— *Candy Castle* —
A Prototype for Pervasive Health Games

Christoph Stach
Institute for Parallel and Distributed Systems
University of Stuttgart
Universitätsstraße 38, 70569 Stuttgart, Germany
Email: Christoph.Stach@ipvs.uni-stuttgart.de

Luiz Fernando M. Schlindwein
Institute for Parallel and Distributed Systems
University of Stuttgart
Universitätsstraße 38, 70569 Stuttgart, Germany
Email: mattoslz@ipvs.uni-stuttgart.de

***Abstract*—Serious games have primarily the function to educate and train, and secondly to entertain. We present a serious game used for the treatment of diabetes and for teaching a diabetes-aware lifestyle. The game encourages the player to walk around in his / her surrounding and check the blood sugar level in as many different places as possible. Undoubtedly, the special feature of *Candy Castle* is our feedback loop which can be used for on-the-fly data analysis and automatic adaptation of the application. Thus, the patients as well as their doctors can be automatically alerted if their blood values deteriorate.**

In this demo paper, we explain both the design of the game as well as some interesting implementation aspects of our prototype. Even though we concern just on the topic of mobile games, all introduced techniques can be transferred to a general setting and used in any other mobile application.

***Index Terms*—pervasive application; health game; health education; data analysis.**

1. Introduction

Everything can be much more fun with a little of imagination! Games can not only be used for entertainment, but also to educate, teach or train the player in real life. Kids like such a stimulus to make them accomplish a task in an easier or more pleasurable way. These games, serving a higher purpose, are called *serious games* [1]. The area of serious games is enlarging constantly, and is opening for a wide range of domains (e.g. education or health care). Considering the health care aspect, serious games capture the user's attention in order to help them to understand their health condition and to promote a better lifestyle [2].

So far, health games largely run on consoles (e.g. Nintendo's *Wii Fit Plus*) or desktop computers, restricting it's execution environment. However, health games can be played anywhere at anytime when using smartphones. These devices also provide features a desktop computer has not to offer such as GPS [3]. Though, the big problem of platform dependency among the different smartphone systems impedes these efforts. For solving this issue we introduced a generic approach to implement mobile location-based games for common web-browsers to overcome the system gap [4].

In this paper we present a web-based health game for children having diabetes to support them on checking their blood sugar level (BSL). Section 2 will present some work already published in the area of health games. *Candy Castle* is going to be introduced in Section 3, before Section 4 explains some implementation aspects. Finally, Section 5 gives an overview of the showcase, we want to present at the PerCom Demo Session.

2. Related Work

As games usually engage and motivate a player to reach a certain goal, these features can be used in health care to support the treatment of chronic conditions [5]. For instance, Lange et al. [6] designed a video game for post operative breathing exercises. In the game the player controls a bird using his / her breath, only. The therapist configures the levels, according to the appropriate breathing exercises and receives quantitative results of the patients progress and commitment. Martin Knöll [7] presented different game approaches, how to support children suffering on diabetes, as diabetes is becoming a major epidemic. Inter alia, he introduced a game idea to support a player to fulfill health-critical BSL test regularly. Thereby, it is possible to provide an understandable evaluated feedback, immediately. As a positive side effect, the responsible doctor gets a better and faster access to individual as well as aggregated and evaluated health information – currently, the so called diabetes diary are by hand, mostly. That makes them often incomplete or illegible and thereby useless.

3. Candy Castle

For our prototype, we adopted Knöll's original idea called *Candy Castle*, where children become owner of a virtual castle, and made many improvements and changes to the game idea. Additionally, we added some features for automatically analyzing the game data. We see *Candy Castle* as a perfect showcase for our approach of a feedback loop for mobile applications, as introduced in [8]. While the original version of *Candy Castle* intends to give children

the role of stylists and the richness of furniture represents their health condition, we like to give them a bigger scope of action: The game attaches the player's diabetes data to real life locations. A player builds his / her castle with a protective wall around it by entering the value of a BSL measurement for the first time. From then on, the location of each measurement will become a tower point to give more scoring points and more protection against mysterious *Dark Forces*. The game's objective is to protect the castle and earn as many points as possible. Thereby, the player is forced to walk around and measure the BSL regularly. Currently, the measuring and the BSL data transfer has to be done by hand, as we have no access to a glucose meter which can be connected to the smartphone – thereby, especially young children are tempted to *cheat* in order to reach good values and game points. Unfortunately, devices, collecting and sending BSL data to any mobile are extremely seldom at the moment. A more detailed description of the game is given in Section 5.

