then generated by the web server and displayed on the PDA by Aladin's integrated OpenNetCF web browser.

The first three entities typically run on a single machine. Via the remote interface of MySQL it is possible to distribute these entities, e.g., due to performance reasons.

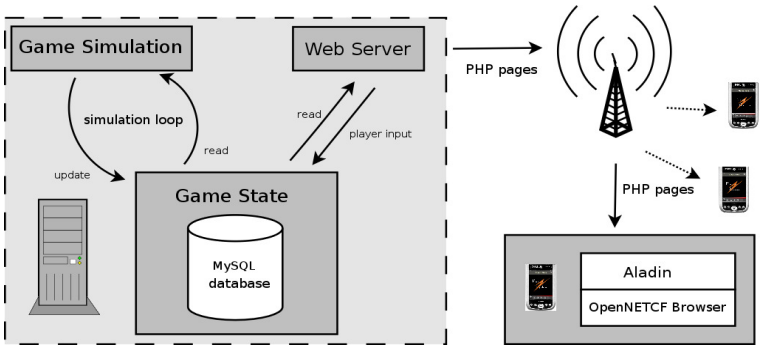

Figure 5: Technical Infrastructure of Paranoia Syndrome

Since HTML is a pull only protocol, a push service was implemented to support immediate information/event forwarding from the server, e.g., alerts, etc. This mechanism, running in JavaScript on the web browser, periodically checks a certain URL for state changes. The requested page is never cached, but is dynamically generated from the database each time it is called. When the game simulation has an event to send to a client, it places an entry in the game database, containing a URL. The JavaScript service checks for this URL and, if present, calls the related page.

Paranoia Syndrome utilizes the Aladin framework [1] for underlying application support. Aladin provides context-aware applications an open service model and flexible plug-in system, which enables framework extensions at runtime. Aladin employs a hybrid approach combining standard web presentation technologies with plug-in-based context detection and interpretation. The underlying software architecture provides two principle abstraction layers allowing an Aladin device to be highly customized. These abstraction layers include: (1) context detection and (2) context interpretation. This overall structure decouples the Aladin runtime from low-level dependencies and allows common functionality, such as plug-in management, state management, error recovery mechanisms and event handling, to be shared between devices.

As game state for Paranoia Syndrome resides outside of the Aladin framework, Aladin is used to provide low-level context information as well as a mechanism for game presentation. For Paranoia Syndrome, the Aladin RFID plug-in was used in conjunction with a specialized context interpretation plug-in which provides context information directly to the web presentation layer in the form of query parameters.

5 Experiences

The Paranoia Syndrome game was played on several occasions using different combinations of ISNM offices and labs as a playing field. As expected, game play involved a high amount of social interaction between players when coordinating their actions. While an emphasis of social interaction is typical for many pervasive games (compared to PC or console based games; cf. e.g., [7]), several aspects of the Paranoia Syndrome game design apparently contributed to particularly high coordination requirements: (1) Cooperation of players with different roles is the only viable strategy for winning the game. (2) A player can only observe the state of his or her alien opponents in one room at a time. Thus, players need to branch out into different locations and communicate their respective information about aliens in the various rooms in order to develop an optimal strategy for game play. And (3), certain actions of the players themselves might be (virtually) dangerous to other players, e.g., detonating a bomb in a room will hurt both aliens and humans in a room. Here again, communication between players becomes a crucial element of game play.

Feedback from players indicated that the overall game idea - fighting an alien invasion by physically moving from room to room while acquiring room information and activating weapons through RFID scans - was well understood by novice players. Some problems were reported concerning the inspection of the weapons' states for which scans of the physical objects' RFID labels are required. Future work could involve the addition of displays or speakers to the tangible objects which would provide players a faster understanding of the weapons' current state during game play; i.e. an evolution from more or less passive tangible objects to "smart toys" [7].

6 Conclusions and Future Work

Paranoia Syndrome is a multi-player, location-based pervasive game that uses PDAs for visualizing a virtual world of aliens who have invaded the physical space in a building environment. Players interact with the game by physically moving from room to room, influencing the game state via a virtual interface on their PDAs and tangible interactions with physical objects.

The relatively simple and inexpensive approach to location tracking and tangible interaction using RFID labels makes the Paranoia Syndrome game highly portable. Future automatic location tracking mechanisms could possibly improve the playing experience by freeing the player from the task of reporting his or her locations actively, leading to a more natural form of interaction. Also the granularity of the playing field could be improved from room-level to sub-sections of rooms, increasing realism and tactical possibilities.

Additional future work may also include strategies for recovering from gaps in wireless LAN coverage. Currently, whenever a player moves out of reach of one access point and into range of another, a delay of a few seconds occurs; disrupting the connection to the game server and factually halting game play for the player. A proactive strategy might be incorporated which establishes new connections in the background; providing seamless WLAN coverage and an improved gaming experience.

Paranoia Syndrome places an emphasis on the social interaction between players; as only a coordinated team effort can lead to a successful outcome of game play. The need for social interaction is increased through the inclusion of various player roles and elements from traditional real-time strategy games as well as players' general uncertainty about the artificially intelligent alien enemies whose actions can only be observed based on the current players' locations. In our opinion, the inclusion of role-playing and artificial intelligence elements represents a next step in the evolution of pervasive gaming; analogous to the advancement of PC and console games from simple instances like Pong and Pacman to today's highly complex gaming experiences.

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