Universidade do Minho
Escola de Engenharia

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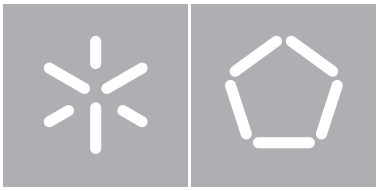
Gamification in social environments to promote behaviours regarding energetic sustainability

Junho de 2013



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Gamification in social environments to promote behaviours regarding energetic sustainability

Dissertação de Mestrado
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Cesar Analide e Fábio Silva

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Resumo

Com a evolução da tecnologia e o aumento do número de aparelhos usados e o respetivo impacto no consumo de energia, assiste-se a um aumento na quantidade de energia gasta, suplantando os esforços efetuados na produção de aparelhos com consumo de energia mais eficiente. Este aumento tem vindo a ser verificado desde há alguns anos e os números atingidos são cada vez mais preocupantes, resultando numa crescente aposta no desenvolvimento de sistemas que promovam a sustentabilidade. Estes sistemas, até agora desenvolvidos, têm, sobretudo, atuado sobre os ambientes e os seus aparelhos eletrónicos, deixando de parte os hábitos dos utilizadores destes mesmos ambientes. Uma vez identificada esta lacuna, este projeto propõe-se a atuar sobre os hábitos desses utilizadores, aplicando o conceito de *Gamification*, de modo a, não só fomentar um maior compromisso entre o utilizador e o sistema desenvolvido, mas também incentivar uma competição saudável entre os utilizadores do sistema, com o intuito de estes melhorarem os comportamentos não sustentáveis ou promover os bons comportamentos; posteriormente, é importante obter uma forte difusão de informação acerca destes bons comportamentos e de quem os pratica para que se possa influenciar outros utilizadores. A plataforma a ser desenvolvida para atingir o objetivo deste projeto será modular e desenvolvida com o intuito de poder ser integrada em outros projetos que atuem nesta área de forma a complementar os esforços efetuados por estes, para optimização do ambiente, atuando sobre os utilizadores.

Palavras-chave: Sustentabilidade; *Gamification*; Sistemas Inteligentes

Abstract

With the technology's evolution and the rise of the number of electronic devices used, we are noticing an increase in the quantity of electric energy consumed, supplanting the efforts that are being made to build electronic devices with more efficient energy consumptions. This increase has already been in process since a few years ago and the numbers reached are increasingly worrying, resulting in an enhanced focus on the development of systems that promote sustainability. The systems, developed so far, have, mainly, acted upon the own environments and their electric devices, leaving aside the very own habits of the users of these environments. Once identified this gap, this project proposes to act on the habits of those users, applying the concept of Gamification as to, not only foster a higher engagement between the user and the system developed, but also incentivise a healthy competition between the system's users, with the goal of improving non-sustainable behaviours or promoting the sustainable ones; subsequently, it is important to achieve a strong diffusion of information about these good behaviours and the users who practice them in order to be able to influence other users. The platform to be developed to achieve the goal of this project will be modular and developed with the purpose of allowing it to be integrated within other projects that act in this area as a way of complementing the efforts accomplished by these, towards the optimization of the environment, acting upon its users.

Key Words: Sustainability; Gamification; Intelligent Systems

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Abbreviations

ACA	**A**synchronous **C**ommunication **A**gent
AmI	**Am**bient **I**ntelligence
API	**A**pplication **P**rogramming **I**nterface
A-EMS	**A**daptative **E**nergy **M**anagement **S**ystem
FIPA	**F**oundation for **I**ntelligent **P**hysical **A**gents
GMA	**G**amification **M**anager **A**gent
GE	**G**amification **E**lement
HCI	**H**uman-**C**omputer **I**nteraction
HTTP	**H**yper**T**ext **T**ransfer **P**rotocol
IMA	**I**nformation **M**anager **A**gent
IT	**I**nformation **T**echnology
JADE	**J**ava **A**gent **DE**velopment
Java EE	**Java E**nterprise **E**dition
JPA	**J**ava **P**ersistence **A**PI
JRE	**J**ava **R**untime **E**nvironment
JSF	**J**ava**S**erver **F**aces
MVC	**M**odel-**V**iew-**C**ontroller
PHESS	**P**eople **H**elp **E**nergy **S**avings and **S**ustainability
PUBS	**P**attern of **U**ser **B**ehaviour **S**ystem
P2P	**P**eer-to-**P**eer
URL	**U**niform **R**esource **L**ocator

Chapter 1

Introduction

In recent years, one can observe a tendency to promote energetic sustainability and an increasing need of saving. In this context, and by taking advantage of the fast evolution in technology, several projects that seek support in the new technologies to improve the mentioned concept of energetic sustainability are starting to appear. This project arises to promote the same idea, with a new approach consisting on the use of Gamification's concept, which has gained notoriety, lately, and has been applied to different areas like education[55], driving behaviour[38], ecology[61], intelligent systems[35], health[64] and even at business enterprises[29]. The approach is very similar between the different areas, consisting on the application of game mechanics and model techniques of games, with the main purpose of increasing the users' engagement and changing the behaviours of these users.

Furthermore, there has been a strong interest in the application of intelligent systems to improve the energy efficiency, mostly by focusing in the improvement of a system[27, 39] and neglecting the users' behaviours.

Another emerging concept is the information diffusion, mostly in social networks, with various projects dedicated to study their effectiveness[3, 8] and demonstrating that they can be used to influence peers and increase the collaboration between a community[7]. Taking into account that social networks are one of the most used channels for information diffusion nowadays and Gamification will

be applied with the objective of changing human behaviours regarding a major aspect of everyone's life, both social networks and Gamification are strongly intertwined. This relation is due to the fact that community and feedback can be important dynamics of Gamification, peer pressure can be very influential to the behavioural change and social networks can be integrated to increase the reach of these dynamics.

1.1 Motivation

The development of a sustainable environment is one of the main concerns identified by a United Nations' survey, conducted around the world, about major issues that can impact the future[62]. It becomes natural that more and more projects appear towards energetic sustainability but, after reviewing the literature, our findings showed that most of these projects try to tackle the problem in the system and not the one in the human behaviour.

This is a comprehensive stance since tackling the system is often engineered in the area of IT (Information Technology) as well as Mechanics or Electronics, mostly through the optimization of systems, and addressing this problem means determining what should be the system's behaviour. On the other hand, trying to change human behaviour is directly related with psychology and sociology; changing human behaviour or encouraging the persistence of recently acquired behaviours can be a complicated and difficult aspect to be worked in IT and that is, perhaps, the reason why it has been left a bit aside.

Our motivation comes from the possibility of filling in this gap by helping users improve their behaviours/actions as well as providing a good component to address behavioural changes to other projects who act upon energetic sustainability but prefer to focus on the gather of information about the environment. In order to conciliate IT and Intelligent Systems with this sociological component, we chose to use the recent concept of Gamification which has the following definition as the most accepted one: the use of game elements in non-game contexts[18].

This concept proves to be important because, although people seek to adopt sustainable behaviours, their actions, go against this claim many times and the reason found has to do with the fact that most humans are more willing to change their behaviour if they get to see the results of these changes in a near future[37], which is hard to happen in a context like the one addressed here. With the application of Gamification, we want people to receive feedback when adopting correct behaviours and see the consequences of their actions translated to more quantifiable ones like the attainment of points or the acknowledgement of good deeds; besides, it is also our intention to stimulate a sense of progression and duration in the user by the application of, for example, levels and late rewards. This way, even though the consequences related to energetic sustainability remain difficult to observe, it will be possible for the user to see the consequences of his behaviour in our platform. The approach to this concept is extremely motivating for being a recent concept, with a recognised potential and, taking into account the literature reviewed, for having obtained very promising results[16, 55] in other areas of application.

Another concept that will be addressed is the information diffusion, mainly occurring in Social Networks. Once taking into consideration the growing success of these, their integration in everyday life and how the issue that we want to tackle concerns most people, the possibility of making the platform more dynamic and with a greater capacity for information dissemination, by implementing a social component to it, are points of great importance. Furthermore, with this implementation, there is a strong possibility of some users being capable of influencing other peers or users feeling more committed to our platform due to the feeling of community and belonging and the greater exposure to the public that a social component yield, much like it happens in some of the most known Social Networks[3, 22].

In sum, the approach to such modern concepts as Gamification and Information Diffusion, as well as, the development of a system that attempts to promote and change human behaviour in a problem of increasing concern like energetic sustainability, provides much of the necessary motivation when developing a project

like this one.

1.2 Objectives

People have habits and behaviours so marked that, many times, these are very difficult to change, even more so when it comes to energetic sustainability and people have no awareness of the urgent need to improve it. Nevertheless, nowadays we live in a technological world where it is possible to gather a vast amount of information about any environment and its users.

The main objective of this project is the development of a platform with the ability to create and manage a competition on social environments through the application of elements of Gamification. Regarding the choice of elements that are to be implemented, this is a decision that must be weighted. Furthermore, this competition will be based in the data collected from the environment of each user and/or from the behaviours identified; since there are already many projects that aim to collect the type of information needed in this platform, it was decided that this platform would integrate a communication component to be able to receive the aforementioned information and use it to sustain the competition, instead of having the ability to collect the data itself. For the purposes of testing the platform, we decided to use a project being developed at the University of Minho, People Help Energy Savings and Sustainability, that possess the capacities to collect the data needed.

Since the bigger purpose of this platform will be to change misconduct behaviours or promote the sustainable ones, the engagement between the users and the platform is a priority. In order to achieve a high level of engagement, and since not only users but also rooms and whole environments will be managed, a sub-objective of the project is to provide the platform with the ability to adapt different types of competitions according to each of these entities, fostering both competition and teamwork between the users and the environments to whom they belong. One way of fostering these features in the project can be through the

social component of this platform, resulting in a diffusion of information about the the actions adopted by the users and attracting more people to engage this competition.

One sub-objective, that derives from the main objective of this project, is the development of a platform with the capacity to be modular regarding the elements of Gamification to be applied, because the right application of this concept may be dependent on the context where it will be integrated as well as the players that will participate on the competition, so it would be interesting to provide a customizable platform.

1.3 Work Plan

The development of this dissertation evolved through five well-defined stages that are shown in Figure 1.1 below. By deciding upon these stages, it was our goal to better establish what was necessary to do and in which period as well as defining a development process for this dissertation. It is important to note that there was a constant awareness about the iterative nature of this process resulting, consequently, in periodic updates of each stage.

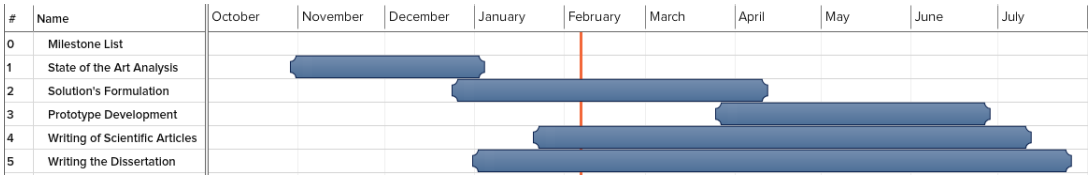

FIGURE 1.1: Scheduling

In Figure 1.1, it is easy to visualise the five outlined stages for the development of the dissertation. A brief description of each stage follows:

1. The first stage refers to the analysis of the state of the art over the main concepts approached like Energetic Sustainability, Ambient Intelligence, Gamification and Information Diffusion.

2. The second stage consists in the specification of the solution for the platform's development while already taking into consideration the concepts already reviewed in the first stage.

3. The third stage consist on the development of a prototype, implementing the features mentioned above and the analysis of the results obtained.

4. The fourth stage, which will be done in parallel with other stages, concern the writing of scientific articles regarding the concepts applied in this dissertation.

5. The fifth stage, also done in parallel with the other stages, regards the writing of this dissertation's document.

1.4 Research Methodology

This dissertation has been developed according to an action research methodology in which a problem is identified, so it can be analysed and better specified[56]. During the development process, information about the problem is gathered and analysed, continuously, so as to provide a support for the solution to the problem. Once this is done, the results achieved, during the observation, must be interpreted and valuable conclusions should be settled. In order to apply this methodology, a set of steps must be followed. First, a problem must be specified along with its characteristics, followed by a constant update of the state of the art must be done as well as the design and implementation of the system. The next step is the analysis of the results gathered and the conclusions achieved. Finally, the validation of the system must be done and the acknowledge acquired should be shared with the scientific community.

1.5 Structure of the Document

This document will be divided into six main chapters where the first chapter, the current one, describes all the motivations for the development of the project and what this project proposes to offer at its final stage, as well as, the steps outlined for this process and the type of research that was used as a guideline.

The second chapter describes the analysis made to the state of the art, in which are included the main sections of Energetic Sustainability, Gamification and Information Diffusion. In each of these sections, it is explained their main idea, how it relates to our project and some of the related work being done in each of those areas that can be used to improve our work, followed by an overall analysis to each of the projects reviewed.

In the third chapter, it is described all the technologies that were applied while developing this project. Moreover, it is explained all the decisions regarding the choosing of each technology, along with the reasons that led to those choices. Ultimately, a brief analysis to these choices is made where it is assessed the validity of them and if they proved to be correct.

The fourth chapter details the platform developed, in a comprehensive way. It starts with an explanation about the architecture from which we structured the platform, followed by the description of all the important communication that takes place between the different agents that are responsible for this component. Additionally, all the Gamification elements and dynamics implemented are explained and the interface created is shown, along with the respective decisions that were taken.

A careful analysis on the data collected and the results accomplished is made on the fifth chapter. It is described the methodology as well as the treatment process applied to the data collected and the results are analysed in order to infer valuable conclusions.

In the last chapter, it is put together a review of all the work developed and the results obtained. Furthermore, all the important contributions authored, while

working on the project, are enumerated, along with all the future work that can be done to improve this platform and to better validate the results.

Chapter 2

State of the Art

In this chapter, we will do an analysis to the work that has been done in the different areas that our project approaches. First, we are going to define the concept of Sustainability by examining the work done in this area and, afterwards, a small evaluation to some projects that support Sustainability, through the application of Ambient Intelligence, as well as an overall analysis is carried out. This same process is repeated to the concepts of Gamification and for Information Diffusion.

2.1 Energetic Sustainability

Energy efficiency represents the optimal use of energy to meet the goals and needs that arises from the people, the environment and the interaction between them. According to Herring's studies[28], over the past 25 years, energy consumption has increased and, even though the efficiency of electronic devices has also increased, this one has been voided by the growing number of energy consumption devices used. Actually, the energy consumption within commercial and non-commercial buildings is said to be between 20% and 40% of total energy consumption[45]. Initial reports from the energy efficiency policies state that small changes in behaviour can save up to 10% in home energy consumption. Although users have difficulties in changing their own behaviours for psychologic reasons, as

was mentioned in the Motivation section, the awareness of their total consumption and the individual consumption of each appliance is a great starting point for the users to become more predisposed to accept behavioural recommendations for energetic efficiency and to reduce their expenses[13].

On the other hand, sustainability is a multi-disciplinary concept related to the ability to support something at a certain percentage or level. The United Nations has defined this concept as the meeting between the needs of the present without compromising the capacity of future generations to meet their own needs.

Due to the importance of energetic sustainability, different authors presented measures to evaluate and characterise it. A common consensus is based on 3 different indicators (social, economic and environmental, as it is depicted in Figure 2.1) which are used to assess the energetic sustainability of a given environment [60]. In this approach, a system can only be classified as sustainable if the values from all the 3 indicators are met; this is the only restriction of a sustainable environment. From this point of view, energetic sustainability concerns a sensitive balance between these indicators and actions regarding the optimization of one indicator can affect the other two; as an example, if a person decides to turn on all the electric appliances, the social indicator will be maximised but both the economic and the environmental indicators will be lowered. As a result, planning for energetic sustainability becomes a complex problem where the best solution may not be the optimization of individual indicators but rather a compromise between all of them.

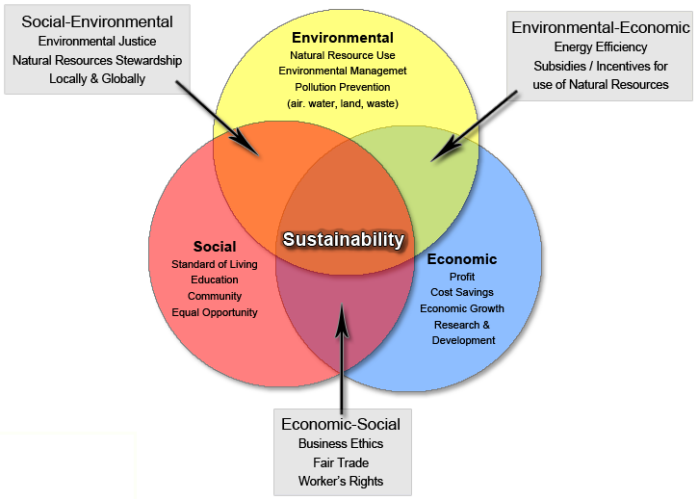

FIGURE 2.1: Sustainability Indicators

Additionally, some authors propose a fourth dimension, institutional, that represents the governing decision power within an environment, an entity that must make sustainable decisions about the environment and stand as a way to protect and support sustainability.

Though they are different concepts, both energetic sustainability and energy efficiency work towards a better environment and are both very important to it. By fitting them together, it is possible to identify two clear objectives: to be efficient in the way the resources are consumed, since it is not necessary to consume more than what is necessary to meet our needs; and the other one, relating to energetic sustainability, concerns the feasibility of our actions in the present, as well as, in the future. During the design of energy efficient systems, both objectives must be addressed to assess whether the solutions are sustainable and if these solutions try to achieve efficiency, even when energetic sustainability has been reached.

From an IT perspective, although it is not possible to directly solve the problem of energetic sustainability, we can plan and develop solutions to automatically assess the energetic sustainability of an environment. This is not possible without obtaining information, with a reasonable quality, from the users and their environment. The scientific research that has been done in the field of Ambient Intelligence supplies us with a wide range of methodologies and opportunities to

acquire the data needed in a non-intrusive way, in addition to the capacity of categorizing data inputs, organizing these same inputs according to certain interests and offering useful knowledge from the information gathered.

Ambient Intelligence is an emerging area that is having an increased growth by taking advantage of the technological evolution that is happening nowadays, mostly in the evolution concerning mobile devices. This area is based on the idea that via technological enriching of an environment, through the integration of sensors and devices connected to a network, a system can be built to act as a "virtual helper" with the ability to feel the characteristics of the users and the environment, to reason over this information collected and, ultimately, choose which actions it should take in order to assist the users in that same environment[14]. Next, the projects People Help Energy Savings and Sustainability, IRoom, Pattern of User Behaviour System and Adaptative Energy Management System will be reviewed, in this order, regarding their purposes in this context.

