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Safety in Pervasive Gaming

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Abstract

Pervasive Games have been increasing in popularity over the last few years. This gaming genre reached mainstream appeal with Ingress, but it exploded when Pokémon Go appeared in 2016. Over the next few years, more games would appear, also using strong franchises names to create more engagement, such as Minecraft Earth, Harry Potter: Wizards Unite and a few more.

Pervasive Games demand a certain degree of interaction with reality. They expand into the unexpected and in doing so creates new rules, new game boards, new players and game entities, which in big or small ways alter the way the game is played and have the possibility of influencing someone's life outside their usual gaming location.

This unexpectedness is not without its problems, a few of which this research exposes and attempts to provide a prototype solution to resolve the matter. These problems can create dangerous events or interactions for its players. These safety hazards were encountered in the literature but received an especially great deal of attention with the boom that was Pokémon Go. Many other Pervasive Games followed the trail, but these issues are rarely resolved by the developers.

Parents started to develop concerns about their children, and with due right, as the games appeal greatly to children using franchises that are directed at them such as Pokémon and Harry Potter. The immersion these games provide, combined with real-world unrestricted movement create possibilities for dangerous situations. Parents know this and are afraid for their children's safety. Some game developers have placed regulations on their games, but most of the time, they are simply to avoid legal issues. There's still no good parental control for Pervasive Games, and parental control systems provided by mobile developers such as Apple and Google are not very detailed.

This dissertation proposes a different take on parental control systems, creating a specific one for Pervasive Games, attempting to solve most of the safety hazards this work uncovered. A questionnaire sent out to parents with children that played Pervasive Games gave a bit more insight on their fears and worries whenever their children played this type of games. A service was then created that functions on the background of a mobile device, supervising a game through the assistance of the device's Operating System but never interacting directly with the game is our proposed prototype to employ these safety measures. This prototype was then evaluated with functional testing to assert its accuracy and efficiency.

Interpreting the questionnaire and functional testing results, it is possible to perceive some initial benefits in this type of approach when ensuring the safety of children while they play Pervasive Games.

Keywods - Pervasive Games, Pervasive Games Safety, Gaming Parental Control

Resumo

Jogos Pervasivos têm aumentado em popularidade ao longo dos últimos anos. Este género tornou-se popular com o jogo Ingress, mas explodiu em fama quando o Pokémon Go apareceu em 2016. Nos ultimos anos mais jogos têm aparecido, alguns usando franquias populares para criar mais adesão, tais como Minecraft Earth, Harry Potter: Wizards Unite entre outros.

Jogos Pervasivos exigem um certo grau de interação com a realidade. Eles expandem-se inesperadamente e ao fazerem isso criam regras, novos tabuleiros de jogos, novos jogadores e entidades de jogos, que de uma maneira pequena ou grande alteram a forma como o jogo é jogado e têm uma possibilidade de influenciar a vida de alguém fora do seu local normal de jogos.

O imprevisto nestes jogos não é sem os seus problemas, alguns do quais as pesquisas realizadas neste trabalho expõem e tenta providenciar um protótipo de uma solução para resolver o assunto. Estes problemas criam acontecimentos ou interações perigosas para os seus jogadores. Estes perigos têm vindo a ser encontrados na literatura, mas receberem uma atenção ainda maior com a chegada do Pokémon Go. Muitos outros jogos pervasivos seguiram este jogo, mas os problemas continuavam a não ser resolvidos pelos desenvolvedores de jogos.

Os pais começaram a desenvolver preocupações sobre as suas crianças, e com razão, pois estes jogos apelavam a elas usando franquias normalmente direcionadas a elas como Pokémon e Harry Potter. A imersão que estes jogos providenciam, combinada com o movimento não restringido pelo mundo real aumentam as possibilidades de situações perigosas aparecerem. Pais sabem disto e temem pela segurança das suas crianças. Alguns desenvolvedores de jogos colocaram mecânicas de regulação no jogo, mas muitas das vezes servem apenas para evitar problemas legais. Ainda não existe nenhum controlo parental adequado a Jogos Pervasivos e os sistemas de controlo parental de criadores de *smartphones* como Apple e Google não são muito úteis.

Esta dissertação propõem um sistema de controlo parental diferente, criando um específico para Jogos Pervasivos, tentando resolver a maior parte dos perigos à segurança que este trabalho descobriu. Um questionário enviado a pais com crianças que joguem Jogos Pervasivos providenciou um bocado mais de conhecimento sobre as suas preocupações e medos, sempre que as suas crianças jogavam este tipo de jogos. Um serviço foi criado que funciona em segundo plano num dispositivo móvel, supervisionando o jogo através da assistência com o Sistema Operativo do aparelho, mas nunca interagindo diretamente com o jogo. Este serviço é o protótipo proposto para empregar as medidas de segurança, ele depois fi avaliado com testes funcionais para assegurar a sua precisão e eficiência.

Interpretando o questionário e os resultados dos tetes funcionais, é possível perceber alguns benefícios iniciais neste tipo de abordagem ao garantir a segurança de crianças enquanto jogam Jogos Pervasivos.

Keywods - Jogos Pervasivos, Segurança em Jogos Pervasivos, Controlo Parental em Jogos

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Daniel Nunes

"So Long, and Thanks for All the Fish."

Douglas Adams

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Abbreviations

PG	Pervasive Game
LARP	Live Role-Playing Games
API	Application Programming Interface
MMORPG	Massively Multiplayer Online Role-Playing Game
UI	User Interface
RQ	Research Question

Chapter 1

Introduction

The first chapter of this work is the Introduction, in this chapter, the context in which this Dissertation falls into is explained and the problems it still has and could be solved by this work. The motivation behind solving the identified problems of the area, and why they are academically interesting. This leads the report into its objectives followed by what does the Dissertation intends to specifically solved with the Research Questions. A brief paragraph on the remaining structure of the document ends this chapter.

1.1 Context

Just as Eva Nieuwdorp stated in her introduction in the article "The Pervasive Discourse: An Analysis" [Nie07], the word pervasive, according to the dictionary, has a clear meaning: existing in or spreading through every part of something [1]. According to the online dictionary, the word is itself mostly negative since it's used to adjectivize things we don't want to spread through all parts of something. But that usually does not apply to Games, in fact, for Pervasive Games we want to *go through*, to blur the edges of the virtual and real, concurrently providing the player with a different experience if he would only play in and with the virtual world [Mon05].

Starting the report with such a definition on the word Pervasive will be important later on, in Chapter 2, where we will see that Pervasive Gaming has a broaden connotation but starting with the meaning of the word helps to understand Pervasive Gaming definition.

In September of 2018 a study from Newzoo showed by the end of 2018 39% of the world population would use a smartphone and in 2021 that number would grow up to 49% reaching almost 4 billion people.[2] The same study shows that in 2018 76% of the entire mobile app revenue came from mobile games, that is around 69.9 billion dollars, this number is also expected to grow up to 106 billion in 2021. Pokemon Go, probably the main contender of the most played adaptive pervasive game in the world, grew 35% in revenue in 2018 comparing to 2017, their total revenue

[1] Retrieved from the online Merriam-Webster dictionary, https://www.merriam-webster.com/dictionary/pervasive on 07/01/2019.

[2] Retrieved from https://venturebeat.com/2018/09/11/newzoo-smartphone-users-will-top-3-billion-in-2018-hit-3-8-billion-by-2021/ on 05/02/2019

amounted to 800 million dollars[3], and we can verify that's just a small amount of the 69.9 mobile games, barely 1%.

As the area of mobile devices continues to increase so is the video games area for the same area so does its necessity to keep its users safe. Research has shown that mobile phone users' attention whether they are indoors [Hua17] or outdoors[NT13] is more directed at the device instead of their surroundings and doing that increases their chances of hurting themselves and others. Every developer, either a game developer or a general applications developer should have the safety of its users as a big concern in designing, creating, and implementing its idea into a game or application. Therefore, physical safety becomes a major concern for game developers. But legal safety is also a major issue and an important since unfortunate events that may or may not be foreseen by the developer can bring bad press and financially harm a company and set their plans back a few months or years due to the fallout of a legal process. For example, Niantic's Pokémon Go game suffers from these problems, as a shining example (for better or for worse) in Pervasive games, this game has had issues concerning safety since its inception. There have been many news outlets providing articles on this matter over the last few years. such as legal issues with trespassing [4], personal security threatened by wandering into dangerous locations [5] and minors safety while playing unattended and privacy worries [6]. These and many more reports put safety as a major concern while developing pervasive games.

1.2 Problem

Due to the inherent characteristics of Pervasive games, the stage when developers are deciding its design and developing features is a critical one because it's when complications in pervasive design show up. These complications bring challenges that can become problems or even liabilities if not properly solved at an early creation phase. The way a pervasive game merges with reality and uses it to create its features may create unforeseen situations and from those situations danger may occur to its players. The unexpected gaming nature of the merging the real with the virtual may put its players in harm's way and it is something that pervasive game developers do not control. Even if an appropriate mechanic is picked, technology and hardware challenges might provide a bad or unpleasant experience to the player, but since these problems do not arise from design implementation, they could be harder to predict [JC11, Sat01]. This problem has been researched for a few years as researchers have been gathering safety issues concerning Pervasive Games, we will get into more detail in chapter 2 of this document.

[3]Retrieved from https://sensortower.com/blog/pokemon-go-revenue-december-2018 on 05/02/2019
[4]Retrieved from https://www.bbc.com/news/technology-46426930 on 05/05/2019
[5]Retrieved from https://www.bbc.co.uk/news/world-europe-36841828 on 05/05/2019
[6]Retrieved from https://heimdalsecurity.com/blog/is-pokemon-go-safe on 05/05/2019

1.3 Motivation

The interest in pervasive games and the challenges provided by its mechanisms and their adaptability to reality creates a relevant area to study and test. The conclusions from Wangs' "survey on attitude towards pervasive games" [WGZ+10], were a good motif to reevaluate whether pervasive games provide value to a game, in his survey up to 57% of the respondents felt that value when playing a game with pervasive features. With the increasing amount and commercial success of pervasive games, such as Pokémon Go, Ingress and others, the area of pervasive games becomes more interesting in researching and exploring. But as previously mentioned the blend between real and virtual, creates problems and from these problems, dangerous behaviours and events emerge during gameplay provided by these games. Since predicting unexpected behaviour and situations in pervasive games are complicated tasks, game developers should focus part of their attention in creating safety restrictions to its players to ensure their safety. Hence planning and constructing a system designed to keep a player safe and perhaps ingrain it into a pervasive game application is a great motivation in researching and designing such a system, all to keep a player safe and continuously entertained.

1.4 Objectives

At the end of the Dissertation, this work intends to design and implement a background service for a mobile device (Android) with safety restrictions for a specific application (game). In the next Chapter we explore and examine the state of the art in which the Pervasive games area and safety issues concerning such area at the present time, the research done in the chapter allows us to pick safety hazards and pervasive mechanics to be tested with the service. Hopefully, if a niche is found, we can explore further, enriching the area. The designed service will act as a protector for the players' actions, keeping him from hurting himself or others through possible unexpected events or actions. The service will be tested to assert its fidelity using the data from a mobile device and the tests will determine if the safety restrictions are too gameplay intrusive. Hopefully, the frustration of not being able to play will be minimal. In the end, the service should enact all safety policies correctly and non-intrusively, while maintaining a high amount of gameplay considering the restrictions in place.

1.5 Research Questions

With the summary on the scientific area, some questions pop up and are further supported by the literature review in the state-of-the-art chapter. Leading the work some of the following questions helped this dissertation a lot in keeping its path, and hopefully proving this work beneficial to its scientific area.

These research questions were planned and established before the Covid-19 pandemic and unfortunately, that pandemic hindered the final result of some, mainly RQ3, RQ4 and RQ5 that

involved user testing and the pandemic did not allow for great interaction with others. Out of those three last questions, the one that suffered the most was RQ4 since it needs user-testing on a wider degree.

All research questions have their results combined and answered in section 6.1. The research questions are now enumerated bellow and then they have a small paragraph that explains a little bit better each one:

- **RQ1** - What are threats to player security while playing Pervasive Games?
- **RQ2** - What are safety measures to tackle the security threats?
- **RQ3** - How can one evaluate the impact of the safety measures in player experience?
- **RQ4** - What is the impact of such safety measures for the player experience?
- **RQ5** - What is the impact of such safety measures for the parental supervisor, regarding their safety fears?

What are threats to player security while playing Pervasive Games? - While studying and researching the state of the art, this question resolves itself by exposing the threats a player experiences while playing a Pervasive Game, throughout the literature that is found and presented.

What are safety measures to tackle the security threats? - Part of this question resolution is achieved at the conclusion of the research done in chapter 2, but this work is the other part of the answer to this question. After procuring and listing dangerous behaviour and possible dangerous events, that same list becomes safety restrictions to implement in the service, which will solve this question at the end.

How can one evaluate the impact of the safety measures in player experience? - To evaluate how safety measures intrude into the gameplay of a player one must structure and prepare a methodology for its effects. But how can this be done? The idea behind this question is to prepare an evaluation method to analyze the safety restrictions placed within the service and how they affect the gameplay experience.

What is the impact of such safety measures for the player experience? - With a methodology set in place, the practical application of said evaluation methodology is to be performed in order to assess with how the safety measures proposed with this work alter the player experience.

What is the impact of such safety measures for the parental supervisor, regarding their safety fears? - This question is relatively similar to the previous one but has a different final target, the supervisor. This question evaluates whether the supervisors' safety worries about their offspring's have been resolved with the aid of the safety service.

1.6 Document Structure

This document is structured in five main chapters, the current chapter is the Introduction chapter, and it will be followed by chapter 2, the State of the Art, focused in 2 scientific areas, Adaptive Games and Pervasive Games, with their respective definitions, characteristics and features. The third chapter is the conclusions of the work done in the state of the art in preparation to arrive to the Proposed Solution in chapter 4. The final chapter is the Work Plan, where a more detailed work plan with the dissertations' Gantt chart.

Chapter 2

State of the Art

The main scientific area for this Dissertation is the area of Pervasive Gaming or Games. This dissertation has an emphasis on Safety, hence the focus on that area in Pervasive Gaming. This chapter presents the scientific literature state of the areas since their perceived beginning and their current state.

The State of the Art chapter begins with a description of how the research to write this chapter was done. The Research approach subchapter explains the reasoning behind the difference between the methods for each studied area.

It's followed by the Pervasive Games subchapter, where we can find its definition and part of its early years. Pervasive Characteristics on how to recognize a Pervasive Game as the features with which to implement a Pervasive game come after. This section is closed by an analysis of Mobile Pervasive Games. The next big area is in the safety within the area of Pervasive Gaming and parental concerns around their offspring's security while playing games in the real world. This subchapter speaks of the problems encountered in Pervasive Gaming, safety measures already enacted and a brief examination on Parental Control Systems

The section ends with a scientific area overview of what has been found in the literature.

2.1 Research Approach

This state of the art analysis was created with two separate research approaches, for section 2.2 a backtracking approach was used, for section 2.3 a more systematic approach was used.

The reasoning behind the backtracking approach for the Pervasive Games section was an attempt to begin the exposition of this scientific area from the start. Most of the initial work involved gathering references from some articles, and continuing down the path of referenced articles to encounter some sort of "where it all began" for the scientific area. Then, starting from those early articles, the literature was read chronologically read over where pervasive games were being used, what defined them and how they're designed.

The researched started leading into the Safety of pervasive game users or players. Some common sense knowledge tells us not paying attention while being a pedestrian can cause danger to

ourselves and others, but not all events, whether their end result is injury or death are reported, and not all of these events are reported as traffic incidents. To explore this even further, it was attempted to precise and combine all information about safety issues regarding pervasive games, to focus more on hazardous events surrounding pervasive games.

The keywords chosen to carry out the research were decided while reading up on the literature, many Pervasive Games keywords have some sort of interchangeability with the word exergames, location based games and augmented reality games (i.e. Pokémon Go). To broaden the idea of *problems* in Pervasive Gaming safety, the words "challenges", "accessibility" were added to the research keywords.

ID	keyword(s)	Date	Timeframe
1	pervasive AND game AND problem	05/11/2019	2015-2019 (inclusive)
2	survey AND pervasive AND games	06/11/2019	2015-2019 (inclusive)
3	challenges AND pervasive AND game	07/11/2019	2015-2019 (inclusive)
4	safety AND pervasive AND game	21/11/2019	All
5	safety AND exergames	21/11/2019	All
6	safety AND "mobile exergames"	22/11/2019	All
7	Accessibility AND pervasive AND game	22/11/2019	2009-2019 (inclusive)
8	Accessibility AND adaptive AND game	23/11/2019	2009-2019 (inclusive)
9	safety AND Augmented Reality Games	23/11/2019	2015-2019 (inclusive)
10	safety AND Location Based Games	23/11/2019	2015-2019 (inclusive)

Table 2.1: Search keywords, date and timeframe for Pervasive Game problems research.

The search engine picked up was Scopus, and the keywords were used in there. Table 2.1, summarizes the research that was executed to find the problems within this area. This table shows the keywords used for that specific search, the date when it was executed and its timeframe. All searches had filters and sorters applied to them equally, the filter was "Limit to > English Language" and the sorter was Date(newest). The Date(newest) sorter was put in place because the focus on the research was recent years, this, combined with the timeframe being usually from 2009 or 2015 and up helped gather more current articles. Some searches had the timeframe "All" due to low initial results, so the All filter was enabled to enlarge the research on those specific keywords. In all searches, the field about the Subject area was left open to keep the search broad and maybe find interesting and unexpected articles in different areas, the narrowing of the research would come later.

Table 2.2 shows the results of the research approach done to increase the understanding around pervasive problems and safety in pervasive games (and similar keywords). In all the searches there was a specific method - equal to all - for gathering and accepting literature.

The abstracts of each article were read, and the gathering process involved exactly that, reading the abstracts to understand if a determined article was relevant for our research. Gathering articles meant selecting articles to be studied later. This would reduce the pool, giving us a smaller number to work with, focusing the last results for a final selection for a full review. For accepting the literature piece to be further analysed, the Introduction and Conclusion of each article was read

ID	keyword(s)	Results	Gathered	Accepted
1	pervasive AND game AND problem	60	7	3
2	survey AND pervasive AND games	35	8	4
3	challenges AND pervasive AND game	63	19	0
4	safety AND pervasive AND game	12	2	2
5	safety AND exergames	34	11	6
6	safety AND "mobile exergames"	2	0	0
7	Accessibility AND pervasive AND game	15	6	0
8	Accessibility AND adaptive AND game	26	2	0
9	safety AND Augmented Reality Games	98	21	0
10	safety AND Location Based Games	44	17	11

Table 2.2: Results of the research approach.

for each gathered article. Interesting enough there was a small number of overlaps between some of the searches, although the exact numbers were not tracked, this remains as a small occurrence.

That became increasingly more noticeable while the searches increased (for example hardly any or extremely very few overlaps were noticed between search number one and number two) Keyword number 6 only returned two results and were papers already retrieved in the number 5 research, so they're disregarded in the gathering process. This Research approach provided 26 articles to be studied and analysed, these selected articles draw a view into the state of the pervasive games' safety area that is written down in the following sections.

2.2 Pervasive Games

With his paper on "The Computer of the 21st Century", Mark Weiser believed ubiquitous computers would gradually become more dominant in the next 20 years [WM99], that was in 1991. In fact, he was right, as this omnipresent paradigm effectively exists around us, as proven by the steady increase in smartphone users in the past years[1]. Although ubiquitous computing does not exist only as a result of smartphone usage, the ubiquitous nature of those handheld devices helped immensely in spreading this paradigm.

2.2.1 The word Pervasive and the Magic Circle

As mentioned in the Introduction chapter, the word pervasive is well defined by Merrian-Webster[2]. However, as we will see in the next subsection, the Definition of Pervasive Games, they do not have an easy definition [Mon05]. Falk & Davenport asserted pervasive games "move beyond the traditional computer interfaces and into the physical world to occupy time and place on a human scale" [FD04a].

[1] 5.135 billion unique mobile users with 68% mobile penetration as of January 2018, from https://wearesocial.com/us/blog/2018/01/global-digital-report-2018, on 14/05/2020.

[2] "existing in or spreading through every part of something", https://www.merriam-webster.com/dictionary/pervasive on 14/05/2020.

The magic circle[3], a very well-known phenomenon in the world of games, was digitally coined by Zimmerman & Salen in their book Rules of Play[SZ03]. A magic circle states when players are playing a game, they *leave* the real world for the game world constructed for the player (or players). This action may happen unconsciously or consciously to the player, and inside this magic circle the players are governed by a different set of rules, the idea and conceptions are usually well explained, and the players usually recognize each other as player or participants of said game. Even though this concept may change from game to game, they're usually found in several games throughout history and ideally what happens in a game stays inside the game, as governed by the idea of the magic circle.