4. Implementation

We decided to design *Candy Castle* as a web-based game with a tree-tier architecture, as shown in Figure 1. We distinguish between three different user groups: patients, doctors and administrators. However, further roles can be defined whenever needed. We are using the Google App Engine to build and host *Candy Castle*. By using the App Engine we can not only rely on Google's scalable infrastructure, but also uses it's large-scale persistent storage service. Furthermore, this makes the use of Google accounts within a web application for authentication purpose possible.

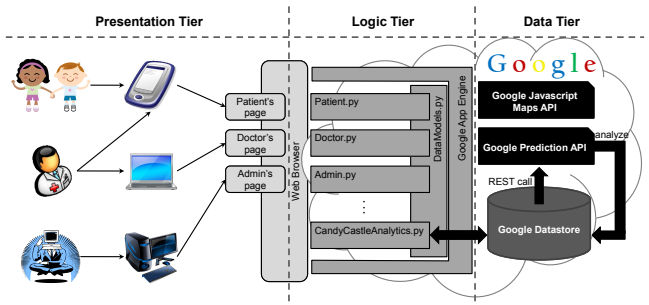


Figure 1. *Candy Castle*'s Architecture

As shown in the architecture diagram (Figure 1), besides data model definitions and modules for the program logic for each role, we have also implemented the *CandyCastle-Analytics* component. This is the heart of our feedback loop. In addition the Google services mentioned above, which are fully integrated in the App Engine already, we also use the so called Prediction API for the realization of this analysis loop. The Google Prediction API offers a set of machine learning algorithms to analyze any kind of user data and predict future outcomes. It sends REST requests to the Google Prediction API, in order to initiate analyzes of the data in the Datastore. The results are written back into the database, afterwards. Subsequently, these results are available to all user categories. This feedback enables *Candy Castle* to react automatically to any occurring situation, e.g. by sending messages to patients or doctors when some data is out of the usual range. However, this method is not limited to this single use-case and can therefore be used in any other application for any arbitrary data.

For the presentation of the map which represents the game field in *Candy Castle*, we use the Google Maps JavaScript API V3. It provides a number of utilities for manipulating maps and is optimized for mobile devices. The map controls have been adjusted for our necessity (e.g. we added a button for the glucose test). Our map page is kept simple, thus the user won't be distracted.

As mentioned before, the game is web-based, so it can be played by almost every smartphone, which makes *Candy Castle* accessible worldwide and platform independent. The only requirement towards the system is any geolocation device, for determining the location of the BSL measuring, and connectivity to access the web.

5. Demonstration Content

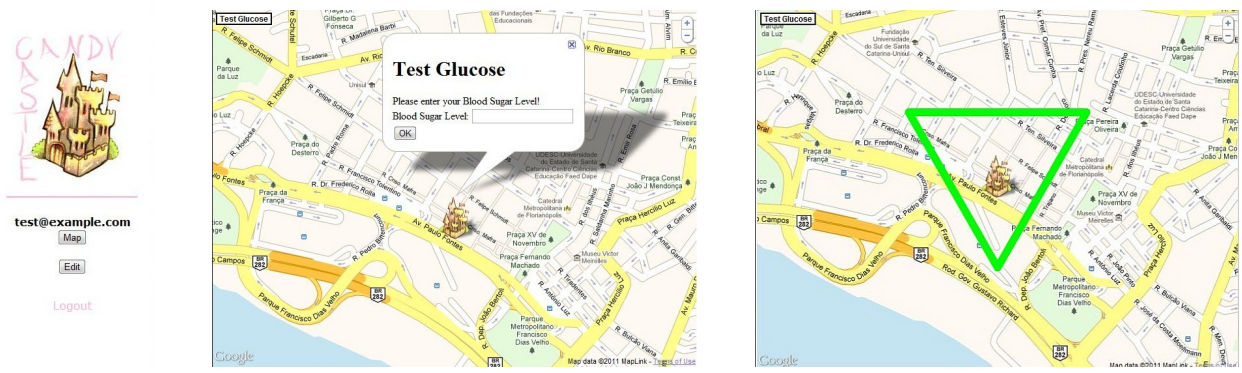
In our demonstration we will present the typical game-flow of *Candy Castle*, including the data analyses and the doctor's access to and control over the patient's data.

Step 0: A doctor has to determine appropriate candidates for *Candy Castle*. Before a patient get his / her account the doctor explains in a brief tutorial how to play the game and helps with the registration. From now on, the patient is able to play *Candy Castle* on his / her own. This introduction phase is what we reference as *Step 0*.