2.1.1 People Help Energy Savings and Sustainability

As it has been mentioned along this document, the area of energetic sustainability has suffered a strong interest from a wide range of entities, resulting in the development of many projects. One of these projects is the People Help Energy Savings and Sustainability[53], a research project developed at the University of Minho which seeks to assess the sustainability of an environment and its users. The main approach is focused on the user and his interactions with the environment, measuring their impact concerning energetic sustainability. The main objective is to build an ambient intelligent platform that through the use of indicators will promote an overall energy efficiency and sustainability.

As such, the assessment of energetic sustainability used in this project was integrated in a multi-agent system with the main goal of managing the data gathered and the flow of information among the user community, coupled with the promotion of sustainable behaviours.

This project is built upon a multi-agent system divided into three major components: data gathering, reasoning and actuating. The first component comprises software agents, like sensing agents that are responsible for the constant monitoring of an environment and supply the data to the reasoning component. This reasoning component is where all data transformations occur as well as the definition of the indicators and their respective calculations, for each environment and its users. In this component, there are two types of agents: a modeling agent that models the data gathered by the sensing agents and the reasoning agents that are accountable for the use of ambient data and model information in testing hypothesis of recommendations, to users, regarding the promotion of energetic sustainability on the environment where the system is operating. Lastly, the acting component uses the information processed by the reasoning component to promote changes in the environment and alert the users with recommendations related to their behaviours and the effect on the environment.

As already mentioned, the platform developed in this dissertation will possess the ability to communicate with other projects in order to obtain data collected from the environment and its users. The choice of selecting this project to communicate with the prototype to be implemented is due to the fact that PHESS (People Help Energy Savings and Sustainability) is being developed in proximity to the authors of this dissertation, is being developed in a multi-agent system (as will be explained later, in this document, was also an option for our platform) and is capable of providing environment information already modeled, making this choice the most logical one.

2.1.2 IRoom

The project denominated "Intelligent Room"[5] is focused in the development of an experimental platform for the research in AmI (Ambient Intelligence) systems. The platform will act in a room prepared with sensors and actuators, like sensors for luminosity, temperature, motion detectors, remote control of electrical switches, loudspeakers and displays, and which includes real furniture, such as

sofas, tables, telephones and televisions. These sensors and actuators allow the gathering of information, not only from the environment, but also from the people that use the room, and it can provide valuable information for these people so they can take more thoughtful actions in the environment.

2.1.3 Pattern of User Behaviour System

In this system, the authors'[2] main focus is the efficiency of the environment itself. The developed system aims to provide an intelligent environment with the ability to find frequent behavioural patterns. For this to succeed, it is essential to collect and model, over time, the information about the environment that is gathered through the use of the existing sensors in that environment. For the gathering of data, a wide range of sensors are used: from sensors on appliances to context sensors like temperature, luminosity and humidity and motion sensors; these last ones, the motion sensors, have the goal of figuring out the location of the user. Thus, from the assessment of the data gathered, the system wants to infer users' behaviours and optimise the environment according to these same behaviours.

2.1.4 Adaptative Energy Management System

The A-EMS[40] is a project that aims to control energy consumption by converging heterogeneous networks like power line communications, Wi-Fi networks, ZigBee and all types of sensors that are, nowadays, used in the context of AmI. This projects arises from other projects already existent in the field of Home/Building Energy Management System[11, 66] which had the same goal, however their lack of adaptability made them rejected by its targeted users. A-EMS purposes to integrate an adaptive capacity into this field through the use of P2P Universal Computing Consortium technology that is capable of connecting sensors and other devices to each other while detecting the services and the devices using the

P2P (Peer-to-Peer) network. The ability to adapt to different lifestyles is guaranteed through a phased architecture where the number of phases implemented in a building depends on the required level of management or the sensors/actuators devices available. The system works with a sensor cloud-based feedback system that gathers data from sensor nodes for luminescence, temperature, humidity and motion, plus an installed smart power trip to return the electrical values and information about the appliances. Besides, depending on the type of the installed smart power trip, the system may take actions like switching off the standby appliances for energy saving. At a higher level, if exists healthcare sensors installed like body temperature, heartbeat or weight, operations can be executed to satisfy comfort levels or specific conditions. Lastly, the living climate control can have awareness about the equilibrium between the natural and artificial control since it can take advantage of the information on the heterogeneous networks and from the weather sensors and the micro-grid. If fully implemented, this system not only collects information from the environment and its users, but also shows this information and advises them and acts upon the environment according to its reasoning.

2.1.5 Overall Analysis

The similarities between these projects concerning the use of different types of sensors prove that AmI is getting increasingly resourceful. Furthermore, it is possible to see how easily it is to gather different sources of data about an environment, its users and their interactions; with PUBS (Pattern of User Behaviour System) as an example, we can see how projects are now trying, and succeeding, in the optimization of the environment so it becomes more efficient and act according to the users' behaviours or, in the case of A-EMS, it is possible to verify how smooth the integration between AmI and the environment can be and how unobtrusive it can be for the user thanks to the ability to adapt itself to the users' behaviours and to reason over the data collected. However, these systems have drawbacks like interfering directly with the behaviour of the system which can be considered

an invasion of privacy, so some projects like PHESS and IRoom prefer to gather this information from the environment but, instead of acting according to the data collected, they opt for displaying the modeled data to the users, leaving them responsible for having the initiative to improve their own environment. This is a big difference in the projects because these latter projects make the interaction with other systems more smooth since they do not act directly upon the environment and do not change it, while PUBS and A-EMS are full-fledged systems that aim for a higher interaction with the environment by trying to predict and recognise behaviours and manage the system according to the patterns detected, features that may be regarded as downsides, since there are a lot of variables that need to be taken into consideration when identifying human behaviour, the amount of information that needs treatment is enormous and the changes on the system may not satisfy the user.

Concerning the last point, that was another important reason for the integration with PHESS project since it does not actuate over the environment so the effect of Gamification can be better assessed because the data recorded is directly dependent of the users' behaviour.

2.2 Gamification

The concept of Gamification has already been applied since several years back but it only appears documented for the first time, under this denomination, in the year of 2004, with Nick Pelling using the term Gamification as a part of his business consultancy[44] although, at the time, it carried a different meaning from the current one, and the term only began to be widely adopted in the second half of 2010 when the game designer and teacher at Carnegie Mellon, Jesse Schell gave a presentation where he stated that game elements will invade part of our daily life and will gain more prominence over time[52]. Even though it is a recent concept, it has been applied with several purposes and there is much debate regarding its exact definition. The current and more consensual definition, and one with which

we agree and chose to follow, is "the use of game design elements in non-game contexts"[18].

While the concept is recent, the idea from which it is based is not. The notion that the design of the user interface can be build by other design practices has a great tradition in HCI (Human-Computer Interaction); during the first peak in the development of computer games, in the early 80s, some authors[12, 36] analysed game designs in order to create more interesting and pleasing visual interfaces. With the solidification of videogames and a wider adoption of these by people, the game design suffered a thorough research and their interest grew. Following this tendency, researchers explored the concept of playfulness as an attractive user experience and the best way to outline it; however, no consensual solution was achieved. Many attempts were made, from Gaven that tried to describe "activities motivated by curiosity, exploration and reflection rather than externally-defined tasks"[24] by calling them "ludic activities" to Korhonen, Montola and Arrasvuori that combined the "pleasure experience" framework of Costello and Edmonds [15] with an advanced study on user experiences with video games and created the Playful Experience Framework that was able to classify 22 playful experiences[34], probably an overly complex analysis that prevented it from reaching a consensus. Likewise, none of the alternative terms were widely accepted.

In the 2000s, researchers in the field of HCI became very interested in investigating the design and experiences of video games in proper conditions so, through the development of methods to measure metrics like user experience, *playability* heuristics and game experience, they achieved ways to quantify and classify a video game concerning the experiences it provided[6, 30, 59].

Thus, the games developed with a main objective other than entertainment, usually training or educating users and named as "serious games"[1], date back a few millennia in the military sector and has reached the education and business in the second half of the 20th century. In the early 2000s, the increasing growth and consumption of digital games revitalised this area, making it a solidified industry with an own field of research.

In regard to the future of Gamification, the previsions, made by some entities responsible for analysing the world markets, are extremely promising. On one hand, M2 Research predicts that Gamification market will reach $2.8 billion in US, by the year of 2016[47], while Gartner reveals that by 2015, 40% of Global 1000 organizations are going to use Gamification as the main component to transform business operations[23]. Even though these are only predictions, they came to contradict some critics of Gamification that refer to this concept as a trend without intrinsic value and that it can have negative effects like the design of simple game-like interactions as an end goal, instead of creating a complete product with value[43], or the losing of important elements like the capacity to tell a story or providing experiences that are essential to make a game effective and engaging, or even the simple adding of one game element to a product instead of the application of solid game mechanics[46, 49]. However, a brief analysis to these critics show that they can be refuted by arguing that they are referring to how Gamification has been applied in diverse applications, frequently applied incorrectly, and not to the concept itself, which we intend to follow and employ correctly.

Deepening the analysis to the definition from Deterding, Gamification can be put closer to games and further from playfulness; as stated in game studies, the difference between game and play is strongly related to the differences between the Caillois' concepts of *paidia* and *ludus* as two extremes of the play activities' dimension[10]. In these studies, *paidia*, associated with playing, is characterised by free-form and expressive behaviours while *ludus*, associated with gaming, is identified by a structured set of rules followed by the players and the existence of a competition between these players towards a clear goal. The classic definitions of game studies also follow this thought and declares that games are defined by an explicit system of rules and the struggle of players towards a discrete goal or outcome[51].

On the other hand, we are addressed to the elements present in games. Here, it is worth noting how the concept of Gamification differs from the concept of "serious games"; while the former confines itself to the integration of some elements of games, the latter means the construction of games with a very high degree of

maturity and build with non-recreational purposes. However, the line that separates a game from an application with game elements is, most of the time, poorly defined; so, for this reason, the following considerations will be taken: an application as well as the social elements of a game must be taken into consideration and applications' elements must be designed with the objective of providing gameful experiences instead of being gameful by nature. After this, only remains the need to define which elements belong to the set of games' elements. There is great uncertainty about the composition of this set because there are many kinds of games and, even between digital and non-digital games; furthermore, the way the elements of games can be perceived are dependent on the user role. Everything considered, Deterding defines as elements of games the ones that are characteristic to games, which means the elements that can be found in most games but not necessarily in all of them, the elements that are rapidly associated with games and that play an importante role in the gameplay, like, for example, points, rewards, virtual currency, leaderboards and badges.

Another fundamental point in the definition followed is the design since the applications that apply Gamification are not the only ones where elements of games saw their purpose altered. In different fields of IT, video game designs are used with different purposes so, for the sake of an existing clarity, both conceptual and terminological, it is helpful to reserve the term "Gamification" for the description of game design and not game-based technologies or practices. Through the literature reviewed, it was found that such game design elements can be classified at different levels of abstraction and, according to Deterding, all those levels should be included in definition and can be ordered from the more concrete to the more abstract (as depicted in Table 2.1)

Level	Description	Example
Game interface design patterns	Common and successful interaction design components and design solutions for a known problem in a context, including prototypical implementations	Badges, leaderboards, levels
Game design patterns and mechanics	Commonly recurring parts of the design of a game that concerns gameplay	Time constrains, limited resources, turns
Game design principles and heuristics	Evaluative guidelines to approach a design problem or analyse a given design solution	Enduring plays, clear goals, variety of game styles
Game models	Conceptual models of the components of games or game experience	Challenges and Mechanics, Dynamics, Aesthetics
Game design methods	Game design-specific practices and processes	Playtesting, playcentric design

TABLE 2.1: Levels of Game Design Elements, according to Deterding[18]

Looking at the examples provided for each level of this table, we can see how all the projects analysed had implemented leaderboards, mostly a consequence of all projects using points as a reward, and levels, also called as status, and used with the purpose of distinguishing different kind of users. At the second level, we find elements that are not used very often like time constraint and turns that, from the projects reviewed, could only be seen at UbiAsk[35] where you earned points by answering question, a kind of turns, and the fastest the answer, the better - time constraint. At the third level, we have the type of play and clear goals, elements that are also seen in a variety of projects, although due to the fact that Enterprise Gamification [29] is intended to be generic, there is no clear goal as it depends on what context the framework is applied. Finally, the fourth and fifth level are too much abstract too be defined as elements of Gamification, also the validity of these examples regarding any application is dependent on the type of user.

Once analysed the table, it is possible to see how this model for the division

of elements puts interface design patterns at a different level of abstraction when compared to game design patterns or game mechanics. Even though they are related to the concept of pattern languages, contrary to interface design patterns, game mechanics and game design patterns do not refer to any kind of implementation and this can verified by the fact that both can be implemented with various and different interface elements.

Last but not least, comes the explanation about non-game contexts. As the "serious games", Gamification also makes use of elements of games for other goals than the ones we would expect from a game, assuming that games are still developed with the main goal of entertaining its users. Thus, a good user experience and engagement are the primary purposes on which Gamification is used, even more when considered that gameful experiences are, most probably, a design goal. By taking this into consideration, it is possible to start looking to Gamification as a concept to be applied only to specific usage contexts, purposes or scenarios, something that should be avoided since this limitation does not bring any obvious advantage.

When Gamification refers to the use of design elements, it is putting those terms against the implementation of a specific technology or the development of a full-fledged game, and when it mentions the non-game contexts, it means a wide approach to any type of context without taking into consideration any specific usage purpose. This definition puts Gamification against various concepts discussed here and it can be categorised in a two dimension universe[18]. First, the dimension with the opposites playing/gaming that represent the nature of a given concept regarding the type of behaviour that the users exhibit; in this case, and according to its definition, Gamification belongs to the "gaming" quadrant whereas, regarding to the second dimension represented by the extremes whole/parts, it is set in the "parts" quadrant since the purpose is to take advantage of some elements characteristic to games and not to develop full-fledged games. Through the cross of both dimensions, "parts" and "gaming" (Figure 2.2), it is possible to distinguish Gamification from other concepts that emerge in this context, such as "serious games" or playfulness.

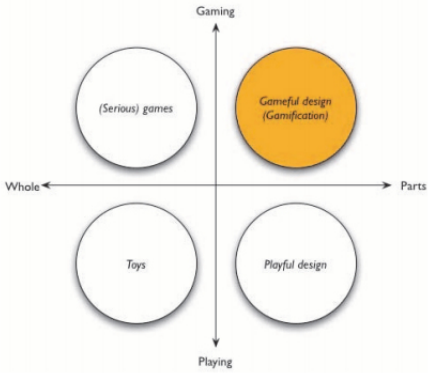

FIGURE 2.2: Gamification between the dimensions *whole/parts* and *playing/gaming*

Since this is such a recent and increasingly discussed concept, one can find many examples of applications that implement game design elements in non-game contexts. The projects that we are going to present were selected to represent the broad range of areas where there has been a steady growth of interest in Gamification.

2.2.1 Foursquare

Probably the most known example of Gamification and one of the first applications to be recognised through the use of this concept. Foursquare[16] is a location-based social networking website where users can check in where they are physically. The user is rewarded for doing these check-ins via virtual points, and acquire the status of "mayor" for the user who has most points in a certain place; furthermore, users can obtain badges by checking in at venues or by completing specific tasks. Real world companies can take advantage of the mechanics of games applied by Foursquare to improve their own business and, as an example, we have Starbucks that offers $1 discount to each of the Starbuck's store "mayor". As it is possible to verify, we have game elements like badges, points and status in a context of social networking. The huge success of this implementation is proved by their 30 million users and the millions of check-ins made everyday.

2.2.2 MEECO

MEECO[61] was developed as the final thesis project in a Multimedia Creation, Design and Engineering Master's degree. The problem that this project seeks to solve is the lack of encouragement given to people that try to adapt their lifestyle to a more eco-friendly one, for advantages at a global scale, by offering perceivable individual benefits. Despite the fact that more and more countries are becoming aware of ecology's importance and most people know of the advantages, in a global perspective, of adopting better behaviours, there is still much that needs to be done.

To change these behaviours, this framework allows its users to share their daily actions and tips, analyse and explore actions from other users, support their friends' actions and promotes a competition among the users for a position in the top rank; it is also possible for users to learn more about eco-consciousness by playing mini-games and puzzles or by challenging themselves into building a green status through the collection of items.

Through the use of game elements like points, rankings, teaming up and collection of items, in addition to the integration of a social competition, developers hope to keep their users highly engaged in their framework and start adopting the correct behaviours. Lastly, after the users have posted their actions, they receive feedback from the system and from other users, providing them a feeling of acknowledgement for the actions realised.

2.2.3 Schoooools.com

Schoooools.com[55] is a social learning on-line platform that purposes to offer a collaborative and social learning environment and it is targeted to students from 6 to 12 years old and their respective teachers. This platform provides Gamification features as tools for teachers so that they can *gamify* their classes; herewith, the authors try to take some elements of games that foster an engagement and apply them in a school environment in order to verify if the students become more

engaged in the studies which is a context where, usually, most of them is not engaged at all. Several Gamification features were implemented, among them is the possibility of providing immediate feedback and rewards to students when they perform their assigned tasks and these same students can reward other peers and appraise them; moreover, students will be able to get academic achievements in their profile, organise themselves in teams in order to better accomplish a given task and share/gift rewards between them as a way of congratulating.

2.2.4 Enterprise Gamification

This is another example reviewed in the literature in which the authors[29] developed a service-oriented and event-oriented architecture framework where all participants communicate via events over a message broker. This system is composed by a set of game rules that defines all types of game elements such as immediate feedback, rankings/levels, time pressure, team building, virtual goods and points - karma/experience points. Every time a user "completes" a game rule, an event is triggered and the rule engine assigns a reward event for the user over the message broker. Furthermore, there is an analytical component that may be used to analyse user behaviour and in pursuance of an improvement to the game rules and optimization of the long-term engagement. As it is possible to notice, this framework does not provide any specific context, besides the generic area of enterprise, where this system can be applied; it is, however, reasonable to state that most common games' elements are present and that the whole system can be employed independently of the context.

2.2.5 Overall Analysis

Through the examination of all these examples, we can see that their approach is very similar regarding the use of games' elements for the Gamification of each application. The Enterprise Gamification project can be set in a higher level since

it provides a wider range of elements to be integrated, however this has the downside of bringing generic elements into play without giving them a strong context, something that various critics point as one of the negative effects of Gamification. On the other hand, we have Schoooools.com that chose a small set of elements and brought them all together with the primary objective of creating the feeling of community and engagement in their students. MEECO appears here as a mixture between both projects because, even though they use a good variety of games' elements, they are well integrated within the project context and their mission has a clear purpose beyond the simple interaction with the users. Additionally, all projects avoid the pitfall of implementing just one element; instead they implement full game dynamics for the users' enjoyment. At a total different level is Foursquare that, thanks to its huge success, makes the task of indicating clear failures, regarding the Gamification of their application, very difficult; plus, one of the things that we can learn from them is how the strife between users and the social component are important features in this context.