But here lies the intersection of a game's magic circle and a pervasive game, since a pervasive game *goes through something*, we can say that something is the magic circle and trespassing the magic circle allows for the real world to mix in with the game world since the real world cause changes to the virtual world and vice-versa.

2.2.2 Definition of Pervasive Games

In its early years (before 2005) the category of pervasive gaming seemed to be intertwined with Ubiquitous gaming and Live Role-Playing Games (LARP)[FD04a, FD04b]. In fact, in 2001, without even mentioning the word pervasive, Björk et all, created the game Pirates![4]. This game used the world as a game board as stated from the title of its article [BFHL01], the game used proximity sensors on the handheld computers, and similar sensors at different locations in an area. This allowed the game to know where the players' location at any given time, the players could battle amongst themselves if they meet at a certain location, trade goods, travel to other islands (other map locations), among other features.

When attempting to show "how computer games can be designed to regain some of the social aspects of traditional gameplay" [BFHL01] with their creation, Björk et all. simply called their game a game, although they referenced the word ubiquitous computing to describe how they intended to make their game work. But that was only a few of the several definitions if we can even suggest they gave one.

In her article "The Pervasive Discourse: An Analysis" [Nie07], Nieuwdorp gathered several definitions of that time to portrait what Pervasive Games were, she aggregated a great amount of work from many authors of that time, collecting up to 10 different understandings on what Pervasive Games were, showing how foggy and entangled the term was during its early years. Her work split the category of Pervasive Games, at the time, in two perspectives, a technological one, that simply considers that the technological advancements such as the computer, are just the means to create and design a game, and a cultural one that focuses on the game independently of the technology it implements.

One of those perspectives was exposed by Montola in his article "Exploring the Edge of the Magic Circle: Defining Pervasive Games" [Mon05], where he stated the following:

[3]The term magic circle was originally mentioned by Huizinga's 1938 book Homo Ludens

[4]Not to be confused with the Commodore 64 game Pirates!, © 1987 by Microprose.

Pervasive game is a game that has one or more salient features that expand the contractual magic circle of play socially, spatially or temporally.

This sentence was cited afterwards almost to the letter by other authors, such as Kuntze [Kun07], Nevelsteen [Nev15] and Spallazo [SM18]. Even so, some authors differ in their wording on what pervasive games do to the magic circle, whether they break, blur or expand the magic circle to encompass the real world [Har06].

As Hinske et al. state, "Pervasive Games are a ludic form of mixed reality entertainment (...) based on the utilization of Mobile Computing and/or Pervasive Computing technologies" [HLMR07], although the definition is not incorrect, by asserting that a pervasive game is tied to mobile computing it narrows its definition, possibly denying other games to be considered pervasive.

Montolas' definition is much broader and allows for more research into the subject. Hence why it was chosen to continue the research on the subject, attempting to broaden the horizon for a future better understanding of what are Pervasive Games.

2.2.3 Pervasive Game Characteristics

By following Montola's definition of Pervasive game and after explaining what is the magic circle, digitally speaking, we reach the three expansions he cited in his work[Mon05, MSW09, Mon12], spatial, temporal and social. These expansions of the magic circle form basic characteristics for a game and by extension, since it's a super-category, pervasive games. These expansions can be used to characterize a pervasive game [Kun07], making clear the differences between a Pervasive Game and other game types. Reis S. used them for her own categorization of the games she created for her thesis [Rei13], in that document she classified the game's expansions while demonstrating her results. Reis also explained the expansions in the form of questions "where the game is played" [Rei13], "when the game is played" [Rei13], "with whom the game is played" [Rei13] for spatial, temporal and social expansions respectively.
The expansions are explained and defined below according to a few authors, although all referenced Montolas's expansions for Pervasive Games:

Spatial Expansion - According to Nevelsteen, spatial expansion is provided "through a blending with the physical world"[Nev15]. Kuntze, in his work, says the "socially constructed location of the game is unclear or unlimited" [Kun07].

Montola in both his book and thesis gave a more complete definition on Spatial Expansion (and the other two), with some examples and metaphors. Montola affirms that "Spatial Expansion indicates that the socially constructed location of the game is unclear or unlimited" and "spatial expansion only applies to games that are affected by the player's spatial context, usually in relation to physical places or to other players."[Mon05] According to him a spatial expansion happens when the virtual world overlaps with the real world, a non-pervasive game seeks to isolate the player from the real world, his surroundings, while pervasive games do the exact opposite, it does

not intend to isolate the player from the real world but compels the user to interact in some way with the real world in an unexpected or unclear manner. A Pervasive Game appropriates objects (of any sort, manmade or natural) and properties of the real (physical world) into its gameplay.

Some aspects of pervasive gaming, such as the concept of game entity are very hard to determine, due to the blurry nature of the category of Pervasive Games as mentioned by Kampmann Walther (2005) [Wal05]. He reinforces the unexpected nature of this game category since when playing a game that takes you everywhere, the player does not know who is an NPC or a PC, what is a game object or not on the first moment of viewing them/it, only if the player attempts to interact with those (and other) type of game entities will he know which is which.
Simply combining a physical space with cyberspace does not make it pervasive, only the games that take the gameplay to “unpredictable, uncertain, and undedicated areas” [MSW09] should be considered. pervasive.

As every concept has its advantages, usually they also have their problems and/or challenges, Montola in his 2005’s article, warns about the problems spatial expansion in causing "unwanted public disturbance, creating hazardous situations in traffic" [Mon05] and if the game expands towards an area the player usually would not enter it may cause legal issues to the player and/or even the game put the player at life’s risk.

Temporal Expansion - In his work, Nevelsteen simply states temporal expansion is provided "through ubiquitous availability" [Nev15]. In his thesis, Kuntze wrote the temporal expansions happens explicitly in play sessions where "the socially constructed game session is interlaced and mixed with ordinary life" [Kun07].

According to Montola when "Pervasive games expand temporally from the explicit play sessions; the socially constructed game session is interlaced and mixed with ordinary life."[Mon05] A temporal expansion in a Pervasive Game happens when a play session[5] becomes barely distinguishable if not fully indistinguishable[MSW09]. The players inside the game know they’re playing a game in according to their game session[6] but they do not know when the game will call upon them to react, this could happen in the middle of a business meeting or a classroom presentation as two perfectly mundane examples. This leads us to problems and challenges of the temporal expansion of Pervasive games where Montola in 2005 declares “the essence of the problematic side of temporal expansion is the same; game might require attention at worst possible times or require generally too much attention. If the price of failing to attend the game when needed is too steep, the game may become very taxing over time.”[Mon05] These are the pitfalls of many MMORPG’s and Online Multiplayer Games, in the latter case, we find such examples as Tribal Wars[7], where a player starts with a village and its goal, among others, could be "world domination" so he intends

[5] Björk & Holopainen (2005) stated a play session is the uninterrupted stretch of time when one player is actively playing a game.
[6] “A game session is the whole activity of one player participating in such a game (Björk & Holopainen, 2005)
[7] https://www.tribalwars.co.uk/

to take as many villages as possible, but in doing so, he has to attend and protect them or other might conquer them, making him lose all and having to start over, managing more than 15, 20, 100 villages ended up being a *full-time job* due to the amount of time a person could lose [And09]. "If the game is played constantly, the privacy considerations also become an issue: as Sotamaa [15] points out, using the search function of Botfighters to find friends playing the game is the obvious thing to do" [Mon05]. Niantic's 2016 game, Pokemon GO, since it collected a massive amount of players in its early days[8] provided a wide range of examples of dangerous events a Pervasive Game could interfere with daily life such[9].

Social Expansion - For Nevelsteen this expansion "is supported by participants communicating through bi-directional diegetic and non-diegetic communication" [Nev15]. When reading Kuntze, we find a social expansion "in unexpected places and times where the expanded games are played, unexpected people make a difference regarding the gameplay" [Kun07, Mon05].

Probably one of the trickier expansions to recognize since the Social Expansion does not necessarily mean a player playing a game purposely interacts with another in a Pervasive Game, for instance in Killer[10] a player should attempt to conduct his murders without any bystanders (other players in the area of the crime), in that game a player actively attempts to avoid other players until he reaches his target. In other games, such as Cruel 2 B Kind[11], players must collaborate to achieve in their goal, all this happens inside the game itself. Another example, although different from an early pervasive game is The Beast[12] This game made its players work collaboratively to solve puzzles online and offline, but some players took the game further and grouped up in online forums not only solving the game but attempting solutions for real-life problems and situations [MM03]. A Social Expansion in a Pervasive Game may draw unwilling participants into its activities, substantiating even further the wide range of a social expansion from unwilling participants who may become NPC's to full-fledged playing characters inside the game. The participant roles in this expansion were studied by Montola et Waern in [MW06].

This creates problems since this expansion may risk drawing these unwilling players into the game, and their presence in it may harm the game experience or worse, harm or bother the unwilling player that had no interest in playing the game [Mon05]. Creating a new social relationship inside this type of games does not come without its liabilities.

All these expansions can sometimes mesh together, as in, for example, stated by Montola "temporal expansion ties in with social expansion, as the temporal span of the game is often obfuscated to the point where even the players might be unaware of whether they are playing at

[8] 50 million players worldwide in 19 days since its launch - https://expandedramblings.com/index.php/pokemon-go-statistics/- accessed on 19/01/2019

[9] Retrieved from https://www.digitalspy.com/gaming/pokemon/a800902/pokemon-go-crazy-real-life-events-provoked-by-the-game/ on 19/01/2019

[10] Killer: The Game of Assassination (1981). Steve Jackson, Steve Jackson Games. Ref. 4th edition, 1998. Based on traditional forms of play, known as Assassin, Deathgame, and Circle of Death

[11] Cruel 2 B Kind (2006). Jane McGonigal and Ian Bogost, USA. www.cruelgame.com

[12] Beast, The (2001). Jordan Weisman, Elan Lee, Sean Stewart, and others. Microsoft. A.k.a. "The A.I. Web Game," "The A.I. Web Puzzle."

a given moment. When the game can call the player without a warning, the player answering her cell phone does not know if that answering constitutes a game action or not" [Mon05].

2.2.4 Features in Pervasive Games

With the definition of the gaming subgenre and characterizing it in order to clearly recognize and understand what is and what is not a Pervasive Game, what follows is the answer to how a game can be pervasive. This answer was already researched by Nevelsteen when he surveyed engine features for Pervasive Games in 2015 [Nev15], collecting several component features used in Pervasive Gaming, this work cannot go unnoticed since the features are important in allowing a game to become pervasive. His work possesses a much more detailed analysis on the subject, and its reading is recommended, but for the sake of easiness in transmitting information, the component features will be listed below with a brief explanation:

1. **Virtual Game World with World Persistence** - No world that is more persistent than the real world, hence when a virtual game world overlaps with the real world that virtual world becomes a persistent world[dH09, Nie07]. As Richard Bartle defined, a persistent world "continues to exist and develop internally even when there are no people interacting with it"[BR03].

2. **Shared Data Space(s) with Data Persistence** - Shared data space means that a system has data that is distributed between devices/users. Persistent data is data that is constant across sessions. In gaming terms, this component feature signifies that the game state has the capability of being disseminated across all the gaming devices.

3. **Heterogeneous Devices and Systems** - Related to how a player with the help of an unusual input devices that can be sensors of any sort, location, biometric or other types of sensors, is interfaced with the game, experiencing the gameplay through those devices.

4. **Context-Awareness** - Context-aware is a component for mobile systems that possibilities its systems to sense their physical surroundings and if needed adapt its actions appropriately. Thus, it has the capability to change the location of use, offers the possibility of a user interact with nearby users with the same component [SAW94]. Several variables can be considered for an implementation of a context-aware component, such as weather [Bar08, Rei13, RP17], "location, body orientation, available networks or noise level" [Nev15].

5. **Roles, Groups, Hierarchies, Permissions** - This component asserts if a game has some sort of difference between players, whether by different roles, grouping players, hierarchization and permissions. These differences can influence the gameplay of a singular or group of players.

6. **Current and Historical Game State** - This means the game records event data, creating logs of any size. This type of feature is extremely important for game analysis and future

work. And concerning the current state, means it includes player and game information in the present

7. **Game Master Intervention** - Game masters are players that operate at a superior level of *regular* players. When a game can only run with the intervention of such a *super-player*, the game becomes semi-automatic instead of fully automatic [Nev15]. Game Masters usually monitor the game, intervene in real-time, during the game and manipulating its state.

8. **Reconfiguration, Authoring and Scripting in Run-Time** - This component seems immensely close to an adaptive system since this component means that the pervasive game can change and alter itself during gameplay, either by reconfiguring parameters, authoring new elements into the game or inserting new scripts with different rules and objects.

9. **Bidirectional Diegetic and Non-Diegetic Communication** - Diegetic communication means specialized communication, where the players communicate their game state with each other directly or through a game interface (integrated chat system). Non-diegetic communication happens when there's a communication that is not relevant to the game or is not specialized at the players.

Some of these components share traits with the pervasive expansions and can be traced back to them, to cite the more obvious ones, such as the fourth, seventh and ninth components fall perfectly into the social expansion and support that expansion. The temporal expansion can be seen in any type of persistence data, so the first and second component back that expansion. And providing an example of a spatial expansion, the first component holds that expansion by enlarging the game world for the player. Some of the components, such as the first can support more than one expansion.

2.2.5 Mobile Pervasive Game Analysis

With an established definition, "Pervasive game is a game that has one or more salient features that expand the contractual magic circle of play socially, spatially or temporally" [Mon05] and settled the Pervasive Game characteristics, spatial, temporal and social expansions [Mon12], a survey was bunched up to provide a staging ground for evaluating Pervasive Games. "A survey on pervasive mobile games" by Valente & Feijó, served our purpose since it narrowed the research and giving a more focused analysis. Valente established their norms with four steps, two mandatory – collecting games that used mobile devices and that are context-aware[13] - and two optional, games that accessed remote data on the move and multiplayer games.

With their parameters, 24 games were collected and categorized by platform, year, sensors used and network usage. Each game also provided the normal references and description that assisted in the characterization of each game.

[13]Context-aware is an important term but to keep the report on target, the definition used is the one gave by Anind Dey in 2001 where context is "any information that can be used to characterize the situation of an entity" [Dey01].

Assisting with the characterization of each game, for each expansion, two criteria were picked.

For the Spatial Expansion, where space influences the game we have:

- When players are taken to unpredictable, uncertain and undedicated areas. Socially constructed location of the game is unclear or unlimited;

- Appropriates objects (of any sort) and properties of the real (physical world) into its gameplay.

For the Temporal Expansion, where times influences the game we have:

- There is an unexpected interrelated experience between life and game. (Game session is interlaced and mixed with ordinary life);

- Play sessions become blurred and uncertain. (a well-defined time span game can be pervasive, but not temporally) becoming barely distinguishable if not fully indistinguishable.

For the Social Expansion, where social interactions (or possible lack of) influences the game we have:

- A player may not know beforehand who the other players are;

- A non-player may change gameplay unknowingly, for example, a player chasing another can ask a non-player if he has seen the other. (outsiders involved in the game).

With the criterion established, figure 2.1 shows the table of games according to their respective expansions.

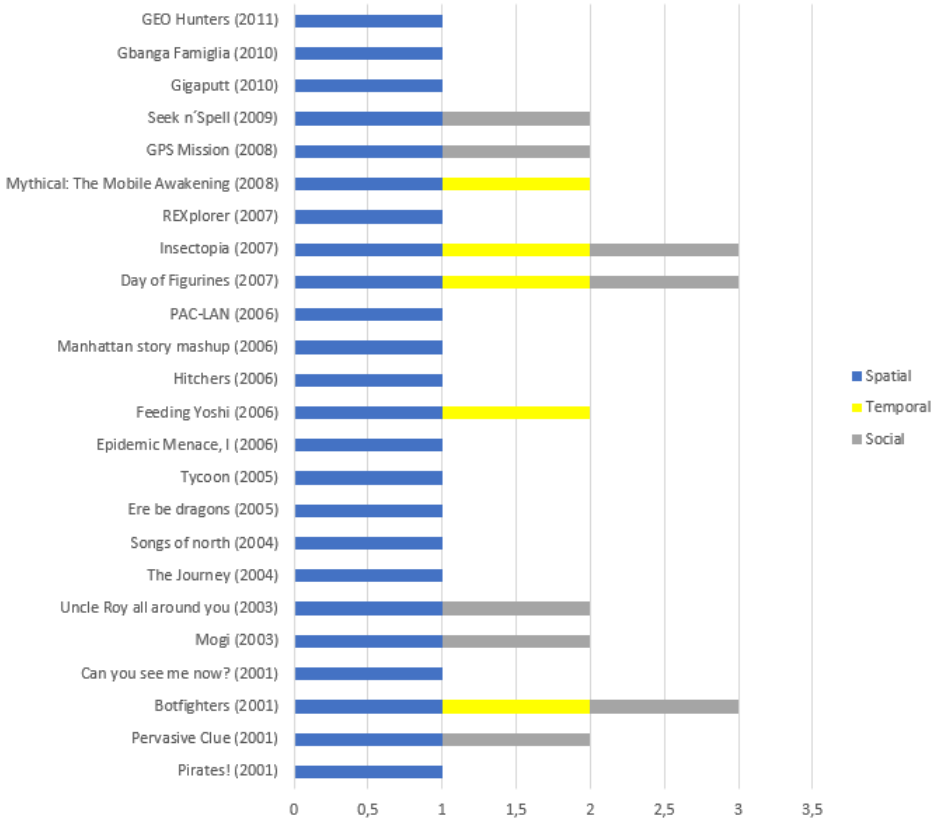

Figure 2.1: Table of Expansions characterization.

The first thing that pops into someone's attention is the blue lines, representing the spatial expansion of each game. This trend became clear during the middle of the analysis, the reason ends up being simple, all games used some sort of GPS tracking system, such as phone's GPS, proximity sensors or even self-reported positioning systems, where the players would communicate where they were. By using these types of sensors all games were able to take the player to unpredictable and uncertain areas. Some of these spatially expanded games used real-life objects to represent game objects, these games where Pervasive Clue [SSK01], Uncle Roy All Around You [BFD+04], PAC-LAN [RBC+06], REXplorer [BKB+07].

Due to the nature of mobile applications a user can move freely around the world and thus gaming in these devices become loose from an anchored position. This is an indicator of how a spatial expansion can be easily achieved by attaching some sort of tracking system of players in the real world. Nowadays due to virtually all smartphones possessing an integrated GPS in their builds, makes the spatial expansion much more accessible to designing and creating Pervasive Games.

Five games were categorized as having a temporal expansion, and eight in having a social expansion.

The five-game that expanded temporally were Mythical, Insectopia [PSB07], Day of Figurines [FGBA07], Feeding Yoshi and Botfighters [Sot02]. These games were considered because they interfered with the players with their daily life, calling upon them when they least expected and

due to the games' mechanics play sessions where complicated to understand when they began or ended.

As expected, Social expansion, since it's the hardest characteristic to define, was also the hardest to recognize, even so, eight games were considered socially expansive, Seek n' Spell, GPS Mission, Insectopia [PSB07], Day of Figurines [FGBA07], Uncle Roy all around you [BFD+04], Mogi, Pervasive Clue [SSK01] and Pirates! [BFHL01]

To be noted it was attempted to differentiate between a multiplayer game and a pervasive multiplayer game. The assertion made was that even though both are multiplayer games, in a *classic* multiplayer game reveals all players to the players, they know who they are instantaneously after a few moments of playing. In a Pervasive Game, like declared before, in a Pervasive Game a player may not know beforehand who the other players are.

These expanded games can be extremely unique, for instance, Insectopia[PSB07] is a game for one or two players, but the socially expansive design of the game comes from using Bluetooth devices as spawn for the virtual insects, therefore we can assume that the more people using a Bluetooth device around the players the more insects the players will catch, hence proving our second point criteria for a Social Expansive game, "a non-player may change gameplay unknowingly".

2.3 Safety in Pervasive Games

With the predominance of mobile phones increasing every year[14], a worrying trend has appeared, texting and scrolling on smartphones has increased pedestrians injuries by 800% over a course of 6 years (2004-2010) [15]. Another report, this time in the United States and much more recent [16], stated than in 2017 more than 16,2% of traffic deaths were pedestrians. That number rose to 17,2% in 2018. One of the most vulnerable age group in 2018 was the 5 to 9-year-olds, where although their deaths numbered 58 it was 18% of all traffic deaths during that year. These stats can be verified at this link (https://injuryfacts.nsc.org/motor-vehicle/road-users/pedestrians/data-details/) In Europe in accordance with the Traffic Safety Basic Facts of 2018, which is a European Commission road report, the 24-page long communique, has plenty of facts of each European country, but as the United States report we see an unfortunate trend, although numerically speaking the children deaths are low, percentage-wise, they're still quite high, around 35% of all road fatalities for the age groups of 5 to 9-year-olds and 10 to 14-year-olds. In this case the percentage is much higher than in the United States. This section delineates problems, safety hazards in Pervasive Games and some ways to fix those same problems, protecting its players.

