

DESIGN AND DEVELOPMENT OF USER-FRIENDLY AUTHORIZING TOOL  
FOR LOCATION BASED TREASURE HUNTS

By

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## Statement of originality

The presented work at this thesis is the outcome of my personal occupation with the subject that is being described in the abstract. I declare that this thesis has not been submitted for a degree or for any other reason again. As far as I know this thesis does not contain any content - material that has been published by another person until now, except the specified fields with references and that any other material by other people that have been included, are fully acknowledged with the standard procedure and practices.

Charalampakos Orestis

2018

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## Abstract

Location based games can be a very attractive way to make the participants discover new places, learn about their history, or just play around! In a treasure hunt, riddles guide the players from point to point. The creator determines the content and the scope of the game, set the riddles and the places that must be found.

Physical playground, mixed with the use of mobile technology can create location-based games with rich content, digital and physical. Creators of such games are not programmers, may have not knowledge of developing app-game with theirs content. An authoring tool for location-based games must be used by those people to create their games. This tool must be user-friendly, so the creator can easily design a game with his content.

This master thesis refers at the development of a web-platform authoring tool for location-based scavenger hunt games. There are two main sections in this project a) the web platform for the design of a game and overview a gameplay, b) a mobile app for the gameplay. The platform provides to the creator an interactive map. By clicking on this map, the creator is setting a point in the requested area. There are four types of point, the starting point, the point of interest, the help point and the ending point. The digital content of a point-riddle is text, image, video, URLs. The game will be consisted by those different spots of interest. Through overview a coordinator can supervise a specific gameplay of a game. The mobile app is used to present the designed games. A user can select the game through the app and create an instance of a game or participate in an already created instance. The app support team gameplay.

This authoring tool can be also used by teachers for creating location-based treasure hunts with rich content for educational purposes.

## Περίληψη

Τα παιχνίδια που βασίζονται στην τοποθεσία που βρίσκεται ο παίκτης, μπορούν να αποτελέσουν ένα πολύ ελκυστικό και ενδιαφέρον τρόπο για την εξερεύνηση νέων περιοχών, την γνώση της ιστορίας τους. Σε ένα παιχνίδι κρυμμένου θησαυρού, ο παίκτης ακολουθεί την πορεία που προκύπτει από την λύση γρίφων που βρίσκονται κρυμμένοι στην περιοχή, μέχρι να ανακαλύψει το θησαυρό. Ο δημιουργός του παιχνιδιού καθορίζει το περιεχόμενο των γρίφων τα σημεία που θα τους κρύψει καθώς και την σειρά που θα πρέπει να ανακαλυφθούν.

Το φυσικό περιβάλλον σε συνδυασμό με τη χρήση της κινητής τεχνολογίας και των κινητών συσκευών μπορεί να αξιοποιηθεί για την δημιουργία παιχνιδιών με πλούσιο περιεχόμενο, φυσικό και ψηφιακό. Ο δημιουργός ενός τέτοιου παιχνιδιού δεν είναι προγραμματιστής, μπορεί να μην έχει την τεχνογνωσία ανάπτυξης ενός. Ένα εργαλείο ανάπτυξης τέτοιων παιχνιδιών από ανθρώπους που δεν έχουν ιδιαίτερες γνώσεις προγραμματισμού χρειάζεται να χρησιμοποιηθεί ώστε να τα δημιουργήσουν. Αυτό το εργαλείο πρέπει να είναι απλό, εύκολο στη χρήση, χωρίς περίπλοκες διαδικασίες, ώστε να μπορεί να χρησιμοποιηθεί χωρίς δυσκολία.

Η παρούσα διπλωματική εργασία έχει ως θέμα την ανάπτυξη μίας διαδικτυακής πλατφόρμας σχεδίασης παιχνιδιών κρυμμένου θησαυρού σε πραγματικό χώρο. Υπάρχουν δύο βασικά μέρη σε αυτή την υλοποίηση, α) η διαδικτυακή πλατφόρμα κ β) μία εφαρμογή για κινητές συσκευές (tablets, smartphones) για την εξέλιξη του παιχνιδιού. Η πλατφόρμα παρέχει στον δημιουργό ένα διαδραστικό χάρτη στον οποίο επάνω μπορεί να τοποθετεί σημεία. Το ψηφιακό περιεχόμενο των σημείων μπορεί να είναι, κείμενο, εικόνα, βίντεο. Το παιχνίδι αποτελείται από τα διαφορετικά σημεία που έχει τοποθετήσει ο δημιουργός στο χάρτη. Η εφαρμογή χρησιμοποιείται ώστε να παρουσιάσει τα σχεδιασμένα παιχνίδια. Ένας χρήστης της εφαρμογής μπορεί να επιλέξει ένα παιχνίδι και να δημιουργήσει το δικό του στιγμιότυπο του παιχνιδιού. Σε κάθε στιγμιότυπο δημιουργούνται ομάδες στις οποίες συμμετέχουν οι παίκτες. Αυτό το εργαλείο μπορεί να χρησιμοποιηθεί από εκπαιδευτές για την δημιουργία παιχνιδιών κρυμμένου θησαυρού με εκπαιδευτικό περιεχόμενο.

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## Chapter 1: Introduction

Games play a significant part in human life especially in the early stages of growth. Game is a part of the procedure through which a child shapes his character and his behavior, his personality. The game at the first years of a child's life helps the evolution of the comprehension and imagination, the obedience in ethical rules [1]. With the game children as much adults, are being socialized, discover and absorb new knowledge in a funny and carefree way.

Many learning theories align with the gaming process. In games student are highly motivated by involving with the subject of study, stimulate learning by doing. With the growth of technology digital games have been developed and a new age in Game-Based Learning had arisen. Nowadays every child has grown up in an environment with tablets, laptops, and smartphones. Learning process pass through Wikipedia and google search. Therefore game-based learning has its own evolvment with digital games. Even games that are not designed to be used in education have correct content or simulating real-world situation [2].

Mobile computing among wireless networks allowed, users to have access in content, apps, games and more from everywhere at any time. The combination of mobility and wireless networking had as an outcome the tremendous growth of mobile apps to support almost anything. A description of our days could be that is the age of information at our fingertips according to Bill Gates. Smartphones are the most common handheld devices that made this vision, reality. Over 2.5 billion is forecast to be the smartphone users by 2019. About 36 percent of the world's population is estimated that uses a smartphone [3] [4].

In an era where almost everyone has a mobile device is more than common sense that learning process is adjusting, not just in the mobility of the device that provide the content but from the aspect of the mobile technology as a participant in this procedure. Between the participants, learners, technology and other elements, of this learning system and their interactions knowledge is come into existence and being absorbed [5].

Mobile computing and the localization technology opened a new way in gaming and mobile learning. Mobile devices are used to determine player's location and provide them with the relevant content. The field of the game is beyond the screen of the device, extends to the real world. Digital content is combined with physical things, locations, enriching the gaming and the learning experience. Location Based Games have met high interest in recent years. Both in academia as also in industry, games which are based in determining player's location have gained more space. "Pokémon GO" is a successful paradigm of such a game with more than 500 million downloads and the players walked more than 4.6 billion kilometers during gameplay. [6]

The use of LBGs can be something more from just playing around. In many sectors like tourism as also in education these games are increasing the motivation and provide the necessary guidance to the participants through this procedure. The value added in learning process turns out from the fact that the learning material, is embed in the real world which exceed the traditional formal educational ways [7].

A ludic LBG must have the right content and a very meticulous design to fulfill its educational purpose. Therefore, a specialist needed to create the content and design the learning path through the game. In a LBG used in tourism a tour guide is needed to indicate the content to be displayed when the tourist arrives in a spot with an attraction as also the correct sequence of this content. In an educational LBG an educational expert is needed to design the learning path through the game, the given knowledge at each time. In both cases a programmer must intervene and create the game, write the code and the game functionality and embed the given content. More than one professionals with different eras of expertise must work together to produce a fully operational and educational LBG. Some researchers present even the learners as the designers of the LBG regarding this process to engage students with the educational content of the game, find and absorb new aspects around the topic [8].

A subdomain in LBG are treasure hunts which can be aligned with educational purposes independently of the certain domain of knowledge. A player must solve riddles, think and

search to fulfill the tasks of the hunt. Every riddle could be associated with an educational goal. This kind of a game can be very intuitive, highly engaging and motivating for students and learners [9].

The easiness in designing and developing treasure hunts from teachers, educators, students, or from whom it may be needed could lead to an increment in usage of such learning techniques with the benefits that have been described above. An authoring tool must intervene to fill the gap in programmatic knowledge, so it can be realistic from a non-programmer to develop a scavenger hunt. This tool must be easy in use, with an understandable procedure for setting points, adding digital content and finalizing the game without difficult sequence of actions from the developing aspect.

### 1.1 Scope and Objectives

In this master thesis will be described a new authoring tool for designing and developing location-based treasure hunts. The stimulus of this work has been the need for new methodologies and ways improving learning experience as also the effectiveness of this process.

The research motivation is grounded in development research trying to give a solution to the described problem. Development research contains certain activities. Preliminary investigation is needed to analyze the problem, its extensions, the state-of-the-art in this domain, to have a better conceptual understanding of the tasks and the substance of the problem. Theoretical embedding in the design and development process is necessary to connect the state-of-the-art theoretical knowledge with the taken design choices. It is required to be in a prominent spot the documentation, the analysis and reflections of the development, the aspects of the design and implementation, the followed methodology of this procedure. Empirical testing and evidence can be used to concept the effectiveness of the solution to the given problem, make correctional actions and at the end characterize as a successful or not the conducted research [10].

The presented work aims to support game-based learning with a prototype environment in which every interested can easily design and use location-based treasure hunts and take leverage of their benefits in learning process. The proposed prototype is divided in two sections. The first one refers to a web-based platform through which a creator can design and publish a game and the second one is about a mobile app where the published games can be accessed, initialized and played by users.

The platform provides to the creator an interactive map with a toolbar with available types of spots. By clicking on this map with a selected type of spot, the creator is setting a point in the requested area. There are four types of points, the starting point, the point of interest, the point of help and the ending point. Every point represents a riddle with digital and/or physical content. The digital content of a point-riddle is text, image, video, URLs. Actions, like answering questions, or scanning QRs, are also may be embedded in these points, and the player must conclude them to proceed. The game will be composed by those different spots.

The mobile app is used to present the designed and published games. A user can select the game through the app and create an instance of a game or participate in an already created instance. Every instance hosts teams in which every player can participate. The actual gameplay consists of a map used by the player to navigate in the game area, the digital content of the current riddle and a chat that will be used by the teammates to communicate.

## 1.2 Thesis Volume Overview

This thesis is structured in seven chapters.

The first chapter contains the scope and objectives of this work as also an introduction.

The second chapter is concerned about the theories that driven this thesis. In this chapter is being studied the basic learning theories that conceive the game as a key feature in human development as well in learning process, to conclude at the merit gaming has in education.

The third chapter refers at the idea and the technology behind Location-Based games. Are being described the main concepts in designing an LBG. It is also containing a review of



some LBG used in Education. Finally, in this chapter some design platforms for location-based games are examined ass related work.

The fourth chapter describes the technical approach of the development of “Hide a Treasure” design platform and the “Find a Treasure” mobile application.

The fifth chapter presents the technologies that have been used for this implementation.

The sixth chapter contains the case study. Game creation and gameplay are presented to examine the functionality.

At last, the seventh chapter contains the conclusions and some thoughts for future work on this subject.