From the projects' strengths and weaknesses, it is important to learn that the number of elements used is not very relevant but a strong connection between the ones implemented is, along with a good context and the integration of the social component. The stimulation of a competition between users is another important notion when trying to develop a strong sense of community within the application. Furthermore, we should avoid implementing just elements and, alternatively, develop Gamification dynamics and set a solid end goal where Gamification acts as a means to achieve the goal set.

2.3 Information Diffusion

Another considerably recent and important concept that will be part of this dissertation research is the information diffusion, in this specific case, through social networks. This concept relates to how the information is disseminated through the peers and if this dissemination occurs as influence of external peers.

Even though the studies about information diffusion on social networks are new, the study about different types of information diffusion is not. In 1962, Everett Rogers[50] advanced with the theory that there are four main elements that are directly tied to the spread of an idea: the innovation, communication channels, time and a social system. Each element plays a role in the information diffusion where the innovation refers to the idea, practice or object to be adopted, communication channels are the ways through where one message travels from one person to another, time is the length of time required to pass by the process of deciding about the innovation and the social system is "defined as a set of interrelated units that are engaged in joint problem solving to accomplish a common goal".

Along the years, new social systems have emerged while others became obsolete. The most common social systems nowadays are blogs[26], social networks and social media like newspapers, advertisements and magazines; since all these social systems became much more effective thanks to the use of Internet, their role in the information diffusion also became more impactful.

With the increasing number of social networks and the increasing success of these, as it can be seen by the growing number of users of Facebook or Twitter, it is important that the interactions in these social systems can be replicated in our application as a way of increasing the level of engagement of its users and stimulate a strong feeling of community.

Once examined the literature, several studies were found[41, 65] proving that social networks have a great potential to spread information at an elevated rate as well as allowing people to influence their peers. However, this strong ability to influence brings downsides like the power of this influence being strongly tied to the different types of users or the sharing of incorrect information that may mislead other users; by taking into account that we seek to address a problem that affects everyone, it becomes important that we maximise the information diffusion and make the users themselves play an active role in this diffusion.

2.3.1 Twitter

Twitter is a real-time information network where you can follow other users and discover stories, ideas and opinions *tweeted*/posted by those users. Thanks to the more than 500 million users registered and a highly connected network, a lot of information is spread through the use of this social system. Studies[17] show that the integration of user context such as activities or locations, in a post, performs better in the discovery of diffusion, a fact that can be associated with the concept of user homophily which states that users engaged in social activity appear to easily associate themselves with other users that are similar to them within a certain set of characteristics. Furthermore, the diffusion characteristic can be very different across different themes, thus the shared content can have more/less impact depending on how it is done. Even though a high rate of information diffusion was verified, the results are limited to the scope of the dataset, which was only a small part in the study previously mentioned.

2.3.2 Facebook

Facebook is a social network with the biggest number of users registered, over one billion users since 2012. Since a user is connected to other users and can see what they post, each user is exposed to different types of information and they can share this information themselves, affecting other people. Due to this complex network, several studies were made through the use of a small dataset from Facebook in order to account for the possible influence that may happen and how successful is the information diffusion. Bakshy *et al.*[3] analysed a dataset from Facebook and concluded that it is very difficult to determine if a given action was influenced by an apparent spread of information since social networks may influence an individual's behaviour but also reflect its own behaviour, opinions and interests. Nevertheless, by taking into consideration these 3 possibilities: a user shares one link because another friend also shared it, two users shared the same link because they visited the same website independently and, third scenario, a

user shares a link within and external to Facebook and another users shares the same link through the external influence, it is possible to infer some of the influence that users are subjected to. Through the analysis of the first and third cases, the authors found that the majority of influence results from exposure to individual weak ties, which indicates that most information diffusion on this context is driven by simple contagion. Even accounting for the limitation of this study regarding the detection of interactions external to Facebook, it is possible to predict that social networks have the potential to increase a user's exposure to new information and cause the effect of information diffusion in social networks.

2.3.3 Overall Analysis

All the examples reviewed above show evidence that information diffusion happens within social networks and, even though these are not the only means of information diffusion, lately they have been used with great success. It is also important to note the difficulty of assessing, with great accuracy, the rate of this information diffusion since it is almost impossible to determine if an action of a user was influenced or not by another peer. Another important point to retain is that there are different ways of implementing a social component on platforms and there is no data about which are the best. Due to the fact that the use of social networks as social systems in information diffusion is recent and there is still much to be explored in this field, our best option is to identify the main characteristics that contribute to the success of the existing social networks, implement them in our platform and adapt them to our context with the objective of increasing dynamics like community and peer pressure, in addition to spread the information diffusion concerning the sustainable behaviours.

Chapter 3

Technologies

To fully understand the work developed in this project, this chapter will give a detailed explanation about all the different types of technologies used by the platform. Each section refers to an individual type of technology used that had a major impact in this platform and the reasons that led to our decision of adopting them.

3.1 Programming Language

The choice of the programming language in which we would develop the back-end system fell into Java. Java is a versatile, class-based and object-oriented programming language that supports concurrency. It was developed by James Gosling at Sun Microsystems and released in 1995[25]. Since then, it has taken big steps in its evolution and counts, now, with eight different main versions. It is design to be simple although it can be very verbose and is related to C and C++, even though its organisation can be considered differently, and it is strongly and statically typed. For this reasons, or some others, the fact is that Java is one of the most popular programming languages being used nowadays, with the number of users ascending to millions.

Even though these are valid reasons, they were not the important ones we

took into consideration when adopting Java. However, being largely adopted for so many users and having a high degree of portability resulted in the development of a broad number of frameworks and this was, in fact, the main reason for the adoption of this programming language - as it will be explained below, our platform was mainly implemented through the use of two of these frameworks. Due to the fact that all our choices for implementations relate to Java, we know that they will be available, working and maintained in all the Java EE (Java Enterprise Edition) containers for some time, a characteristic that can prove to be invaluable when remembering that one of the main objectives is the development of a platform capable of interacting with other platforms available.

As it happens with all other programming languages, Java has its own flaws. The main criticism to it concerns the slow performance and highly memory-consuming processes, when comparing to other prospective programming languages like C++[21]. However, the need for a Java Runtime Environment makes possible the cross-platform advantages that Java offers, meaning that it can be developed on any advice and run on any other as long as this last one has a Java Virtual Machine[20].

In sum, the adoption of Java was a conscious decision, taking into consideration both its advantages and disadvantages and, knowingly, trading some performance of the system by a cross-platform capacity and a wide range of different implementations.

3.2 Web Component

Taking into account the objectives defined previously, it becomes clear that the platform to be developed needed a web component in order to better fulfill the requirements set. Within this spectrum, there were many and different alternatives and, after an analysis to the possibilities, the Java specification JavaServer Faces was chosen. JSF is a component based MVC (Model-View-Controller) framework, built on top of the Servlet API (Application Programming Interface) and provides

one single controller, the FacesServlet, to handle all the HTTP (HyperText Transfer Protocol) requests and responses; as a side note, JSF started to be formalised in 2004 by the Java Community Process. Another important feature of JSF is the use of Facelets as its default view declaration language, which is heavily based in the components of the User Interaction available in JSF and it is focused in the built of the component tree that reflects the views of a JSF application[9]. Once chosen JSF, we could opt between two implementations: Oracle Mojarra and Apache MyFaces; after an analysis to each implementation, it was concluded that both were pretty equal regarding performance, support and maintenance so there was no wrong option and we went with Apache MyFaces.

This was the choice made since, even though we had never had any contact with it, JSF is a standard part of the Java EE meaning that it is well integrated with the other parts of Java EE and it has some very powerful component libraries that makes the development of a prototype much faster and consistent. On the other hand, the downsides to this specification, from the analysis of different opinions that were found, include the fact that it is not suitable for high performance applications and that is not very scalable. Regarding the component libraries available, again we had several choices where the main ones were Primefaces, RichFaces and ICEFaces, and Primefaces was preferred for its simplicity, easy integration and because it has been having evolving at a good pace.

Obviously, these drawbacks are impactful but, in our case, we only pretend to develop a prototype in order to validate our theory so these have less importance when considering the great versatility given by Java specifications and its easy to use components' libraries that makes for a simple and faster development.

3.3 Communication Component

Given that it is our intention, from the beginning, to develop this project with a broad capacity of communication with other ones - as it was already stated, PHESS will be one but we want to make it possible for others - and we want this

capacity without compromising the modularity of the framework so it is possible to easily adapt itself to other environments, the choice for the communication technology carries an enormous importance.

The integration with the PHESS project, mentioned above, forced us with the the adoption of the JADE (Java Agent DEvelopment) framework to communicate with it[54]. However, after analysing this framework, several other factors contributed to this option, with the most important ones being the ability of this framework to operate in a heterogeneous, networked environment such as the Internet and the capacity to provide monitoring services, besides the fact that we had already had a previous experience working with this framework and the impressions left on us were positive. Other important features also taken into account were the autonomy, modularity and interoperability that are built into the systems developed through this framework [48]. Additionally, and another point in favor of this choice, is the ability to extend the traditional channels of communication that a system have, by the implementation of communication via exchange messages between agents, guaranteed by the framework as well as the ability of JADE agents to access and control Web Services, since the use of these were strongly taken into consideration[42]. Furthermore, the adoption of this framework had a strong influence on the adoption of Java and JavaServer Faces so all major technologies could be well integrated and communicate easily with each other. To better understand the use of this framework, it is important to understand the paradigm of agent. An agent is a particular component with autonomy to provide an interoperable interface to a system and to behave like a human agent; additionally, an agent is characterised for being autonomous, social, reactive and proactive since it can act without direct human intervention, it can cooperate with others, it has a perception of the environment where he is and can respond to stimuli and it takes initiative. An important ability of these agents is their capacity to communicate with each other, the social characteristic, by only requiring an ontology and it is this capacity that gives JADE the ability to extend the traditional channels of communication that was mentioned above[4].

In order to ensure the features already mentioned, we looked at some implementations in JADE during the final stage of this analysis. In MADIP, the authors [58] developed a mobile platform, based in a multi-agent system with the goal of allowing physicians to detect abnormalities in their patients and the ability to see, in real-time and ubiquitously, the patient's data using a PDA, a laptop or a computer; on the other hand, the patients can have their vital signals measured and these results submitted to their physician automatically and autonomously through their mobile device. Their choice of developing this platform in JADE arose from the need to, not only operate the system in a distributed and heterogeneous environment like different operative systems or mobile devices, but also have an open architecture and good scalability to favor the platform's evolution by the integration of new components, since applications developed in JADE are extensible and open; moreover, they sought a secure infrastructure which is provided by the framework since it ensures message integrity and the confidentiality and authorization verifications when agents perform an action. Another important requirement is related to the complexity of the health-monitoring field that makes the modularity provided by JADE essential to achieve extensibility by the partition of functions in smaller logical units that can be changed independently.

Another example reviewed was a multi-agent system that aims to restore a distribution network of electric energy and is capable of performing fast and efficient swaps to isolate faults, restore power to "de-energesied" areas and minimise the existence of internal overloads[32]. In this project, the authors chose to develop a multi-agent system because of its adaptability, capacity of self-knowledge, autonomy, quick response to the environment and the ability to offer a rapid and timely solution; inside the universe of multi-agent systems, JADE was selected due to its wide support in industry and its open-source status.

3.4 Server

The last technology going to be discussed, in this chapter, is the Web container used to deploy our platform. Among the alternatives, the main contenders were

JBoss, GlassFish and Tomcat and we chose the last one. Just like it happened with JADE, we had previous experience in deploying to Tomcat and it has always proved to be very straightforward. Additionally, both JBoss and Glassfish are matured Java EE application servers, consequently providing a wide range of features that would not be needed in this platform and having a steep learning curve[57]. On the other hand, Tomcat is simply a Java servlet container and an HTTP server meaning that it is capable of handling servlets and JSF implementation, the only requirement here, it is very lightweight and provides a clean administration interface. Another relevant point is the fact that migrations to more mature servers are common in advanced stages of a project and Tomcat eases these migrations so, since the stage of our project is the implementation of a prototype, Tomcat provides all the necessary functionalities.

Once again, the fact that we intend to develop a prototype to verify our theory had a major influence in the choice made. The case being that this is not supposed to be a full-blown platform and, consequently, performance and scalability were not a main issue, leading to the opinion that using JBoss or GlassFish would be a big overhead for the goals that had been set. Contrarily, the simplicity of Tomcat and the fact that it combines just the required features to run the platform, were critical factors to its adoption.

3.5 Overall Analysis

Once developed the platform and looking back to all the decisions made regarding the adoption of the technologies above, we can affirm that the each decision was satisfactory, even though some would be made differently. Starting with Java, this decision would remain untouchable since this gave us an opportunity to develop expertise in one of the most used programming languages while delivering the platform delineated with no major drawbacks in the final result. Besides, the easy integration with other important components proved to be invaluable during the development of the project, as it was expected.

Regarding the use of JSF, and specifically of Apache MyFaces, it is very difficult to say that Oracle Mojarra would be a better choice when taking into consideration the fast evolution of MyFaces and the good results that it has obtained in benchmarking tests agains Mojarra[1]. Like it was said, both implementations are very similar, with a little superiority to MyFaces and since the development of this platform occurred steadily and without any critical obstacle due to this choice, we can thoughtfully state that we would not change our choice. However, about JSF, and even though we reached our goal, some major setbacks needed to be solved and it is possible that the decision made would not be the same. Learning a component-based framework was very interesting and it may reveal useful in the future but the adoption of a framework like Grails or Spring could have had a big impact in the productivity during the development process and are also highly supported. Grails is a web application framework developed in the programming language Groovy which is based on Java, is heavily designed according to the MVC paradigm and the "convention over configuration" paradigm and is based on technologies such as Spring, Hibernate and SiteMesh; with these main features, Grails provides a faster and highly productivity development environment and abstract much of the complexity present in other frameworks[31]. Spring is a popular web application framework for Java and also adopts the "convention over configuration" paradigm as well as the MVC, however they have their own understanding and implementation of this concept; it is a request based framework and has a vast community and are these characteristics that makes the adoption of Spring appealing[33]. All things considered, JSF was not a bad decision but the use of another framework like the ones mentioned above would have been a wiser one, with a small personal disposition to Grails.

Concerning the adoption of JADE framework for the implementation of the communication features, we could not be more pleased. All the expectations built up from previous experiences were exceeded and we have the opinion that this framework improved the ability of our platform regarding communication

[1]Understanding JSF 2 and Wicket: Performance Comparison, Leonardo A. Uribe P., May 2012

and modularity to a whole new level. It is obvious that complex problems arose while developing, mostly taking into account the multi-threaded nature of this framework and our access to the database, but once they were solved, the final results could not be more positive.

Finally, the server selected to deploy our platform should have been another when looking at the alternatives that were already mentioned and how much the Tomcat influenced the development stage. Although the use of JBoss or GlassFish would still be a big overhead and using Tomcat was as easy as expected, we believe that we could have taken advantage of this opportunity to gain experience with more mature application servers; this means that in our opinion the overhead of using JBoss or GlassFish would be a reasonable price to pay in order to improve our platform, acquire new experiences and facilitating the development. As a final note, having the possibility to choose again, we would lean towards JBoss for its wider base of users and versatility.

Chapter 4

Prototype Implementation

In this chapter we will approach every relevant decision about the prototype developed, including its architecture, the communication happening among the different components, all the Gamification elements and dynamics implemented and the interface created that led to the final product. After all aspects of the platform were explained, we will do a brief review to the prototype as an end product and analyse what could be done differently or what should stay the same.

In the interest of giving a general overview of the platform developed, the Figure 4.1 shows our system divided according to the two frameworks used, JSF and JADE, and in a three-tier architecture.

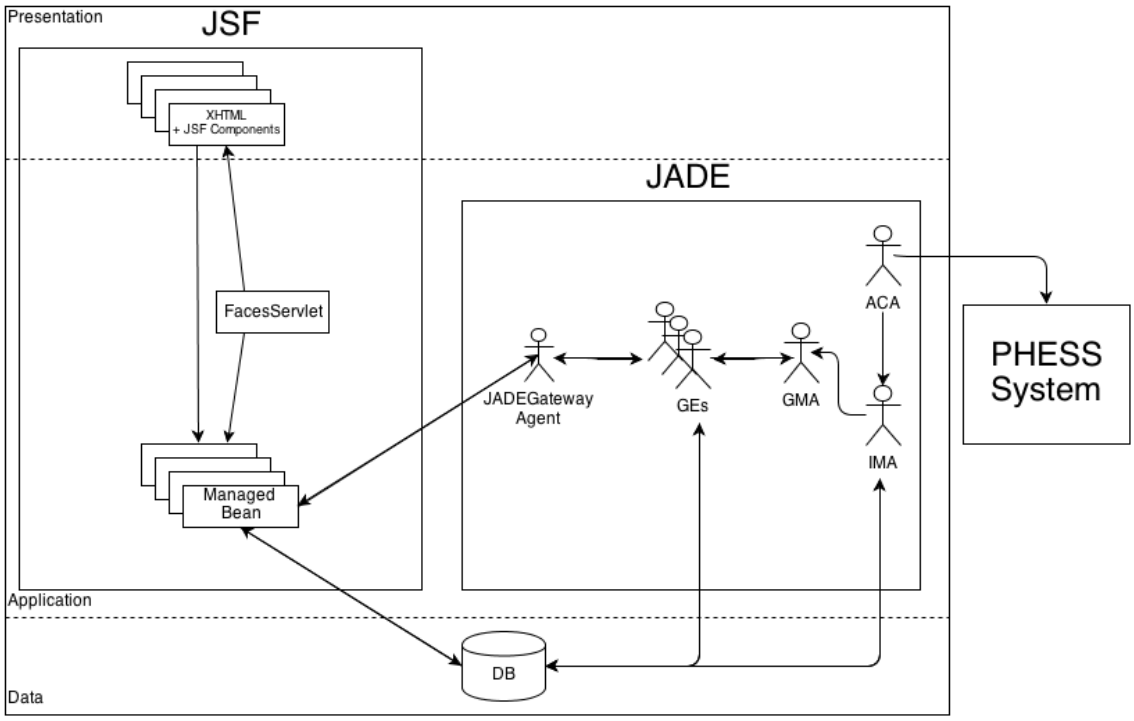

FIGURE 4.1: Architecture of the Platform

In the Figure 4.1, the three-tier are clearly identified and we can see that, at the top, is the presentation tier composed by the platform's interface, which, in this case, is part of the JSF framework. At the second tier is the application tier and it is where all the logic is represented as well as the application's functionality and we can verify that this part is composed by both JSF and JADE frameworks. Since this part is the most complex and where most components come together, we will explain it more detailed in the paragraphs below. Lastly, there is the data tier specifying the database servers and representing the information stored and retrieved.

If we make an attentive study regarding the JSF component, we can see the MVC paradigm with the views being represented in the presentation tier, the FacesServlet as the sole controller and each managed bean functioning as a model. On the other hand, in the JADE component, we can corroborate that the ACA (Asynchronous Communication Agent) is the agent communicating with the PHESS system and sending the information collected to IMA who stores it in our database. GMA (Gamification Manager Agent) communicates with IMA (Information Manager Agent), being informed when all the new information has been

stored, and with the various Gamification Elements implemented/active, each being responsible for the rules that concerns their element.