[14]Retrieved from https://venturebeat.com/2018/09/11/newzoo-smartphone-users-will-top-3-billion-in-2018-hit-3-8-billion-by-2021/ on 28/05/2020

[15]Retrieved from https://www.dailymail.co.uk/health/article-7961881/Texting-scrolling-touchscreens-sent-pedestrian-injuries-soaring-800.html on 28/05/2020

[16]Retrieved from https://www.nsc.org/home-safety/safety-topics/distracted-walking on 28/05/2020

2.3.1 Safety Problems in Pervasive Games

As probably like every media, Pervasive games are not without its inherent problems, it stems from issues in its very core design. So it became clear that identifying the underlying safety issues and problems derived from Pervasive Games was the next step. Over the last years due to the success of Ingress and Pokémon Go, Pervasive games research have somewhat merged with those games as we can show over in the next sections, when searching for problems in Pervasive gaming, the intertwine with Pokémon Go, for example. In articles found, “players cited concerns about safety, privacy, and time commitment” [TGL+17], but not only that, playing with mobile phones forced players to “spend the same amount of time looking at their phones” [TGL+17], which increases the possibility of putting themselves in danger because their attention is not focused on their environment around them. Many of the problems of this type and others were found among the several articles collected spoke about similar issues, making a stronger case for the pursue of safety in Pervasive Games.

The first problem encountered is **inattention to surroundings**. It’s understandable that a Pervasive Game will require the player to frequently (or continuously) look at the screen. This dangerous behaviour befalls into the Spatial Expansion where it’s clear that is a problem deriving from using the surroundings of a player, the playing field where the player interacts with the game is different in a Pervasive Game, in other more *traditional* types of games, the playing field is usually between four walls. Many authors and articles report such cases where the inattention to surroundings creates safety issues to the players. Many reports address that "too much immersion in the virtual world can make a user unsafe as they focus more on the virtual world at the expense of the physical"[SADT17], focusing more on the virtual world in a Pervasive Game means players direct their attention on the game, making them less aware of the possible dangers arising around them.

This issue is recurring in the literature about Pervasive Games, with a big concentration in Pokémon Go. Adding some more examples about this problem in Pervasive Games, it has been cited that "this type of game can lead players to not pay attention to their surroundings as they travel through space"[SBH+17], and (Pervasive Games) "draws people into the gameplay at the cost of oblivity to the surroundings, even to the extent that accidents occur due to this loss of presence" [Haa18]. Both Serino and Franti speak about these same issues in their papers, "in PokemonGo, additional risk comes from the fact that players are looking at the mobile screen to catch the Pokemon. This makes them aloof from the surrounding real world" [FMIS17], "players have been hurt chasing Pokémon due to inattention to surroundings while walking"[SCMM16].

These past examples focused plenty on *normal* walking activities, but there are some example where players play Pervasive Games while, running/biking or even driving, increasing the danger of being inattentive to their surroundings, as stated in Chittaro’s and Karpashevich’s articles, "during activities such as running and biking, users’ visual attention needs to be focused on the surrounding environment for safety reasons"[CZ13], "some interviewees confessed to playing while driving, having a mobile phone holder installed on their dashboard, even though they know

this is a legal offense"[KHD+16]

The second problem found pertains the **personal physical safety** concerning situations where the player has negative interactions with other players or just non-players while playing his game, it's essential to remember that in a Pervasive game, non-players, *regular* people that have no idea someone is playing a game, can unbeknownst interact in a pervasive game with its players. Several reports have been identified in the literature, "incidents of threats of physical violence towards players (they're strangers playing, playing a somewhat competitive game at arm's length of one another" [PKA+17]. These events where players physical safety is actually threatened or just the feeling of being threatened comes from "players who take the game 'too seriously' were sometimes considered a source of danger. A few players had insulted and threatened others via COMM (the in-game chat), and some even went beyond that, directly confronting another player and following them home." [KHD+16] This is a worrying situation in the Pervasive game genre. Players have reported being afraid of theft [BWI+19] and also that "experienced real world safety issues–such as being stalked or harassed–while interacting with strangers" [BWI+19].

In a particular study, parents have expressed concerns about "their children getting harmed by strangers or getting physically hurt" [SBH+17]. This parental concerns also stem from their worry that while their children would be playing a Pervasive Game they could be too distracted and not pay attention to possible threats coming from other people, for example.

The third problem found was **restrictive locations**, this can mean that players are put in several situations where they are in unfamiliar, prohibited or dangerous locations, among other similar locations issues, concerning the position of the player on its *gameboard* - the Pervasive game world, that blends the virtual and the real. These concern about locations have been expressed by players and pointed out by authors in their articles. "Going to unfamiliar places is dangerous"[BLLF19] and "going out to unfamiliar locations, Gyms located in dangerous areas, speeding cars near raid Gyms"[BWI+19] was reported by players about their own concerns about their safety while playing Pervasive Games. Also "players can find themselves wandering in dangerous or prohibited areas"[FMIS17], these situations are sometimes created by the pervasive game design that generates unforeseen paths or locations in a game for a player to play. About this problem that comes from the game design, Karpashevich mentions that "game designers, therefore, have a responsibility "to not lure players into taking unnecessary risks", to consider legal issues (e.g. trespassing)"[KHD+16]. The trespassing issues are important to note and hopefully fix to prevent legal liabilities to both players and game company, for instance in 2019 it has been reported that Niantic had to settle a class-action lawsuit worth $4 million.[17] This also happens with children since they become "engrossed in the excitement of the game might forget that it is inappropriate to enter someone else's property"[SCMM16], understandably children's conceptions of personal property are not as developed as adults, so this becomes a liability that a pervasive game usually does not take account to.

A fourth problem was also identified, **timed challenges** where a game sometimes provides players with challenges or opportunities that possess a *clock* counting down for the player to

[17] Retrieved from https://bit.ly/2YLPwKd on 15/06/2020

perform an action, notable examples are Pokémon Go raids, where players have 45 minutes to successfully defeat the *boss*, these are usually timed challenges that are shown to players and they know how much time they have left to perform an action, but some other challenges or events do not display the time left, such as the appearance of Pokémon on the map, the player never knows how much left he has to catch said Pokémon, this creates a sense of urgency because "that makes its players race against the clock" [FMIS17], which can be especially harmful if a player is not attentive to his location and surroundings since this could create a "desire to rush to cross a potentially busy street" [CTSL+17]

Unexpected billing is another problem, the fifth, that was singled out in articles, this is when a player spend unwanted amounts of money in a game, by accident or by deceit, for example, phishing, scam or in-game currency *traps*. This has also been reported in the literature being pointed out by Balcerzak, "phishing and Spam targeted at elders, but there's similarities with younger people as well" [BKN+18]. In this category, another similar one is also bundled up such as "heavy data usage can lead to unexpectedly large cell-phone bills for parents at the end of the month" [SCMM16]. This is especially dangerous when a player does not understand its mobile payments he's required to do or is inattentive to how much data he has consumed while playing.

Finally, another issue, that can create opportunities for dangerous events is **weather conditions**, although there were not many accounts found concerning this problem it still exists and heavy rain, flooding, extreme wind situations can harm players if they're not careful enough. Also, avalanches are particularly dangerous and clearly, some players play in the middle of blizzards as shown from this statement, "friend almost got hit by an avalanche while playing in winter" [KHD+16]

2.3.2 Safety Measures enacted in Pervasive Games

After collecting problems in Pervasive Games, and the danger this type of games can put their players in, there are some safety measures that somewhat protect the player while they're actively playing the game, already implemented or suggested/tested in academic literature.

Speaking about what was found in the literature, for the problem with the **inattention to surroundings** there has been a few suggestions from authors on how to fix such problem Sharma suggests that the games could offer "individual spaces be constructed so that the user only operates in mixed reality in safe areas"[SADT17] or pop-ups can remind the player to be attentive and alert at all times, something Pokémon Go uses, at the beginning of each playing section, in the loading screen, the game remembers the player to be aware of its surroundings.

Types of mediation have been suggested by Sobel, these types included "restrictive mediation (e.g., setting rules for how far older children were allowed to travel), active mediation (e.g., having discussions about where to travel to next)"[SBH+17] or even "co-use (e.g., playing together such that a parent takes on the role of always keeping the phone in his or her pocket)"[SBH+17]. Sobel also proposes mediation as a deterrent for physical harm towards children.

Another suggestion to combat inattention to surroundings is some sort of audio queue, like in "audio storytelling, that does not require the player to look at the screen during running (for

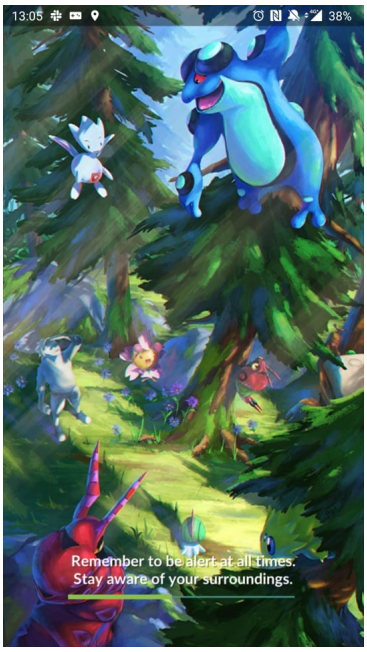

Figure 2.2: Pokémon login screen, remembering players to be aware while playing

eg.)"[CZ13]. Using this idea from Chittaro of having some sort of sound trigger to help protect players and remembering them to look up could help in solving these issue, but as Rector has pointed out "constant auditory feedback through their headphones while outside, this could pose a serious safety risk" [Rec17], so this safety measure could only be used if properly tuned and tested, otherwise the cure would be worse than the disease.

Modern Pervasive Games are built with some sense of protection, the peril of suffering a lawsuit is to be avoided so they create mechanisms to safeguard them from legal issues, such as placing pop-ups in the game whenever the player is doing a dangerous action, this involves playing while driving for example, and one of the main issues game developers try to fix.

Rushing towards a goal or making a sense of urgency for the player while there's a gameplay session occurring can put a player in harm's way as it has been verified in the previous section, avoiding game content appearing, for example, across the street or road from the player's location has been suggested by Colley since this could reduce "the desire to rush to cross a potentially busy street" [CTSL+17]. This strategy has been experimented and employed by Jacob in his previous work[JC11, Jac17] where he created a pervasive game based on location, to test out his theory of preventing NOCs from appearing near crossroads.

But as previously mentioned, over the last few years, big names have appeared industry area in Pervasive Gaming, games such as Wizards Unite, Pokémon Go, Minecraft Earth amongst others. These modern pervasive games have been attempting to minimize the safety risks its players may have while playing those games.

For instance, weather has been a concern in Pokémon Go since its game actively uses weather conditions to in the game, making the Pokémons stronger or weaker (for example) depending on weather. But if the weather conditions become too severe the game sends out a warning sign such

as shown in figure 2.3.

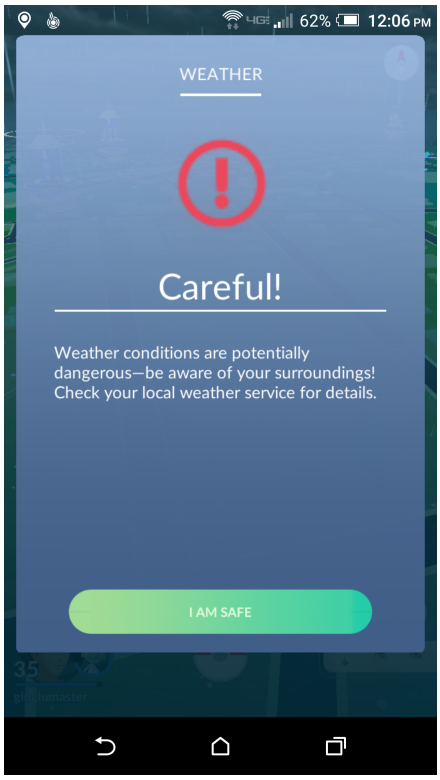

Figure 2.3: A weather warning sign for Pokémon Go

At the beginning of the first implementation, the game had another warning, much more restrictive, the extreme weather warning[18], but according to pices of information the game developers have removed since the players did not enjoy it because the game would strip down the weather bonus from the pokémon if the weather was extreme [19] [20].

Continuing with safety features industry pervasive games have implemented into their games, there's the driving *problem*, as players sometimes play while driving which endangers them and others. Game developers have started to implement warning restrictions that inform the player he's travelling too fast, for as we can see in figure 2.4 and figure 2.5.

Minecraft Earth goes a step further and blocks players from interacting with *tappables* (game items on top of the game board), effectively preventing of playing that game feature. Minecraft Earth also has a video inside the game simply informing and warning players of possible risks.[21].

[18]Retrieved from https://pokemonblog.com/2017/12/08/new-extreme-weather-warning-screen-now-pops-up-in-pokemon-go/ on 15/06/2020

[19]Retrieved from https://www.polygon.com/2017/12/11/16749834/pokemon-go-extreme-weather-pop-up on 15/06/2020

[20]Retrieved from https://gamepress.gg/pokemongo/zh-hant/node/280371 on 15/06/2020

[21]Retrieved from https://www.youtube.com/watch?v=djKPSKufFJU on 16/06/2020

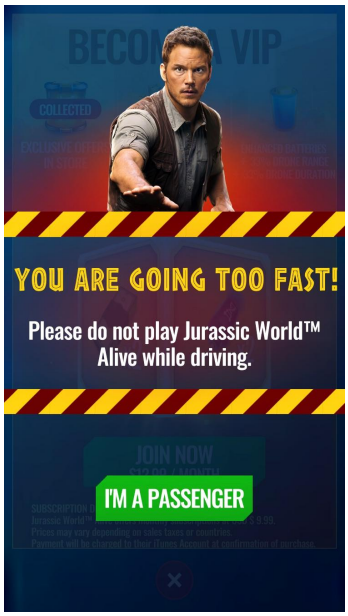

Figure 2.4: Warning to not drive while playing Jurassic World Alive

Figure 2.5: Warning to not drive while playing Pokémon Go

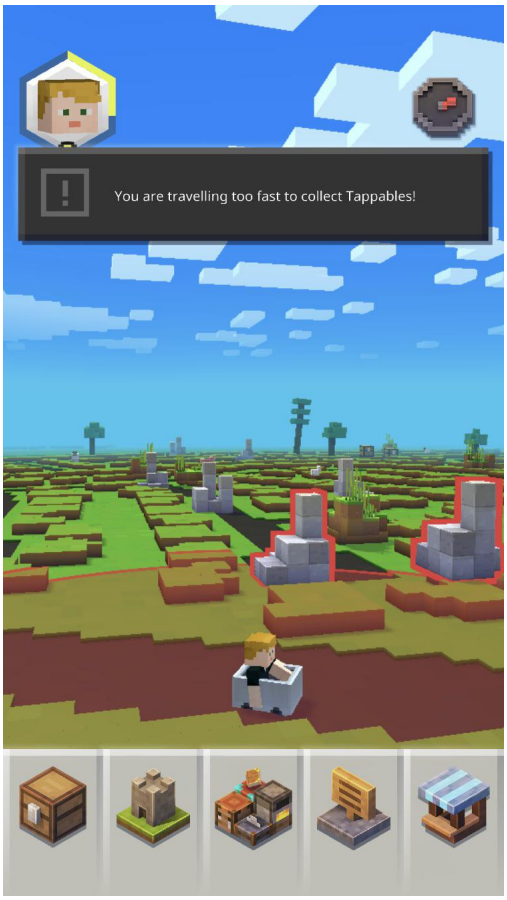

Figure 2.6: Driving warning for Minecraft Earth

2.3.3 Parental Control

Having encountered many problems with Pervasive Games, the next step was to encounter appropriate safety measures for those problems, the last two sections provided information in regards with those two topics, but not every problem had a straightforward solution. Some problems had safety measures that could solve or help mitigate the dangers arising from those same problems if the players would just be more attentive with their play, but that maturity can't always be found in children or early teens. Hence why some of the problems still remain when referring to children playing these games and many websites try to speak to parents on hazards in Pervasive Games and safety measures they can try to provide to protect their children [22][23]

Niantic, Pokémon Go game development company, regarding safety issues has suggested in their faq[24] parents could control certain aspects of their children gaming session through the use of Apple or Android parental control systems. This usually means restricting content from their respective stores, though this action little to no consequence brings into the actual play of Pervasive Games.

Apple parental control system goes one step further and allows the parent to prevent the use of localization services in games, by doing this, the children are basically shut off entirely of playing Pervasive Games, because most of the modern games require - and demand - that functionality to be turned on. Apple's parental control[25] can also restrict access to mobile data definition, but it's no more than to prevent altering its definitions. In Apples' Parental control a parent can also restrict the children's interaction with its Game Center, where a parent may prevent the children from playing multiplayer games or add friends, as a measure to prevent possibly dangerous interactions with strangers.

Google Parental Control is activated in Google Play[26], it restricts what can or cannot be downloaded or purchased through the Store. As pointed in the help link, "parental control works varies across Apps Games, Music, Movies, TV, and Books", the way the parental control works for Apps Games is simply setting the rating for the applications the children see in the store, enforcing the age restrictions in accordance to the age rating the game possesses.

As it has been searched, no Pervasive Games have strong parental control options, most rely on the mobile device manufacturer to provide such options, but only Apple goes a step further, although for example on the location setting, goes too far, since it completely blocks play.

2.4 Conclusions

In this chapter, it has been recounted the history of Pervasive Games, as it spends the last 20 or so years having many names, such as LARP's, location-based games, ubiquitous games, etc. This

[22]Retrieved from https://www.essentialparent.com/lesson/is-it-safe-to-let-my-child-play-pokemon-go-2327/ on 16/06/2019

[23]Retrieved from https://www.positiveparentingsolutions.com/parenting/4-tips-pokemon-go-safety on 16/06/2020

[24]Retrieved from https://niantic.helpshift.com/a/pokemon-go/?s=safety-securityf=safety-faqs on 16/06/2020

[25]Retrieved from https://support.apple.com/pt-pt/HT201304 on 17/06/2020

[26]Retrieved from https://support.google.com/googleplay/answer/1075738?hl=en on 17/06/2020

brief history was further explored with the realization of the 3 expansions by Montola's work. A very big *event* was the birth of mobile devices, that aided pervasive games industry booming. Since these mobile devices, were walky-talkies, GPS devices and input/output devices, and many other features, all in one.

Mainly to the amazing success of Pokémon Go, the game became almost a synonymous of Pervasive Gaming and a poster child for augmented reality games in smartphones. But not all success stories are without some problems or issues. These safety hazards or security issues that arise from Pervasive Game should be documented in an effort to further protect and safeguard its players. As mentioned in the Research Questions, section 1.5, this was our first RQ, that has been answered in the previous subchapters, chapter 6 will have a recap on this question.

Hence the Safety in Pervasive Games sub-chapter where the threats to a player safety while playing a game are explored and detailed, and an attempt to find if any of those safety issues have been resolved or any idea has emerged to fix those issue. But since not all safety issues have been fixed, this work intends to provide a possible fix, or at the very list shed some light in the situation. The following chapter will seek to present a solution to these safety issues.

Chapter 3

Conceptual Framework for Regulating Safety in Pervasive Games

As established before, Pervasive Games, have grown tremendously over these past years and that makes its security towards players much more important. Hopefully with this work more *frail* people such as children can experience the entertainment value of these type of games, but more securely, that can offer their parents some peace of mind that their offspring are both enjoying themselves gaming and far from harm's way. So, in this chapter a proposed methodology for this dissertations work is outlined, beginning with the established problem to provide a baseline for the chapter, a solution proposition on how to tackle the problem and ending with the proposed validation for the solution.

3.1 Established Problem

According to research, there are several safety issues and problems concerning Pervasive Games, with emphasis on Mobile Pervasive Games. Using a systematic approach while studying the literature, a number of issues were uncovered from that review performed within this work. subsection 2.3.1, in particular, identifies safety problems concerning Pervasive Games, which are now recalled to serve as a baseline for this chapter work.

- Inattention to surroundings
- Personal physical safety
- Restrictive locations
- Timed challenges
- Unexpected billing
- Weather conditions

Most of these safety issues intertwine at times - such as weather being dependent on time and place - but nonetheless, they will be separated into the 3 expansions to provide a structure into the development.