## Chapter 2: THEORETICAL LINKS & MOTIVATION

This chapter is concerned about the theories that driven this thesis. In this chapter is being studied the basic learning theories that conceive the game as a key feature in human development as well in learning process, to conclude at the merit gaming has in education. Furthermore, we examine the fundamental concepts of Game-Based Learning, Ubiquitous Computing and Mobile Learning. Finally, we research on how Location-Based Games can contribute in the learning process and more specific on how treasure hunts may apply.

### 2.1 Social Constructivism and Activity Theory

At 1924 Lev Vygotsky established his theory which shown that in humans appears a special kind of mental operations. He named them “higher mental functions”, mental operations which are given by the nature but in a process transform in operation in a supreme level, mechanical memory be converted into logic, impulsive representations turn into, concentrated thought or creative imagination. These operations are generally called conscience. This conscience take shape through the social interactions and because of them [11].

According to Vygotsky a critical issue is to clarify the relation between learning and development. In order to resolve this issue, he introduce the zone of proximal development. This zone is divided in two developmental levels. *“The first level is called the “actual developmental level”, and refers to the phase where the development of a child’s mental function is a result of the previous concluded developmental cycles (...) if we offer leading questions or show how the problem is fixed, the child completes it or solves it in collaboration with other children ”* [12]. This phase describes the zone of proximal development where a child may conquer with some guidance.

Vygotsky’s work was continued by Aleksei Leontiev, who developed the activity theory. The main concept of Activity Theory was presented a "cultural-historical" school of psychology. Altogether, Activity Theory “is a philosophical and cross-disciplinary framework for studying different forms of human practices as development processes, both

individual and social levels interlinked at the same time” [13]. In this theory, activities are in the focus area. Not just the certain action but the context in which every act takes place, what drives the movement and by movement we mean that activity it is not static in time. It has a past, previous conditions and phases and new states which may contain previous forms. Another key principle in Activity Theory is that activities have artifacts which operate as mediators [14]. A paradigm of this approach can be found in the work of Engels “Dialectics of nature” and the role of tools in the humanizing of the ape as part of the labor which is the activity. An activity can be completed by taking out several actions which one has operations [15].

In preschool age play is the leading activity of a child’s development through which satisfies his unrealizable desires [1]. With a guidance and a proper design of the game, play as an activity can be the medium in conquering knowledge at any age.

## 2.2 Game-Based Learning

Based on the origin motivation of playing, a game-based model should be approached not from the point of view of the pleasure that during play is gained, but from the aspect of the goals, the attempt to reach them [1]. Considering this point, games are structured in levels with scores, tasks and missions.

The desideratum in education is the increment of the motivation by the students to learn, acquire new knowledge. In gaming motivation is predominant. Especially in digital games, player’s engagement in well designed and structured games reach hours, even days, occupation. The conflation of digital gaming motivation with learning content is being discussed from the 90s with simulations, learning games in physics, entire projects from MIT [16].

According to Kiili [17], in a gaming flow, player’s tasks, to maintain stable or be increased must fit with his skills level. A lower level will lead at a boring situation where the user will stop playing or he will continue mechanical without achieving a higher value. From the other hand if the skillset of the gameplay is much higher from player’s level anxiety

will be produced and failure may be followed by negativity. Game designer must create the game-flow based on learning theories, combine activities with learning objectives.

Games are ideal for problem-based learning and the skill in solving problems is one of the most importance in human's skillset. A game can be considered as a big complex problem with subproblems needed to be solved, in order to finish it. In this procedure the student must discover the solution which is a better way to absorb, in contrary of memorizing learning content. To increase the learning merit, it is important to provide immediate feedback at the player, set clear tasks and goals. A reward system could be helpful for kind competition between players as an extra factor in motivation [17] [18].

The effectiveness of Digital Game-Based Learning has been the subject of many researchers and experiments [19] [20] [21]. A negative aspect is described by Mitchell & Savill-Smith [22], who indicate that a student is being distracted by the gameplay and this may affect learning process. The effort to win may shunt the learning effectiveness. In some experiments students even treat quizzes as guess games to complete them in the minimum time and achieve a bigger score [20]. Another positive factor in learning effectiveness that worth to be mentioned is the use of "cognitive tools" as chats, forums, surveys and polling tools, during gameplay to support collaboration. This use of such tools has been the subject of experiments which shown that groups who used them had a better performance than others who did not make use of them [23].

In conclusion, making use of games motivation and engagement factor learning process can be boosted. Taking under consideration the developmental level of the learner and the level of knowledge to be acquired games can be a supportive environment.

### 2.3 Ubiquitous Computing

Ubiquitous computing is a term introduced by Weiser at the early 90's [24]. He had the vision of an environment so suitable for computers that everyone will use, but no one would even notice them. The key components as he had imagined them was pads and tabs, which in that time, at Xerox Palo Alto Research Center was under development. The main

problem which ubiquitous computing was called to solve, according to Weiser was the information overload, the need to have more information available at anytime, anywhere. The solution that he proposed is to move the computer in the human's daily life and environment in contrary of entering the human in computer's environment [24].

The first concept that had to be solved in moving forward at this direction was the mobile infrastructure and his development. Ubiquitous computing does not mean mobile computing but is one hundred percent depends on it. The data that is being transferred require a substantial bandwidth to support the exchange [25].

Nowadays ubiquitous computing has made a lot of progress. During the years the meaning had changed a bit. Refer a little bit more in mobile computing and the ability to carry with you all the time a computer. Smartphones and tablets are with us almost all the time, anywhere we go. But this is the mean of ubiquitous computing at the end. Using computers without understanding it to draw on information. Even with smartphones today our health status is being recorded and analyzed if we want. A numerous of health care applications using different microcomputers are in wide use and make our lives easier [26] [27].

E-learning with a broader mean, learning based on the technology, in the classroom or outside, relies on ubiquitous computing. Entire learning environments have been developed under this term. They are used to support learning activities from anywhere at any time, to personalize the learning experience using context-awareness and feedback based on user location and activity. From the tablets that are being used in the classroom from different learning activities, to serious location based mobile games that are played outside the classroom [28].

## 2.4 Mobile Learning

Considering learning as a socio-cultural activity [12], mobility could not be a major factor in its effectiveness. Mobile learning enhanced by technology is the evolvement of learning in a ubiquitous era. Learners are moving around between physical places, from school to home as also in theoretical areas from topic to topic. The technology in education made the

transition to the new age of learning. Smartphones, tablets, laptops are the new medium in the learning process. These tools even function as agents which observe, provide guidance and feedback to the students [5] [29].

When mobile learning appeared, the basic usage was to just deliver the learning content. Today mobile learning and the technology that is being used refers to a more personalized perspective. Content is aware of the location and time, even the needs and the interests of the learner [30].

Communication is a key feature in mobile learning. An interaction between a learner and a teacher, or the leader of the group, communication with co-learners support the collaborative learning even if the learners are distributed in different places, help in absorption of the new knowledge [5].

In Mobile Learning as in every learning procedure the motivation is the key to start the learning process. Obviously, a walk in the city or in a museum, or even at the countryside is itself a factor of motivation. From the other hand the use of technology in this procedure is also a motivating factor. Combining Mobile-Learning with games and game-based learning has admirably results in learners' notion and comprehension [5] [7] [21].

## Chapter 3: STATE-OF-THE-ART & RELATED WORK

The following chapter refers at the idea and the technology behind Location-Based games. Are being described the main concepts in designing a LBG. It is also containing a review of some LBG used in Education. Finally, in this chapter some design platforms for location-based games are examined ass related work.

### 3.1 Location Based Games

Every game which requires from the player to move around to complete a task and proceed can be categorized as a Location Based Game. The use of localization technology makes possible to locate the player's position and display the game elements depending on the location. Location Based Games are built upon the physical world, but with an addition of an extension of a virtual world which enables the interaction of physical and cultural items and linked-to them-data with the player. Therefore, some other terms are used as also for games with significant similarities with location-based, like "pervasive games", "mixed-reality games", "geogames" etc. [31] [32] [33].

#### 3.1.1 Determining player's position and navigation

The main theme on Location Based Games is to determine the player's position as more accurate as you can. There are many approaches, we already mentioned some. GPS, cell tower triangulation, Wi-Fi, single cell tower and IP are the most used. In some cases, RFID tags may be handy [31].

GPS is the most popular technology for this scope due to its high accuracy. It is consisting by a GPS sensor which is discoverable by the GPS satellites. Because of that it is available everywhere without the need of a tower cell or any other signal. Some problems are inside closed spaces, like buildings etc. Another disadvantage is the high energy consumption although many devices nowadays have enough reserve [34].

A combination of methods is the best and most accurate way of locating the device, eliminating the environment factor [31] [35]. Modern localization techniques, more

accurate are being explored to solve more complex problems than locating a player in a game, like navigate autonomous cars [36].

Another basic feature which many, but not all, have is a navigation system mostly provided by a map. The map can be considered as the board, the digital representation of the real world, the representation of the game arena. On a map, more information can be revealed, referenced on a certain position and a physical space. The map can be conceived as a cognitive tool in navigation and gameplay [37].

### 3.1.2 Pattern of Location Based Games

Every Location-Based game is built on a pattern on how it moves the player around. Search and Find refers to the games that guide the players to specific location, so they can interact through the virtual world with their- real-life – surroundings. It is the same pattern for games that gives a multiple choice to the player to go and play. It is the main pattern for data-acquisition Location-Based Games.

Follow the path is another pattern on these games. Like the previous pattern the player must reach a destination, but the attention is given on the path and not on the finish. It may come with penalties for leaving the specified routes etc. The route of the player can also be recorded to draw an object by the lines made by his path. Follow the path is the most used game pattern for treasure hunts.

Chase and catch as we can understand by its name is referred to a pattern in which the player has to chase a moving object or another player. The difference here is that the destination is changing by the time. A mentionable but not much used pattern is the Change of distance in which the player must come close or go far from a location to interact with the game [35].

### 3.1.3 The first examples

From the early 2000 many articles refer to Location Based Games as the new trend. “Pirates!” Is one of them, a multi-player game implemented on handheld devices connected



in a WLAN. The players in Pirates! used the physical environment as the game arena [38]. The development in mobile computing and telecommunication with the global positioning system (GPS) was the next big step towards Location Based services and games. In 2003 the game “Can You See Me Now (CYSMN)” implemented the GPS technology. The players could move around the city-arena with a fixed speed, could see the city map and the position of the other players. They could also communicate with each other using walkie-talkies [39]. According to Gartner’s forecast in 2006 the Pdas and smartphones industry would increase sharp and that GPS would be installed in more than 40% of mobile devices by the end of 2010 [40]. Now we see that the tendency which Gartner had foreseen was true.

### 3.2 Location Based Games in Education

The tremendous increment in smartphone usage have been exploited by the educational system to enhance their technological equipment. Bring your Own Device (BYOD), started as a way of decreasing productivity costs by using employees self-gear but afterwards, proceed at the education [41]. It is an active debate on educational themes on ICT around BYOD. A key aspect is that the cost for this equipment is charged on the parent. Another basic section in this debate is the usage and the control of this use inside the school’s environment [42]. It is obvious though, that a smartphone at everyone’s hand can be the tool under circumstances for the technology enhanced education to take place.

The last two decades Location-Based-Games were subject of research, were tested and used for educational purposes. A benefit in serving educational goals by this type of games is the ability to connect the information and knowledge with the real world, real locations, cultural objects, monuments [43]. Especially in learning history digital context about monuments can be displayed through a game when a player interacts with a specific location [44]. The combination with augmented reality elements can enhance the learning procedure in many ways. The digital display in a virtual layer on the real world of a monument could be the contribution [44] [45]. One of the first attempts to combine those

technologies in an educational game was “Environmental Detectives” in which the participants had to investigate a toxin pollution in their campus. The game included virtual interviews, taking measures and analyzation in simulations [46].