When analysing carefully the second tier, it is possible to notice that the connection between both components is made through the JADEGateway Agent[1]. This is a agent with a very unique behaviour, responsible for receiving requests from the managed beans and dispatch them to the correct agent. It waits for a response and replies it to the managed bean who sent the request. The behaviour of this agent will be more detailed in subsection 4.2.5.

4.1 Data Model

Starting the explanation of this platform from the bottom, we will begin with the data model. However, to better understand the relationships between the entities, we decided to partition the whole data model in five parts. In Figure 4.2, it is depicted the part of the logical data model that represent how the information retrieved from PHESS platform is stored.

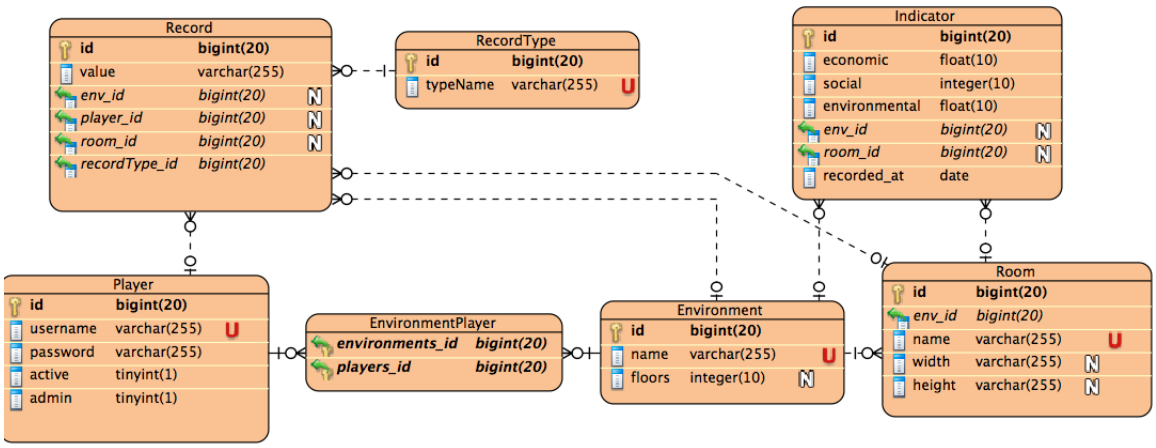

FIGURE 4.2: Logical data model for storing PHESS information

Analysing the figure above, we have three different entities upon which the system acts: Environment, Room and Player - environments' users. Each one of these entities will have a set of records that were registered on the PHESS system

[1]JadeGateway Tutorial, Viktor Kelemen, 2006

and each record has belongs to a type, like light or temperature or electricity, according to the type of sensor that registered the value. Besides these values, PHESS also provides the sustainability indicators that were set for each environment and room, by players that belongs to those environments. It is important to underline that our system is prepared for a player to have several environments in the same way that an environment can have several players.

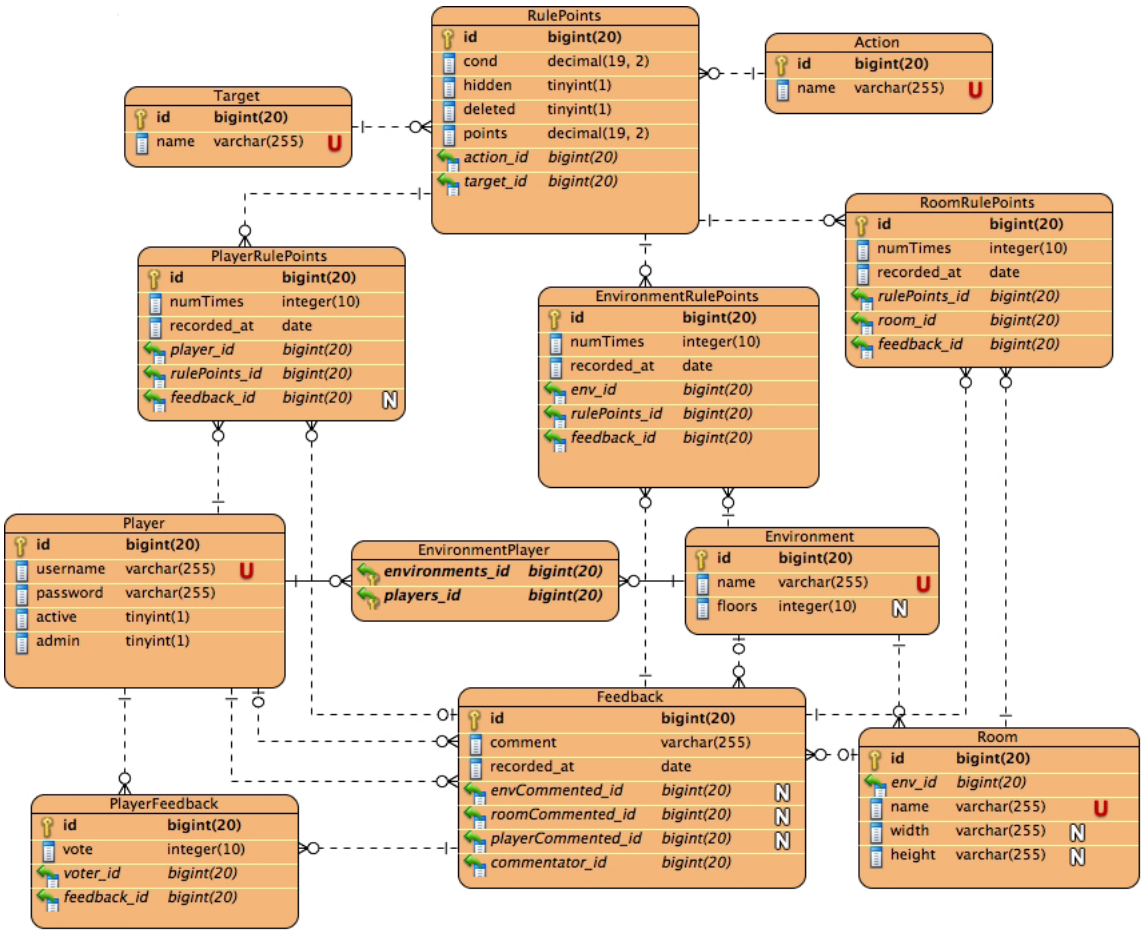

FIGURE 4.3: Logical data model for implementation of points element

In Figure 4.3 (full image in A.1) is shown the entities and their relationships that are stored in order to implement the Gamification element Points. For the purpose of this platform, we created the entity RulePoints that will store the set of rules that an administrator wishes to apply for this specific element. It is clear that these rules may be applied to many environment, rooms or players and each of these can "fulfill" many rules. Furthermore, each rule can have a specific target definied, either environments, rooms or players, and is composed

by a certain action. As a way of fostering the feeling of community, the players can give feedback/comment to other players and to any room or environment. These feedbacks can be voted, up or down, by the other players and there is the possibility of players being rewarded for giving useful feedback; this actions are stored in the Feedback and PlayerFeedback entities. All these features related to Gamification elements and dynamics will be deeply explained in section 4.3; this explanation is only intended to clarify the relations between the different entities. In the next figure, we delineate the logical data model regarding the Gamification element Levels.

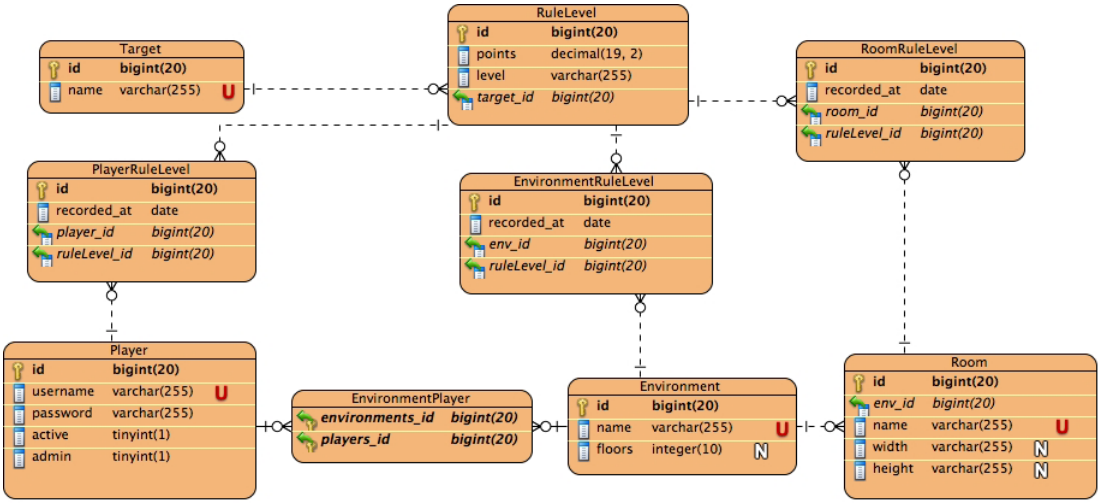

FIGURE 4.4: Logical data model for implementation of levels element

Figure 4.4 (full image in A.2) is similar to the 4.3 regarding the relations between the players, rooms and environments and RuleLevels. However, it is important to note the existence of some restrains about the relationships for this element of Gamification since each environment, room or player can only complete a rule once; for example, a player can achieve a given level only one time. A common entity that this figure has, when comparing with rulePoints, is the Target entity which has the same goal as explained above, allowing the possibility to set a specific target for a certain ruleLevel. Next figure shows the logical data model created to represent the Gamification element Achievements.

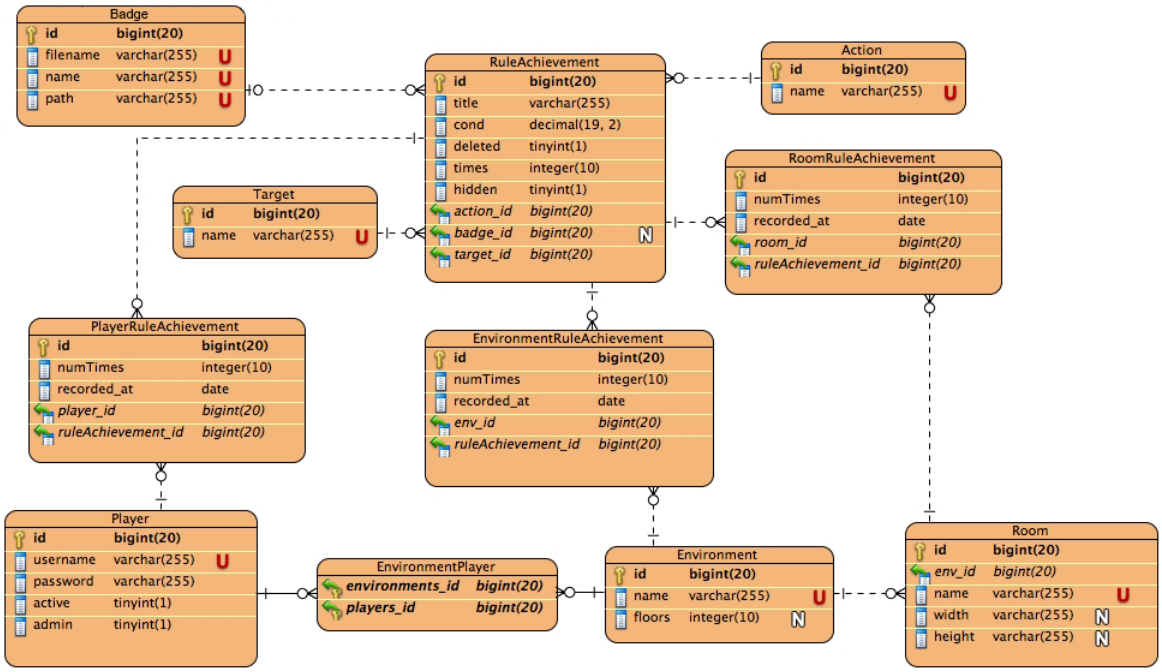

FIGURE 4.5: Logical data model for implementation of achievements element

Looking at Figure 4.5 (full image in A.3), it is possible to see similarities, regarding the relationshsips, with both RulePoints and RuleLevels logical data model parts'. The same constrain that exists in RuleLevels is applied here, since each environment, room or player can accomplish a certain achievement only once. Both Target and Action entities have been present before and, regarding the rules related to achievements, they have the exact same purpose; setting a target to specify the entity who can accomplish a certain rule and defining the action that is evaluated to check if the achievement was accomplished. In addition to these two specifications, we have the Badge entity which can be set in an achievement in order to reward the player, room or environment, when the achievement is "completed", with the respective badge as a token of ackownledgement for this accomplishment. Lastly, the Figure 4.6 was specified to store information for an events feed.

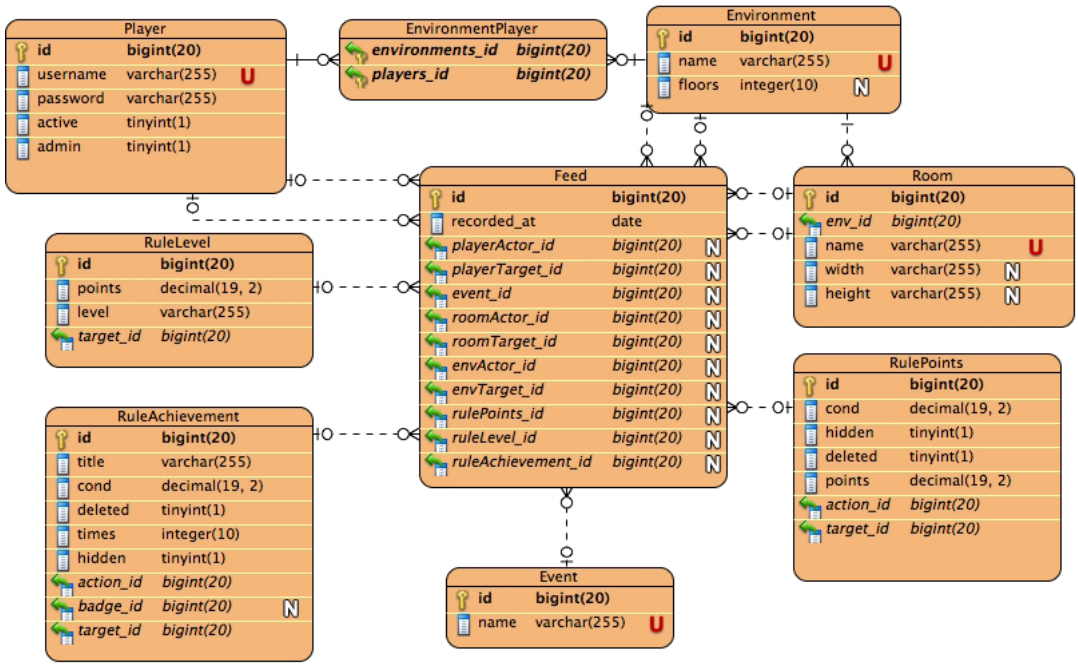

FIGURE 4.6: Logical data model for implementation of events feed

Figure 4.6 (full image in A.4) demonstrates how the information about an event that happens on our platform is stored. Any important occurrence happening in the platform is stored in the Feed entity, belonging to a specific type of Event, in order to keep any player up-to-date about anything happening in the community. The two relationships that exist between Environment, Room or Player and Feed entity is due to the fact that any of these three can either by the ones responsible for triggering an event or be the ones who were target of an event.

One last note to the fact that all the mapping between the Java classes and the database tables are handled by the Hibernate framework through the use of JPA (Java Persistence API) annotations. These annotations replace the use of XML mapping files and Hibernate supports caching memory, reducing the number of round trips between our platform and the database, and all the main types of relationships between entities as well as their mapping to Java collections.

4.2 Communication

As it has been mentioned numerous times, the communication component is one of the main features of this platform resulting in the adoption of the JADE framework to be responsible for providing a strong communication capacity. For

this reason, we are going to expose all the different set of communication steps that happen along the platform and explain their importance. The following Figure 4.7 represents the main steps of communication that happen between the agents developed for this platform.

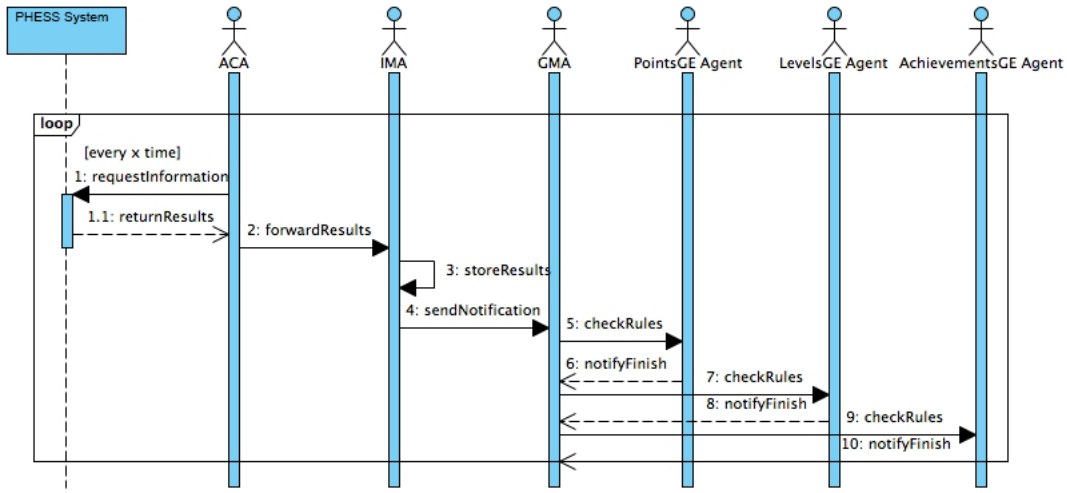

FIGURE 4.7: Sequence Diagram representing the communication in the system between agents

As it is possible to verify, we have the Asynchronous Communication Agent that will do several requests for information to a designated agent on the PHESS platform; these requests will happen on cycles of a given period of time determined by the administrator of our platform when initializing this agent. Each set of results received will be forwarded to the Information Manager Agent who is responsible for storing all the information contained in these same results and, after all the requests have been made and the responses obtained, a notifying message is sent to Information Manager Agent informing all of the expected replies were forward.

Subsequently, Information Manager Agent will receive messages containing the results and will store this new information. When the storing of all information is completed, this agent will send a message to Gamification Manager Agent so as to notify him that our system is up-to-date, setting in motion the rules checking task that is performed by each agent associated with its respective Gamification element. This set of steps have a defined order for the sake of preserving the isolation property of our database; for this reason, Gamification Manager Agent

sends a first message to PointsGE Agent, awaits for him to reply after all the rules have been checked, then sends another message to LevelsGE Agent and, again, awaits for the reply reporting that all rules have been checked and, finally, the same series of events happens with AchievementsGE Agent.