The immersion the players have while playing the game makes "players pay less attention to the outside world"[KHD+16]. This inattention to surroundings has been deemed a spatial problem since the player is affected by its geographical position. Restrictive locations, that can be unfamiliar, prohibited or dangerous locations, also befall the spatial expansion.

The temporal expansion possesses two problems, a Time problem and a Weather problem, the latter comes from the weather conditions that can threaten a player's safety, the former does not directly come from such problems as timed challenges, but from the Temporal expansion itself, as we know the temporal expansion interferes with real-life scheduling of a person (the player) because the game keeps informing the player of situations happening unexpectedly.

Personal physical safety falls into the social expansion, where the interactions among pervasive game players with themselves occur. About this problem, there are specific parental worry points regarding "their children getting harmed by strangers or getting physically hurt" [SBH+17] and "being unsupervised while talking with strangers" [BWI+19]

There was one problem that was not exactly correlated to the expansions, and that was unexpected billing, but since excessive behaviour, without regard to currency constraints while playing Pervasive Games, may put a strain in social relationships and since scam and phishing also fall into this category and they're somewhat social interactions, it was decided to place it in the social expansion.

Furthermore, the research showed a bit of an unexplored ground concerning children safety, most often relegating safety measures to OS and mobile device developers and manufacturers. There are a few interesting ways to aid in safeguarding children, but not all problems found by the literature were fixed in parental control systems. This was a reason that gave strength to this work.

Since the commercial success of Pokémon Go, Mobile Pervasive Games scientific research received significant attention and growth in the academic field. A quick study in the Scopus library shows that after 2017 (inclusive) one can retrieve 809 (out of 1907) search results with 8 different keyword strings, with the older date being 1997 concerning Augmented Reality Games. One can see that Augmented Reality Games research received a huge boost after the appearance of Pokémon Go (almost doubled the 2016 research in the next two years (2017 and 2018). Also, Location-based Games received a similar boost, all others had negligible increases or decreases. As expected, there was no research concerning Pokémon Go, previous of its official launch in July 2016, but skyrocket from that moment to 2018, having 279 documents (articles, papers, books, etc.) with the subject.

3.2 Proposed Solution

After gathering complains and worries from the players, and safety issues and design problems concerning those same issues, this dissertation proposes a methodology in Safety for Pervasive

Games. Creating a service that could run in the background of a mobile device and restricting the player-s actions that could put him in harm's way, this idea was chosen to resolve or at least mitigate those complains and problems. For example, one of the services' purpose is to prevent a child to stray into dangerous and prohibited locations such as bad neighbourhoods, cemeteries or hospitals, etc. These unsafe movements can be prevented e.g. by inserting a geofence around certain locations. Another type of geofencing, such as a relative geofencing may include creating a "ring" around the parent to ensure the children do not go far their protector.

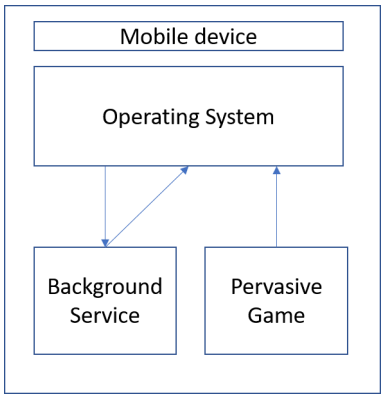

Figure 3.1: Conceptual Diagram of the solution

The image 3.1 shows a conceptual diagram of the idea a prototype of this work, a service will run in the background of a mobile device interacting with the operating system that in return interacts with a Pervasive Game, and through that connection, the prototype can restrict (slightly) the playtime of player that plays the game.

3.2.1 Safety Issues

The safety hazards recovered from the literature and identified as relevant issues allowed for a collection of safety issues the service intends to address. Within the scope of this dissertation, these issues are the following:

1. Prohibited locations, such as trespassing private property or even governmental property.
2. Dangerous locations, such as cliffs, highways, or big water reservoirs (such as rivers and oceans/lakes).
3. Weather, such as using an application in clearly dangerous situations.
4. Time, using the application in an inappropriate moment.
5. Personal physical safety, regarding interaction with other players/non-players.
6. Monetary concerns, specifically heavy data usage.

These are the six main safety issues or problems this dissertation proposes to address. These problems will be discussed on how they can be fixed in the next section.

Prohibited locations	Digitally generate a fence around the designated location. Using the phones GPS, a geofence can be used to trigger the fence on the location when the
Dangerous locations	Generate a field around the designated location. Using the phones GPS, a geofence can be used to trigger this measure
Weather	This measure will be triggered by the combination of the phone's GPS location service with real-time weather data, allowing the application to assert weather conditions.
Time	Prevent the users' phone to use the application around other specific phones
Personal physical safety against others	Prevents the game from being played if in the presence (in a radius) of a dangerous or unwanted individual
Monetary concerns	Prevent network and mobile data usage to go beyond a certain value

Table 3.1: Overview of how to solve each problem.

3.2.2 Identifying Safety Measures

After identifying problems related to safety hazards in the design of Pervasive Games, this work also identified some measures that have been attempted to tackle those same problems, as mentioned in section 2.4, not all have been resolved. Each safety issue has a brief overview of how this dissertation intends to solve each particular problems. Table 3.1 has this overview, where the column on the left is the problem to be resolved, and the column on right an idea on how to approach the issue and fix it.

3.2.3 Designing Safety Measures

After having enumerated in the previous section six proposed safety measures to be enacted in this work, the next step is to design the safety measures from what was identified on the previous step. This design proposal will be developed and implemented in this work, and in chapter 4 the *how* this design was implemented will be further detailed. So in order to safeguard a player while playing the game, these safety measures that were collected would be transformed into rules, rules that a system would use to preventing harm happening to its players.

Since there was some exploration room for parental control systems applied to Pervasive Gaming, an idea emerged to do exactly that. Creating a parental control system curated by parents where they could oversee and protect their children. This parental control system would be active while the children played a specific Pervasive Game, and the rules set in that system would oversee and protect the children from dangerous events.

When designing the safety measures' implementation it was taken note that measures would work with a mobile device, since most Pervasive Games are played with those type of devices. So these safety measures are created to be able to interact with several services from the Operating System of a mobile phone. These services would provide information in real-time of the mobile

device, such as the position of the user and the time of the device at that moment, among other services that would cross-reference with the rule set in place for the player.

Each safety measure to correctly perform its duties will need to perform the following:

1. Prohibited locations
   (a) have access to the users' mobile device location
   (b) a list of prohibited locations
   (c) a digital fence created around each element of the prohibited locations.
2. Dangerous locations
   (a) have access to the users' mobile device location
   (b) list of dangerous locations
   (c) a digital fence created around each element of the dangerous locations
3. Weather
   (a) have access to the users' mobile device location
   (b) have a connection to a real-time weather data API for the user's location
4. Time
   (a) users' phone current date and time
   (b) list of dates (day/month, hours/minutes) in which the user can not use the application;
5. Personal physical safety against others
   (a) have access to the users' mobile device location
   (b) have knowledge of others' mobile device location
6. Monetary concerns
   (a) have access to the users' mobile device network and mobile data usage
   (b) predetermined value to limit data usage, and enact a measure if this value equals the user's mobile device data usage

But for these types of safety measures to also provide a range for the parent to educate their children the settings for the parental control should provide such capability. Teaching children besides preventing them from falling into harm's way, is also important. To help regulate these safety measures, an idea was thought up from Nikken and Jansz work[NJ06] where they proposed 3 type of parental mediation of children's playing time. This proposal was also cited by DeCamp, where he offered good examples on how each mediation would work: "restrictive mediation (e.g., monitoring games and selecting appropriate ones), active mediation (discussing games' content

with children), and co-playing the games"[DeC19] (co-playing, as the name indicates, means parents playing together a game with their young children).

But for this particular work, the restrictive and an in-between the restrictive and active mediation are proposed. The restrictive measure this work proposes serves the same purpose, to monitor and prevent unwanted behaviour by force. While the *in-between* although still monitoring, does not prevent the behaviour but attempts to provide a learning experience for the child, since the service tries to inform of what is doing wrong but still allows the child to play.

Recalling the safety measures, they will be six and for each measure, the service will have a dual-option of being restrictive or alarmist, which will be named alarmist (because it will only send out an alarm). These two options are designed to offer a better range of control of the system. In a quick example, the restrictive type will actively stop the player from performing actions that could cause him any sort of harm. While the alarmist can be used to teach the child that what he is doing although allowed should be better thought over on whether he should do or not the action that lead to that alarm.

3.2.4 Use Case Situation

To assist in explaining how the solution would work, a use case scenario with personas was created where we simulated the opinions and desires of a child and its parent. The two personas are the following:

• Player – João, child, 12 years old, plays Pokémon Go with his father and friends, goes to middle school during weekdays, close to his own home, around 3km. He is usually obedient but sometimes he becomes unaware of where is going and may end up strolling into fields, in search for Pokémon, where heavy machinery sometimes is working.

• Supervisor – Rui, parent, 36 years old, works 8h/day during weekdays, on weekends plays Pokémon Go with João on the park near their home. Works for a minimal wage so money is spent wisely in his household.

The following paragraph will enact a supposed behaviour of a Supervisor concerning the Player. It will explain the reasoning and actions of the Supervisor in using the Service Dashboard:

"Rui, fearful for his child safety, does not enjoy that after leaving school he comes running through fields of wheat, so he places a marker in the centre of the nearby wheat field to create a circular geofence around it. And determines the severity of the measure, marking it as a warning. João will receive a warning when entering the field, so will Rui, being informed his child is entering the field. Furthermore, Rui believes his child may not regulate properly the usage of the game, so he determines that João cannot play during 9 am to 12 am, because he's in classes. As this avoids his child to be distracted while attending classes, he chooses a more restrictive measure, stopping João from using the application."

This use case shows how parents can monitor their children with the proposed solution.

3.2.5 Summary of solution design

In short, this work intends to develop a service - in the background - that can be used with a mobile Pervasive Game. This service will receive a list of safety measures and its restriction types, which whenever the game boots up, the service will use Operating System processes such as GPS, date/time, and other processes it may require, to compare if the values or rules in those safety measures are being broken.

The six safety measures that were enumerated in subsection 3.2.2 provided the second part of the answer to the RQ2 - "What are safety measures to tackle the security threats?" In chapter 6 a more complete answer to RQ2 will be provided.

3.3 Proposed Validation

Proposing a validation for any work is an important step in asserting its benefits or issues and ideas that could be improved.

The proposed validation in this chapter was planned before the Covid-19 pandemic, so, unfortunately, some tests were not able to be done, but it was considered that the ideal validation work that planned here was relevant and could be repurposed for a future work. In chapter 5, we conclude the evaluation of this methodology and expand on its performance.

So to assert the benefits an results for this dissertation, the proposal would be to share a **parental questionnaire** with parents that have underage children that play Pervasive Game and assess their current worries and satisfaction with safety measures in current Pervasive Games. Perform **functional testing** to the service that was created to enforce the safety measures from the parents. And the final validation proposal would be **user testing** with players, where they are given certain objectives to perform and evaluate the service while the players play a Pervasive Game.

Out of these three types of validation, the user-testing with players was not able to be performed due to the pandemic, the questionnaire was done and its results are presented in subsection 5.1, the functional testing of the service is demonstrated in subsection 5.2.

These tests would provide answers for the Research questions three through five, but as stated before, in section 1.5, due to the pandemic they ended up somewhat incomplete, but still, they received attention in section 6.1 and all findings are noted there.

3.3.1 Parental Safety Measures Evaluation

A parental questionnaire about their safety worries concerning their children playtime habits and events were created to assist in answering the RQ5 - What is the impact of such safety measures for the parental supervisor, regarding their safety fears?.

After an exploration through the Scopus directory, no questionnaire oriented to the needs and intentions of this work was found. So it was necessary to create a new one. Although none was found about Pervasive Gaming there were plenty questionnaires related to children gaming

addiction or internet addiction/monitoring to parents. So it was decided to attempt if any of the found questionnaires could serve as a basis for this work's parental questionnaire.

The parental questionnaire that was constructed here had its basis in Pons-Salvador work, with the article "Internet Use by Children Aged six to nine: Parents' Beliefs and Knowledge about Risk Prevention"[PSZMFN18]. This was a questionnaire built for parents about their children internet usage. The original questionnaire was nowhere to be found, so some questions were inferred from it. Thus, from the answers given and recorded in the article, it was able to infer the questions and use that information to construct the questions in this work. For example, the question - in this work - "Do your children play any sort of Pervasive Games?" was inferred from answers about children using the internet and many other similar questions. These translations of internet usage to pervasive gaming gave a more strong and tested foundation to create this work's questionnaire.

The final result for this work's parental questionnaire is demonstrated in section A.3 where all twenty questions are demonstrated. These questions are a mix of four open-answer questions, four yes/no questions, four multiple-choice questions and eight multiple option questions (only one choice was allowed as an answer)

3.3.2 Methodology Validation

In order to validate the service, fourteen test scenarios were planed. These scenarios are meant to cover all safety restrictions.

Expansion	Restriction	Restrictive	Alarmist	Time frame
Spatial	Prohibited location	1	2	moment
Spatial	Dangerous location	3	4	moment
Temporal	Time interval	5	6	periodic
Temporal	Time spent	7	8	daily/monthly
Temporal	Weather	9	10	moment
Social	Physical	11	12	moment
Social	Financial	13	14	monthly

Table 3.2: Functional tests identification.

As we can observe, each row corresponds to a restriction, created from the previous literature review and written as a restriction key in the safety measures file. Each row has its designated Expansion, their safety restriction type, the identification of two scenarios - a restrictive one and an alarmist one - and a time frame.

The time frame column signifies how each restriction is tested and repeated. For example, a restriction with a time frame of "moment" is tested once every five seconds and depends on whether the player is actively breaking it. The rows with time frames of "daily, monthly and periodic", represent safety restrictions that depend on the day and/or hour of the playing session, and will repeatedly trigger during the duration of those restrictions.

These functional tests have their input parameters and expected outcome in order to evaluate their success or failure. Table 3.3 is the template used to create all fourteen tests. All tests are to

Test ID	The test identifier, it is unique, and each test represents a restriction and its respective type.
Expansion	One of the three expansions Spatial, Temporal and Social
Restriction name	The name of the restriction
Restriction type	There are two restriction types, restrictive and alarmist.
Time frame	If the restriction is verified in a specific time interval, daily, monthly or if it is a single moment
Conditions required	Conditions required for the restriction to take place
Rules parameters	A portion of the safety measure rules, respective to the specific test
Steps Required	Necessary steps for the restriction to be verified
Expected Behaviour	Systems' expected behaviour once the restriction is verified
Continued actions	What happens once the restriction is verified but the user continues to trigger the restriction

Table 3.3: Template for functional testing.

be prepared following those parameters, and the full list of functional tests are further detailed in section A.2. This test template explains each row and what it is for, the column on the left is the field name, what it is to be done, and on the right the reasoning on how to do it and the expected outcome if applicable.

3.3.3 Methodology Evaluation - Test Protocol

For the service evaluation test protocols were planned, and are to be done with players playing a Pervasive Game while having the safety measures enabled in their mobile phone. This evaluation of the methodology would hopefully answer the two research questions, namely RQ3 - How can one evaluate the impact of the safety measures in player experience? - and RQ4 - What is the impact of such safety measures for the player experience?.

But as it was pointed out at the beginning of this section, Covid-19 did not allow a safe testing environment, so this test protocol did not go through. Still, there was work that was done and prepared for the eventuality that the tests could proceed safely. Summarizing the initial plan for this evaluation, the test protocols would be conducted on the field, and the players would use a mobile device with the solution that was planed and the safety measures adequate for the test. Two scenarios were planed for this. At the end of the test scenarios, the player would respond to a questionnaire about the system.

For more details on the two scenarios planed, they are mostly covered in section A.5.

3.4 Summary

This chapter picks what was learned from chapter 2 and designs a solution to the problems this dissertation intends to fix. Problems those that were mentioned in section 3.1 and were inattention to surroundings, personal physical safety, restrictive locations, timed challenges, unexpected

billing and weather conditions. These problems would give the baseline for the safety issues to be identified in subsection 3.2.

The proposed solution identified the issues and designed safety measures for those issues, providing a simple use-case scenario with made-up personas. This chapter would be expanded further in chapter 4, where the development would be explained and all the safety measures would be inserted into a service (the background service) to create a prototype for this methodology.

The proposed validation for this dissertations methodology was also written in subsection 3.3, where three types of validation and evaluation were originally proposed, parental questionnaire, functional testing and user tests, this latter eventually dropped due to unforeseen issues of the pandemic.

In the next chapter, the Development will be a more technical chapter where it will be shown how does the background service receives the safety measures and how collects data from the Operating System to enforce those safety rules.

Chapter 4

Background Service Development

The Development chapter speaks about the work done in this dissertation - besides the research done to answer our two first Research questions - is more hands-on, where the proposal for a service that can help in solving or improving safety issues and parental concerns for their children while playing pervasive Games.

This chapter comprehends an explanation of the service and how the service uses Android's data to perform its ruling of player actions. A plan for how the development was originally outlined, a more in-depth explanation about how the service was constructed and certain development choices were decided while in development and issues and challenges aroused while developing the service.

4.1 Service Description

This works' proposal is to provide parents with a tool in which they can safeguard their children from harm, whenever they are not around while still allowing the children to play and entertain themselves with pervasive games, being able to experiment with the wondrous of location-based games and similar.

So a parent by having a background service in their children mobile device, with rules concerning safety, they can protect to an extent their children's security. The background service in the mobile device acts as a watcher, warning or even restricting the children's actions depending on the safety measures set in place.

The service is installed in a mobile device and when switched on it will operate in the background of that device, whenever the application intended to be supervised is on the foreground - visible to its user - the service will enact its rules in order to safeguard the children, these rules are to be set previously by the parent. The service reads these rules into its system and saves them throughout multiple play sessions until they are changed or overwritten. Whenever the children break a rule, depending on the type (severity) the service will send out a warning into the children's mobile device screen informing what happened. If the severity is of the type restrictive, the

mobile phone locks the player from playing the game, until the rule set in place ceases from being broken by the player actions.

4.2 Service Diagram

To better explain the previous section, a diagram of the service is to been arranged, below the architecture structure of the solution for our work is represented.

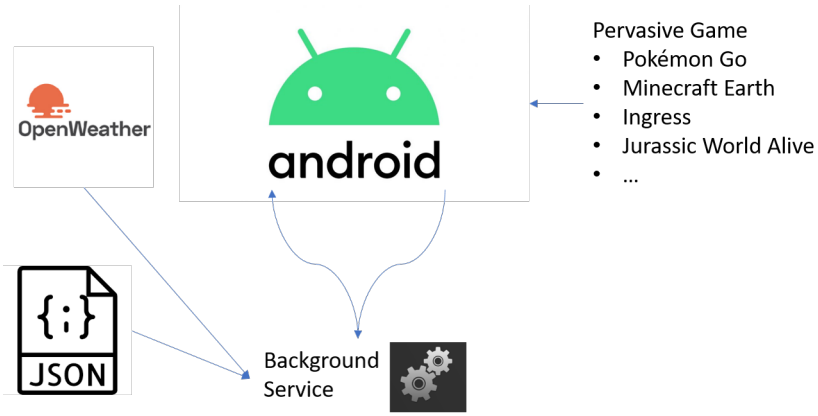

Figure 4.1: Service Diagram

The five parts shown in 4.1 are representative of five important features, API or services the whole system uses in order to do its job.

This image depicts what is happening in a child's mobile device, the Android logo represents the mobile device and its Operating System with its own services such as GPS availability, date and time, data usage among other necessities the system needs to perform his duties.

The Background Service is where a lot was done, it receives a JSON file, with the safety rules required by the parent, the service puts these instructions in place and using the Android OS services and external API services such as OpenWeather[1], whenever the respective application (the Pervasive Game) is running on the foreground, the service will know and act accordingly.

4.3 Safety Measures file

As previously mentioned the safety measures researched are an important component of this work. The problems encountered with the safety in Pervasive Gaming allowed for the creation of safety measures proposed from those faults, these measures had to be translated into something a machine could read, interpret and enforce, so a relatively straightforward option of creating a JSON file presented itself.

This JSON file is then be placed inside a folder inside the mobile device file system and when the service is first started it would read the contents of this file and turn its content into rules to follow while the player plays its respective Pervasive Game.