An experiment with students who played “Frequency 1550” showed the effectiveness of Location-Based-Games with learning content compared with the formal educational methods [47]. Treasure hunts as a sub-area of those games had also been under tests to examine their effectiveness in learners’ motivation and feedback in learning procedure. Tests have shown that students outperformed using a treasure hunt to find a learning object [48] [49].

Avouris and Yannoutsou made a classification of Location-Based-Games. They divided them in three major categories, ludic, pedagogic and Hybrid. In Ludic they assign treasure hunts [50].

### 3.3 Treasure Hunts at Cities in Greece

Treasure hunts are very popular games that take place in many cities in Greece, usually during the carnival. The origin of this game in Greece can be found at Patras in 1966 in which participate about one hundred players with their cars. Now in a treasure hunt, tens of teams with more than 50 players each are participating [51].

Treasure Hunts we can also find in other cities as well. The participation at Heraklion’s treasure hunt count hundreds of players. The hunt take place the previous Sunday of the carnival parade. A background story is always guiding the hunt which contains several riddles in scattered spots in the city, waiting to be solved and found [52].

### 3.4 Authoring tools for Location Based Games

Usually, the creators of such games are not programmers, have no knowledge in any programming language. Accordingly to the purpose, the designers may be educators, tourist guides, historians, or just people who want to play around. In most cases the use of technology is absent in a treasure hunt. The participants must confirm that they solved the

riddle and found the right place by visiting a certain spot from where the coordinators are giving them the next clues.

The usage of authoring tools for location-based games and experiences can be the non-expert tool with which no special skills are needed to create a game. Authoring tools for these activities must implement some basic functionalities. The first requirement is to provide the right interface for the authoring procedure. A map is the visual representation of the real terrain and is mostly used to set the spots of interest. The second requirement is the end-user app from which a game is accessible. Some admin functionalities are also a part of the requirements. These functionalities are used to check the gameplay, test the game and its spots, see the gameplay as is being conducted [53].

Some systems approach the solution to this problem by enabling the users with the creation of the games content. “Tidy City” and “Geocaching” are some examples of this approach [54] [55] [56].

MAGGELAN European project co-funded by the European Commission within the 7th Framework Programme, have implemented a platform for creating rich-content AR and VR location-based games. The platform provides the ability to design 3D models and elements [57] [53].

7scenes is an authoring platform for storytelling projects and experiences. An interactive map in which it can be placed different types of multimedia, questions and other elements that compose a story. The origin of this project can be found in the mentioned game “Frequency 1550” [58] [53].

A work presented by Laboratory of distributed Multimedia Information Systems team of TUC describes a platform named “PlayLearn”. Through “PlayLearn” a location-based activity can be designed and through an end-user app, players can participate and experience this activity. The design interface provides four types of tasks that can be implemented in the activity, “move” task, “inspect” task, “answer the question” task and “capture” task [59].

“SILO” is an authoring tool for creating location-based-games with the technology of augmented reality, presented in 2015. The logic behind the design of a game is led by completing activities such as “moving to a specific point”, “Collecting a virtual object”. The designer can give a sequence to missions or he can just leave the player to complete them in his preferable row [60].

“ARIS” is an authoring tool developed by the team of “FIELD DAY” at the University of Wisconsin – Madison. Through “ARIS” a user can create interactive location-based activities, digitalize his stories and interpret the virtual with the real world. The platform has been used for creating games and tours with AR content, VR content. Some of the features that “ARIS” provides are quests, collecting items, interact with virtual characters. The basic modules of this tool are “objects” and “triggers”. The combination of those two can produce a “scene” in a game [61] [53].

“TaleBlazer” created by MIT's Scheller Teacher Education Program lab is an online authoring tool for location-based games. It uses a block-based scripting language to digitalize a story using key words associated with agents in the story. Allow players of a created story to interact with virtual characters and objects in real locations [62] [53].

## Chapter 4: Treasure Hunt System analysis & design

This chapter presents the analysis, design and development of the “Treasure Hunt” system which consists of three main components namely the “Hide a Treasure” component, the “Find a Treasure” component and the Administration component as shown in Figure 1 and Figure 2 which present the system architecture. The following sections elaborate on the analysis and design of the “Treasure Hunt” system as its main components.

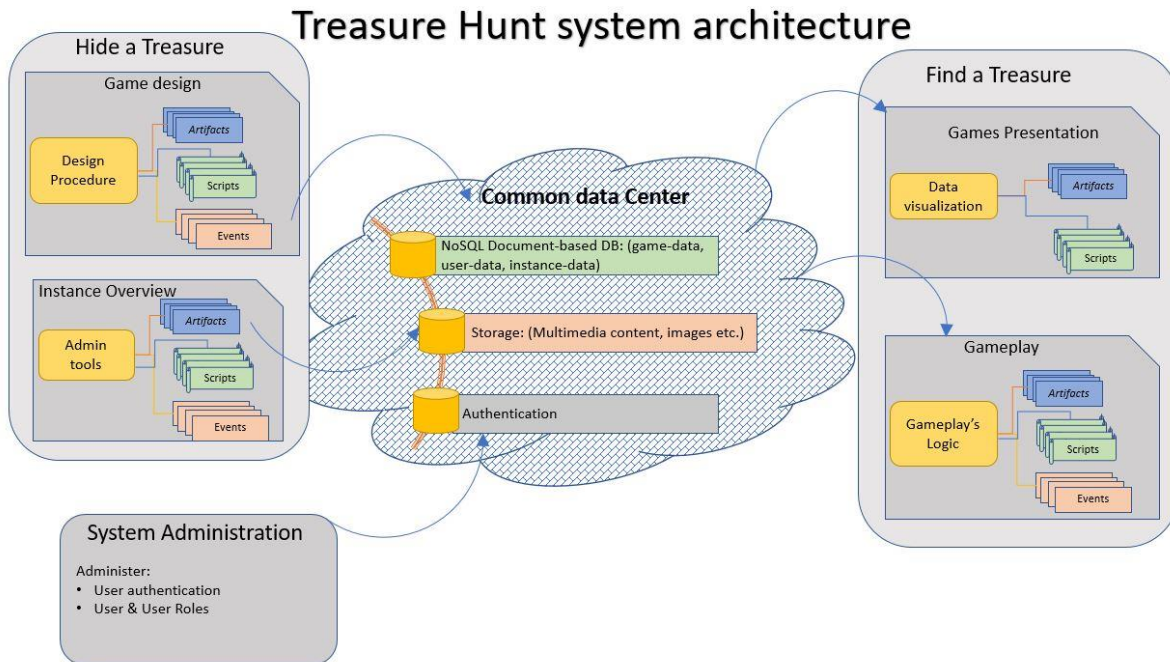


Figure 1. "Treasure Hunt" system architecture

### 4.1 The System Architecture

The system is divided in two main subsystems; a) Hide a Treasure design platform and b) find a treasure mobile app. Both uses the same database for saving, retrieving data and authenticating users.

“Hide a Treasure” consists of three main components. The first component is the designGame component which is responsible for the design editing and saving a new treasure hunt game. PreviewGame component is an admin tool for previewing created games. The last component is responsible for the authentication of the users. Those components and its functions are accessed through the web interface.

“Find a Treasure” consists of four components. There is also an auth service for the authentication mechanism. The game logic is implemented in play services component. Game services are used to retrieve games’ data from the database. Last, geo services are responsible for tracking player’s position at any time. Mobile app’s graphical user interface is the medium to use these operations.

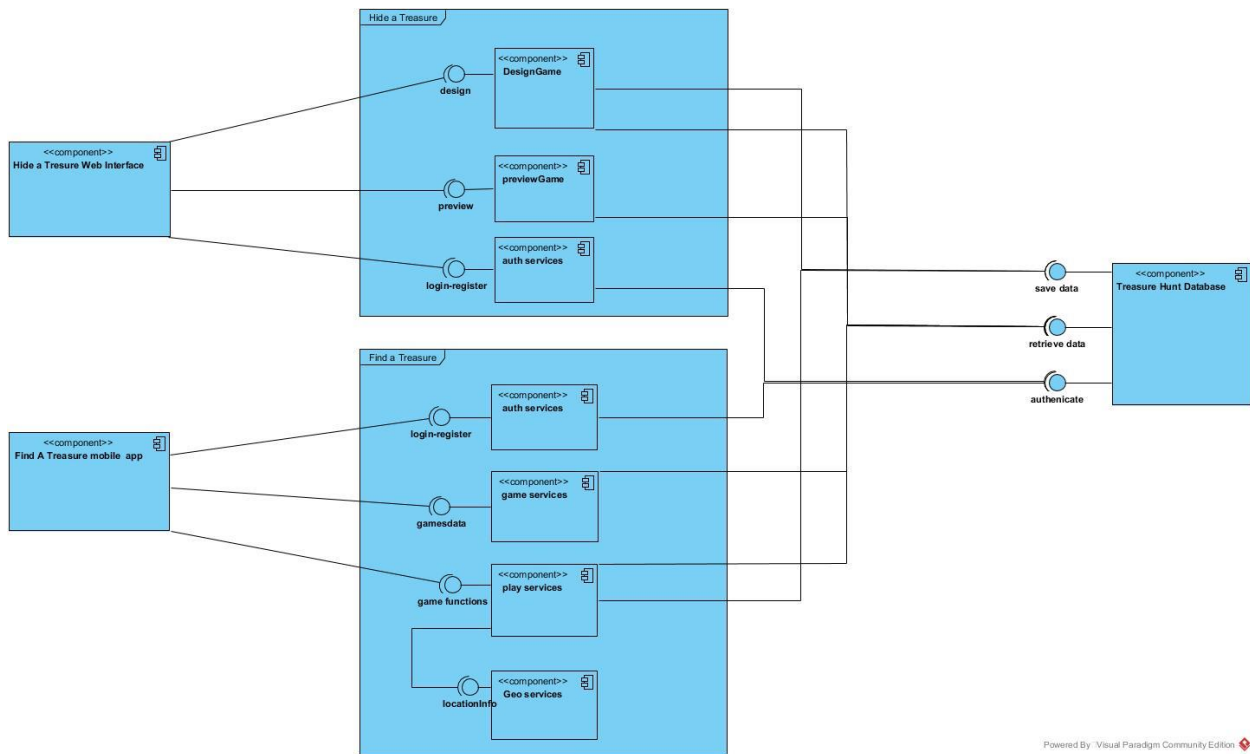


Figure 2 Component Diagram of Treasure Hunt

## 4.2 The Administration component

The user’s roles in the “Treasure Hunt” system are the simple user and the creator at the “Hide a Treasure” component. The roles at the “Find a Treasure” component, are also the simple user, the participant, the team-leader and the player.

At the “Hide a Treasure” component the user is a logged in actor who has not created a game. A user can navigate in the platform, have access in information about the games and the platform, his profile. A User can also create instances from published public games. The creator has the task to design and create the game through the platform. The creator must be registered user. Every user could be a creator at his own game.

At the “Find a Treasure” component the user is a logged in actor who can navigate in published games. When a user entering an instance of a game is becoming a participant of this instance. By joining in a team, the participant becoming player, and if the participant creates a team becomes team-leader.

Authentication mechanism have been deployed to require user’s logged in status in both components, to proceed.