When the last step is finished, the interaction stops and this set of steps happen all over again, starting from the beginning, when the time step by the administration has elapsed. Taking into account that figure C gives a too much generic overview of the messages exchanged in the system, we will proceed to a more detailed explanation of the most important conversations.

4.2.1 Ontology

As a way to communicate, these agents must share the same language and vocabulary, besides the ones available by following the FIPA (Foundation of Intelligent Physical Agents) standards such as the communicative acts (inform, confirm, request...). Because of this, we have defined our own vocabulary and language, also named ontology, for the messages' contents exchanged between our agents. As a matter of fact, two different ontologies are used by our agents: one named PHESS Ontology that defines the content of the messages swapped with the PHESS project to retrieve the information needed in our platform and another named Gamified Ontology, used by the agents communicating just within our system to deliver the requested results.

Both ontologies will be explained with more detail next. However, in order to better understand them, it is important to know the main notions like Concepts that represent objects that can have complex structure, Predicates that act like questions about the environment, having a value of true or false and expressing facts and Agent Actions which specify actions that can be requested to a specific agent.

Phess ontology, represented in the Figure 4.8 with Crow's Foot notation[2], is used, specifically to our platform, by the Asynchronous Communication Agent, the PHESS designated agent and the Information Manager Agent; it is important to note that this figure only shows the ontology entities requested by our platform.

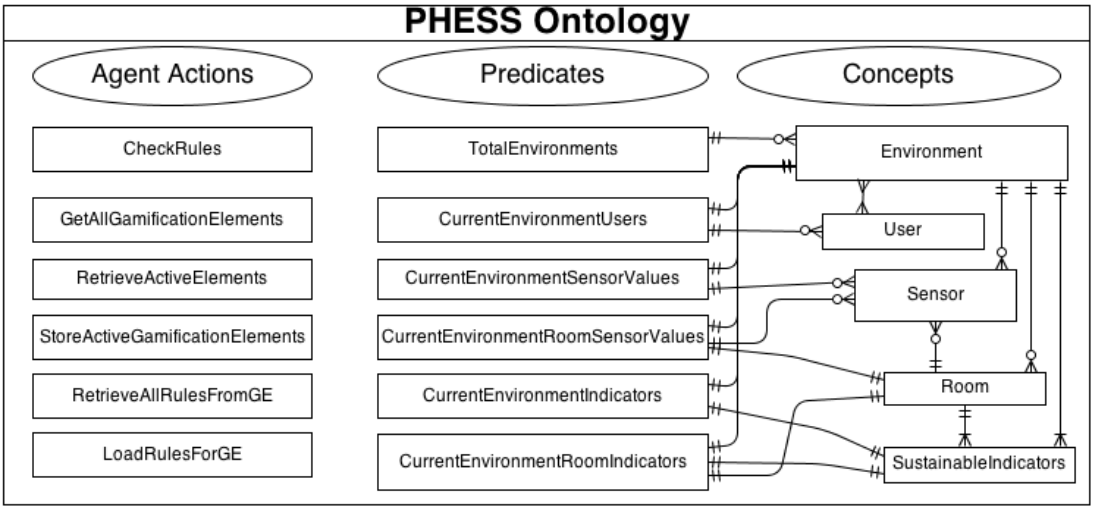

FIGURE 4.8: Ontology used to communicate with PHESS system in Crow's Foot notation

Taking into consideration the notions explained before, each concept represents the information available of the respective entity. As such, we need the information about the sustainability indicators, the sensors, the environments, their rooms and their users. This information is requested by sending agent actions to the PHESS system and waiting for the replies with the predicates containing the concepts. Even though any agent action can be replied with any predicate, or set of predicates, when sending a specific agent action, the system is expecting a reply composed by one or more predicates of a specific type. The Figure 4.8 represents these links when reading it from the left to the right since we aligned, horizontally, an agent action with the expected predicate. As an example, you can read it like this: after sending agent action ObtainAllEnvironments, the sender

[2]Crow's Foot notation was established by Gordon C. Everest at the University of Pennsylvania and at CACI by Barker, Ellis and Palmer. It is an entity-relationship model variant and is used to represent the cardinality of different relationships with the minimum cardinality being represented towards the center and the maximum towards the end of the line of the relationship.

will expect predicates TotalEnvironments as a result which is composed by zero or more Environment concepts. Through these agent actions, and the respective predicates and concepts, our agents can request all the information, necessary to feed our platform, from PHESS system.

On the other hand, Gamified ontology, represented by Figure 4.9 and also in Crow's Foot notation, is mostly used by the Gamification Manager Agent and the agents responsible for each Gamification Element and, as shown, it is very distinct from the PHESS ontology.

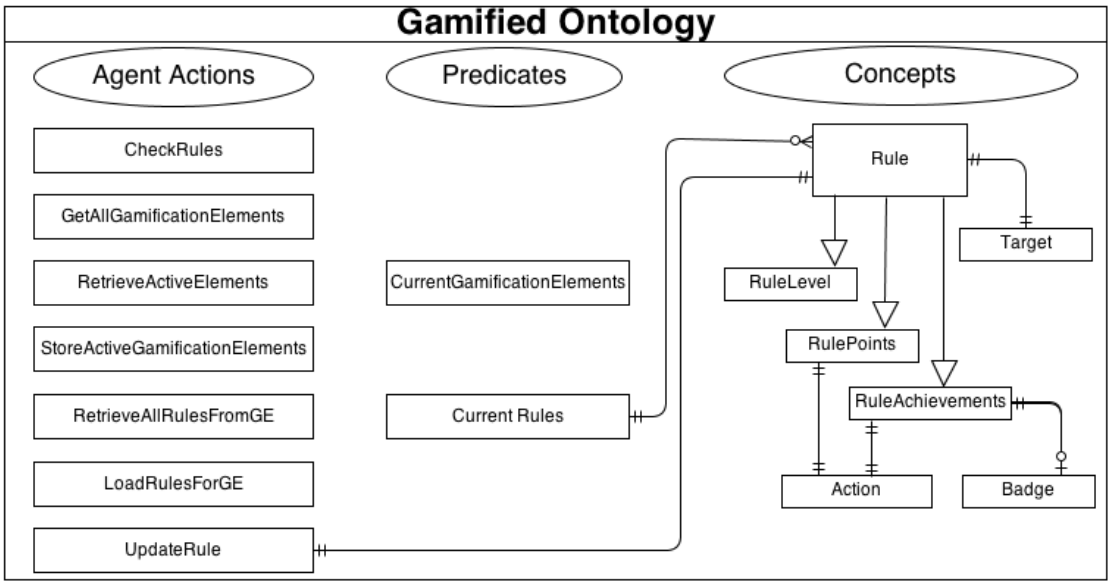

FIGURE 4.9: Ontology used by the agents of the platform in Crow's Foot notation

One important detail is the use of a hierarchy regarding the rules, since there is the generic concept of Rule and, then, each element of Gamification has its own rule concept that implements the generic one, reducing the complexity and the need for more agent actions and predicates. Another important feature is how some actions are only used to trigger certain events and it is not expected to deliver any valuable information. As an example, the agent action CheckRules is sent from Gamification Manager Agent to one of the Gamification Elements' agents to make it run the process of checking rules and only awaits for a message

There are three different symbols: a circle, representing cardinality "zero", a bar, representing cardinality "one", and a crow's feet, or three bars connected, representing cardinality "many"[19]

confirming that the process has finished; no predicate is returned. This will be more visible below, when the conversations of the Gamification Manager Agent are reviewed. Just like in Figure 4.8, Figure 4.9 is also aligned horizontally and should be read from the left to the right to better understand how the agent actions, predicates and concepts are applied.

4.2.2 Asynchronous Communication Agent

This agent can be considered one of the main agents due to its function of requesting all the relevant information that the PHESS system has gathered which, in turn, triggers most of the conversations that happen between other agents. In Figure 4.10, it is shown the different requests that Asynchronous Communication Agent sends to PHESS and the respective replies.

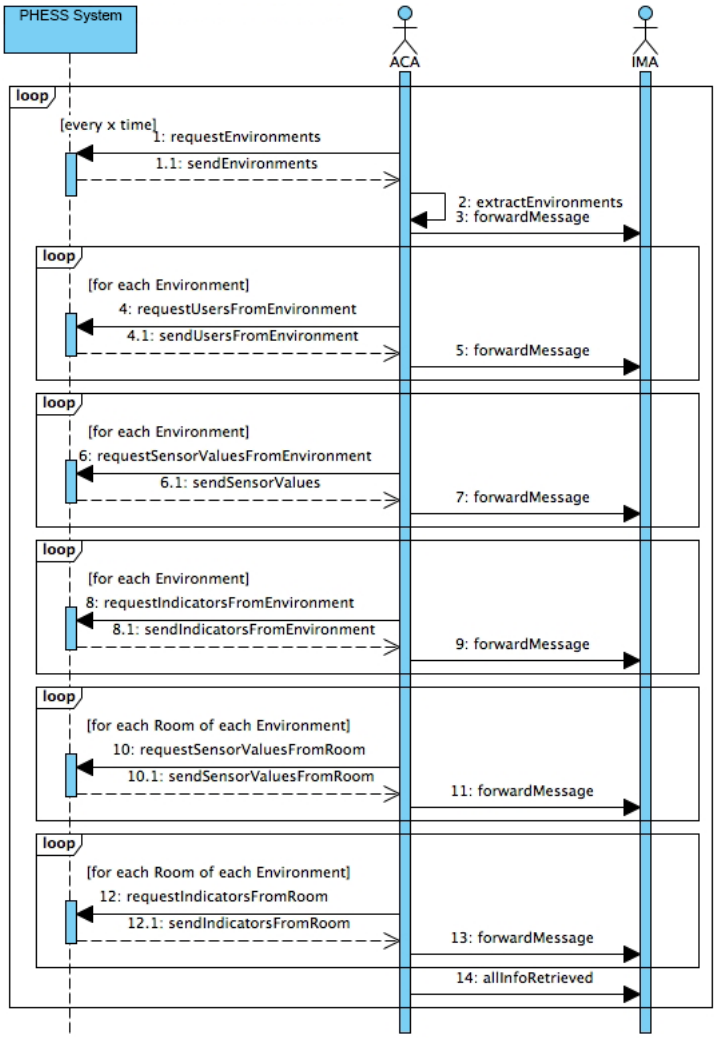

FIGURE 4.10: Communication of the Asynchronous Communication Agent

In order to retrieve all the information needed from PHESS, the agent starts by requesting all the environments that they handle. Once received the reply, for each environment, a request is sent to obtain all the users of the given environment and after all the requests have been sent, the Asynchronous Communication Agent will wait for a number of replies equal to the number of environments. The next step is to send a request to collect the sensor values recorded, for each environment, and wait for every reply regarding each environment; this very same process occurs for the collection of the indicator values.

Finally, for each room of each environment, we will repeat the process of sending a request to retrieve the sensor values recorded and the indicator values set, in the respective order, and waiting for all the replies to each request before

advancing to the next set of requests. When everything has been retrieved, a last message is sent to Information Manager Agent to inform that there is no more data.

4.2.3 Information Manager Agent

This agent has a simple functionality and an even simpler behaviour, only waits for messages sent from the previous agent described and store the contents of those messages in our database. When one of the messages received is to inform that there is no more new information, this agent passes this notice to the Gamification Manager Agent. We opt to develop the system with this structure because it becomes more modular and easier to maintain; due to the simple nature of the conversations that this agent have, we did not feel the need to show any diagram detailing its behaviour.

4.2.4 Gamification Manager Agent

This agent will play a central role on the update of the rules accomplished by the players, rooms and environments since it is the one responsible for dispatching the "orders" to start the checking of rules accomplished. Regarding this matter, there are two types of checking orders as it is outlined in Figure 4.11.

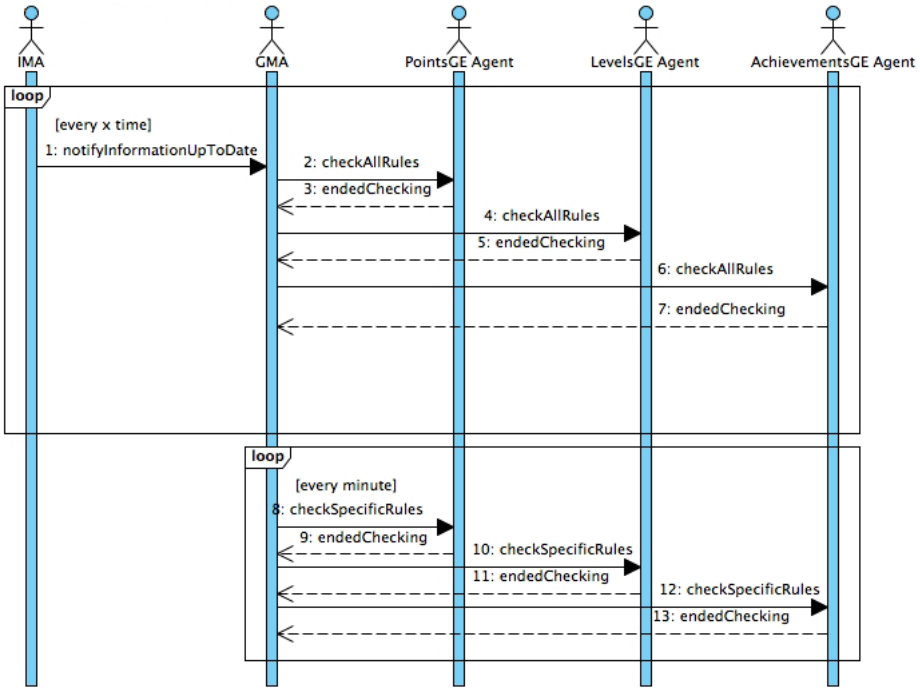

FIGURE 4.11: Communication of the Gamification Manager Agent

The first checking happens when Gamification Manager Agent receives a message from Information Manager Agent, indicating that our database is up-to-date with all the most recent information collected by PHESS and the agents of Gamification Elements can start checking if any of the rules have been completed accordingly to the new information. The second checking needs to exist when considering that the request of information from the PHESS system is very demanding, it cannot happen very often and there are rules that can be completed by players while using our platform, so this checking is more specific and can happen much more often. Important to note that when doing this second checking, each Gamification element agent will not check all rules but only the ones that can be completed without the need of PHESS information; as an example, all the rules related to feedback

As it was previously stated, each checking has a defined order due to the multi-threaded nature of the JADE framework - each agent runs in a single thread - which may causes inconsistencies in our database, so the Gamification Manager Agent first sends a message PointsGE Agent and awaits for his reply stating that all the rules have been checked. After receiving the reply, this process is repeated,

first for the LevelsGE Agent and, then, for the AchievementsGE Agent.

Finally, another important behaviour of this agent is the one responsible for receiving requests from the managed beans and reply with the appropriate information. This is mostly necessary to obtain or save the Gamification Elements activated by the administrator.

4.2.5 JADEGateway Agent

This is a very specific agent with a very specific goal: receiving agent action requests from a managed bean, dispatching the request to the correct agent, waiting for the result and sending the result back to the managed bean. With the use of JADE, it is natural that we need to request information from agents or send information to them and the JadeGateway Agent acts as a bridge between the JSF, specifically the managed beans, and the agents operating in the system. For this process to happen consistently, every time a request is made through this agent, he has the ability to lock the managed bean, for a timeout set value, while waiting for the results and unlocking it when these have been received. Even though there is no diagram to represent the exchange of messages of this agent, since the exchange is dependent on requests made from the players in the platform, this agent's function is crucial for the operability of the platform.

4.3 Gamification Elements and Dynamics

When considering the main purpose of this dissertation, the implementation decisions that are going to be explained have a paramount importance. In this section, we will show how we decided to apply the knowledge acquired about Gamification and what were the Gamification elements and dynamics implemented[3].

[3]Much of the Gamification elements and dynamics applied and decisions taken, regarding this matter, were a result of the knowledge acquired in the Course of Gamification from Coursera, given by Professor Kevin Werbach

However, before we start detailing, it is important to refer some considerations made, mostly due to the fact that this project tries to solve a problem for the greater good. This factor can have several impacts since our intention is to make people adopt sustainable behaviours but keep the intrinsic motivations that should exist; for example, we opt for not giving incentives since this could make people adopt the behaviours for the incentives, and not for the environment, which could lead to the abandon of those behaviours if the incentives stop and, for this same reason, we chose to not implement virtual currency. Furthermore, when studying other work done in Gamification, we noticed how the implementation of a virtual currency withdraws value from other elements and everything becomes centered in the virtual currency. The following subsections will analyse, in detail, each Gamification element or dynamic implemented.

4.3.1 Points

The choice of starting with this Gamification element is also a way of explaining its importance. Points is one of the most common elements associated with Gamification and one of the most used; in fact, we think that they are so fundamental that we chose to force the administrator to select it. This decision can be justified by the fact that the attribution of points is a clear and easy to understand way of rewarding a player, providing feedback, displaying progression and giving him a way of comparing himself to other players; additionally, some other elements and dynamics can make use of this element to improve the mechanics of the platform.

Taking this into consideration, we needed to develop easily configurable rules for players, rooms and environments to score points while also giving some complexity to these rules. As so, a rule which awards points is composed by a given action, for now we provide the actions "Energy Spent" and "Feedback Provided", a condition to be fulfilled, a number that determines how many times the rule must be fulfilled to be considered completed, an attribute to set the rule as hidden or visible, the number of points to be awarded when the rule is completed and

the target of the rule, to whom this rule is applied. With this, it is our intention to diversify the way points are awarded, imbue the player with the necessity to keep improving and be able to precise rules to a specific entity, players or rooms or environments. The attribute hidden is, normally, appealing to the psychological aspect of a player since he cannot see the rules defined as hidden and if he completes them, the surprise of this event will act as a motivator.

4.3.2 Levels

Levels is another common Gamification element and is frequently applied. It can also be called Status since both work in the same way, grouping players within the same tier. This element is important because it can set more reachable goals, determine the difficulty curve of the platform, provide a better sense of progression and set players in the same level according to their performance and distinguishing the ones who have a better performance. The increase of the points needed to a new level as our level becomes higher is a good example of these characteristics and are present in many games.

Once again, we provide the administrator with the possibility to set these rules accordingly to his intentions. These rules are composed by a name that identifies the level, a value representing the number of points needed to achieve the level and a target, either players, rooms, environments or all of them. By specifying a target, the administrator can set different scales for the levels of each referred entity; as an example, every player, room and environment should fulfill the "Level 0" rule which needs 0 points and are targeted to everyone but to reach "Level 5", a player may need 500 points while an environment may only need 200; this can come handy if we remember that environments and players have different rules and their energy spendings can be different too. In the specific case of our platform, if the levels element is active, we opted to show a progress bar where the player can see the percentage of his current level that is completed and how much is missing until the next level, providing a goal and acknowledging what has been done until that moment.