[1] https://openweathermap.org/

So, moving on into explaining the content of the file, the first options should be configurations values, there were two deemed important for the early stage of developing, a key named *config* and another named *gamename*. The *gamename* it is the name of the game, although the name is self-explanatory, there are some nuances about this key-pair value that are better explained in 4.4, the key *config* is for the periodic renewal of the rules, this option was not widely used nor tested since it provided little insight or real value on how a parent could safeguard his child, although it was considered a good option for simplifying future work providing more comfort tools for the parent, so it remained throughout development.

The next values are three objects that represent the three expansions, Spatial, Temporal and Social. These three objects hold the actual rules that a parent can set in place to shield their children from dangerous actions or events. To create a sort of uniformity between all expansions, each of these expansions have three layers, that are explained as the following:

- The first layer is the name of the expansion itself, it indicates that all key-pair values inside this respective layer fall into that specific expansion (i.e.: “social”).
- After that comes the second layer, which holds the safety measures that were planned and designed in subsection 3.2 and are to be enforced by the service;
- And finally, the third layer is a list of the requirements necessary to the rules to be successfully implemented, so the service can perform its job properly and enforce each safety measure.

Entering a more detailed explanation, each layer (or expansion) will be explained on how it works within the JSON file, starting with the Spatial expansion layer.

Spatial

```
"spatial": {
  "prohibited_local": [{
      "name": "Hospital S. Jo o",
      "position": [41.181533, -8.60011],
      "type": "restrictive"
    }],
   "dangerous_local": [{
      "name": "FEUP",
      "position": [41.1779519, -8.5949384],
      "type": "alarmist"
    }]
  }
```

This expansion has two restrictions, prohibited_local and dangerous_local, these are two safety concerns parents usually have when their children play Pervasive Games, although programmatically speaking these concerns end up being the same but for proper organization, they remained two separate measures in the file. Each of these safety concerns are addressed mainly with the *position* value, where the file provides the service with the latitude and longitude of the location to be prohibited or deemed dangerous. A name is also requested but this key-value serves more as an informative value.

Each measure ends up with a type of restriction, as all other measures in the file do. This option is a common and constant variable across all safety measure requirements is the *type* variable that indicates whether that measure is restrictive (locks the application) or alarmist (only displays a warning in the children's phone).

Temporal

```
"temporal": {
    "time": [{
        "dayOfWeek": "2",
        "startime": "9h",
        "endtime": "12h",
        "repeating": "yes",
        "type": "restrictive"
      },
      {
        "dayOfWeek": "1",
        "startime": "13h",
        "endtime": "15h",
        "repeating": "no",
        "type": "alarmistic"
      }],
    "timeSpent": {
        "repetition": "daily",
        "time": 2,
      "type": "restrictive"
      },
    "weather": [{
        "warningType": "red",
        "type": "restrictive"
      }]
  }
```

Moving on into the Temporal expansion, where it can be seen that the expansion has three

security measures, *time*, *timespent* and *weather*. Starting with *time*, this is a list of time intervals during a week, where the players' gaming time is being supervised, parents may choose how many intervals they desire their children to be supervised, the numerical values for this value represent the day in the week ranging from 1 to 7, where 1 is Sunday and 7 is Saturday, and its respective start and end time for the time interval, the *startTime* and *endTime* are integers ranging from 0 to 23 representing hours of the day. I.e. a parent does not wish for the child to play during morning classes, may block gaming activity from 9 AM until 12 AM. This measure can be repeated throughout every week, with the option *repeating*.

The second temporal measure is the *timespent*, this measure was not originally in the safety threats discovered in the research, but while developing the service this feature, if we may call it a feature, came up in discussions as a fairly straightforward and easy to implement measure. This measure is an uncomplicated measure that simply tracks the amount of time (with the key-pair value *time*) during a certain period of time - daily or monthly, and restricts the time a player has to play a game depending on the value of *time*.

The final temporal measure is the *weather* one, where parents can determine if their children can not play under certain types of weather, to facilitate the options provided at parents this safety measure is regulated by choosing three warning types, green, yellow and red. These weather warning types can at times depend on the country they're announced, each country can have different requirements, small differences on what they consider a yellow weather warning for example. How this was calculated in this service is explained in detail in 4.4.

Social

```
"social": {
   "physical": [{
       "id": "3091",
       "range": "auto",
       "type": "restrictive"
     }],
   "financial": [{
       "value": "900",
       "type": "alarmist"
     }]
 }
```

The final expansion is the Social expansion, that has two safety measures, the *physical* that protects a child from unwanted and possible dangerous persons, and the financial one that attempts to protect children - and their parents' wallet - from exaggerating in the data plan usage, costing weekly or monthly pay more to parents that they would want to.

In total, our JSON file has seven safety measures. Measures that attempt to secure children well-being and keep them focused on real-life, before being focused on the virtual life. There is a JSON file example is in section A.1 of the Appendix section of this document.

While the safety measures file proved relatively straightforward to create, it took a few iterations to get it right but it is an integral part of the background service, without it the service would not work properly, the service itself and how it was developed and implemented is what it will be presented in the next section.

4.4 Service Development Process

The background service implemented is an indispensable part of the experiment for this dissertation. Within it, is where the safety measures are applied and a parent can actually supervise their children and rest assure their children are having fun while being protected from possible dangerous of a Pervasive Game. This section examines development decisions and explains how does it receive the necessary data to enact the rules and how it reacts depending on the data received and the rules set in place.

4.4.1 Service Requirements

To test and implement parental safety measures, it was devised a background service, for Android, that would act as a watcher, lurking on the background of a mobile device enforcing the safety measure rules. The service will need the following requirements to do its job:

- Connection the mobile phones OS services (such as GPS, network consumption, time and day, among others). The data provided by the mobile phone services are used to enforce the rules from the safety measures file - explained in the next point - many of these services require the phone to permit access.
- The safety measures file - settings file- to enact the safety measures, this file which was explained in 4.3, is inside a specific folder denominated Service inside the mobile phone file system and the background service uses it to enforce safety rules onto the Pervasive Game that is being monitored.
- Some sort of connection with the desired Pervasive Game, meaning since a direct connection might not be possible but through the Operating System services, the background service knows when the Pervasive Game is being played.

4.4.2 Background Service Construction

For the service itself, a few attempts were made with several Android Service components such as ServiceHandler[2], JobService[3] and IntentService[4], all three gave equal results to the necessities

[2]https://developer.android.com/guide/components/services?hl=en
[3]https://developer.android.com/reference/android/app/job/JobService
[4]https://developer.android.com/reference/android/app/IntentService

of the background service that was to be implemented, but IntentService was deprecated in API 30, although it did not influence much our final objective. The component JobService was the first component tried out and working with that component felt comfortable so the development followed with it. These attempts and tryouts, though, where only a basic level, the instructions and testes done to each service were: create intent, start service with intent, print a Toast[5] with the intent contents, run an mp3 file and stop the service.

All services ran on the background of a mobile device, but the service would be destroyed if the application holding the service was closed. This remained an issue throughout testing but was decided not to waste time to fix that problem as the idea is to provide a draft service for testing the methodology and the service termination would not interfere with the testing nor the responsiveness of the player with the game.

After the initial research on how to handle services and tests, the constructions of small services named block services, which are described in subsection 4.4.3, which follows this section, was initiated, trying out new features, starting small but incremental difficult and complexity.

In this JobService, all block services data, JSON file safety rules, and notifications to the user are created and operate together, it is what holds the background service united. Inside there is a ScheduleExecutorService[6] that controls the time interval in which the service checks to see if any rule is being broken. The fixed-rate was set at five seconds and it runs on a UI thread so it can display Toast widget to the player using the service and the playing the game.

4.4.3 Block Services

Block Services are files that are the link between external components to the background service being developed, such as Operating System services or external API's, such as OpenWeather. To create a proper structure development and keep the code modular, each external component that provides data to the background service has its own file and logic

There are four *block services* created, *DataUsage*, for network data used by the Pervasive Game, *DateAndTime* where the service receives data from the systems' clock, *LocationBlock* where a connection to the Google API is done for creating the Geofences and finally the *WeatherBlock* that holds the calls done to the OpenWeather API that provide meteorological data to create the weather warnings.

This classes would then be used to validate the safety measures values in the provided JSON file and make sure the rules are properly enforced when needed. This would happen inside an if-clause control system, inside the JobService class of the background service, evaluating every safety measure every five seconds.

In the next sections, each service block is explained in more detail.

[5] https://developer.android.com/reference/android/widget/Toast
[6] https://developer.android.com/reference/java/util/concurrent/ScheduledExecutorService

4.4.4 Data Usage

As indicated in the small summary in subsection 4.4.3, this file connects the background service to the Operating System services that inform of data usage. It is important to note that it was not achievable to simply query the mobile device about a certain app (for example our Pervasive Game) and request how much data it was consuming, so what the service does it records how much data the mobile device has consumed at the moment the Pervasive Game is turned on and saves that amount. It continues to refresh while the game is active - on the foreground - and when and if the sum of the data usage reaches and overtakes the values set in the Data Usage rule, the JobService class enforces that rule, depending on the type (if it's restrictive or alarmist).

In this block, our background service also receives information on what application is at the foreground, which is a very important detail that allows the background service to enact and enforce our rules, since every rule enforcing depends on this particular method that returns which app is at the foreground.

JobService class receives both the knowledge of which application is at the foreground and the data usage of the respective application (after its calculations). The knowledge of which application is being used is a very important one, since the JobService only reacts if the name of the package that is on the foreground contains any character that is equal to the *gamename* value from the safety measures file. This was done to eventually safeguard the privacy of the user in the best way possible, all of the interest in this dissertations work and parental control relies upon the specific pervasive game the parent is supervising, whatever that game is.

4.4.5 Date and time

DateAndTime class is a small and straightforward one, it contains methods to retrieve the current date for the system. It formats the date to be read and crossed inspected by the JobService to enforce date and time safety rulings. As previously mentioned, Android SDK determines that day 0 is Sunday, which is important because the JSON file only receives numerical values concerning date.

This information is then sent to the JobService and the safety measure of time interval is enforced, there is a small method that compares the time interval of the safety rules and verifies if the current system date is between it, acting properly if the rule is broken (depending on the rule type) or ignoring it if the rule is not broken.

4.4.6 Localization

For many modern pervasive games localization plays a big part in the playtime of a player. So it is necessary for the background service to access the player position in the world. Google Location Services was an integral part of the developed system, were a challenging feature to add, due to the complexity in using it with background services and bringing them up to run in UI threads (for Toast notifications for instance). But besides that more complicated part, the rest is somewhat

trivial, using the FusedLocationProviderClient[7] to connect with google location services, which requires runtime permission from the user (only one time, then it's saved into the mobile device settings for the application) for apps above Marshmallow, so users may reject this if they want to, negating the location service from the system. To receive a location request is trivial, as the main concern is setting a request interval (10 seconds was the time picked in which the service background receives the position of the mobile phone.

This information would then be broadcasted to the JobService class where it would use the latitude and longitude from the players' position to assert whether the player would be breaking the geofences set in place.

4.4.7 Weather

The weather data was retrieved then, via a connection to the OpenWeather API[8], but two APIS were tested, OpenWeather and IPMA[9], it was important to have an API that would supply the background service with weather warnings (green, yellow, orange and red) but neither provided them, because the weather warnings specifications may change from country to country.

The decision on why OpenWeather was the chosen was because its documentation seemed more complete but mainly because in the initial testings IPMAs' API did not provide wind velocity in numeral form only in verbal form (words such as strong wind, moderate and others) and this complicated the work on calculating weather warnings for the weather safety restriction. Since OpenWeather API provided numerical values for all the parameters required for determining weather warnings and is already widely used in many weather apps, it was the chosen one.

The weather warning calculation is explained in Table 4.5.

OpenWeather API provided the background service with an immense amount of information about weather reports. This class (block) possesses the API call that executes a request directly to their API. The information returned is then passed on to the JobService that analyses the data and creates the weather warnings that are then used to assert the safety rule concerning the weather.

Concerning some values that Open Weather return the most important to note is that at the time of the development of the background service it only provides data about rain for the last hour or three hours before the moment [10], not current, so it is not very feasible to use rain data to assert weather warnings. So rain data from OpenWeather API can only predict future (with forecasting which is not 100% accurate) or past events, which are useless for our intentions.

4.4.8 Recording Logs

The service possesses logging capability where the actions the user makes when the service interferes with the normal gameplay are recorded, for privacy, no other information would be recorded. The logging file is a simple text file saved into the Android file system. The only information the

[7] https://developers.google.com/android/reference/com/google/android/gms/location/FusedLocationProviderClient
[8] https://openweathermap.org
[9] IPMA is the Portuguese national weather institute. The link for the API though is the following, https://api.ipma.pt/
[10] Precipitation for the last hour and three hours. https://openweathermap.org/weather-data

service collects is information if the player breaks any safety rule, otherwise, it does not save any information into the log. Below we can see an example of what a log of rules broken by a player would look like:

```
2020-06-29 13:23:08-Restriction:GameNOTonForeground
2020-06-29 13:23:13-Restriction:Schedule- 1-13->15 -alarmist
2020-06-29 16:42:27-Restriction:GameNOTonForeground
2020-06-29 16:42:32-Restriction:WeatherWarning- yellow -alarmist
2020-06-30 11:29:45-Restriction:GameNOTonForeground
2020-06-30 11:21:50-Restriction:Schedule- 2-9->12 -restrictive
2020-06-30 11:29:46-Restriction:GameNOTonForeground
2020-06-30 11:29:51-Restriction:Schedule- 2-9->12 -restrictive
2020-06-30 11:29:56-Restriction:GameNOTonForeground
```

As it can be seen, the log tries to be very minimal, it has the time stamp to the second of when the restriction happened, the name of the safety measure rule, the values or parameters of the rule when it was broken and the type of restriction.

4.5 Weather Warning

One of the decision behind making the weather warning rules using weather warnings was to facilitate eventually the customization of those same rules for parents, instead of making them write down the wind speed or the minimum and maximum temperature in which they think their children should not be able to play, keeping it simple with weather warnings, ranging from green, yellow, orange and red, made it easy for later customization, but involved more work in the background service. As mentioned before the weather warning values were unavailable in the explored API's, but by retrieving the values needed for its calculation the service can provide its own weather warnings. This section explains how it was done and a parser was developed to read the data arriving from the API.

After some research concluded, the chosen API was OpenWeather since it gave everything needed to run the weather warning parser in the system. Luckily the IPMA website is very much detailed on how the weather warnings are calculated across the country. The scale of IMPA weather warnings can be seen in their website[11], where they display five types of weather warnings in an incremental scale of good to worse, green, yellow, orange and red, the final warning is grey, but it only states that the service is still updating its information.

The parameters for the weather warnings differ from location to location[12], but they differ greatly in terms of temperature, for example, if Porto is experiencing -4^{o}C that is a red weather warning for the district, but if Bragança is experiencing the same temperature its warning is only yellow. Wind speeds also differ from location depending on the height of the location.

[11] Retrieved from https://www.ipma.pt/pt/enciclopedia/otempo/sam/index.html in 29/06/2020
[12] Retrieved from https://www.ipma.pt/pt/enciclopedia/otempo/sam/index.html?page=criterios.xml in 29/06/2020

To minimize the development time it was decided to only utilize values for the Porto district to calculate the warnings. Another attempt to minimize and focus on just one more accessible criteria to evaluate, only four were chosen, wind speed, minimum temperature, maximum temperature and precipitation. The values received some tailoring since the OpenWeather API provided them in the wrong units for calculating wind speed, for example.

Criteria	Yellow Warning	Orange Warning	Red Warning	Unit
Min. Temp.	1 to -1	-2 to -3	below -3	^{o}C
Max. Temp.	32 to 36	37 to 38	above 38	^{o}C
Precipitation	10 to 20	21 to 40	above 40	mm/1h
Wind Speed	70 to 90	91 to 130	above 130	km/h

Table 4.1: Weather warning decision criteria

Table 4.1 was taken from the IPMA criteria website but trimmed to the needs of the service. These values were used to assert weather warning in the background service. It was defined that any warning would be relevant, that is, only one option turns at least yellow, for the whole system to start restricting gameplay. The service always returns the highest warning.

Although the precipitation calculation is coded into the background service, as mentioned in subsection 4.4.7, precipitation from OpenWeatherAPI only provided past or future events(a day ahead), so it was a bit inaccurate, although it is implemented, precipitation calculations for weather warning are not taken into account when asserting the warning.

4.6 Development Challenges

This section conveys the challenges this work faced during development and how it was able to resolve and fix those same troubles. The first subsection talks about decisions during early implementation and the second subsections speak about situations that occurred during mid-development of the service.

4.6.1 Implementation decisions

The choice was to develop using Android, it is true that Android development can, at times be troublesome because of some nuances between manufacturers, screen size, resolution, features, hardware, operating system services, can change from manufacturer to manufacturer, so "while Android are both relatively easy to develop and easy to deploy, there is no guarantee that app will work perfectly on every Android device"[SR13].

Another important reason comes from the literature in which it seemed Apple parental control system had more options for a parent than Google's, this pointed our solution towards Google (Android) devices. Since Google's parental control was missing a few features that would allow a parent for better safekeeping their young, this was one more reason for choosing Android development for this work.

There was one safety measure that ended up not being implemented, from the social expansion the personal physical safety issue, that according to the literature was (but not only) bullying issues and fear of the players' physical integrity being compromised by other players or even non-players. Even during the design phase, this issue was not clear due to ethical constraints, because how could a parent prevent a child of theirs to interact with another person? And on what ground? Could we separate an actual fear for the children's safety with a possible discriminatory action? These questions were complicated to answer but interesting enough, but since the development of this prototype remained solely on Android with no centralized server and the background service is supposedly agnostic with no direct connection with the Pervasive Game, the service could not track the players of the game around a certain a game, this technological constraint would always prevent of experimenting and testing that safety measure component, so in the end that the physical safety issue was left out of the prototype.

4.6.2 Changes while in development

In this section, some of the development choices are explained, on why the development changed something that was initially planned and how the obstacles were overcome.

Starting with development changes due to SDK constraints, to obtain the amount of time in which an application is on the foreground would be deemed an easy chore, but apparently, the content returned from getTotalTimeInForeground is only updated once, when the application is first turned on. So to counter this problem a specific timer was implemented in order to track the amount of time an application was being used (on the foreground of the device), this timer is saved every time the application is terminated and then the value is recovered when the application comes back on.

Another situation was that initially, the idea was to lock the phone if a restrictive measure was triggered, but that felt too intrusive so it was decided to *simply* send the application into the background of the Android phone, conserving its state, making the Home screen come up into the foreground.

There was an issue that the service was not recognizing the application on the foreground this was also brushed aside as a big problem in development seeing the plan was to provide an Android device for the user tests, and that could be solved by lending the mobile device from the brand Xiaomi to participants if needed to. This Xiaomi phone was the one used for tests.

Chapter 5

Methodology Evaluation

After the development is completed, the next logical step would beto evaluate the proposed methodology, in subsection 3.3 a proposed validation was set in place for this chapter to follow. As it was also informed in that chapter, due to the Covid-19 pandemic some tests were unable to be produced and therefore they were not implemented as well as it was supposed to or not at all. But the parental questionnaire, in this chapter first section, and the functional testing,, in the second section, were done and they can aid in answering this works research questions.

5.1 Parental Questionnaire

This Parental Questionnaire was created to validate and support some of the ideas for our methodology and it was conceived in parallel with the service development. This questionnaire was also used to provide an answer to Research Question 5. - "What is the impact of such safety measures for the parental supervisor, regarding their safety fears?" By answering this research question, one could determine if parents in the current year of 2020 share the same safety fears and worries as other parents held in the past.

5.1.1 Questionnaire Implementation

As described in 3.3.1, this questionnaire consisted of 20 questions, with 4 open-ended questions, 4 polar questions, 4 multiple choice questions and 8 multiple option questions (meaning only one answer was accepted). After the introductory text, it had five sections.

1. Demographic questions;
2. Pervasive games played by the children;
3. Gaming habits while playing;
4. Interactions experienced while playing;
5. Hypothetical questions;

The last section, hypothetical questions, was created for parents whose children might not play Pervasive Games, or for those who didn't feel comfortable sharing their children's gaming habits. Depending on the answer to the first section's second question, the questionnaire would either continue to section 2 or section 5. The questionnaire can be found in section A.3

The full questions and options for each question are detailed in section A.3.

The questionnaire was available in both English and Portuguese, and it was shared through social media in Pokémon Go groups, for the city of Porto and also shared with FEUP faculty members. For the social media groups only the Portuguese version was shared, and with faculty members, both versions were shared. Unfortunately due to bureaucratic issues a wide distribution of the questionnaire through the faculty's teaching staff was not possible, shortening the distribution range and possibly lowering the number of answers.

5.1.2 Parental Questionnaire response analysis

These are the most relevant responses given by the parents, not every answer is detailed here, only those that provided more interesting results. The complete list of answers for each question can be found in section A.4.