### 4.3 The “Hide a Treasure” component

The “Hide a Treasure” component has been realized as a web-based platform through which a user can create a location-based treasure hunt. Once the user has successfully log in the Treasure Hunt platform he/she is navigated to the dashboard.

Dashboard contains user’s created games, those who he can edit, as also those he had published and can also preview. In the dashboard page the user can click the create button and start the process of creating a game.

Basic info about the game, like name, city, region, background image etc. are required to be filled in a form, to proceed. After the successful registration of those fields the game has been created in user's dashboard. By clicking edit-button the system provides an interactive map and a toolbar with four types of buttons which everyone refers to a different type of spot, starting point, info point, spot of interest, end point. In the beginning, only the starting point is available. After the set of a starting point, this button become unavailable and the buttons - spot of interest- and -end point- are activated. By setting a spot of interest button -info point- button is being enabled. If an end point is set, then a publish button is available. By selecting a button-point the creator can click on the map and set it in certain coordinates. A form is popped up with fields relevant with the spot. The basic fields are a title of the spot, the description or the riddle, a URL field, an upload image mechanism, an active radius field. If the spot is a spot of interest the creator can set an activity like answering a question or scan a QR code. In the end point's form, a congratulation's text is asked to be completed.

By clicking the publish button a form with basic settings are appeared to the creator. Through this form the creator can set the difficulty level of the game, the state of public or private, set a password. After finishing the settings and hit publish the game is being published and no more changes can be made.

In dashboard page the creator can preview the game, the spots that he had set and the basic info of the game. Also, an extra admin tool has to be designed to support gameplay overview. Through overview the gameplay is being monitored.

The class user represents any user of the system without authoring privileges. Every user can be uniquely identified by his id and email and can perform certain operations like registration, login, and logout.

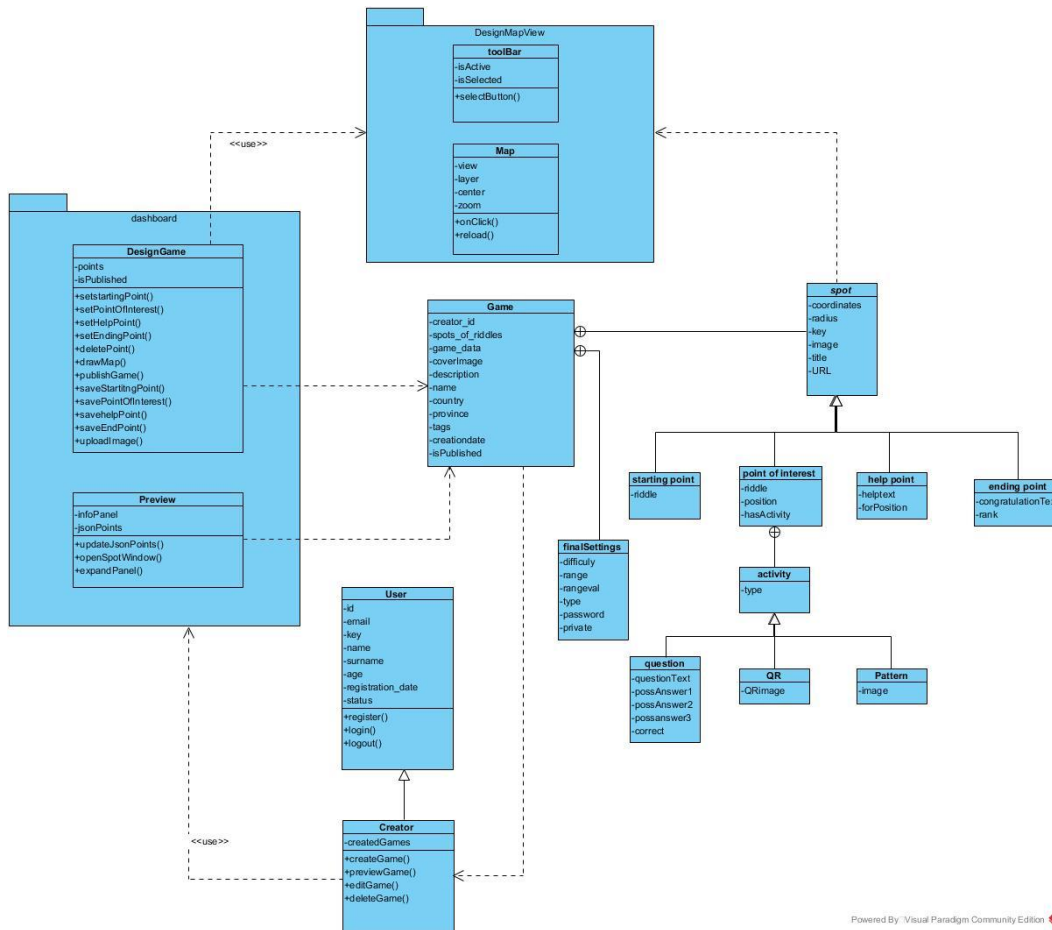
The class creator refers to a user with permissions to create a new treasure hunt game. Every creator has an array of his created games and with the use of dashboard's classes can perform certain operations which are associated with the game creation, deletion and editing.

Dashboard Package contains two basic classes for the functionality of the system. The DesignGame class make use of DesignMapView package to design a game, set the points content and place them on the desired locations on the map.

The DesignMapView package contains the Map class and the toolbar. The combination of those two provide the proper interface for the authoring environment. DesignMapView is required for the spots to be set. Spots are divided in four subclasses depending on their type and contents. Point of interest subclass contains activities which also are divided in three subclasses.

Spots and final settings are the required elements which a game consist of. A game can be previewed.





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Figure 3. "Find a Treasure" Class Diagram

#### 4.3.1 Use cases

The following subchapter presents the basic use cases and their diagrams which describe the functionalities of the developed authoring tool. Those use cases revealed the required functions that had to be implemented in the system and led the development of the web-platform. A user when he is successful logged in, can navigate at the dashboard page from where he can manage his games.

Table 1 Use Case Scenarios for "Hide a Treasure" component

| Use Case        | Scenarios                                    |
|-----------------|--|
| Game management | Create new game<br>Edit game<br>Preview game |

|                     |  |
|---------------------|--|
| Instance management | Instance creation<br>Instance overview<br>Team overview<br>Spot Overview |
|---------------------|--|

[Create new game](#)

One basic procedure of the system is the creation of a new game. Every game must have a title, a country and a region, a cover image, and some tags which indicates its use. When a user is at dashboard page an add button for creating a new game is available. By clicking this button, a form is popped up with the required fields. The user must fill a title for the game, select a country and a province, upload a cover image and select some tags for the game. When the fields are properly filled, the save button is activated and the user can save the game and proceed for editing. The following figure contains the use case diagram for the creation of a game by a user.

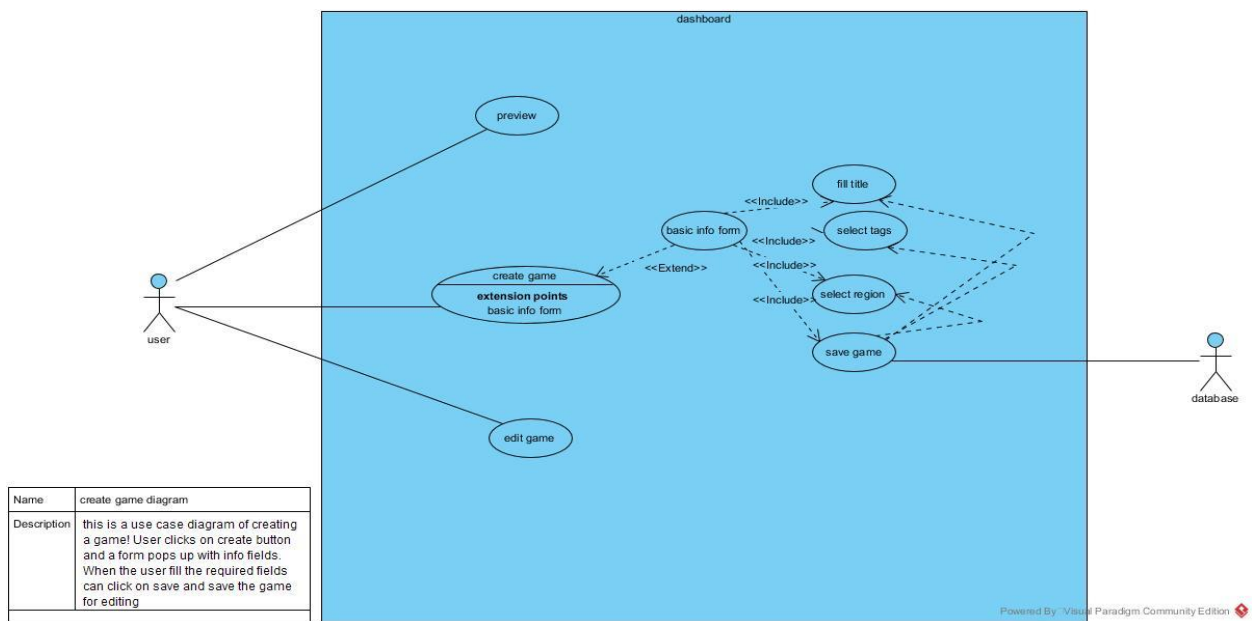


Figure 4. "Create game" Use Case Diagram

The following diagram describes the creation procedure. In dashboard page the creator must act to create a new game.

The interface provides a form with certain fields. The creator fills the form which is being checked for validity by the interface. The user can either save his creation or he can cancel

the procedure. If the user selects to save his work an object is instantiated with the attributes which has given in the form. This object then is being saved in the database.