4.3.3 Achievements

The achievements element was introduced in order to allow the administrator of our platform to set specific tasks for the players, rooms or environments or they can be used as a way of defining global goals that he wants the environments as well as players to accomplish. For this element, there is no "real" reward when someone fulfills a rule; what the entity gets is the acknowledgement of a good work through the display of the achievement's name in the profile's page and, in some specific cases, a star used as virtual representation of the difficulty of the achievement. The achievements can be viewed as challenges and are expected to work as a signal of importance and, for this reason, they are displayed in the profile's page of each player, room and environment. Another important way in which players can envisage achievements is as a collection since each achievement can only be completed once by a given player, motivating them to collect all the achievements.

The rules regarding the achievements are the most complex when comparing to the rules for points and for levels. These rules are composed by an action, from the available "Energy Spent", "Points Achieved" and "Feedback Provided", a title to identify the achievement, a condition to be fulfilled, a value to determine the number of times the rule must be fulfilled to be considered completed, an attribute to set the achievement has hidden or visible, a target to identify the entity to whom the rule is applied and, optionally, a badge which acts as a visual representation of the achievement. Most of these components were already analysed in the Points section and here they were used with the same purpose, giving the administrator the possibility to create complex, interesting and different achievements for the player. As we said above, badges have the sole purpose of providing a visual representation of an achievements' difficulty and a better acknowledgment of the players' good behaviour.

4.3.4 Leaderboards

Even though we implemented the leaderboards, this is a problematic element since it can go either way: it can motivate a player to be in the top of the leaderboard when he is near the top, in the same way that can demotivate a player for being far away from the top. Notwithstanding this problem, leaderboards are a great way of giving feedback on the player and his competition by comparison. After the study made to Gamification and its elements, we tried to soften the problem, mentioned at the beginning, by showing a personalised leaderboard to each player where the position of the player is automatically shown with other four players with a close score. Obviously, the player can see the whole leaderboard if he wishes to do so but, this way, he can set his mind to outmatch the players who are closer and only worry about the players with top score later on. Leaderboards about rooms and environments are also supported but the same method was not applied since players can belong to various environments and rooms.

4.3.5 Community and Feedback

These two concepts are not so much elements as dynamics and we decided to analyse them together because they are closely tied. One of the primary goals for this platform was to foster a good community since peer pressure can have a strong influence in the adoption of new behaviours and the social interaction is very important for players to keep using a determined platform. These reasons can have increased strength when applied on projects developed for the greater good like ours is due to the sustainability issue. Besides, Gamification is not only applied by appealing to competition among players but also to cooperation and our platform inherently provides cooperation, between players, every time we refer to rooms or environments thanks to the fact that these entities are always composed by a group of players and their score is dependent of this group's actions.

When a good community has been promoted, players providing feedback is a dynamic that appears naturally and reaching this state is our goal. However, in the

beginning can be difficult for players to start giving feedback and, even if it is not, providing help should always be rewarded so the administrator is able to reward the good feedback by setting the action of a points' rule or achievements' rule to "Feedback Provided". But the simple act of commenting should not be reason to be rewarded because not every comment is good so we decided to implement a simple voting system where a player can vote up, or down, another player's comment. The next step was to found a fair evaluation algorithm and, after rejecting the system of the average rating because less voted comments could have an unfair leverage and doing a search about evaluation algorithms, we chose to adopt the "Lower bound of Wilson score confidence interval for a Bernoulli parameter", also implemented by reddit[4] and formulated by Edwin B. Wilson in 1927[63], given by:

$$\frac{\hat{p} + \frac{z^2_{1-\alpha/2}}{2n} \pm z_{1-\alpha/2}\sqrt{\frac{\hat{p}(1-\hat{p})}{n} + \frac{z^2_{1-\alpha/2}}{4n^2}}}{1 + \frac{z^2_{1-\alpha/2}}{n}} \tag{4.1}$$

where $\hat{p}$ is the percentage of positive rankings, n is the total number of votes and $z_{1-\alpha/2}$ is the $(1-\alpha/2)$ quantile of the standard normal distribution. In our platform, we defined $z_{1-\alpha/2}$ for a statistical confidence of 95% and, through the use of this formula, the value returned is the correct fraction of positive rankings with a certainty of 95%. What we are able to accomplish by rating the comments this way is that the submission and voting date is irrelevant and the more votes the comment gets, the closer the result gets to its true score, incentivizing the players to vote and only rewarding comments who really have been acknowledge by many players. With this method, when the administrator is creating a rule with the action "Feedback Provided", he must set a condition value between an interval of 1 and 100 and the higher this value, the better the comment must be rated. Furthermore, a player can provide feedback to another player, room or environment, as a way of acknowledging a good behaviour or congratulating that same player, room or environment.

[4] `http://www.reddit.com/`

4.4 Platform

Until this moment, we explained how the platform is architected, how the data is stored, the communications that happen between the different agents and all the Gamification elements and dynamics available in the platform. Now, we are going to describe how our platform works and the web interface developed both for the administrator and for the player. Since one of the objectives was to develop a platform capable of adapting to different contexts, it was decided to implement an administrator component where it is possible to choose what are the Gamification elements that are going to be applied, from the ones available, define the rules for each of these elements and define how often the Asynchronous Communication Agent will make the requests to the PHESS system when initializing it. These are the most important features given to the administrator of the platform and the bigger focus was on providing these capacities in a simplistic and user-friendly way; with this, an administrator can try different implementations of Gamification on its own and adapt the rules according to the players evaluated if he deems necessary.

Regarding the players' interface, our intention was to give a simple and clean interface for each player and an easy way to navigate in our platform to make them feel more predisposed to spend time there, help other players, provide feedback to rooms and environments and, consequently, creating a good atmosphere for a community to grow. A more detailed review of the implementations made will come in the next section where we will do a deep analysis on the how and the why of each Gamification element applied and how they are brought together to foster this feeling of community.

4.4.1 Admin Interface

As it was mentioned, this interface is meant to be simple and ready to use. When an administrator logs in for the first time, he will be asked to select the Gamification elements that he wants to apply, from a list where is shown the

main elements implemented, as shown in Figure 4.12. Note our decision to always include Points as a Gamification element for reasons already pointed in the section above.

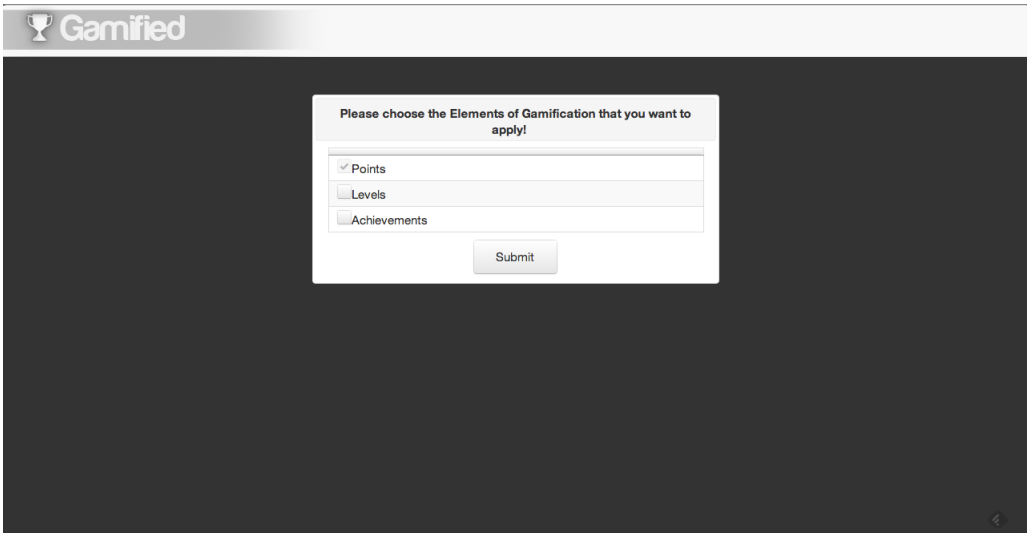

FIGURE 4.12: Admin page to choose the Gamification Elements

After selecting the Gamification elements, the administrator is redirected to an overview page where he is shown the links to each element's management page. In each of these pages, he can add new rules to be applied, edit the ones already added or delete them, as depicted in Figure 4.13.

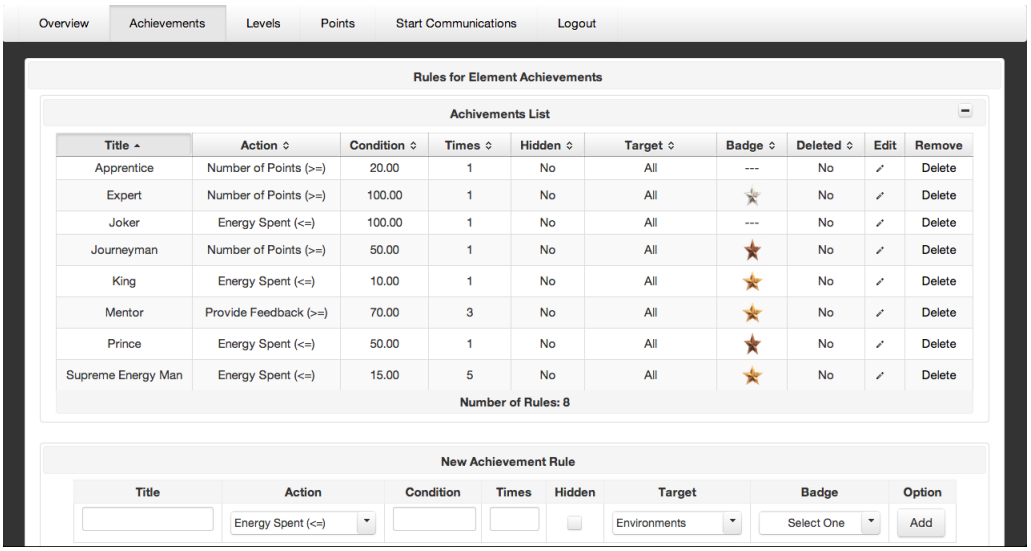

FIGURE 4.13: Admin page for the management of Achievements

Finally, when he has configured the system in the way he wants, he can start the Asynchronous Communication Agent by setting the time between each set of

requests. At any time, the admin can manage the rules for the elements selected but he cannot select/deselect Gamification elements.

4.4.2 Player Interface

Since our main focus are the players and their environments, the development of this interface involved a careful thinking. We concentrated on providing a players' profile that is very descriptive, clean and, at the same time, entertaining and the result obtained is demonstrated in Figure 4.14.

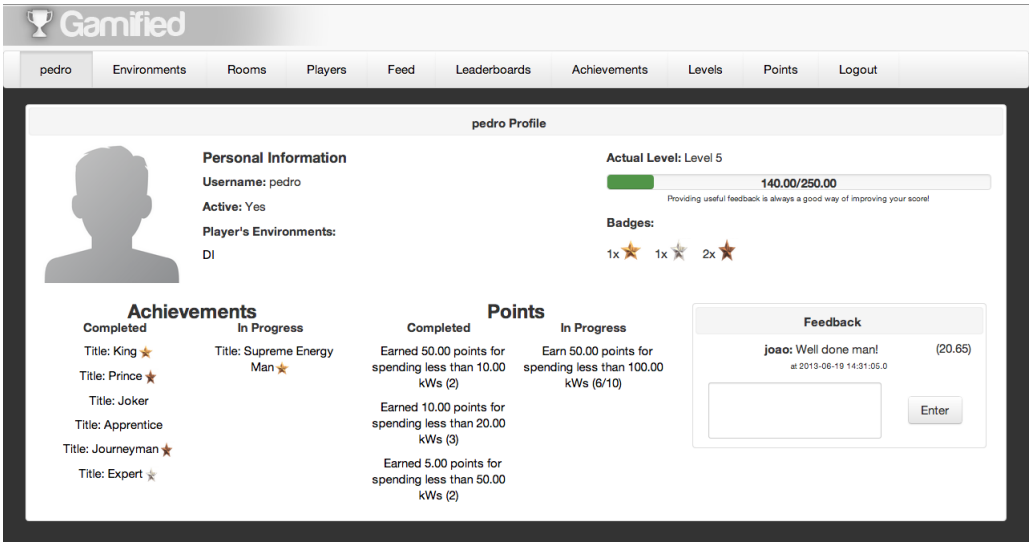

FIGURE 4.14: Profile page for player pedro

As you can see, we show the players' personal information, his actual level and a bar showing is progress and how much is missing to the next level, along with a small hint to help him know how to improve; details that were thoroughly explained in the section about Gamification. Furthermore, we wanted to give the player the acknowledgement he deserves so we highlight the badges he has obtained and give him information about what he has accomplished, both Achievements and Points. Last but not least, we show a small panel for other players to comment, giving him some feedback and making him feel part of a community. This structure was followed for the profiles of both the rooms and the environments.

Another important feature, also analysed in the Gamification section, is the Leaderboards. The player logged can go to the leaderboards' page and check his

position and how many points his players' neighbors have, as well as, the ranking for the rooms and the environments to which he belongs to. Figure 4.15 reproduces how this feature was implemented.

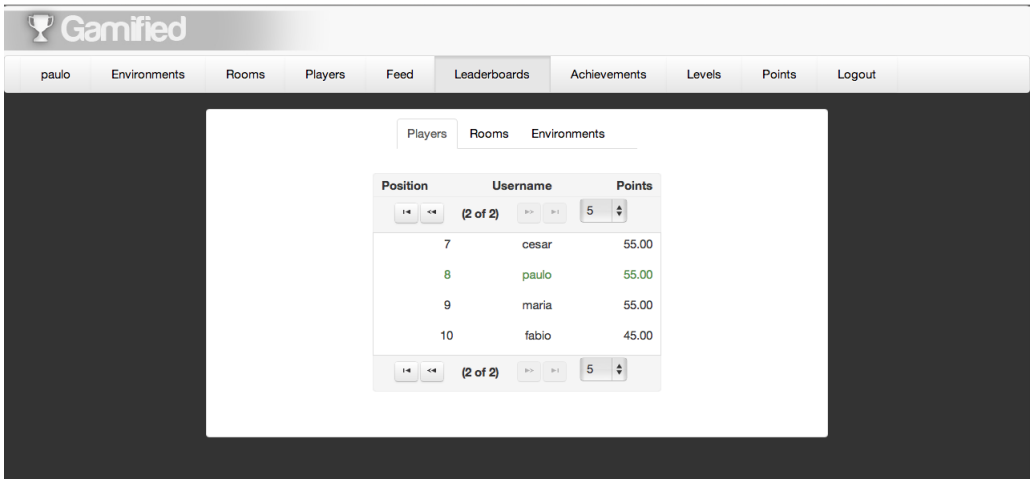

FIGURE 4.15: Leaderboards page with player paulo

The other relevant feature regards the Feed of events developed with the idea of keeping a track of everything happening in the platform and giving the opportunity to any player to know what the other ones have been achieving. With this, we hope to be able to motivate the less participative players and to make them engage in the platform by trying to best the other players as well as interacting with them. The feed implemented, portrayed in the Figure 4.16, should be more appealing but, first, we wanted to know if the players liked the concept.

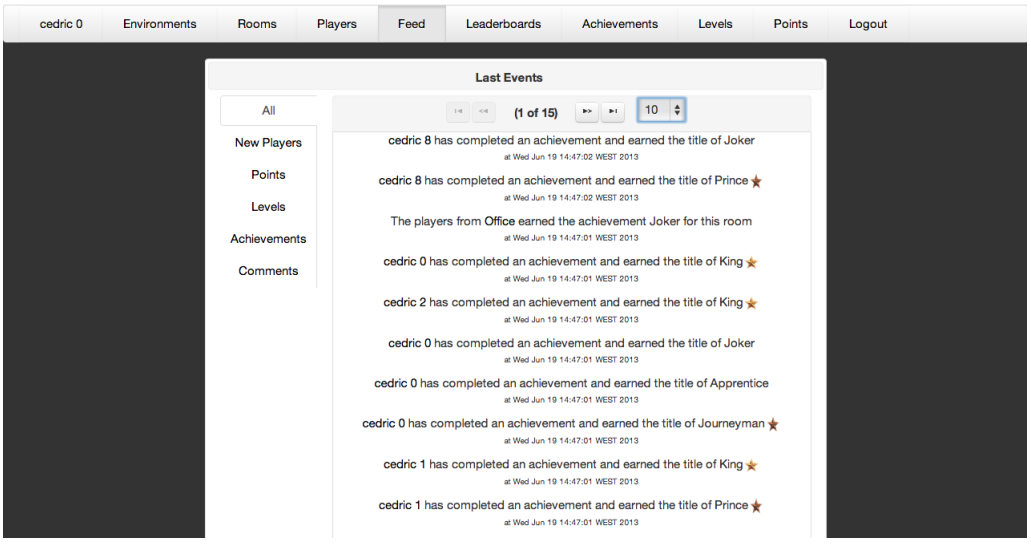

FIGURE 4.16: Feed of Events

Besides these features, the platform gives the possibility to see a list of all the rules, except for the hidden ones, that are active along with their details and statistics about the percentage of players, rooms and environments that completed the selected rule; Figure 4.17 shows a small example of this. Obviously, players not only can browse through any profile of players, rooms and environments as much as we hope they feel incentivised to do it.

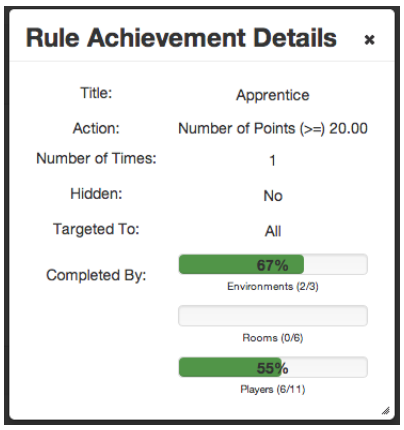

FIGURE 4.17: Detailed view of the Apprentice Achievement

4.5 Overall Analysis

When looking at the final product that was developed, we are pleased with the result. It is clear that the more Gamification elements and dynamics we had implemented, the more options an administrator would have to adapt the platform to different contexts, however this was always meant to be a prototype and we think that the ones implemented were appropriate and already gives the platform some extensibility. From points it is possible to infer how the evolution of a player has been, regarding his sustainability behaviours, while giving a means to compare different players, or even rooms or environments. With levels, it is possible to group the players who have similar behaviours and identify the ones who have the better behaviours; on the other hand, through the application of achievements, players get a way of representing their sustainable behaviours and

being congratulated for them. Leaderboards, feedback and community are intrinsically implemented since they are always very important to drive the behaviour change of players due to the nature of the problem tackled.

The communication between the agents and the interface worked better than expected and it proved to be very helpful in the task of maintaining the modularity that was set as an objective in the beginning of the dissertation. Once we were capable of overcome the problems regarding concurrency, no more problems appeared when implementing the agents, the interface and the database.