The final count of answers to this questionnaire was **seventeen answers**. Following in this section, the analysis of the results by questionnaire sections.

First Section

Parents were asked in which age group their children would fit in, a multiple-choice question. Eleven (11) parents had children between 6-10 years old, and four (4) had children between the age of 11 and 14. This question served as a basis for the follow-up questions as the questionnaire would mostly ask about their youngest child that played a Pervasive Game.

Second Section

This section was about the Pervasive Games the child would play. In a polar question about whether their children played any Pervasive Game, fifteen (15) parents said their children played a Pervasive Game and only two (2) said their children did not play any game in this genre, these parents were redirected to the fifth section of the questionnaire.

In the follow-up question, a multiple-choice one, for parents that answered **yes** to the previous inquiry, they had to pick games out of a list of Pervasive Games. Out of the fifteen (15) parents that said **yes**, all of them choose Pokémon Go. Three (3) children also play Minecraft Earth according to their parents, and they were the same children that also played Pokémon Go.

Third Section

The questions that were asked in this section were about the children's gaming habits. As stated in the section above, only parents that chose **yes** to the question "Do your children play any sort of Pervasive Games?" were able to continue into the third section.

More than fifty percent (53,3%) of the respondents replied that at least one of the parents **always** accompanies the children when they play the game, forty percent (40%) said that only **sometimes** do the children play supervised and the remainder one parent answered that their children always play alone (in this particular answer, the child in question was at least eighteen years old).

Answers to questions 5. and 6. are detailed in section A.4, the answers were deemed irrelevant to the results.

Diving deeper into the children's gaming habits, the questionnaire had three questions about playing time and sessions.

- 7. - How many times a week does your child play the game? - answer in Figure 5.1. Six (6) parents replied "6 or 7 days per week", and over half (8) answered that they played at least 4 days a week.
- 8. - In how many daily sessions does your child play the game? - replies in Figure 5.2. Almost one-third of the replies do not know how many sessions their children play during the day (4 out of 15 answers), and six parents stated that their children only play 1 session each day.
- 9. - What's the average duration of your children's gaming session? - answer graphic in Figure 5.3. It shows a somewhat interesting discrepancy between the times, only five (5) parents state their children play thirty (30) minutes on average but another five (5) say their children play unrestricted amounts of time. These answers are two-thirds of all replies. Only one parent answered "I don't know".

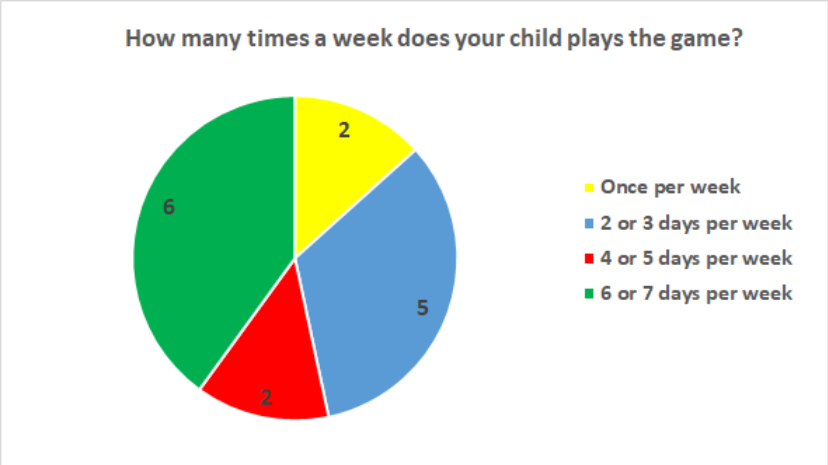

Figure 5.1: Question number seven results - How many times a week does your child play the game?

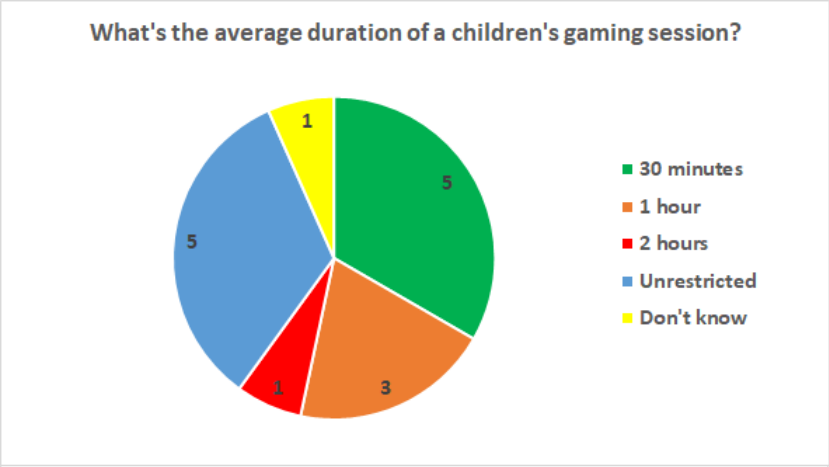

Figure 5.2: Question number eight results - In how many daily sessions does your child play the game?

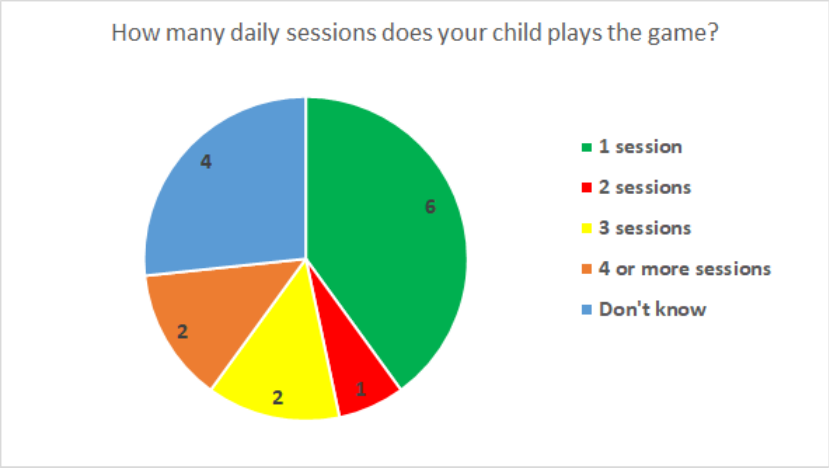

Figure 5.3: Question number nine results - What's the average duration of your children's gaming session?

The final question of this section asked whether parents were aware of the activities their children would participate in and the places they would go while playing the game. Eleven (11) parents (73.3%) stated they always knew what their children would do or where they would go, three parents sometimes knew, and one parent never knew (again, this last one was the parent that had a child over eighteen years old).

Fourth Section

This section's first question (the eleventh one in the full questionnaire) asked if any parent ever had knowledge of threats their children could have been exposed to while playing the game. All (**100%**) answers stated **no**. There was a follow-up question for people that would have said yes, but it was left blank because of the results.

The final question of this section was another polar question, concerning privacy and security. Parents were asked if they were afraid their "children might divulge important personal information to strangers while playing", and in this question the results were very split, seven (7) to eight (8). Seven parents answered with a **no** and the remaining eight answered **yes**. With these answers, an attempt was made in finding a correlation between the parents' fear of their children divulging personal information and the ages of the children, but no correlation was found, some parents with children younger than five were not afraid and other parents with children above 15 years old were afraid, so the presumable *maturity* of the child is not in question here.

Fifth Section

As mentioned in subsection 5.1.1 there was a Hypothetical section in this questionnaire, it was made so that even parents that did not have children that played Pervasive Games could answer and expose some of their ideas and possible fears concerning these type of Games, and at the same time make parents that had children that played Pervasive Games maybe a bit more comfortable in sharing thoughts, ideas or fears.

The first question is a multiple-choice question, asking that on the event that their children were hypothetically bullied while playing, what would the parent do. It originally had four options, with a fifth being "Other...". The most frequent answer given was "Play with my children at all times, supervising them" with seven (7) replies, followed by "Don't allow them to play the game any longer" with six (6). Four (4) parents would use a parental control system, which is a good sign for this work's dissertation. There were two options added from "Other...", which were considered similar, and it was "I would denounce the (other) player" to the police.

The fifteenth question was the final polar question of the questionnaire and asked if parents believed Pervasive Games had good safety measures, this question had a follow-up that asked whoever said yes to enumerate those measures. Twelve (12) parents replied **no**, while the **yes** had five (5) parents considering it.

So for the parents that answered **no**, some of the measures they believed to be good was "warnings" and "constant reminders to attention". Three parents believed the lack of in-game chat was a good safety measure, and also the age control for games was considered a good safety measure.

After this last question, the parents were asked if any of their suggestions fell into determined categories, Figure 5.4 has the full count of all selected options by the parents. Most parents answered **Other...**, typing in **none** or **other** which was considered not specified, as the eight **none** answers were considered not relevant. It can be seen, about six (6) concerns with location, four (4) with dangerous locations and two (2) with prohibited locations. The other big issues parents had concerns about was the financial issue, where in-app purchases received the worries of four (4) parents and with the same count the social expansion issue of harmful interactions with others was another top concern for parents.

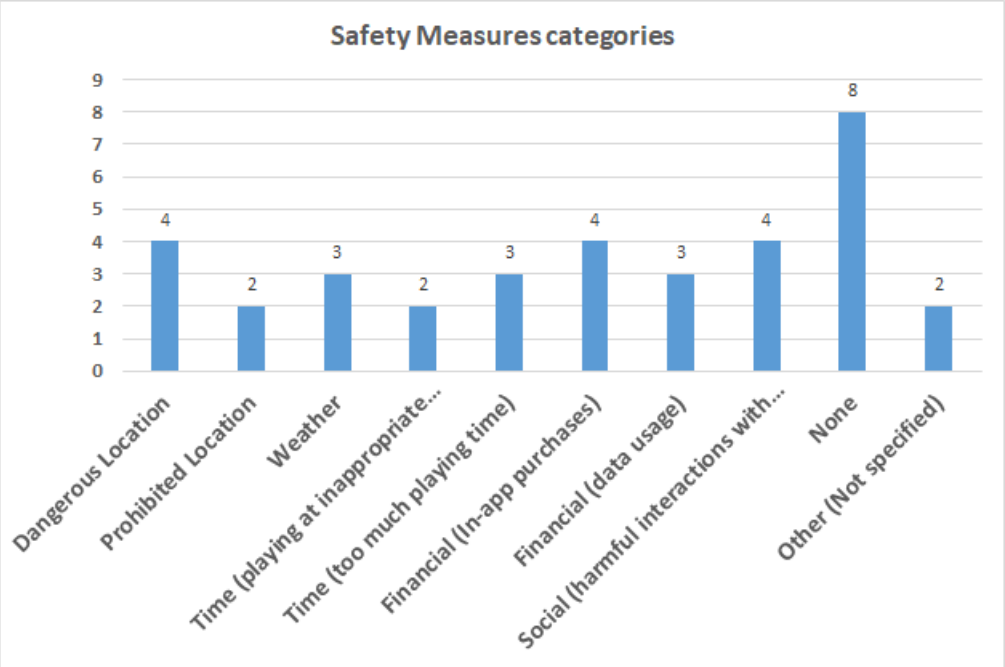

Figure 5.4: Question number seventeen results - Would any of the suggested safety measures fall into the following categories?

The final mandatory question was if as a parent would they be interested in exploring options for parental control to improve the safety of their children and a very good result was provided as fifteen (88,2%) parents said **yes**.

The two last questions were open answer and not mandatory. The nineteenth and penultimate question was a suggestion box, it was asked if the parents had any interest in suggesting a safety measure to better protect their children. Some suggestions involved a "classification of dangerous areas, through collective monitorization of several sources". Warnings sent to the parent whenever any safety measure was breached by the children or having the parents email and send information to that email whenever the children would make in-app purchases or spend excessive time on the game. Another parent had many thoughts about this and proposed remote access to the child's account, sharing the location with the parent, this parent stressed the most worrisome issue was interaction with strangers, and the fact that, until now, Pervasive Games don't have chat where children can talk or share photos is a good thing.

The final question was a simple "Other remarks" where parents could expose any type of concerns not approached in the questionnaire, but the only answer was about the fact the Pervasive Game their children played did not have any private chat, which assured the parents of the child be safe of unwanted (and possibly dangerous) interactions.

5.1.3 Considerations about the Parental Questionnaire

What has been learned from this questionnaire is that parents have some shared concerns that other parents in other articles gathered. Most parents play with their children (80% in question number

five) and according to parents, more than 50% of them stated their child is **never** alone. Children's habits vary almost in equal amounts, although most parents (eight out of fifteen) disclose their children play four or more days per week and the normal average session count per day is one (40 % of parents answered one session).

Eleven out of fifteen parents stated they **always** have knowledge of what their children are doing and where the children are while playing the game. No parent has any knowledge of their children being threatened while playing, but 53,3% (eight out of fifteen) are afraid the children might divulge sensible private information to strangers.

If threats arise for while the children played a Pervasive Games, most parents would start playing the game with them, supervising it even further, but some agreed that parental control systems would be a good way to go since it would improve the supervision on the children. This is supported b the 88,2% of parents that showed interest in the parental control systems.

The top concern seemed to be interaction with strangers and the fact that the games do not have a chat system is important in aiding the safeguard of their children. Other almost equally important concerns would be the dangerous and prohibited locations and financial worries while their children played the games.

Some good suggestions were provided, such parents being informed through email about certain behaviour or actions their children did while playing a Pervasive Game and a classification about dangerous areas, so parents could teach their children or prevent them from going there.

5.2 Functional testing

To produce a proper and controlled service validation, guaranteeing reliability, a simulation system was implemented into the service to assist in test scenarios that were planned in subsection 3.3.2. This simulation system is easily toggled at service startup and the user will only have to enter the values needed for testing, and the service will assume those values as truth throughout the remainder of the test. For example, one can simulate the weather warning as being that of level red, even though there is a beautiful weather of cloudless sky and warm sun at 25^{o}C.

So, continuing with this example, when simulating a value that is not real, such as -3^{o}C, the service can be tested on the parameters for low temperature, that trigger the respective safety measures and that verifies that the service validates that restriction.

Functional testing on the application was executed following the proposed methodology for such tests in subsection 3.3.2. In this proposal, the service would pass through fourteen tests, two tests for each restriction in the safety measures file, one tests would be restrictive and the other alarmist. These tests were done using a testing mobile phone with the background Service installed, a safety measures JSON file and the respective Pervasive Game.

In Table 5.1 the final results of the testing are presented. Tests #11 and #12 were not executed due to the difficulties faced in testing those scenarios plus the ethical problem that exposing volunteers to potentially risky situations to test safety measures. Nonetheless, they were a part of the proposed methodology so they remained as a testing subject but not available.

Expansion	Restriction	Test ID's	Restrictive	Alarmist
Spatial	Prohibited location	#1 ,#2	✓	✓
Spatial	Dangerous location	#3 ,#4	✓	✓
Temporal	Time interval	#5 ,#6	✓	✓
Temporal	Time spent	#7 ,#8	✓	✓
Temporal	Weather	#9 ,#10	✓	✓
Social	Physical	#11 ,#12	N/A	N/A
Social	Financial	#13 ,#14	✓	✓

Table 5.1: Functional Testing Summary.

Each functional test is detailed in section A.2. In this subsection, the results are the be most an important aspect to present, but the detailed list that used the template presented in Table 3.3 is in the Appendix.

5.2.1 Functional Test ID #1

The first test was the prohibited location with a restrictive type. This test, like all other tests in this section, has its own specific test parameters, detailed in subsection A.2.1. The JSON snippet has the rule that the service will consume to supervise the player. In Figure 5.5 the input parameters for the phone's location are set, from now on, the service will assume the player is in those coordinates[1]

After the necessary steps are done, this test proved to be a success, the application kept being redirected to the Home screen as intended, as we can see in Figure 5.6. Also, there is the log that was created at the start of the test that informs of what is happening, the service was not interacting with the game at first ("GameNOTonForeground") then the game was turned on, and immediately the service pushed the game in the foreground to the background, and every time an attempt was made to return to the game, the same result would happen.

```
2020-07-02 17:41:49-Restriction:GameNOTonForeground
2020-07-02 17:41:54-Restriction:Prohibited- 41.181533,-8.60011 -restrictive
2020-07-02 17:41:59-Restriction:GameNOTonForeground
2020-07-02 17:42:04-Restriction:Prohibited- 41.181533,-8.60011 -restrictive
2020-07-02 17:42:09-Restriction:GameNOTonForeground
```

5.2.2 Functional Test ID #2

The second test is similar to the subsection 5.2.1 but now the type is alarmist. This test is specified in detail in subsection A.2.2. The JSON snippet has the rule that the service will consume to supervise the player. In Figure 5.7 the input parameters specific for this test are set, from now on,

[1]This does not affect gameplay since this mechanism does not interact with the game

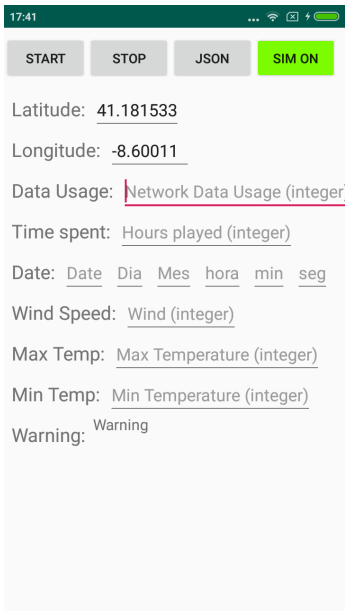

Figure 5.5: Input parameters for Test 1.

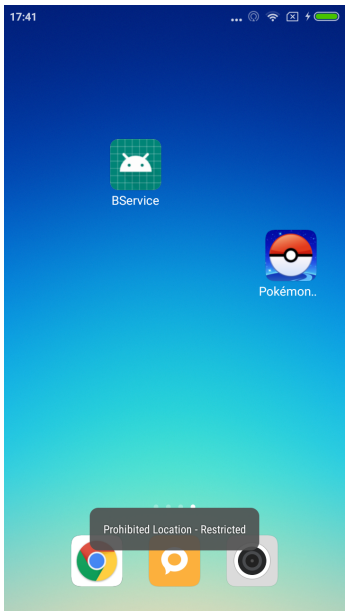

Figure 5.6: Toast and Home screen forced.

the service will assume the player is in those coordinates, and the service will trigger an alarmist Toast the next moment the player turns on the game.

After the necessary steps are done, this test proved to be a success, the application was allowed to continue its startup while the toast appeared periodically to inform the player that the rule was being broke, but gaming could continue Figure 5.8. As we can see in the log created the player after turning on the service can continue to operate the game without going back to Home screen.

```
2020-07-02 17:44:22-Restriction:GameNOTonForeground
2020-07-02 17:44:27-Restriction:Prohibited- 41.1779519,-8.5949384 -alarmist
2020-07-02 17:44:32-Restriction:Prohibited- 41.1779519,-8.5949384 -alarmist
2020-07-02 17:44:47-Restriction:GameNOTonForeground
```

5.2.3 Functional Test ID #3

This third test is very similar to the first one, the only thing that changes is the JSON fragment, which can be verified in subsection A.2.3 and the Toast provided by the service will be different since it will warn of the location is a dangerous one instead of a prohibited. The type remains of the restrictive kind. The input parameters also change to match the local of the geofence set in place for this test, as observed in Figure 5.9.

After the necessary steps are finished, this test passed with success, since the Toast and the restrictive manner that made the game go into the background were true as seen in Figure 5.10. Below the log for this test is displayed.

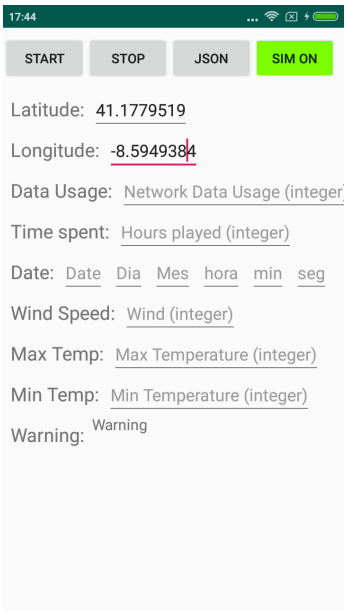

Figure 5.7: Input parameters for Test 2.