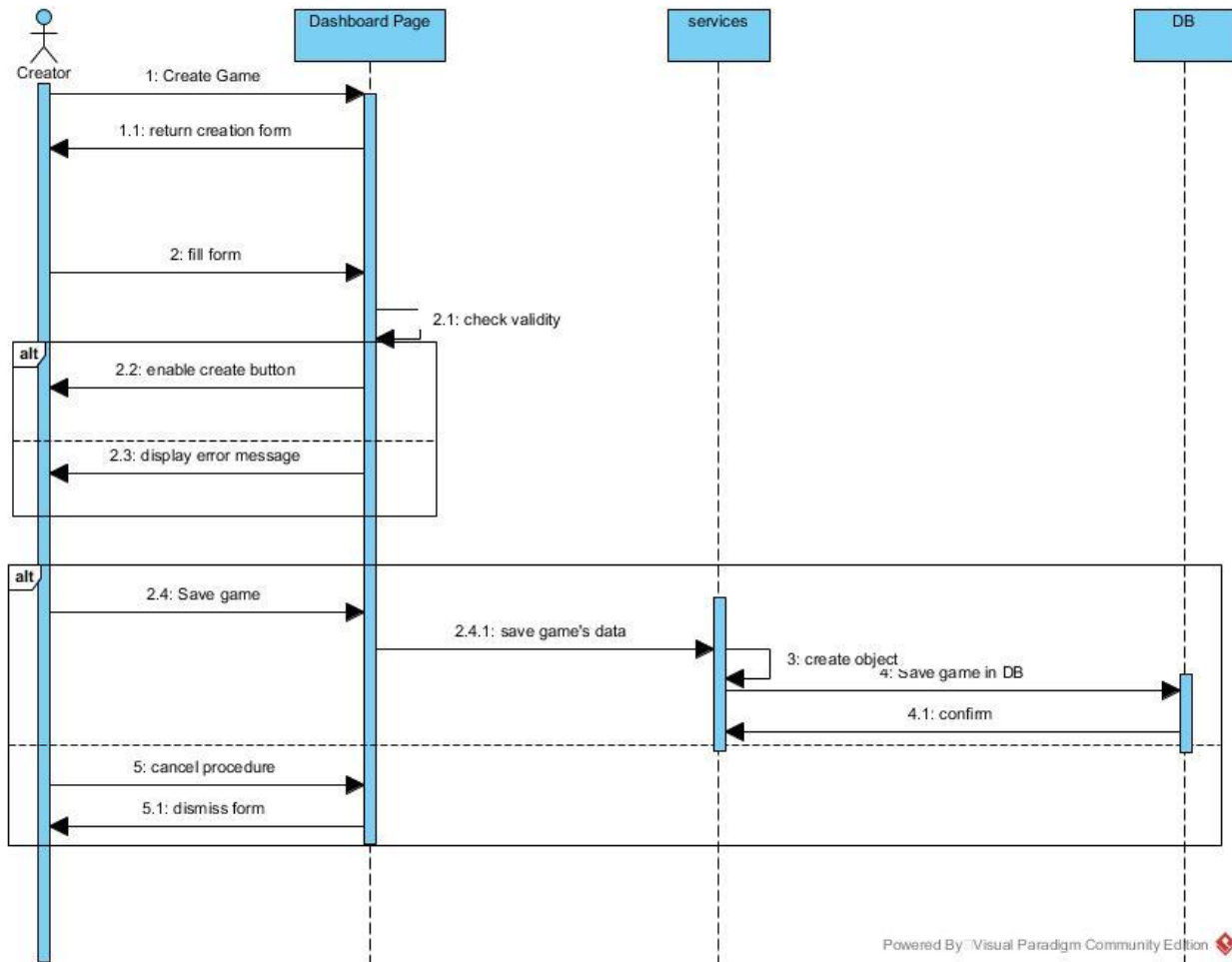


Figure 5. "Create Game" Sequence Diagram

### Edit game

The main functionality of “Hide a Treasure” design platform is the editing of a created game. During editing the creator place the points of interest, enrich the game with the appropriate content, riddles pictures etc. An interactive map is provided by the platform, as also a toolbar with four types of buttons each one refers to a different type of spot. The types are, the starting point, the point of interest, the help point and the ending point. Every game must have at least a starting point and an ending point. The buttons at the toolbar are enabled and disabled in a certain sequence. At the beginning, only the starting point button

is enabled. When the creator places the starting point, its button is being disabled and the interest point button and the ending button are enabled. If a point of interest or an ending point is set, then the button for the help point is enabled. Every help point refers to a certain point of interest or to the ending point. If ending point is set the publish button is being activated, to finish the design of the game and set the final settings. The points are being set by selecting them in the toolbar and clicking on the map. Through forms based on the selected type of point, the content of the spot is filled and saved. All forms have fields for title, image, text, URL. At the form for the spots of interest the creator can request an activity for the player. The activity can be or a question with three possible answers, either to scan a QR code. At the info point's form an extra field require to select the point which the help refers to.

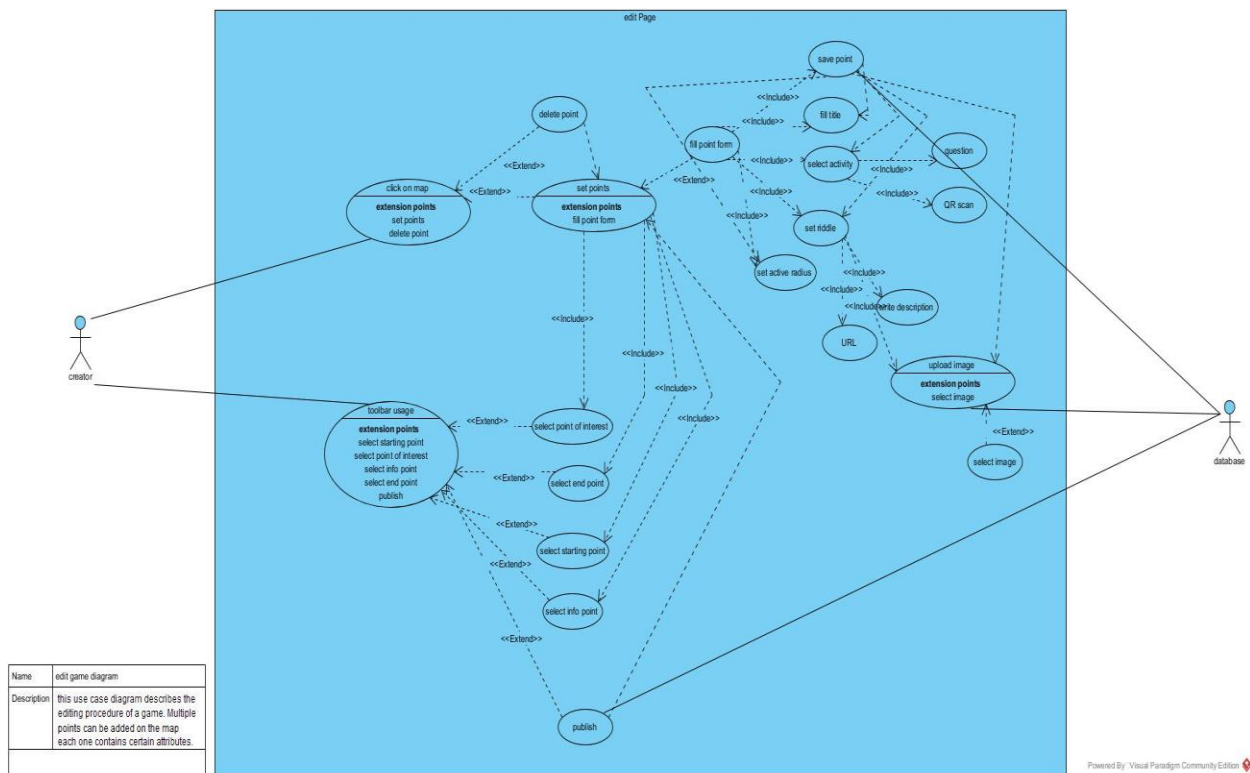


Figure 6. "Edit game" Use Case Diagram

The creator requests the design tools and the system initialize the map and the toolbar and provide them to the creator. When the creator selects the starting point button toolbar set the proper click options and inform the map about them. The creator can click on the map

to set the starting point. The map replies to the designGame Page with the coordinates and the type of spot. The designGame return to the creator a form with the required fields for point's content. The actor fills the form and the Page checks for the validity. The user can either save the point or cancel the procedure. If the user selects to save the spot the point's data are send to the database and the toolbar is notified so it can be properly formatted for setting points of interest or the ending points. The actor can either cancel the procedure.

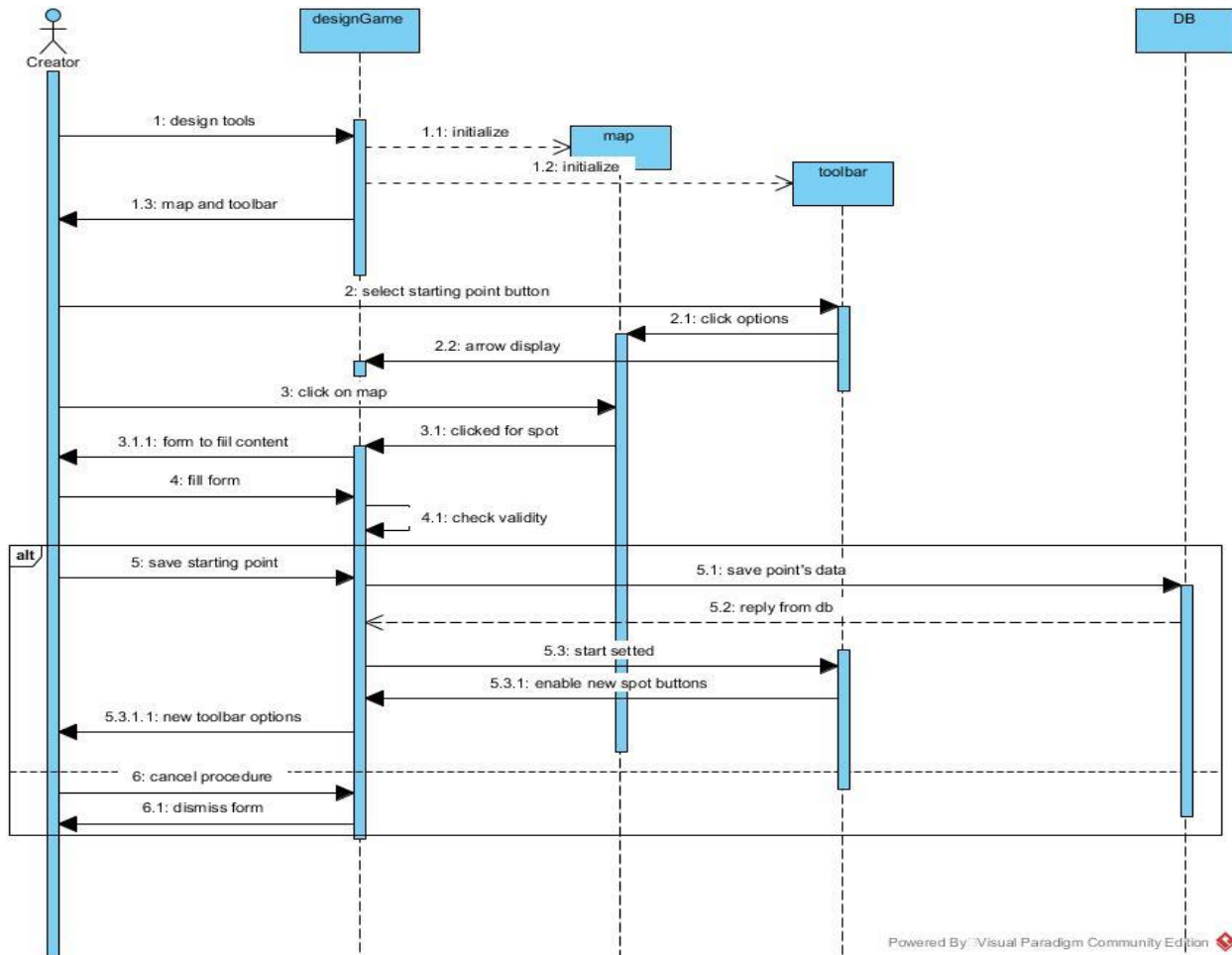


Figure 7. "Set starting point" Sequence Diagram

When the creator selects the point of interest button, the toolbar set the proper click options for the certain type of spot and inform the map about them. The creator can click on the map to set the point of interest in specific coordinates. The map replies to the designGame Page with the coordinates and the type of spot. The designGame return to the creator a

form with the required fields for point's content. The actor fills the form and the Page checks for the validity. The user can either save the point or cancel the procedure. If the user selects to save the spot the point's data are send and saved to the database and the toolbar is notified so it can be properly formatted for setting points of interest or the ending points. There actor can either cancel the procedure. This loop can be done for a maximum number of spots.