Probably, the aspect where the platform falls short is its web interface. Concerning the admin interface, this is not very important since the most important characteristics is to be simple and easily configurable, dropping the aesthetics to second place, and these characteristics were achieved. However, regarding the player interface, aesthetics can play an important role and be decisive to the adoption of the platform by the players; it can even influence the Gamification elements' power to affect players. In this version of the platform, we developed an interface as cleanest as possible and easily navigable, in hope that players are more appealed to the intrinsic value of our purpose, the improvement of sustainability. In later versions of this platform, the aesthetics could suffer an improvement if deemed necessary.

A final consideration about the implementation of a social component; it was our option to implement our own interaction between players and leave aside the integration of other social networks for a main reason: this integration would mean the opening of a small community to a larger audience and this is a step that needs to be made very carefully, even more so when the platform is so dependent of its community; besides, for a recent version of the platform, it is more important a small community with valuable input to give for the improvement of the platform than a bigger community with less attachment to this same platform. With our own social component, we hope to better foster the feeling of community and peer pressure between the players; moreover, once these dynamics are strongly established, the integration with other social networks could be the next step.

Chapter 5

Case Study

As it was mentioned before, this dissertation's primary goal was to assert the effectiveness of Gamification, in this specific case, when applied to a project trying to solution the unbalance in the environment's energetic sustainability. For this study, the platform, reviewed in the previous chapter, was developed and we are now going to verify the results obtained through the analysis of the dynamics within this platform between the Gamification elements applied. Also, several studies were conducted in order to verify the results obtained from different types of Gamification so it is possible to ascertain the best conditions for our context. In this chapter, the process of this experiment will be explained as well as the results obtained and the findings uncovered.

5.1 Methodology

To better determine the effectiveness of the dynamics of Gamification on our platform, we decided to run several tests, where different combinations of the Gamification elements were used. As such, we changed the conditions of our platform in the following order:

1. **Gamification**(**Points**): In this test, we put our platform available but only points are active. A player, room or environment cannot level up or get achievements.

2. **Gamification**(**Points & Levels**): This time, we tried the combination of points and levels.

3. **Gamification**(**Points & Achievements**): In this other test, the combination was of points and achievements.

4. **Gamification**(**Points & Levels & Achievements**): Lastly, this test provided the players, rooms and environments with all the features available in the platform.

For these tests, we decided to see the engagement regarding three profiles: Pedro, Rui and Bruno, representing three different players. The first two players, Pedro and Bruno belongs to the environment DI and Rui belongs to the environment DPS. To obtain the values for these tests, and due to the limitation of our platform to work by itself, we decided to generate the values of the energy spent for each environment and its users and measure their engagement through the points obtained. These tests have the purpose of studying the effectiveness of each possible combination of Gamification elements since the weight of Gamification is not directly proportional to the number of elements used. Again, it is important to remember that the impact of a certain combination of Gamification elements is highly dependent on the players that are participating and the context where the Gamification is applied.

Taking into consideration this methodology, we decided that by watching the evolution on the number of points of each player and environment, we could see how much they are engaged in our platform and, this way, studying the best dynamics regarding the Gamification elements. As so, we decided that each player and environment would have a defined value for the energy spent each day, defined at the Table 5.1, and assess their engagement in the platform through the social component; the more valuable feedback they provided to other players, the more engaged we can assume they are. The points they earned through the energy spent is constant but the points they earn through the feedback is not.

Type of Entity	**Energy Spent per day**	**Points awarded per day**
Players (Pedro, Rui and Bruno)	10 kW	50 points
Environments(DI and DPS)	30 kW	40 points

TABLE 5.1: Values set for players and environments regarding energy spent per day

5.2 Data Treatment

The gathering of data, from each test, was made during one week each, to give enough time for the players to get used to the platform and sense a progression within it. The tables 5.2 and 5.3 show the values gathered from players and environments, respectively.

Player Pedro							
	Number of Points						
Gamification Elements	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**
Points	50	105	155	205	260	315	365
Points & Levels	50	100	150	200	255	305	355
Points & Achievements	50	110	160	210	260	315	375
Points & Levels & Achievements	55	110	170	220	275	325	380
Player Rui							
Gamification Elements	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**
Points	50	100	150	200	250	300	350
Points & Levels	50	100	150	200	250	300	350
Points & Achievements	50	100	155	205	260	310	360
Points & Levels & Achievements	50	105	155	210	260	310	360
Player Bruno							
Gamification Elements	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**
Points	50	100	150	200	250	300	350
Points & Levels	50	100	150	200	255	305	355
Points & Achievements	50	105	155	205	255	305	355
Points & Levels & Achievements	50	105	160	215	270	325	380

TABLE 5.2: Number of points achieved by player Pedro, Rui and Bruno at the end of each day

Environment DI							
	Number of Points						
Gamification Elements	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**
Points	60	120	170	210	280	330	380
Points & Levels	50	100	160	210	270	320	360
Points & Achievements	50	110	160	220	260	320	370
Points & Levels & Achievements	70	120	170	230	280	340	400
Environment DPS							
Gamification Elements	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**
Points	50	105	155	205	260	315	365
Points & Levels	50	100	150	200	255	305	355
Points & Achievements	50	110	160	210	260	310	370
Points & Levels & Achievements	55	110	170	220	275	325	380

TABLE 5.3: Number of points achieved by environment DI and DPS at the end of each day

Both the collection and the treatment of information was simple since our purpose was only to retrieve the number of points achieved by the players and environments already mentioned and those values can be directly retrieved from our platform at the end of each day. It is also important to refer that, at the beginning of each test, the points were reset to zero.

As a side note, we would like to refer that these tests were performed in small environments which can be a positive point since it is a much more controlled space where we can assure that each test occurs under, approximately, the same conditions and observe closely if, and how, Gamification influenced each player.

5.3 Data Analysis

Once treated the data collected, the results can be viewed in Figures 5.1, 5.2 and 5.3 where a graph shows how much points were gathered by each player, in each test, and what were the conditions that led to the higher engagement between the players and our platform.

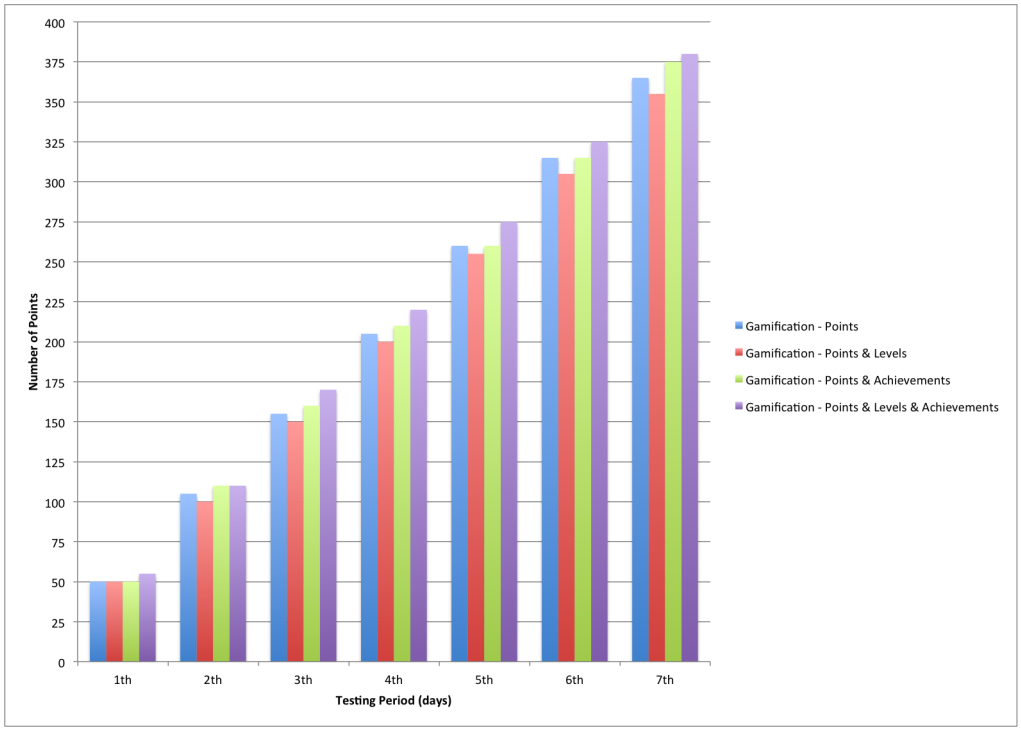

FIGURE 5.1: Graphic representation of Pedro's results

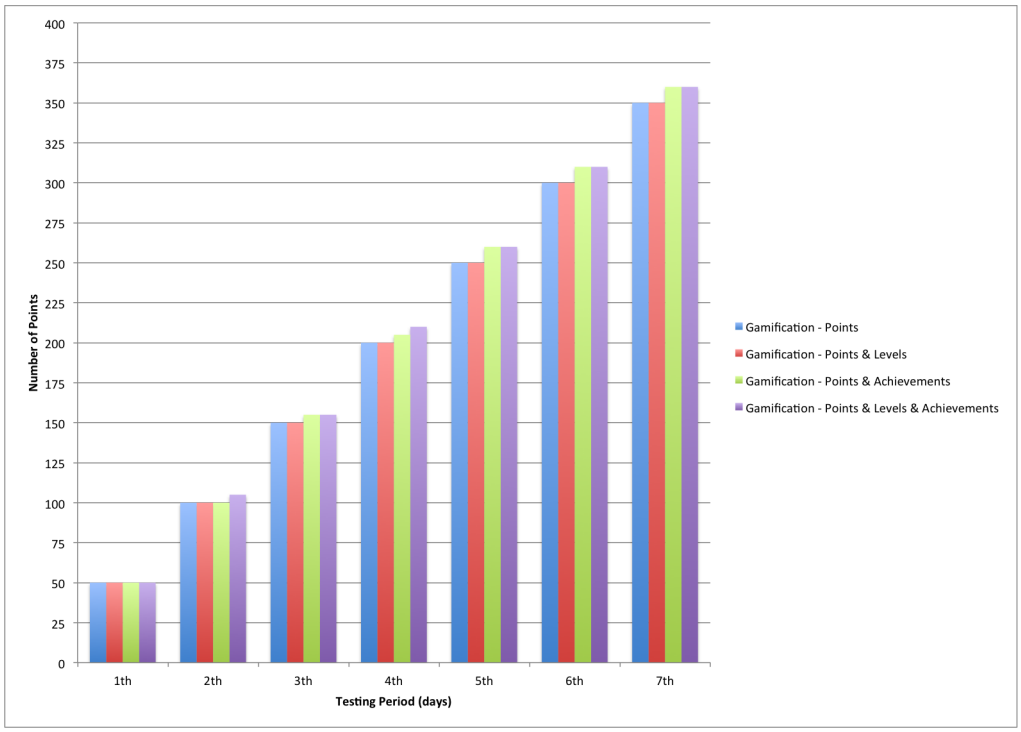

FIGURE 5.2: Graphic representation of Rui's results

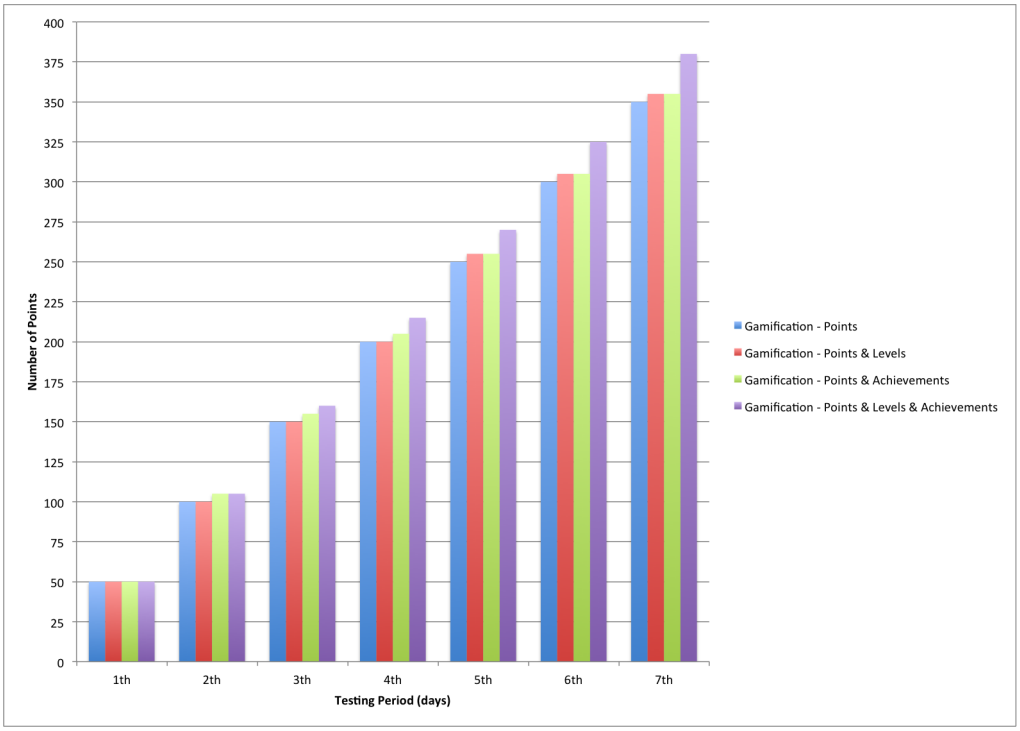

FIGURE 5.3: Graphic representation of Bruno's results

By carefully analysing these three figures, we can see that there are little differences, in all cases, between applying only the Points element or applying Points & Levels or Points & Achievements, with a small leverage to this last combination since when Achievements element is used, we can verify a bigger interest of our participants, mostly when comparing to the first two combinations mentioned. This fact demonstrates a bigger influence of Achievements to the engagement of the players. It is, however, the combination of all three Gamification Elements that shows an higher engagement of players Pedro and Bruno which means they were much more participant, and gave much more valuable feedback when all Gamification elements were used. Regarding player Rui, we can infer that independent of how Gamification was applied in these tests, he simply was not engaged at all which may be due to his little interest in our platform or his dislike about how the Gamification elements were applied. This is due to happen to some players since not everyone is engaged through the application of Gamification; however, one strategy to improve our platform would be to enter in the field of Psychology and perform some psychological tests to these players in order to better assess why the application of Gamification is ineffective and if

it was our implementation of Gamification that was not attractive. Even though the data sample analysed was very small, if taken into consideration that the main purpose of this project is to change behaviours to more sustainable ones, every single player we can help in this change is considered a positive result by us. Figures 5.4 and 5.5, going to be showed next, represent the results obtained for Environments DI and DPS respectively.

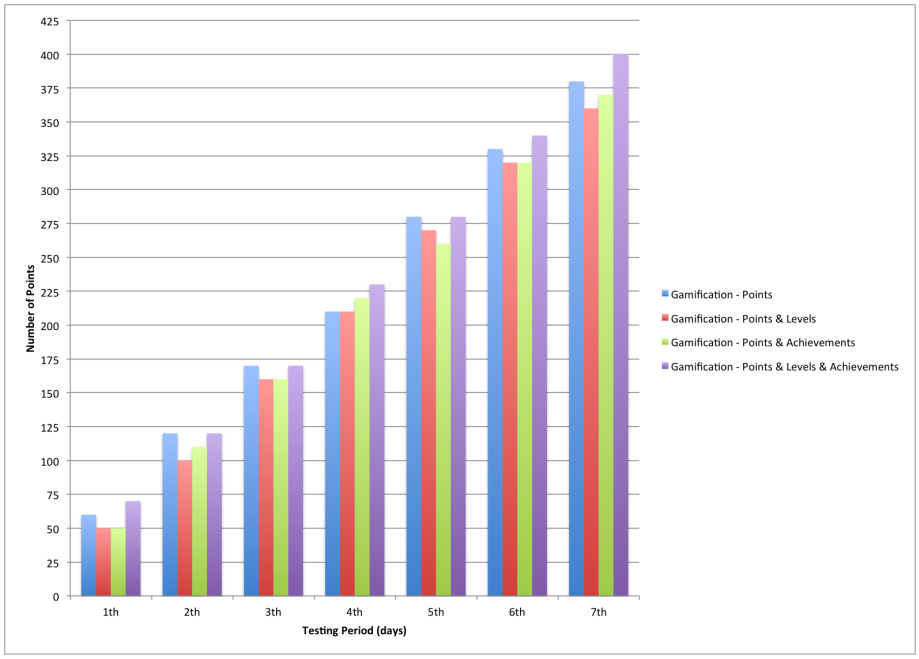

FIGURE 5.4: Graphic representation of DI's results

It is interesting to evaluate the results obtained in the environments, maybe more interesting than evaluating the results obtained from the player like it was done above, since many players can belong to an environment and they must show teamwork in order to better improve their environment. Again, the same conclusions about the effectiveness of different combinations can be inferred from the results of the environments; the application of just Points or Points & Levels or Points & Achievements led to a lower engagement and little differences between each combination. Just like it happened with Pedro and Bruno, both DI and DPS had much more engaged players when the three Gamification elements were applied, showing that this combination can be a good one to be used in this same context, with these same players. It is also important to observe the higher number of interactions that happened in the environments, when comparing to players; a

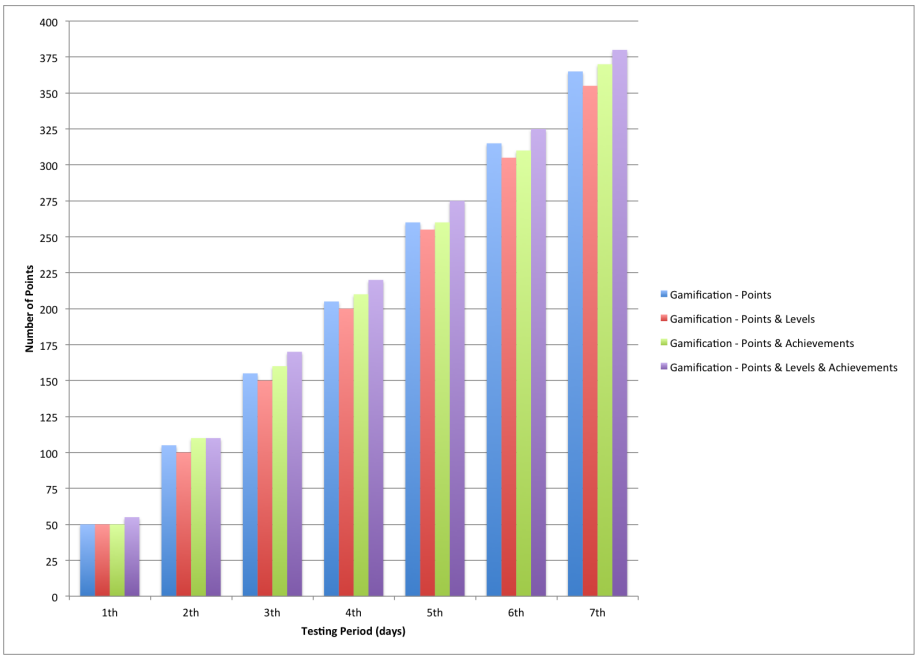

FIGURE 5.5: Graphic representation of DPS' results

valuable fact that demonstrate how working in team to better an environment can be much more attractive than playing "alone". It is obvious that this is very dependent on the players that belong to the environment, and from our sample, we can see that the players from environment DI were more participant and, consequently, more engaged than the players from DPS. Lastly, a side note to the curious case of the use of Points leading to more interactions than the use of Points & Levels, in both environments; a case for which we found no justification.