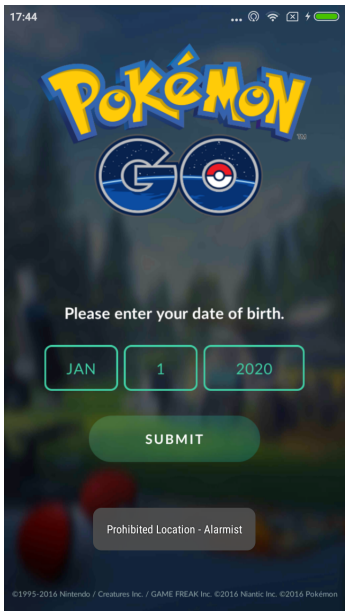

Figure 5.8: Alarmist Toast, but Application continues on the foreground.

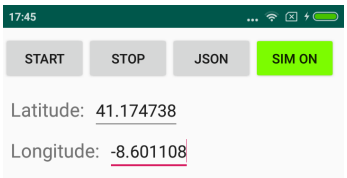

Figure 5.9: Input parameters for Test 3.

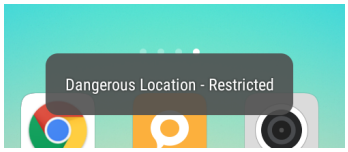

Figure 5.10: Toast and Home screen forced.

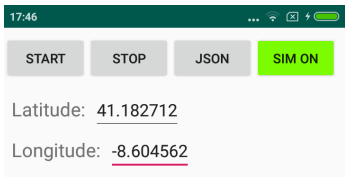

Figure 5.11: Input parameters for Test 4.

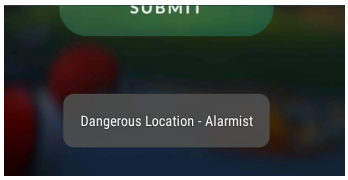

Figure 5.12: Toast and Application continues on the foreground.

```
2020-07-02 17:45:25-Restriction:GameNOTonForeground
2020-07-02 17:45:30-Restriction:Dangerous- 41.174738,-8.601108 -restrictive
2020-07-02 17:45:36-Restriction:GameNOTonForeground
```

5.2.4 Functional Test ID #4

Fourth and final test of the Spatial expansion, this test is very similar to the second one, the only thing that changes is the JSON fragment, which can be verified in subsection A.2.4 and the Toast provided by the service will be different since it will warn of the location is a dangerous one instead of a prohibited. The type remains of the restrictive kind. The input parameters also change to match the local of the geofence set in place for this test, as observed in Figure 5.11.

After the necessary steps are finished, this test passed with success, since the Toast and the restrictive manner that made the game go into the background were true as seen in Figure 5.12. Below the log for this test is displayed.

```
2020-07-02 17:46:32-Restriction:GameNOTonForeground
2020-07-02 17:46:37-Restriction:Dangerous- 41.182712,-8.604562 -alarmist
2020-07-02 17:46:42-Restriction:Dangerous- 41.182712,-8.604562 -alarmist
2020-07-02 17:46:47-Restriction:Dangerous- 41.182712,-8.604562 -alarmist
2020-07-02 17:46:52-Restriction:GameNOTonForeground
```

5.2.5 Functional Test ID #5

Temporal Expansion testing starts with this test and goes until the test number ten. This test (and the next one) proves the service is able to perceive time intervals. In particular test #5 validates the restrictive type, since it places a rule between, in this case, 9 AM and 12 AM, as we can observe in Figure 5.13. See subsection A.2.5 for more details on the test.

Figure 5.13: Input parameters for Test 5.

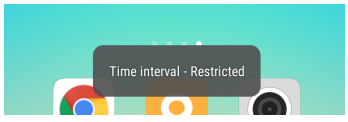

Figure 5.14: Toast and Home screen forced.

Figure 5.15: Input parameters for Test 6.

Figure 5.16: Toast and Application continue on the foreground.

As the Toast appears on the screen and the application immediately goes into the background this test finds its success. The since the Toast and the restrictive manner that made the game go into the background were true as seen in Figure 5.14. Below the log for this test is displayed.

```
2020-07-02 22:42:08-Restriction:GameNOTonForeground
2020-07-02 22:42:13-Restriction:Schedule- 2-9->12 -restrictive
2020-07-02 22:42:18-Restriction:GameNOTonForeground
2020-07-02 22:42:23-Restriction:Schedule- 2-9->12 -restrictive
2020-07-02 22:42:28-Restriction:GameNOTonForeground
```

5.2.6 Functional Test ID #6

Second test to time intervals, on the alarmist type but similar protocol to subsection 5.2.5. The same input fields (seen in Figure 5.15) in the service receive values to be fed into the calculations but the parameters are different as they can bee seen in subsection A.2.6

As the Toast appears on the screen and the application continues to be at the foreground of the screen this test finds is considered successful, as it is shown in Figure 5.16. Below the log for this test can be seen.

```
2020-07-02 22:43:10-Restriction:GameNOTonForeground
2020-07-02 22:43:15-Restriction:Schedule- 2-14->15 -alarmist
2020-07-02 22:43:20-Restriction:Schedule- 2-14->15 -alarmist
```

5.2.7 Functional Test ID #7

Immersing oneself in a Pervasive Game may not be desirable at times, time spent is a restriction that stops the player from playing too much during the day (or month). Test #7 tests the services functionality in preventing a player from playing more than x hours per day, in this particular case 4 hours. The JSON snippet can be found in subsection A.2.7, as well as more details about this particular test. Figure 5.17 demonstrates what parameters should be inserted into the service in order for the test to be executed.

The moment the player turns the game on since the simulated time spent is equal (or higher) than the one in the JSON file, the game immediately goes into the background and the informative

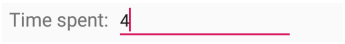

Figure 5.17: Input parameters for Test 7.

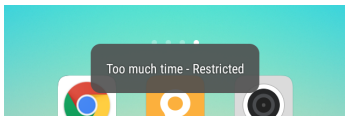

Figure 5.18: Toast and Home screen forced.

Toast of why that happened appears on the screen, Figure 5.18. Below the log for this test can be seen.

```
2020-07-02 23:30:42-Restriction:GameNOTonForeground
2020-07-02 23:30:47-Restriction:TimeSpent- 4 -restrictive
2020-07-02 23:30:52-Restriction:GameNOTonForeground
```

5.2.8 Functional Test ID #8

This is the sister test for subsection 5.2.7 since it has very similar conditions, but the type is now alarmist, the value that is written into the respective service's text box, as seen in Figure 5.19 will counter-check with the relevant fragment of the JSON file, subsection A.2.8. This validation will occur the moment the player switches the game on and the safety measure will trigger.

Figure 5.19 subsection A.2.8

Since this is an alarmist type test, the player after turning on the game can continue to play the game and the warning Toast will continue to appear throughout the day, Figure 5.20. Below the log for this test can be seen that shows the success of this test.

Figure 5.20. Below the log for this test can be seen.

```
2020-07-02 23:32:31-Restriction:GameNOTonForeground
2020-07-02 23:32:36-Restriction:TimeSpent- 4 - alarmist
2020-07-02 23:32:41-Restriction:TimeSpent- 4 - alarmist
2020-07-02 23:32:46-Restriction:GameNOTonForeground
```

5.2.9 Functional Test ID #9

The temporal tests for the Weather safety measure can be executed in many ways since the service will identify the highest danger and trigger the safety conditions with that identification. What does this is mean is, that if the maximum temperature is currently 33ºC (with Porto standards) a

Figure 5.19: Input parameters for Test 8.

Figure 5.20: Toast and Application continue on the foreground.

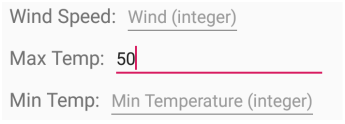

Figure 5.21: Input parameters for Test 9.

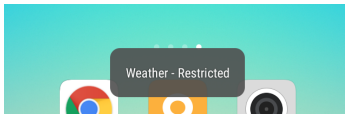

Figure 5.22: Toast and Home screen forced.

yellow warning will be signalled, but if the wind is currently blowing at more than 130 km/h it's a red warning, and that warning is the one that will trigger this safety measure.

Particularly speaking, this test uses the maximum temperature to restrict the players' behaviour, it was simulated a 50°C value as Figure 5.21 shows. The restriction type for this test is restrictive, so the game will go into the background the moment it is switched on, the remaining details for this test can be verified in subsection A.2.9.

Figure 5.22 demonstrates what happens when the test is successful, the game goes into the background and the Home screen is forced into the foreground. Below the log for this test can be seen.

```
2020-07-02 23:31:14-Restriction:GameNOTonForeground
2020-07-02 23:31:19-Restriction:WeatherWarning- red -restrictive
2020-07-02 23:31:25-Restriction:GameNOTonForeground
```

5.2.10 Functional Test ID #10

Alarmist version of the previous test. Since the weather safety measure is more diverse in terms of parameters, for this test, the minimum temperature was used, inserting a 0 as seen in Figure 5.23. For this alarmist test, the weather warning was the yellow warning, as it can be verified in subsection A.2.10.

This test was a success as well, the application was allowed to remain in the foreground and the Toast widget informed the user the weather was dangerous but was okay to continue playing, Figure 5.24. Below the log for this test can be seen.

```
2020-07-02 23:32:55-Restriction:GameNOTonForeground
2020-07-02 23:33:00-Restriction:WeatherWarning- yellow -alarmist
2020-07-02 23:33:05-Restriction:GameNOTonForeground
```

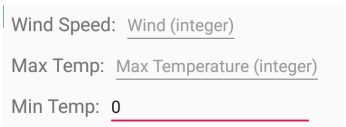

Figure 5.23: Input parameters for Test 10.

Figure 5.24: Toast and Application continue on the foreground.

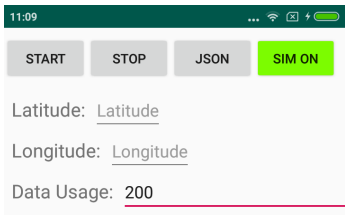

Figure 5.25: Input parameters for Test 13.

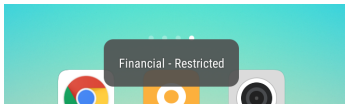

Figure 5.26: Toast and Application continues on the foreground.

5.2.11 Functional Test ID #11

This Social test was not conducted because of some ethical and technological problems that were explained at the beginning of this section. Nonetheless, the test was planned and it can be seen in subsection A.2.11.

5.2.12 Functional Test ID #12

This Social test was not conducted because of some ethical and technological problems that were explained at the beginning of this section. But, like the previous test, it was planned and can be seen in subsection A.2.12.

5.2.13 Functional Test ID #13

Financial aspects are important, the parental questionnaire showed worries that parents had with in-game purchases and related financial situations, although the service does not directly interact with the game, it can help mitigate those worries by creating a block in data usage preventing the children to spend too much data on the game and blowing the months data plan.

This test enforces the financial safety measure, placing a limit for network traffic for the specific game only, this test evaluates the restrictive type of this measure, setting a limit that forces the game to into the background. The limit is set in the service in a way that can be seen here in Figure 5.25. The full details of the test are in subsection A.2.13.

Since this is a restrictive type, the moment the game reaches the limit set by the JSON, the game goes into the background and the Home screen appears, Figure 5.26. Below the log for this test can be seen.

```
2020-07-03 11:10:05-Restriction:GameNOTonForeground
2020-07-03 11:10:10-Restriction:DataUsage- 200 -restrictive
2020-07-03 11:10:15-Restriction:GameNOTonForeground
```

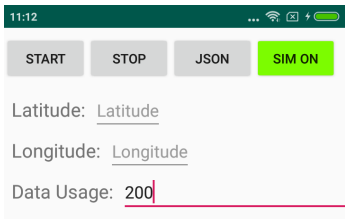

Figure 5.27: Input parameters for Test 14.

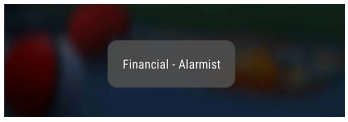

Figure 5.28: Toast and Application continues on the foreground.

5.2.14 Functional Test ID #14

The second financial test tests the outcome of the alarmist type, and what happens to the game when the alarmist restriction is set in place. Using the same limit as the previous test but with an alarmist type, as seen in subsection A.2.14. The limit is set in the service in a way that can be seen here in Figure 5.27.

As an alarmist type restriction, the player will only receive a Toast pop-up informing of what is happening but is allowed to continue playing as expected, seen here in Figure 5.26 Below the log for this test is displayed.

```
2020-07-03 11:13:03-Restriction:GameNOTonForeground
2020-07-03 11:13:08-Restriction:DataUsage- 200 -alarmist
2020-07-03 11:13:13-Restriction:DataUsage- 200 -alarmist
2020-07-03 11:13:18-Restriction:DataUsage- 200 -alarmist
```

5.2.15 Functional Tests Conclusions

The simulation feature proved useful in allowing the background service to be tested outside development. All tests seen here have been executed previously during development stages, but with this test protocol they were then executed in an orderly fashion and were meant to be easy to reproduce the same results verifying their validity.

These tests were simple and quick to prove the efficacy of the prototype, they were not intended to be exhaustive tests into the prototype demonstrating the wide range of values that could be fed into the system and the service would act accordingly. Also, no tests concerning wrong inputs into the simulation feature were done, since if this was an actual product being launched into the market the simulation feature would not be part of the final product.

The tests were a success in demonstrating how to simulate and validate the background service and its (small) interaction with the game.

Chapter 6

Conclusion

In this Conclusion chapter, the results found with this dissertation's work are exposed. The chapter beings with a rundown on the results for research questions that guided our research and work. The prototype implemented as a background service to answer parental concerns on their children's safety. Closing up with the future work section, features or ideas that were incomplete during this process were noted and hopefully will serve as a guide for subsequent works.

6.1 Research Questions answered

Research Questions in this work, just like in many academic works, lead the research and objective. The idea to understand what made a Pervasive Game tick, and how a person could recognize the genre, among countless other genres, the literature research in chapter 2, the State of the Art chapter, was the stepping stone, the preparation to answer these research questions that guided this work. After that, the research questions steered the work, from understanding problems and threats in Pervasive Games, solutions to those problems already attempted with or without success, and how could an implementation of a safety solution improve the gaming experience for juvenile players and improve the comfort parents would have in knowing their children would be playing safely.

These were the questions and the answers this work provided:

- RQ1: **What are threats to player security while playing Pervasive Games?**

  As this RQ led this work throughout the current state or Pervasive Games, its purpose was fulfilled in identifying threats to player security while playing these type of games. There were many threats encountered, each with its distinguishable detail, but to be able to keep the them relatively short they were summarized into six main ones or safety issues in Pervasive Games, which are:

  - Inattention to surroundings
  - Personal physical safety

- Restrictive locations
- Timed challenges
- Unexpected billing
- Weather conditions

These threats were then used as a baseline, or as an objective, to design the safety measures for this work.

- RQ2: **What are safe ty measures to tackle the security threats?**

  This is the RQ1 follow-up question, after identifying threats this work proposed itself to design safety measures (if not yet designed or in existence). Some of the literature provided with a few suggestions for safety measures, such as sound queues to refocus the player on its own surroundings instead of the game or gameplay measures that prevent spawning of *monsters* or NPCs near roads and such.

  Parental control systems were explored and deemed slightly abstract that did not fulfil the needs of parents about their concerns for their children's safety. So taking point with the threats gathered in RQ1, this work planned a parental control system that would apply safety measures to those same threats and enable a more comfortable parental supervision while their respective children played Pervasive Games. Table 3.1 has the summary of the safety measures designed to correct those Pervasive Game threats.

- RQ3: **How can one evaluate the impact of the safety measures in player experience?**

  Evaluation of the impact of the safety measures discovered when answering RQ2 was the next step in this works dissertation, but how could the impact be measured is different than actually knowing (here is what RQ4 is for). chapter 5 has a brief section, subsection 3.3.3, that unfortunately was put on hold due to Covid-19 as testing with real users meant putting them and those close to them potentially at risk, but it was still designed and prepared in this dissertation.

  To evaluate the impact of safety measure in player experience, after the design and development of the background service that could enforce those measures into a Game, that same service would require user-testing. This user-testing, following the proposed test protocol would be able to evaluate the impact, the testing and follow-up questionnaire answers from the volunteers. Following this methodology, this question's answer could have been perfected if RQ4 had been answered, instead of having just a baseline for testing, and no way to iterate and improve the methodology.

- RQ4: **What is the impact of such safety measures for the player experience?**

  This Research question was impossible to answer since it involved user-testing with real players, and the Covid-19 pandemic did not allow for this to happen in a secure way for

the volunteers. This question could be split into two ways of impacting player experience, gameplay and UI.

It could be argued that with the functional testing the UI used for the warnings (Android Toast), is a non-invasive interface with the player, but it is an opinion that can not be backed right now, but in the future is an option to evaluate and assess the impact it would have for a Pervasive Game player.

Concerning the actual impact in gameplay within the player experience, no answer can be provided, since it would require the user-tests that were not possible to be conducted.

- RQ5: **What is the impact of such safety measures for the parental supervisor, regarding their safety fears?**

  The fifth and final question was answered with the help from the Parental Questionnaire replies from the parents, most parents stated that a parent control system would be interesting with an 88,2% of positive answers. Although to be more secure of this answer the participant numbers would have been higher.

  A more perfect way to fully answer this question would be to create a user-test of the background service with both children and parents, but due to the Covid-19 pandemic this idea ended up being discarded.

6.2 Future work

This subsection has ideas that were not possible to be implemented due to time constraints or other challenges, are written. The future work subsection speaks about the social safety measures that are difficult to explore and test due to, in part, ethical concerns, and suggestions about UI improvement for a better understanding on how the prototype could perform his job better without bothering too much the player.

6.2.1 Physical safety against other people

One of the big safety measures that were gathered in research and even planned in the JSON file was the social expansions' problem of personal physical safety hazards against other players/non-players. Unexpected bullying or harassment of Pervasive Game players is a deterrent for those players to continue to play a game. If a player senses his physical well being may be threatened by engaging in a certain interaction with other players/non-players, that same player would feel less inclined to continue playing a game that would continuously place him in those situations.

Children are even more susceptible to fall into these dangerous interactions and parents at times may feel concerned for their children's safety while playing the games related to those interactions with others. The social aspect of preventing a child from playing with certain people, proved a bit more complicated to work with due to the ethical nature of that feature, for instance,

discrimination onto others could arise from enacting those safety measures, this was a complicated ethical subject that required much more time to think and plan. But also it was eventually put on hold due to the impossibility to control because to prevent the player from engaging with others, the service background would require the localization of those others, and doing that is impossible with the current system set in place.

A possible solution would be to implement a central system that could gather the localization of each individual and track them - which again could lead to ethical problems - and whenever a player A with a certain id would approach another player B that had player A's id blocked, player B would not be able to play the game and/or receive a warning to stay clear, but this would require a much bigger architecture for the system, with a centralized server to save and manage the player's positions.

But this work still accounts for this possibility in its safety measure file and background service concept. It was left there on purpose although not used, so it may lead to a future work and more investigation on this subject, providing a head start for it.

6.2.2 Background Service Improvements

This background service that this work developed was intended to be a prototype, and like many prototypes, it lacks a polished UI and a clear indication of what each option does. This was known and accepted, but for a future work, a better implementation for the UI would be needed. The COVID-19 pandemic made it impossible to test this prototype with real-life players, children, and parents, so the UI remained functional, but unappealing and potentially confusing for the end user.

For continuing with this work and to eventually reach user-testing an improved UI would be required and some quality-of-life improvements, for example, proper input validation to prevent wrong inputs from being entered into the system. The service does not validate input right now other than verifying if it is numerical or not.

Another very important feature would be to improve the warning system for both children and parents, create more informative Toasts for the player and also provide the parent with a more direct, on the moment, information about possible safety rule-breaking by their children, so the parent could respond faster, this was a very good concern and opinion provided by a parent in the parental questionnaire that was done in this work.

6.2.3 Addictive behaviour

While working in this dissertation, an interesting idea came up, what if this background service could also be used individually, by its own player, and in this case an adult. Where a player could insert its own parameters concerning time, weather, location, into the file and play the game with those restrictions. This would produce a self-healing addiction service, where an addicted player could attempt to self-heal this personal problem through enacting self-restrictions.

This idea was clearly outside the scope of this work, so it was not pursued, but it felt as it was an interesting approach for a different *branch out* for this work, that could use the background service

implemented as a guideline to explore addiction and ways to fight that addiction in Pervasive Games.

Conclusion

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Appendix A

Appendix

A.1 Safety measures JSON file example

As indicated in 4.3, a safety measure file is a very important component for this dissertation because it translates the research done into the results gathered from that research and turning those results into a rule set the background service could read, interpret and execute while a child is playing a Pervasive Game, successfully enabling its protection.