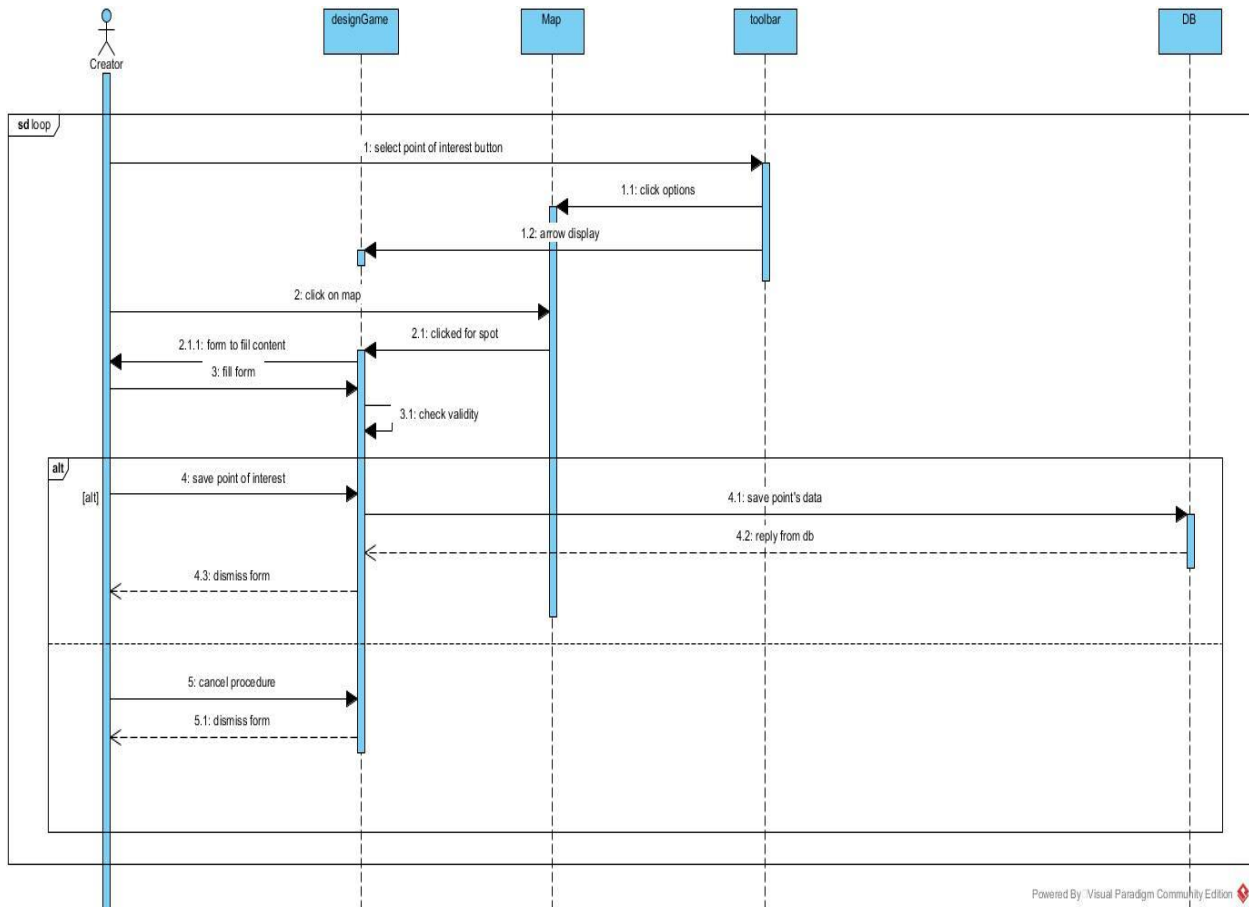


Figure 8. "Set points of Interest" Sequence Diagram

### Preview game

One basic admin tool for the creator is the preview of his game after he has published it. Through preview a creator can see the placed points on the map with different icons for the different types of spots. By clicking on the spot can see the spot's information, the image, the riddle, the type of the activity if it has one. He can also have access in the final settings

of the game, the difficulty level, as also the title of the game and the given tags. In the following figure the Use Case Diagram for previewing a game is presented.

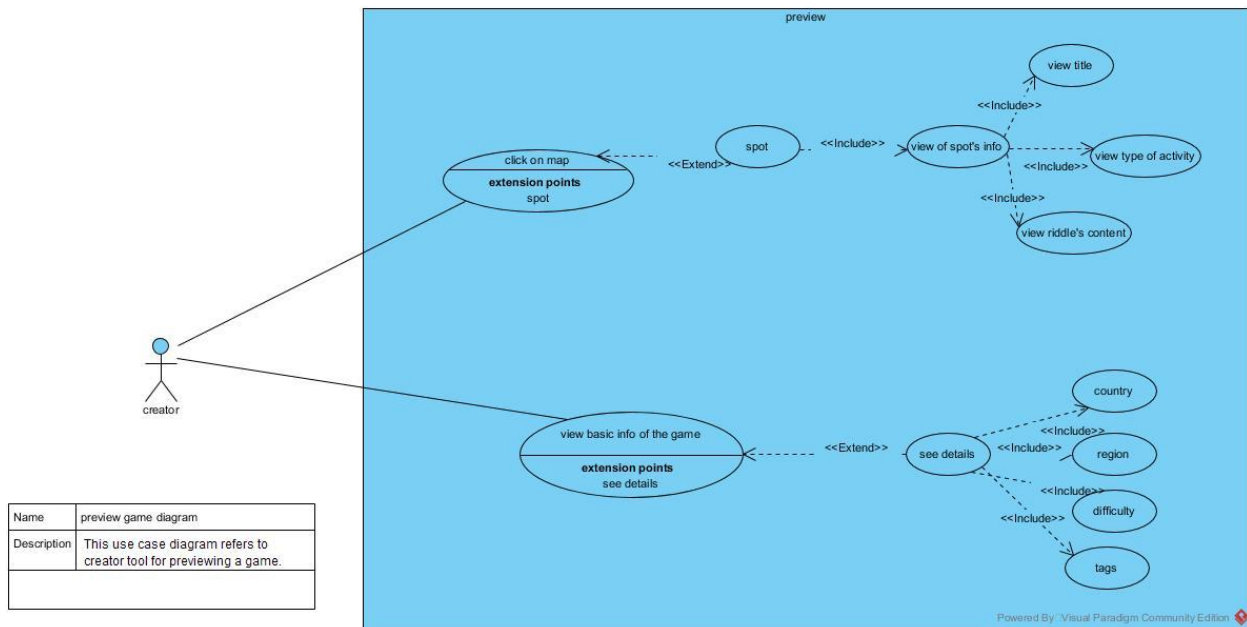


Figure 9. "Preview game" Use Case Diagram

### Overview an Instance

Admin tools may concern the design of a game, but they also refer at the overview of an instance of the game, the presentation and visualization of critical data of the gameplay. This information can be analyzed and extract crucial assumptions about the game and the players condition and abilities. Moreover, through overview a basic view of players' movements and actions in the game give the ability to prevent cheating.

By entering overview Page basic information about the instance are requested and loaded from the database. These data have been produced by another system which implements the gameplay and have been stored in the database. Overview functionalities extend to request and load information about the current instance from the database, request and load information about the teams that are participating in the instances and information about the interactive points of the game. Instance information include the number of teams participating in the gameplay, the current rank and the spots of the game. Team information includes players' location logs. These location logs are visualized through a map, one for

each player. Team information also contain the riddles that the team has found. Spot information include the content of each spot and which teams has found it. In the following Use Case diagram in Figure 10 is being described the presented usage of this functionality.

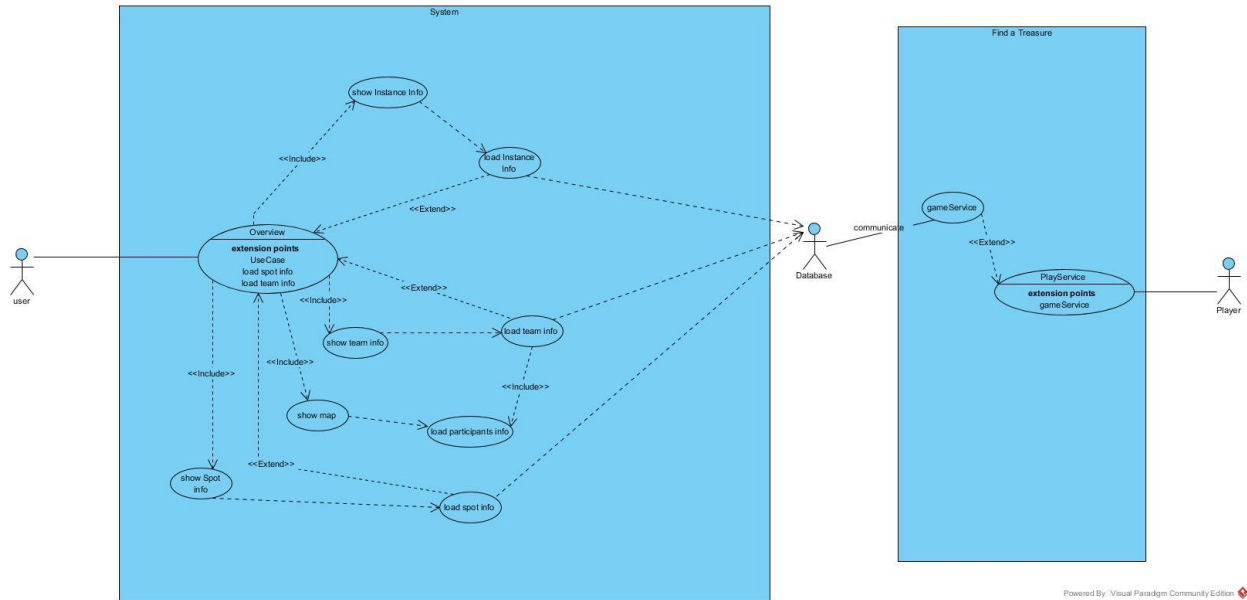


Figure 10. Overview Use Case diagram

#### 4.4 The “Find a Treasure” component

“Find the Treasure” is the mobile app through which players can (a) access the published games, (b) create play instances of those the published games, (c) create or participate in play teams and (d) play a game.

Players must have registered and be logged in to proceed in the app. The first page must present the available games which have been published through the “Hide a Treasure” design platform.

The user can select a game and view the basic information, the name of the game, its description and its cover image, as also the difficulty level and the access status; if it is private and require a password or if it is public. If the game is private a code is needed to continue. If the access has been granted the player can create a new instance of the game or he can participate in an already created instance. An access code may also be needed in this stage too.



Every player must participate in a team to play the instance of the game. The player can participate in an already created team either he can create his own team and become team leader. A player cannot be part of more than one team at the same time. He must leave from one team to participate in another one. A team leader cannot leave his team.

The interface of the gameplay provides the player a map to navigate around, a way to visualize the content of the riddles that the creator had set, and a mechanism to support communication among the members of the team. A player of each team must go to the starting point to unlock the riddle for the next spot of interest. If a player finds the next spot of interest or the end point, then the whole team is being notified about the content of the spot and moving towards the next one. Help points can be found and accessed by the team leader. The team which finds first the ending point is the winning team. During the gameplay teammates can exchange information and thoughts through a chat.

#### 4.4.1 Use cases scenarios

The following sections presents the basic use cases which describe the mobile application. Through this app the published games from the “Hide a Treasure design platform can be accessed. Those use cases revealed the required functions that had to be implemented in the system and led the development of the mobile app. A user when he is successfully logged in, can navigate at the dashboard page from where he can view and participate in a game.

Table 2 Use Case Scenarios for “Find a Treasure” component

| Use Case        | Scenarios   |
|-----------------|---|
| Game management | Preview game basic info<br>Create/participate in an Instance<br>Participate in a team |
| Gameplay        | Navigate through map<br>Use chat to communicate<br>Find spot / complete activity      |

### Create and participate in an instance of a game

A user can browse published games. Games are loaded from the database. The user can select a game. If he chooses to participate in a game the database loads the available instances.