As our final deliberations, regarding the results analysed, we believe that these results were positive. It was possible to verify, as we were already expecting, that some players would not be engaged but this is normal as everyone is different and our goal is to engage the biggest number possible of players. Another important fact is that, both for players and environments, the good results obtained in the last period of tests could be a result of routines acquired during the other period of tests however, since we need to perform the same tests with the same players to validate the combinations, this is something that we cannot do anything against but we should keep this in mind anyway; although the fact of players acquiring routines is a good pointer since the main purpose is the acquisition of better behaviours by the players. Even though it was not possible to test the platform

at its full capacity, using the energy spent of each player and environment, due to time constraints, these tests show that the Gamification dynamics implemented can achieve good results. It is our opinion that the integration of the energy spent would only increase the engagement of the players. It is also important to remember the fact that the realisation of these complete tests would need lengthy periods to check the evolution of the players in the long run; moreover, not only in these tests, but also in tests performed, the lengthier the periods of tests, the better would be the assessment of the engagement since the results obtained from shorter periods can be heightened for the novelty of the platform.

Another substantial conclusion for our platform is that, at least in this context, the combination of the three elements worked really well together, from the players' and environments' values gathered. We can also note that the simple integration of Points or even just the use of Points with Levels is of little interest for the players and only with the application of Achievements either with Points or Points and Levels, the platform starts to become more attractive for them, increasing their levels of engagement.

Chapter 6

Conclusion

This final chapter has the objective of providing a comprehensive synthesis of all the work that has been accomplished along with the findings that were drawn from the results obtained. Furthermore, there will be a brief mention to the relevant scientific work where we collaborated and some insight will be given into the future work that could be done in the pursuit of better results.

6.1 Work Synthesis

With the end of the work we purposed to do, comes the need for a brief report of everything that was done since the beginning. So, once the objectives for this dissertation were defined, we started by investigating the state of the art regarding Sustainability, Gamification and Information Diffusion since these were the main concepts that were going to be approached in this project, as defined in Chapter 1. After this stage, a solution was started to be architected to achieve the objectives set for the project; it was during this stage that we took certain decisions like using Java, adopting JSF for the web component and developing JADE agents both for the modularity and the capacity of communication provided. Once these decisions were made, we started to design some layouts as well as selecting the Gamification elements and dynamics necessary to make this platform solid and

both these resolutions would be used as guidelines in the developing of the end product.

In order to achieve the objective of developing a platform with the ability to create and manage a competition on social environments, the platform developed implements a set of Gamification elements and dynamics that awards players according to the sustainability of their behaviours. The communication component that is included in this platform is used as a way of retrieving information retrieved by other projects regarding environments and its players/users. Like it was mentioned in the section Objectives in the first chapter, for the purpose of this prototype, the PHESS project was used to test our platform and, for this, we had the implementation of the communication in JADE which proved to be capable of fetching such information.

Another objective was that this platform would be capable of fostering user engagement and adapt different types of competitions to increase the competition as well as the teamwork. This was achieved through the implementation of such Gamification dynamics like a community and the ability of players to provide feedback to each other, in addition to the implementation of leaderboards; furthermore, an administrator is capable of setting rules to be applied to players only but he can also set rules to be applied to just environments or rooms, meaning that the players who belong to that environment/room must work together to "complete" those rules.

The last objective purposed was the ability to develop this platform with modularity in order to be possible to apply different combination of Gamification elements so as to be more effective. For this, we gave the possibility to the administrator of choosing which Gamification elements, from the ones implemented, he wishes to apply at the start of the competition. Besides, he is the sole responsible for setting up the rules he wishes to be applied during the competition. With these features, it is our understanding that, when starting a competition, the administrator is able to customize the platform with different characteristics, enabling the testing of different combinations of Gamification elements.

Once completed the objectives mentioned, the following stage was the realisation of the experiment so we only advanced to this stage when the platform was completely implemented in order to perform each test in the same conditions. Once these tests were performed, we reached the stage where the only task left to do was the treatment of the data collected and its analysis. As it was already stated in the previous chapter, the results achieved were very positive and we were successful in providing the platform with the dynamics of Gamification in order to foster the user engagement; however, this does not mean that all the work is done, and we should keep trying to find better combinations between Gamification elements and dynamics to maintain the players engaged and this platform has all the capacities to be the stepping stone on this process.

6.2 Relevant Work

As it was defined in the working plan for this dissertation, in parallel to the development of the project, scientific contributions should also be made regarding the concepts approached in this project. As such, the following scientific contributions were achieved in collaboration with other peers:

1. Silva, F., Analide, C., Rosa, L., Felgueiras, G., Pimenta, C. *"Ambient Sensorization for the Furtherance of Sustainability"*, in ISAmI'13

2. Silva, F., Analide, C., Rosa, L., Felgueiras, G., Pimenta, C. *"Social Networks Gamification for Sustainability Recommendation Systems"*, in DCAI'13

Furthermore, during the period of this dissertation, the course of Gamification in Coursera[1], given by Professor Kevin Werbach, was attended in order to learn more about Gamification so the decisions during the development process were taken more consciously.

One last note to the fact that, very recently, we were invited to submit an extended paper of the work related to this project, to publish in the International

[1] `https://www.coursera.org/course/gamification`

Journal of Interactive Multimedia and Artificial Intelligence (IJIMAI)[2]. At this moment, this task is under development.

6.3 Future Work

There is still work to be done in order to improve both the engagement of the players and this platform (the engagement can be improved without the platform). For once, the tests conducted were dedicated to the study of the dynamics within the platform and tests regarding the integration in real environments should be done. An important fact to take into consideration when performing these tests is the need for the tests to be done during lengthy periods in order to study how the Gamification influence works in the long run as well as avoiding disparity of results due to random events that could have happened in the environments.

Another important feature is to assert the implications of social networks' integration and their effectiveness in these contexts. As it was mentioned in the analysis made in the chapter Implementation of Prototype, section 4.5, the integration of other social networks must be a step very well thought and should be made, at least, once the platform is fully established and mature. Along these lines, further implementations of Gamification elements and dynamics should be developed and extensive tests with different combinations of these elements and dynamics are required. Thanks to the modularity of this platform, the addition of new elements and dynamics can be implemented easily.

Regarding the options available for both players and administrators, there is some work to be done towards the showing of statistics related to each player's behaviours or, in case of the administrator, related to the effectiveness of the elements applied. Besides, as mentioned in the analysis of the prototype developed, aesthetics can play an important role in the application of Gamification and they should be carefully reviewed if the platform is to be adopted more extensively since the interface of this prototype was developed with simpler purposes in mind.

[2]http://www.ijimai.org/journal/

Appendix A

Logical Data Model

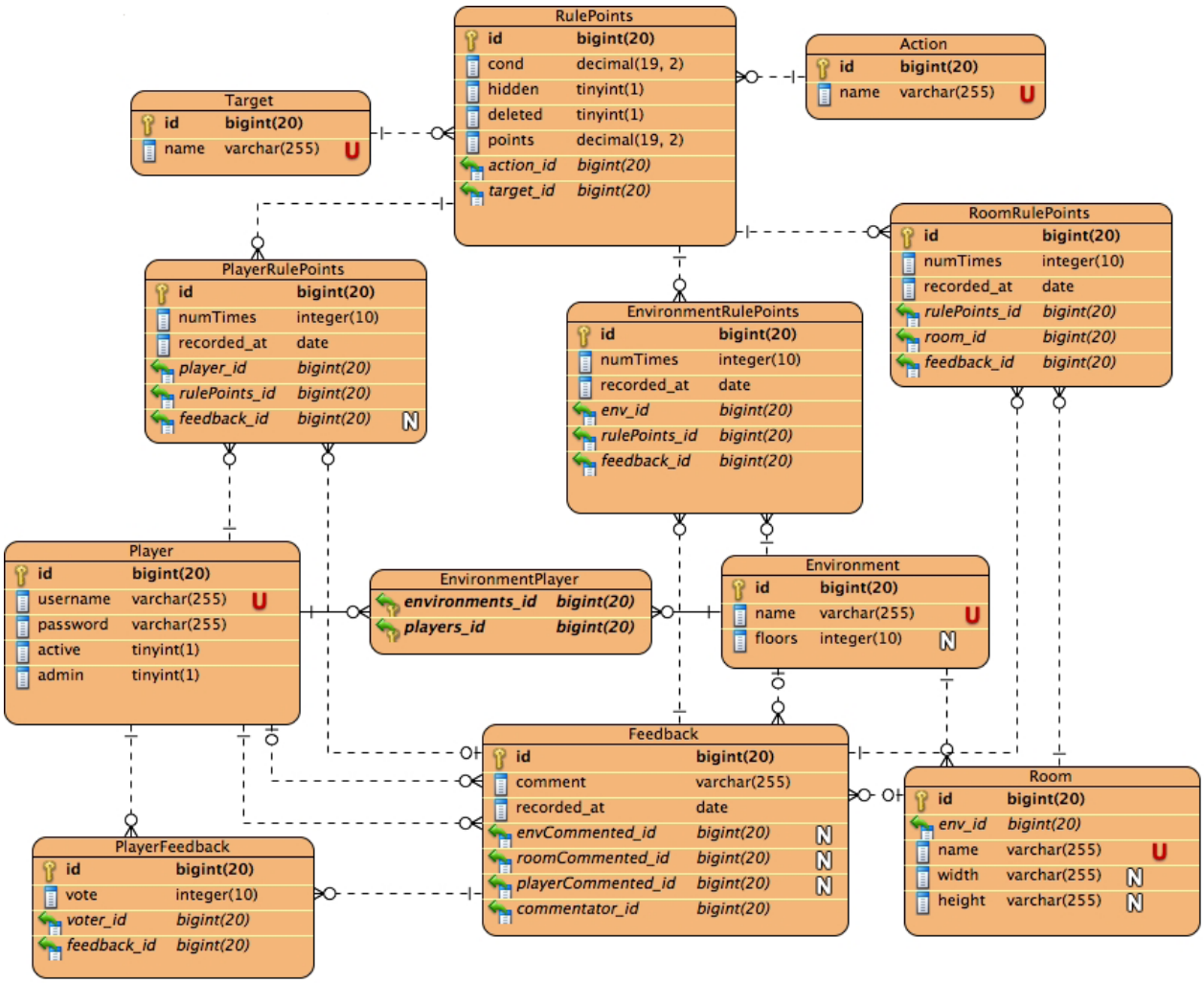

FIGURE A.1: Logical data model for implementation of points element

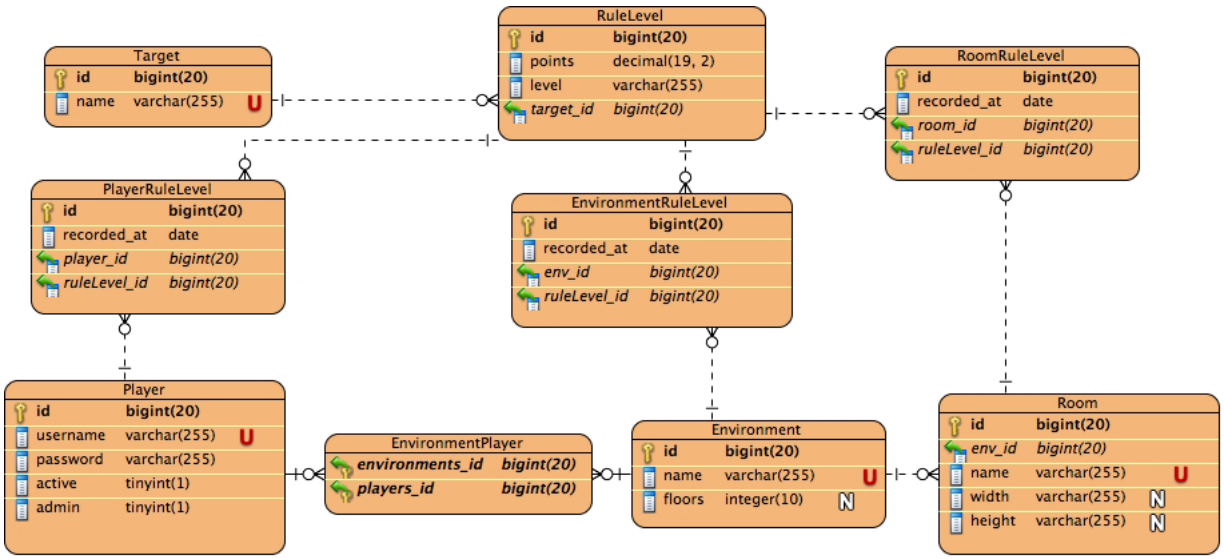

FIGURE A.2: Logical data model for implementation of levels element

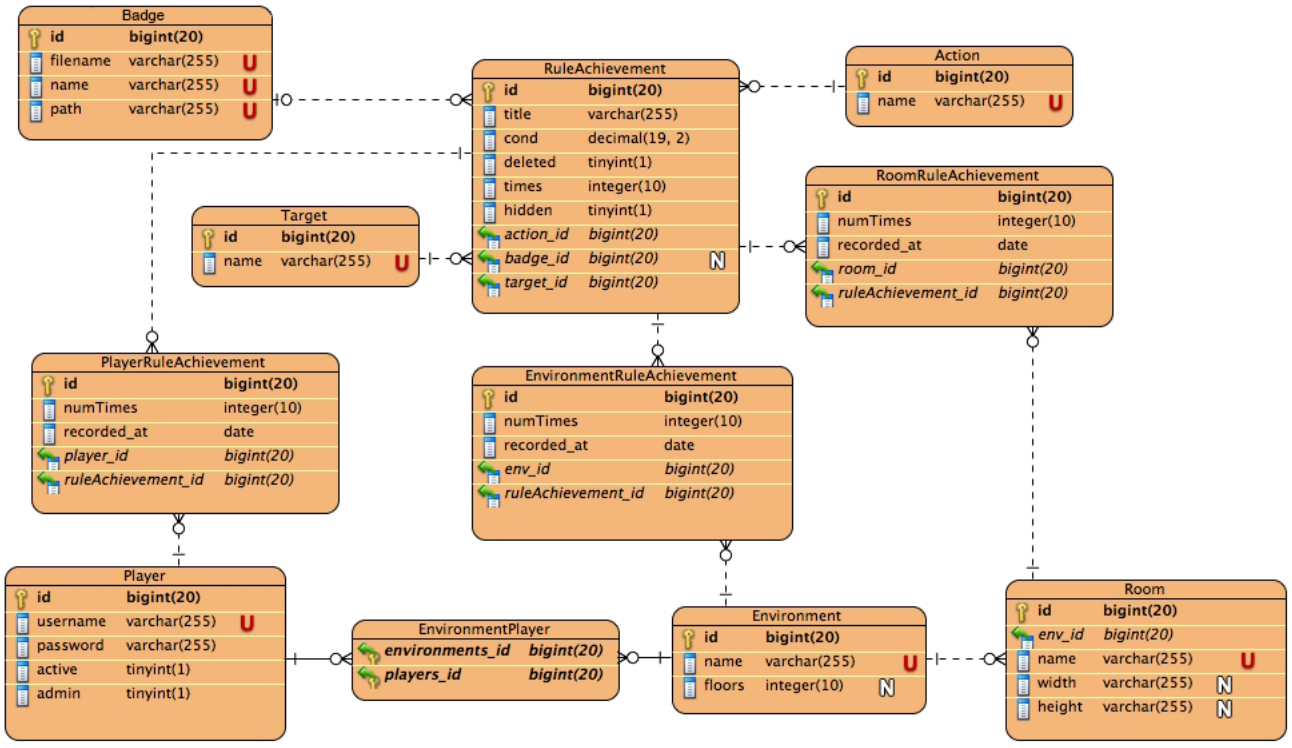

FIGURE A.3: Logical data model for implementation of achievements element

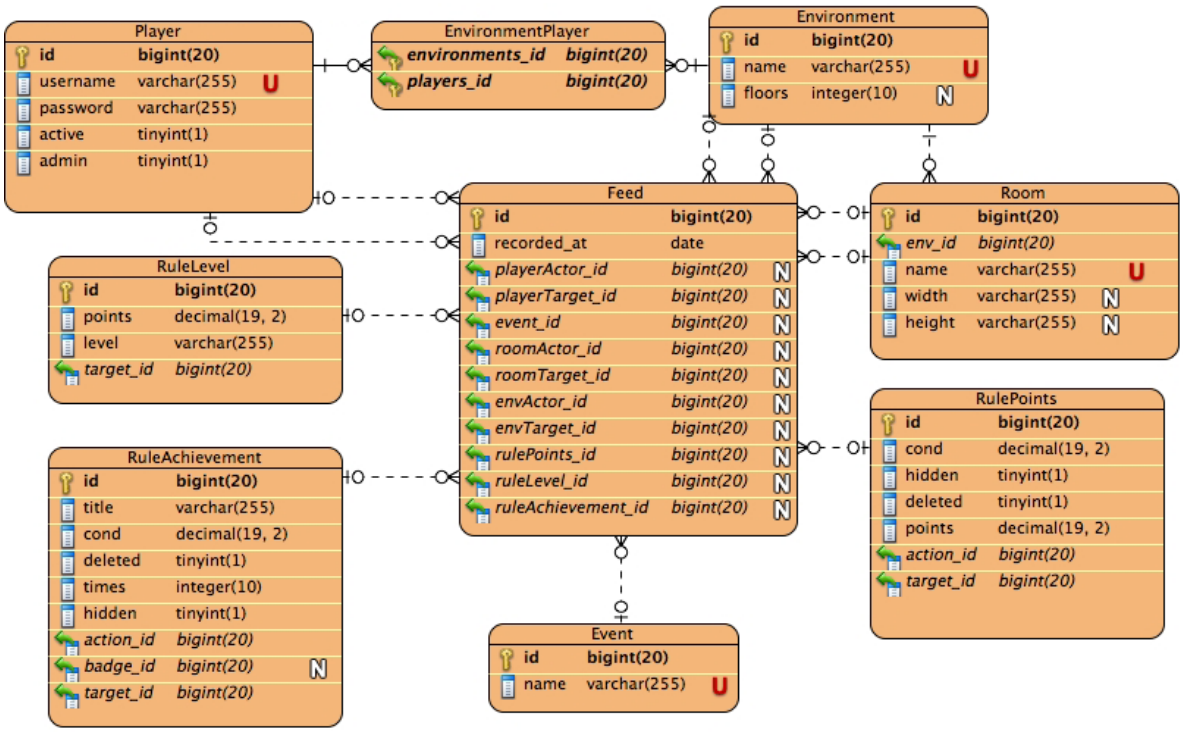

FIGURE A.4: Logical data model for implementation of events feed

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