This example is one of the first experiments/tests done with the service while development.

```
{
  "config": "month",
  "gamename" : "pokemon"
  "spatial": {
    "prohibited_local": [ {
        "name": "Hospital S. Joao",
        "position": [41.181533,-8.60011],
        "type": "restrictive"
      }],
    "dangerous_local": [{
        "name": "FEUP",
        "position": [41.1779519,-8.5949384],
        "type": "alarmist"
      },
      {
        "name": "Cemiterio Paranhos",
        "location": [41.174738,-8.601108],
        "type": "restrictive"
      }]
```

```
  },
  "temporal": {
    "time": [{
        "dayOfWeek": "2",
        "startime": "9h",
        "endtime": "12h",
        "repeating": "yes",
        "type": "restrictive"
      },
        "timeSpent": {
        "repetition": "daily",
        "time": 2,
      "type": "restrictive"
      },
      {
        "dayOfWeek": "1",
        "startime": "13h",
        "endtime": "15h",
        "repeating": "no",
        "type": "alarmist"
      }],
    "weather": [{
        "warningType": "red",
        "type": "restrictive"
      }]
  },
  "social": {
    "physical": [{
        "id": "3091",
        "range": "auto",
        "type": "restrictive"
      }],
    "financial": [{
        "value": "900",
        "type": "restrictive"
      }]
  }
}
```

A.2 Functional Tests

Functional tests served both purposes, one to test the background service while in development, and the other to create simulations of events to confirm the good functioning of the service and the safety measures implemented.

A.2.1 Test ID #1

Test ID		1
Expansion		Spatial
Restriction name		Prohibited local
Restriction type		Restrictive
Time frame		Moment
Conditions required		Target application must be turned on Restrictions JSON must have this restriction in its content

JSON Restriction		<pre>{
		"name": "Hospital S. Joao",
		"location": [41.181533, -8.60011],
		"type": "restrictive"
		}</pre>

Steps Required		Turn on the Service and press the simulation button in the screen. Add location values to the input text fields of latitude and longitude. Turn on the respective Pervasive Game.
Expected Behaviour		The target application will go into the background and the Home screen will be at the Foreground of the device, a pop-up informing why that happened will appear
Continued actions		While the application remains near the location it will continue to go into the background until the user writes a new latitude or longitude

Table A.1: Functional test number 1.

A.2.2 Test ID #2

Test ID		2
Expansion		Spatial
Restriction name		Prohibited local
Restriction type		Alarmist
Time frame		Moment
Conditions required		Target application must be turned on Restrictions JSON must have this restriction in its content
JSON Restriction		1 { 2 "name": "FEUP", 3 "location": [41.181533,-8.60011], 4 "type": "alarmist" 5 }
Steps Required		Turn on Service and press the simulation button Add location values to the input text fields of latitude and longitude Turn on the respective Pervasive Game.
Expected Behaviour		The target application will continue to operate normally, but pop-up will appear to alert the user that he's inside a prohibited location
Continued actions		While the application remains near the inserted latitude and longitude the pop-up will appear at a specific time interval, until the user writes in a new latitude or longitude.

Table A.2: Functional test number 2.

A.2.3 Test ID #3

Test ID		3
Expansion		Spatial
Restriction name		Dangerous local
Restriction type		Restrictive
Time frame		Moment
Conditions required		Target application must be turned on Restrictions JSON must have this restriction in its content
JSON Restriction		1 { 2 "name": "Cemiterio Paranhos", 3 "location": [41.174738, -8.601108], 4 "type": "restrictive" 5 }
Steps Required		Turn on Service and press the simulation button Add location values to the input text fields of latitude and longitude Turn on the respective Pervasive Game.
Expected Behaviour		The target application will go into the background and the Home screen will be at the Foreground of the device, a pop-up informing why that happened will appear
Continued actions		While the application remains near the location it will continue to go into the background until the user writes a new latitude or longitude

Table A.3: Functional test number 3.

A.2.4 Test ID #4

Test ID		4
Expansion		Spatial
Restriction name		Dangerous local
Restriction type		Alarmist
Time frame		Moment
Conditions required		Target application must be turned on Restrictions JSON must have this restriction in its content
JSON Restriction		1 { 2 "name": "IPO", 3 "location": [41.182712, -8.604562], 4 "type": "alarmist" 5 }
Steps Required		Turn on Service and press the simulation button Add location values to the input text fields of latitude and longitude Turn on the respective Pervasive Game.
Expected Behaviour		The target application will continue to operate normally, but pop-up will appear to alert the user that he's inside a prohibited location
Continued actions		While the application remains near the inserted latitude and longitude the pop-up will appear at a specific time interval, until the user writes in a new latitude or longitude.

Table A.4: Functional test number 4.

A.2.5 Test ID #5

Test ID		5
Expansion		Temporal
Restriction name		Time
Restriction type		Restrictive
Time frame		Periodic
Conditions required		Target application must be turned on Restrictions JSON must have this restriction in its content

JSON Restriction		{
		"dayOfWeek": 2,
		"startime": 9,
		"endtime": 12,
		"repeating": "yes",
		"type": "restrictive"
		}

Steps Required		Turn on Service and press the simulation button Add time values to the input text fields of day of week, hour and minute Turn on the respective Pervasive Game.
Expected Behaviour		The target application will go into the background and the Home screen will be at the Foreground of the device, a pop-up informing why the player cannot play during that time period will appear
Continued actions		While the user continues to open the application during that specific time interval, it will continuously go into the background and the pop-up will continue to appear until the upper limit of the time interval is passed.

Table A.5: Functional test number 5.

A.2.6 Test ID #6

Test ID		6
Expansion		Temporal
Restriction name		Time
Restriction type		Alarmist
Time frame		Periodic
Conditions required		Target application must be turned on Restrictions JSON must have this restriction in its content

JSON Restriction		{
		"dayOfWeek": 2,
		"startime": 14,
		"endtime": 15,
		"repeating": "yes",
		"type": "alarmist"
		}

Steps Required		Turn on Service and press the simulation button Add time values to the input text fields of day of week, hour and minute Turn on the respective Pervasive Game.
Expected Behaviour		The target application will go into the background and the Home screen will be at the Foreground of the device, a pop-up informing why the player cannot play during that time period will appear
Continued actions		The user can continue playing during that time interval, but the pop-up will continue to appear until the upper limit of the time interval is passed.

Table A.6: Functional test number 6.

A.2.7 Test ID #7

Test ID		7
Expansion		Temporal
Restriction name		Time spent
Restriction type		Restrictive
Time frame		Daily
Conditions required		Target application must be turned on Restrictions JSON must have this restriction in its content
JSON Restriction		`{ "repetition": "daily", "time": 4, "type": "restrictive" }`
Steps Required		Turn on Service and press the simulation button Add a time (number) value to the input text fields of time spent Turn on the respective Pervasive Game.
Expected Behaviour		The Service counts up the time the application is on the foreground and once that time value equals the restriction value, the application will be sent into the background and the Home screen will come to the front of the screen, a pop-up will appear informing the user about the issue
Continued actions		Each time the user opens the application, it will continuously go into the background and the pop-up will continue to appear until a new day comes

Table A.7: Functional test number 7.

A.2.8 Test ID #8

Test ID		8
Expansion		Temporal
Restriction name		Time spent
Restriction type		Alarmist
Time frame		Daily
Conditions required		Target application must be turned on Restrictions JSON must have this restriction in its content

JSON Restriction		{
		"repetition": "daily",
		"time": 4,
		"type": "alarmist"
		}

Steps Required		Turn on Service and press the simulation button Add a time (number) value to the input text fields of time spent Turn on the respective Pervasive Game.
Expected Behaviour		The Service counts up the time the application is on the foreground and once that time value equals the restriction value, it triggers the pop-up that will alert the player of the time restriction, but the application will continue on the foreground
Continued actions		Each time the user opens the application the pop-up will continue to appear until a new day comes

Table A.8: Functional test number 8.

A.2.9 Test ID #9

Test ID		9
Expansion		Temporal
Restriction name		Weather
Restriction type		Restrictive
Time frame		Moment
Conditions required		Target application must be turned on Restrictions JSON must have this restriction in its content
JSON Restriction		1 { 2 "warningType": "red", 3 "type": "restrictive" 4 }
Steps Required		Turn on Service and press the simulation button Add a numerical value to any of the input text fields of Wind speed, Max temp or Min temp. Turn on the respective Pervasive Game.
Expected Behaviour		Once the application is opened and the service calculates the weather warning, the service will act if the values from that calculation go above the respective ones for each warning, in this case, the application will go into background and a pop-up will inform the player of such
Continued actions		While the meteorological warning continuously being triggered the application will keep going into background whenever the user tries to open it. The pop-up will also appear every time that happens

Table A.9: Functional test number 9.

A.2.10 Test ID #10

Test ID		10
Expansion		Temporal
Restriction name		Weather
Restriction type		Alarmist
Time frame		Moment
Conditions required		Target application must be turned on Restrictions JSON must have this restriction in its content
JSON Restriction		`{ "warningType": "yellow", "type": "alarmist" }`
Steps Required		Turn on Service and press the simulation button Add a numerical value to any of the input text fields of Wind speed, Max temp or Min temp. Turn on the respective Pervasive Game.
Expected Behaviour		Once the application is opened and the service calculates the weather warning, the service will act if the values from that calculation go above the respective ones for each warning, in this case, the application will continue in front of the screen and a pop-up will alert the player to be careful while playing
Continued actions		While the meteorological warning continuously being triggered the pop-up will continue to appear while the application is on the foreground.

Table A.10: Functional test number 10.

A.2.11 Test ID #11

Test ID		11
Expansion		Social
Restriction name		Physical
Restriction type		Restrictive
Time frame		Moment
Conditions required		Target application must be turned on Restrictions JSON must have this restriction in its content
JSON Restriction		1 { 2 "id": 3091, 3 "range": "auto", 4 "type": "restrictive" 5 }
Steps Required		This test is not contemplated in the simulation feature, therefore no steps required are planned
Expected Behaviour		The application will go into the background and the Home screen will be at the Foreground of the device, a pop-up informing why that happened will appear
Continued actions		While the application remains inside the determined radius it will continue to go into the background until the user moves away at least 51 meters from the restricted user

Table A.11: Functional test number 11.

A.2.12 Test ID #12

Test ID		12
Expansion		Social
Restriction name		Physical
Restriction type		Alarmist
Time frame		Moment
Conditions required		Target application must be turned on Restrictions JSON must have this restriction in its content
JSON Restriction		`{ "id": 3091, "range": "auto", "type": "alarmist" }`
Steps Required		This test is not contemplated in the simulation feature, therefore no steps required are planned
Expected Behaviour		The application will continue to operate normally, but a pop-up will appear informing the user of the alarm
Continued actions		Every time the user uses the application the pop-up will appear at a specific time interval

Table A.12: Functional test number 12.

A.2.13 Test ID #13

Test ID		13
Expansion		Social
Restriction name		Financial
Restriction type		Restrictive
Time frame		Monthly
Conditions required		Target application must be turned on Restrictions JSON must have this restriction in its content
JSON Restriction		`{ "value": 900, "type": "restrictive" }`
Steps Required		Turn on Service and press the simulation button Add a value parameter from the JSON file to the input text fields of data usage Turn on the respective Pervasive Game.
Expected Behaviour		The application will go into the background and the Home screen will be at the foreground of the device once the application network data usage is equal or superior to the restrictive value, a pop-up will inform the user of why he was kicked out of the application.
Continued actions		Every time the user tries to open the application it will continue to go to the background and the pop-up will continue to appear

Table A.13: Functional test number 13.

A.2.14 Test ID #14

Test ID		14
Expansion		Social
Restriction name		Financial
Restriction type		Alarmist
Time frame		Moment
Conditions required		Target application must be turned on Restrictions JSON must have this restriction in its content
JSON Restriction		 1 { 2 "value": 900, 3 "type": "alarmist" 4 }
Steps Required		Turn on Service and press the simulation button Add a value parameter from the JSON file to the input text fields of data usage Turn on the respective Pervasive Game.
Expected Behaviour		The application will continue to operate normally, but a pop-up will appear informing the user of the alarm
Continued actions		Every time the user uses the application the pop-up will appear during the remainder of the activity

Table A.14: Functional test number 14.

A.3 Parental Questionnaire

This questionnaire was created to evaluate certain ideas that emerged while developing the service, to continuously aim in the right direction and if needed be to iterate over what was being done at the time. Another reason for his questionnaire is it serves to validate the work being done and reiterate if parents at the present time of 2020 share the same fears and safety worries as many other parents had in the past.

1. What are the age group for your children?
    - 5-
    - 6-10
    - 11-14

- 15-17
- 18+

2. Do your children play any sort of Pervasive Games?
    - Yes
    - No
3. Does any of the following games are played by your children?
    - Pokémon Go
    - Ingress
    - Jurassic World Alive
    - Minecraft Earth
    - Harry Potter: Wizards Unite
    - Other...
4. When your child plays a pervasive game is he/she accompanied by a parent?
    - Always
    - Sometimes
    - Never
5. Do yourself or your partner play the game with your child?
    - Yes, both
    - Yes, just one of the parents
    - No, neither
6. How does your child play the game?
    - With a household device (shares the device with others)
    - WIth a personal device
    - Other...
7. How many times a week does your child play the game?
    - Once a week
    - 2 to 3 days a week
    - 4 or 5 days a week
    - 6 or 7 days a week
8. How many daily sessions does your child plays the game?

- 1 session
- 2 sessions
- 3 sessions
- 4 or more sessions

9. What's the average duration of a child's' gaming session?

   - 30 minutes
   - 1 hour
   - 2 hour
   - Unrestricted
   - Don't know

10. Are you aware of the activities your child does and the places the child goes when playing these games?

    - Always
    - Sometimes
    - Never

11. Have you ever had knowledge of any threat your children could have been exposed to while playing a Pervasive Game?

    - Yes
    - No

12. If so, what threat have you perceived to your children's safety? If you answered "No" on the previous question, please just write "none"

    - Open answer question

13. Are you afraid your children might divulge important personal information to strangers while playing?

    - Yes
    - No

14. Hypothetically speaking if your children while playing Pervasive Games was a target of bullying or harassing what would you do?

    - Use Parental Control systems
    - Play with my children at all times, supervising them.
    - Limit their gaming time

- Don't allow them to play the game any longer
- Other...

15. According to your knowledge do you believe Pervasive games have good safety measures?
    - Yes
    - No
16. If Yes, can you enumerate them?
    - Open answer question
17. Would any of the suggested safety measures fall into the following categories?
    - Dangerous Location
    - Prohibited Location
    - Weather
    - Time (playing at inappropriate moments, i.e. school hours)
    - Time (too much playing time)
    - Financial (In-app purchases)
    - Financial (data usage)
    - Social (harmful interactions with others)
    - Other...
18. As a parent would you be interested in exploring options that could enhance your children's safety with parental control services?
    - Yes
    - No
19. Would you have any suggestion for a safety measure these games could implement for parents better protect their children?
    - Open answer question
20. Other remarks (suggestion box)
    - Open answer question

A.4 Parental Questionnaire Responses

This section has the answers to questions number 5 and 6 that were gathered from the Parental Questionnaire but were not exposed in subsection 5.1.

A.4.1 Question #5 -Do yourself or your partner play the game with your child?

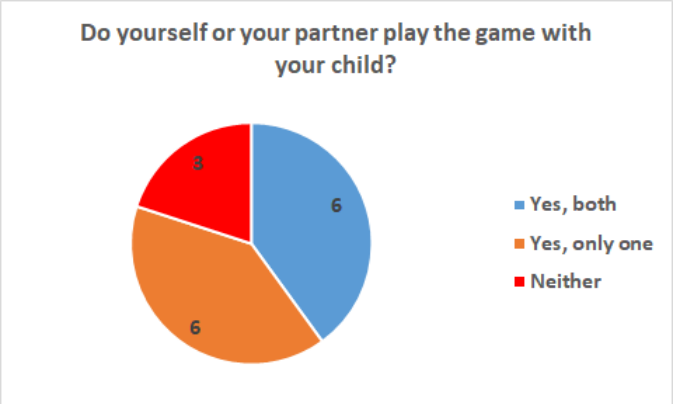

Figure A.1: Question number five results - Do yourself or your partner play the game with your child?

A.4.2 Question #6 - How does your child play the game?

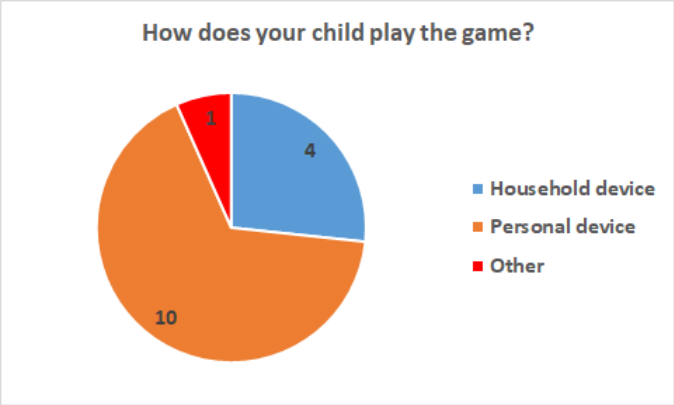

Figure A.2: Question number six results - How does your child play the game?

A.5 User-test Protocol

This test protocol uses the test table from Table 3.2. But now, those tests are meant to be inserted into a test-case protocol built with the scenarios described in this subchapter. Each test-case protocol has a specific scenario designated so that the user can experiment the service while playing a specific Pervasive Game and evaluate the experience afterwards.

Due to the innate nature of a Pervasive Game, not all tests are used in the test-case scenarios, for example, we cannot control the weather so trying to test the service on that specific restriction could prove challenging and time-consuming. Another complicated restriction would be the data consumption because it could also depend on the mobile phone payment system the player would have. Each scenario was to be tested by a player, and during the test, the player would receive a mobile phone, with the background service and the respective game installed, and safety measures

adequate for the game. The player will also receive direction instructions in the form of a digital map with markers on the map. The player will be instructed to play the game and walk to each point as the player sees fit.

At the end of both test scenarios, the player would respond to a questionnaire about the system. With this Questionnaire, there would be hopefully more information on how the service handles itself while a game is being played, how obstructive was the service to gameplay, the opinion on the user interface, the number of interruptions and if the player felt any behavioural change while playing the game

The user-test scenarios will be explained below:

First Scenario

This scenario has a specific JSON, that tests a few of the restrictions. The restrictions to be tested are the #1, #2, #5, #6, #7 and #8 . Three geofences are placed, they can be seen in Figure A.3 with an orange circle. The player should attempt to at least pass by each one of them. The green circle is the starting point of the route. A player is considered being at a designated location if it is standing at the front entrance of the respective building.

Figure A.3: Scenario 1 objectives

Ideally, the travel plan should be that the player travels from FEUP to IPO, then to FMDUP and going through IPATIMUP until he finally returns to FEUP. This is the travel routine that he is instructed he should undertake as it is seen in Figure A.4, the quickest path is in black colour. From FEUP to IPO it is a straightforward line, at IPO there will be an alarmist geofence. From

IPO to FMDUP it is a relatively easy path where the player will encounter an alarmist geofence at FMDUP. He then should go back to FEUP from that position, and he can take several routes to arrive at FEUP, he can take a longer route through Cemitério de Paranhos, a shorter route, around IPATIMUP, or the shortest route that is through IPATIMUP. But the service has placed a geofence on the building so the player cannot play the game if he tries to go through the area. Once the app goes into the background due to the restriction, he will need to rethink his path.

Figure A.4: Scenario 1 path

The player will start at a given time and be informed it has under forty-five minutes to pass by all locations. This course according to Google Maps is thirty-six minutes walking. So, there will be time interval restrictions, one alarmist and another restrictive. The restrictions will start counting at the start of the test and trigger at 35 minutes and 45 minutes, respectively. In doing so, the scenario tests the #7 and #8 test restriction.

This Scenario will test #1, #2 tests concerning the Prohibited location restrictions. And the #5 and #6 tests concerning the Time interval restriction. The #3 and #4 restriction although different on paper from #1 and #2 in an informatic way are the same since they're coded the same way, hence we believe it would not be necessary to test the service this way because the result would be the same.

Second Scenario

The second scenario is a simpler but longer test, where a player plays the game throughout a day so we can evaluate the time interval restriction. This scenario tests the #5 and #6 restriction.

The service records the player's actions while the game is active, and when the condition for the restriction is met the player will receive the respective warning. The player is informed to play the game whenever he wants, but a request is made to attempt playing the game during a specific time period.

The player will do so, and he will be presented with either an alarmist or a restrictive warning, depending on the time period. For this scenario, we have set the time between 10:00 and 12:00 as a restrictive restriction where every time the player attempts to play, the service will send the game into the background. And the time between 14:00 and 15:00 as an alarmist restriction, where the player can play the game normally but will be advised he should not.