To participate in an instance, it must have been created at least one. The user can create his own instance by setting the title of the instance and a password if the status is private. Every instance has also a creator and a created date.

The Figure 11 describes the use case of creating and participating in an instance of a game. Imprint the relations between the user and the database, the operations that are being used.

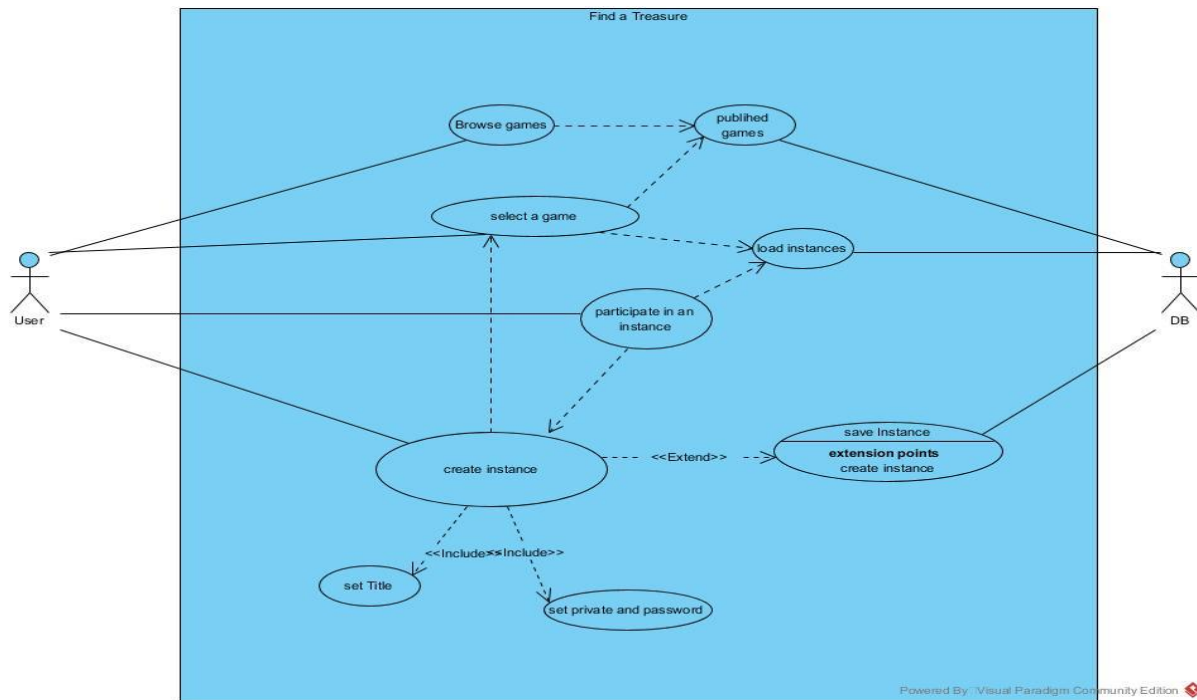


Figure 11. "Create instance" Use Case Diagram

The following diagram presents the required procedure in order to create an instance of a game. First, Dashboard Page request from the game service to load the published games. Game services reach database and retrieve the requested data, which the dashboard page display to the user.

Then the user can continue by selecting a certain game. Then the game page is created, and the available instances are loaded and displayed. The retrieval is managed by the game

services from the database. The user then can either enter in an instance, if there is already one created, or create a new one.

If he selects to create a new instance, must fill game page instantiate a form, with required for the creation fields. The user fills the form and the game page send the request to the game services where it is being handled and send to the database.

The user can also enter an already created instance. Then instance page is created, and game services are retrieving the available teams.

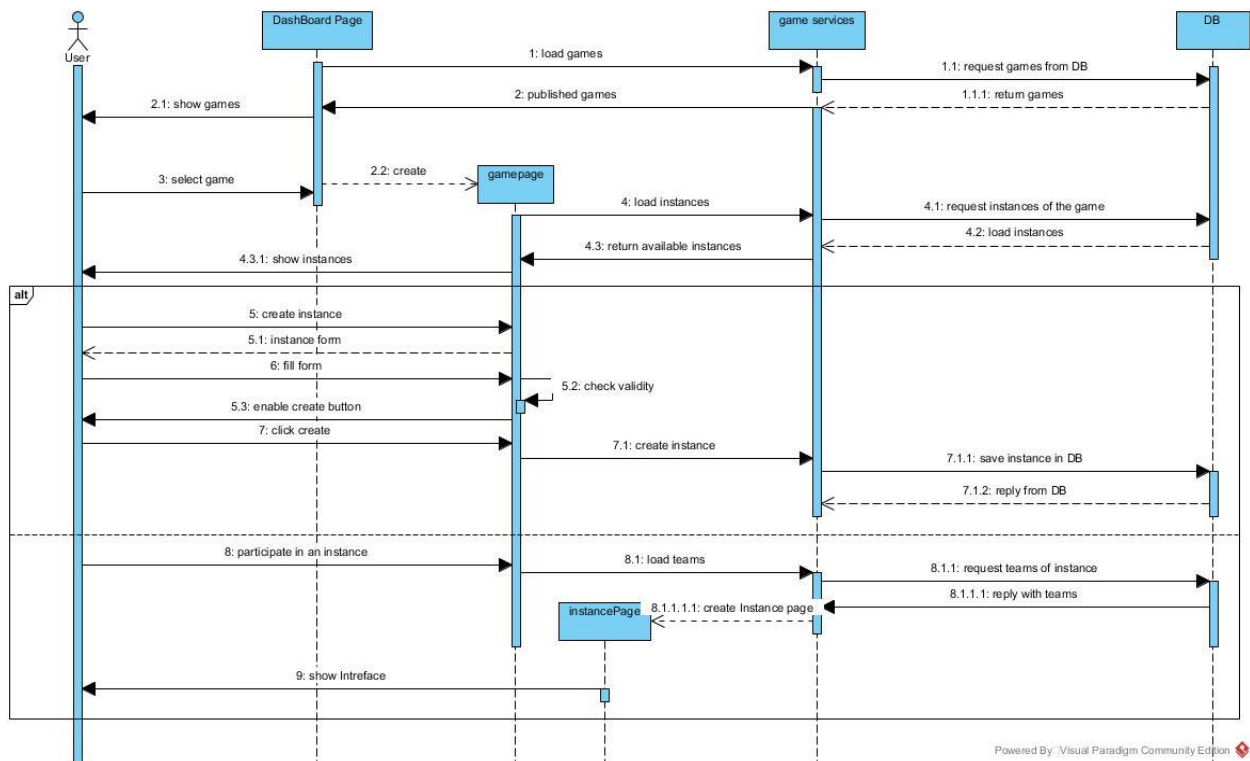


Figure 12. "Create and participate in an instance" Sequence Diagram

### Participate in a team

Every player must be a member in a team. To participate in a team a user must select through the loaded teams list. Teams are loaded from the database. A user can create a team and become the team leader. He must set the name of the team. Each team is uniquely identified by the team leader. Once a user creates a team, team's data are being

saved in the database. If there are already created teams a user can participate in one as long he is not a member of another team. A player can leave his team, if his is not the leader, and participate in another one. Figure 13 refers to the presented in this paragraph use case.

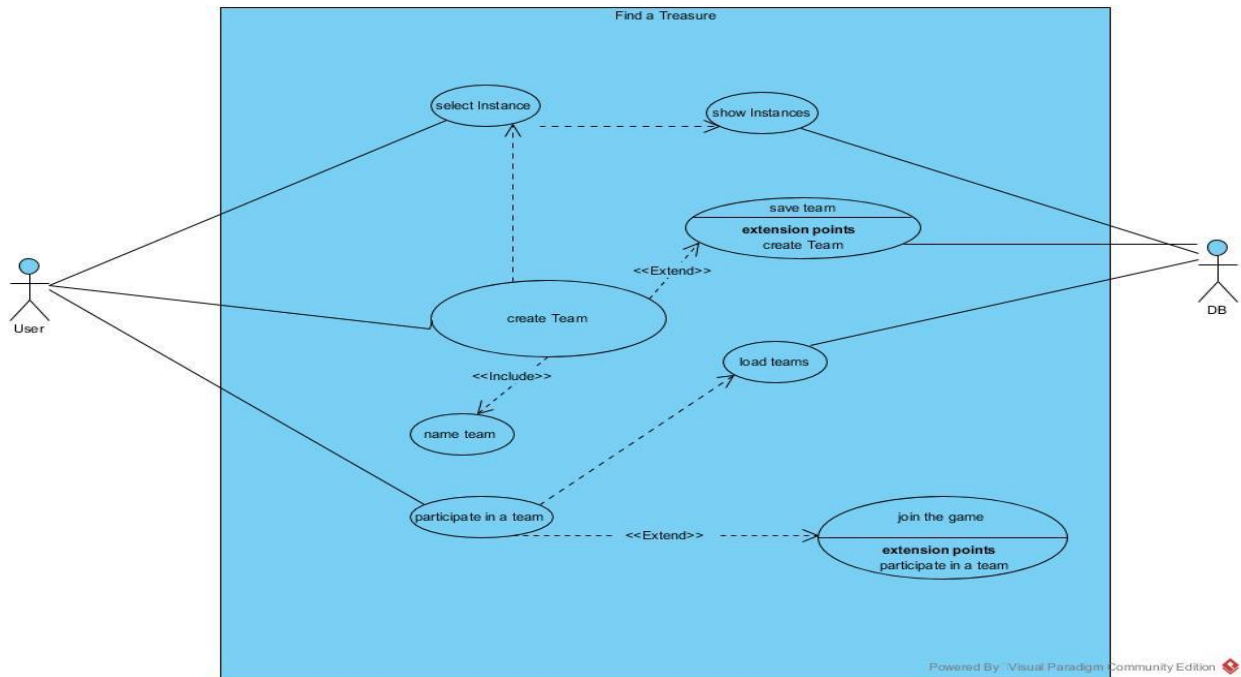


Figure 13. "Create and participate in a team" Use Case Diagram

Game services create instance page with the available teams. Instance page check for user's membership. If he is already member in a team in this instance, then he can only join the game through his team. If he is not a member yet, he can either create his team and become a team leader, or he can participate as a member in an already created team. The following figure (Figure 124) describes step by step this procedure.