Step 1: In the beginning (Step 1) a login screen is shown and the player has to enter his / her Google account data to enter the game (Figure 2a). In the main menu three options are given: One button leads to the map (the game itself) while the other is for corrections of the patient Information. The link at the bottom is for logging out. When *Candy Castle* is played for the first time, a click on the map button reveals an empty map centralized to the player's current position. To enter a first BSL value (and therewith build the castle at the measuring point) the patient has to click on the button »Test Glucose« (Figure 2b). The castle is already surrounded by a wall – the color represents it's condition (green means robust, yellow shattered and red damaged).

Step 2: From now on, *Candy Castle* collects all entered BSL values and arranges them on the map when the game starts (Step 2). Thereby, the most recent game scenario gets reproduced. Whenever a further value gets entered the location of this new measuring point is compared with all the old ones. If it is farther than 5 meters away from an old measuring point, then a new measuring spot is created. Else the value is added to the existing spot. When 3 or more different spots are available, the wall becomes a polygon, instead of a circle (Figure 2c). Each new vertex is worth some extra points, in order to encourage the player to keep creating new spots all over the area.

Step 3: After a random period of time without a new measuring the so called *Dark Forces* attack (Step 3). Every



(a) Login Screen (b) First Castle (c) First Polygonal Wall

Figure 2. First Steps in *Candy Castle*

time this happens the walls get weakened a bit and it's color changes to emphasize that. To repair the wall, it is necessary for the patient to enter new BSL measuring values as fast as possible. The wall recovers unattached from the entered value, as a patient should not be punished for something outside his / her area of responsibility. Only when no new measuring is made, the player has to expect reprisals as the *Dark Forces* attack again and the wall loose one more level of strength. Once again to repair the wall, it is necessary to take a new BSL measuring.

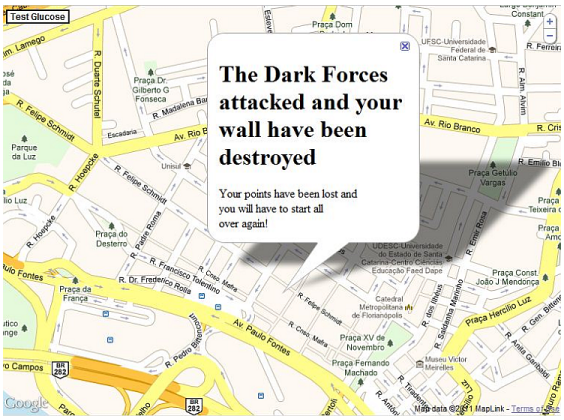


Figure 3. Game Over

When the *Dark Forces* attack and the walls are too weak, the *Dark Forces* are able to destroy them and brake into the castle. If this happens the game is over and the player looses all of the points, as shown in Figure 3. Then the game will start from Step 1 all over again.

At the end of each day the system checks whether a patient has been sloppy with the measuring. Then, the system automatically notifies the patient as well as the corresponding doctor. Constantly the game checks all BSL values and if they are alarming the doctor is informed, also.

Furthermore, we developed a specific website for the doctors in order to give them a better survey of the patients' status. The doctor can specify which data s/he is looking for as well as which group of patients s/he is interested in. Thereby, the doctor can manage the patients in an uncomplicated manner and gets all required information more systematically, than by a handwritten diabetes diary as in the earlier case. Currently, we are working on extending the automatically analyses methods in order to improve the game further and making it even more helpful to diabetes treatment. In addition, we are working on a user-friendly setting option for privacy matters in mobile applications such as *Candy Castle*. This is a major feature for any mobile application, especially in the health sector.

References

[1] C. Xin, "Influence from the Serious Games on Mobile Game Developers' Commercial Strategies," in *ISBIM 2008*, 2008.

[2] C. Watters *et al.*, "Extending the Use of Games in Health Care," in *HICSS 2006*, 2006.

[3] A. Grimes, V. Kantroo, and R. E. Grinter, "Let's Play! Mobile Health Games for Adults," in *Ubicomp '10*, 2010.

[4] A. Brodt and C. Stach, "Mobile ortsbasierte Browserspiele," in *Tagungsband der 39. GI-Jahrestagung*, 2009.

[5] N. A. Bartolomé, A. M. Zorrilla, and B. G. Zapirain, "Can Game-Based Therapies be trusted? Is Game-Based Education effective? A systematic review of the Serious Games for Health and Education," in *CGAMES 2011*, 2011.

[6] B. Lange, S. Flynn, K. Chang, A. Rizzo, and M. Bolas, "Breath: A Game To Motivate The Compliance Of Breathing Exercises," in *Virtual Rehabilitation 2009*, 2009.

[7] M. Knöll, ""On the Top of High Towers..." Discussing Locations in a Mobile Health Game for Diabetics," in *IADIS GET 2010*, 2010.

[8] C. Stach, "Gamework – A customizable framework for pervasive games (Doctoral Colloquium)," in *ICPS 2010*, 2010.