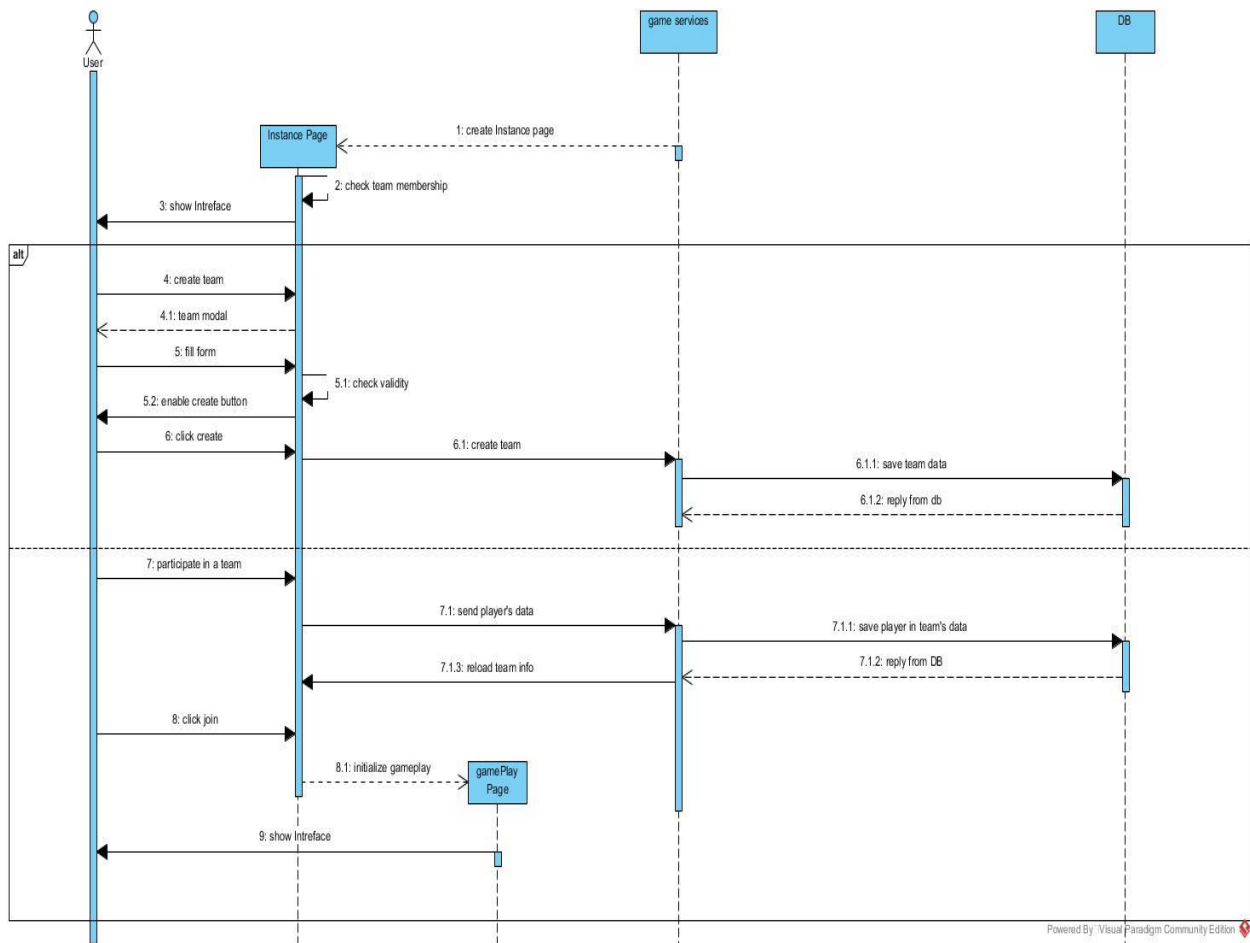


Figure 14. "Create and participate in a team" Sequence Diagram

### Play a Game

When a game is initialized, game data are loaded from the DB. The player can use a map to navigate in the arena and see the starting point and the founded points. Current riddles content can be accessed. Among other elements, the riddle contains a title, a description, an image and a URL which a user can explore. When a riddle is solved, and the spot is found, game data and analytics are send and saved in the database.

The third operation in this use case is the chatting mechanism. The player can read team's messages and participate in the conversation by sending his messages to his teammates. The messages are saved in the database from where the rest of the team can retrieve and read.

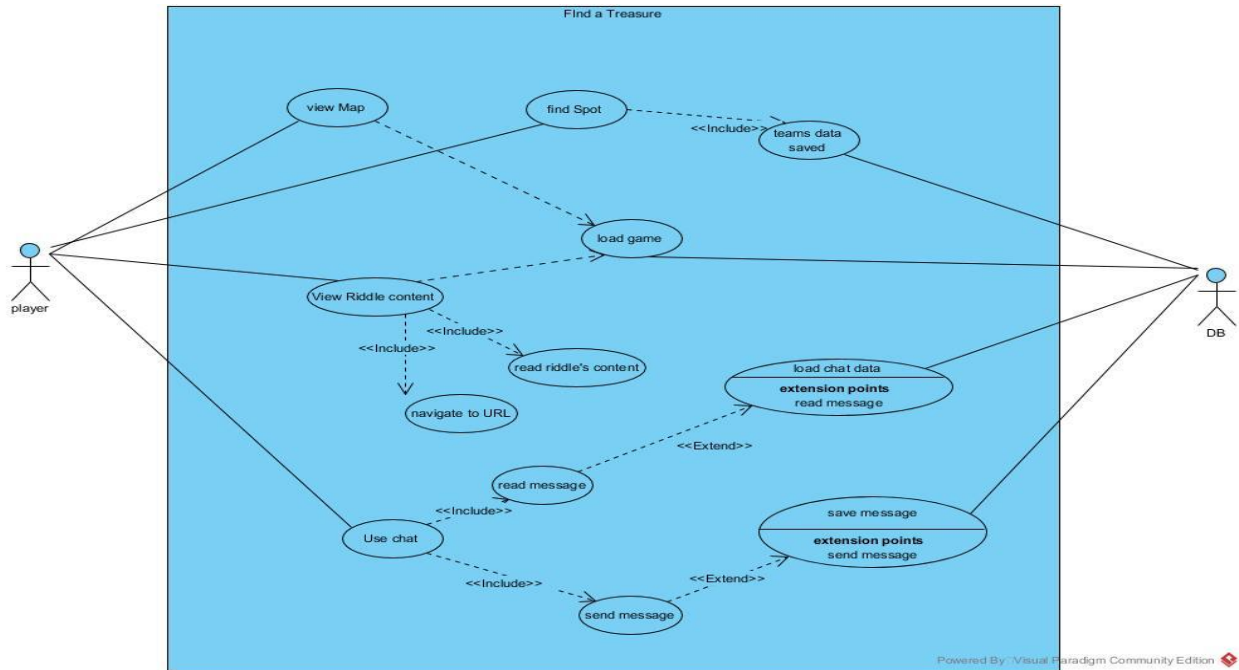


Figure 15. "Play a Game" Use Case Diagram

Three basic elements are consisting a gameplay, a map, a riddle's content visualization, and a chatting mechanism. There are also two main services running on the background, geo services who is responsible for extracting player's position and the game service who check player's position from geo services, and game and team data from the database. Game services also continually calculate the distance of player's position from the spot of interest.

The user interacts with the visual display of the current riddle's content through riddle. Then there are three alternatives. The first is the interaction with the map. The second one is the interaction with the riddle content and the third one is to read team's messages and if he choose to, send a message to the team.

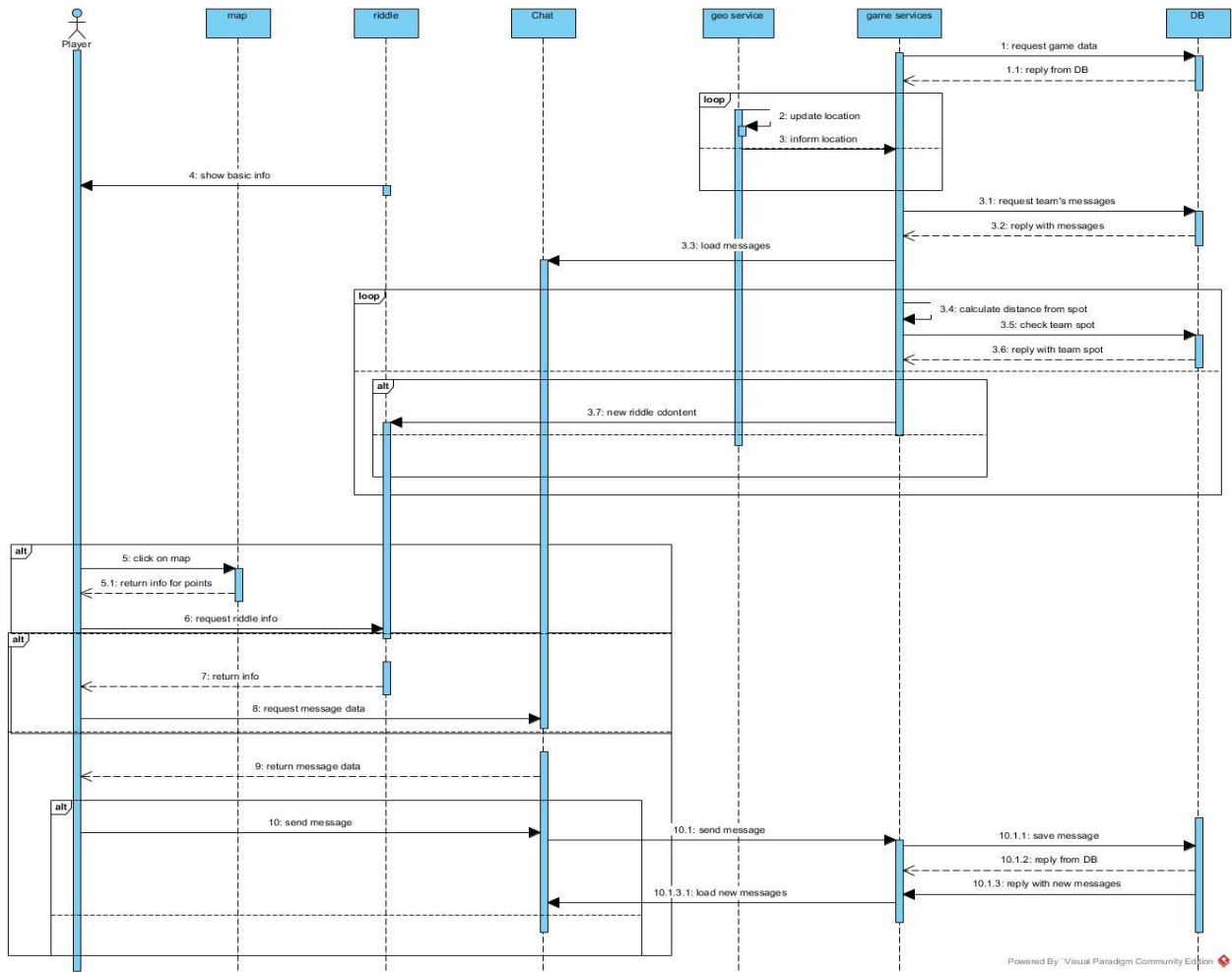


Figure 16. "Gameplay" Sequence Diagram

### 4.5 Common Data Center

The designed system requires a flexible and easily scalable database schema with quick query operations. NoSQL document database will be used to save and store system's data. Data will be stored as objects in JSON format. In Figure 17 are presented the entities which create objects in the database as also the relations between them.

The basic entities and their relations are shown in the Table 3.

Table 3. Entity - Relations

| Entities/Relations | User | Creator | game   | point | Instance | team   | participant | Team data |
|--------------------|------|---------|--------|-------|----------|--------|-------------|-----------|
| User               |      | become  |        |       | create   | create | become      |           |
| Creator            | is   |         | create | set   |          |        |             |           |

|             |            |            |              |            |             |             |             |         |
|-------------|------------|------------|--------------|------------|-------------|-------------|-------------|---------|
| game        |            | Created by |              | Consist of | generate    |             |             |         |
| point       |            | Set by     | Is part      |            |             |             |             |         |
| Instance    | Initialize |            | Generated by |            |             | Has         |             |         |
| team        |            |            |              |            | participate |             | Has many    | has     |
| participant | is         |            |              |            |             | participate |             | produce |
| Team data   |            |            |              |            |             | belong      | Produced by |         |

The first entity is the user. It has fields referring to personal data as also a unique id and e-mail. The second entity is the creator, which is a user who is creating games. The creator has a unique key and a user id that associate a user with a creator.

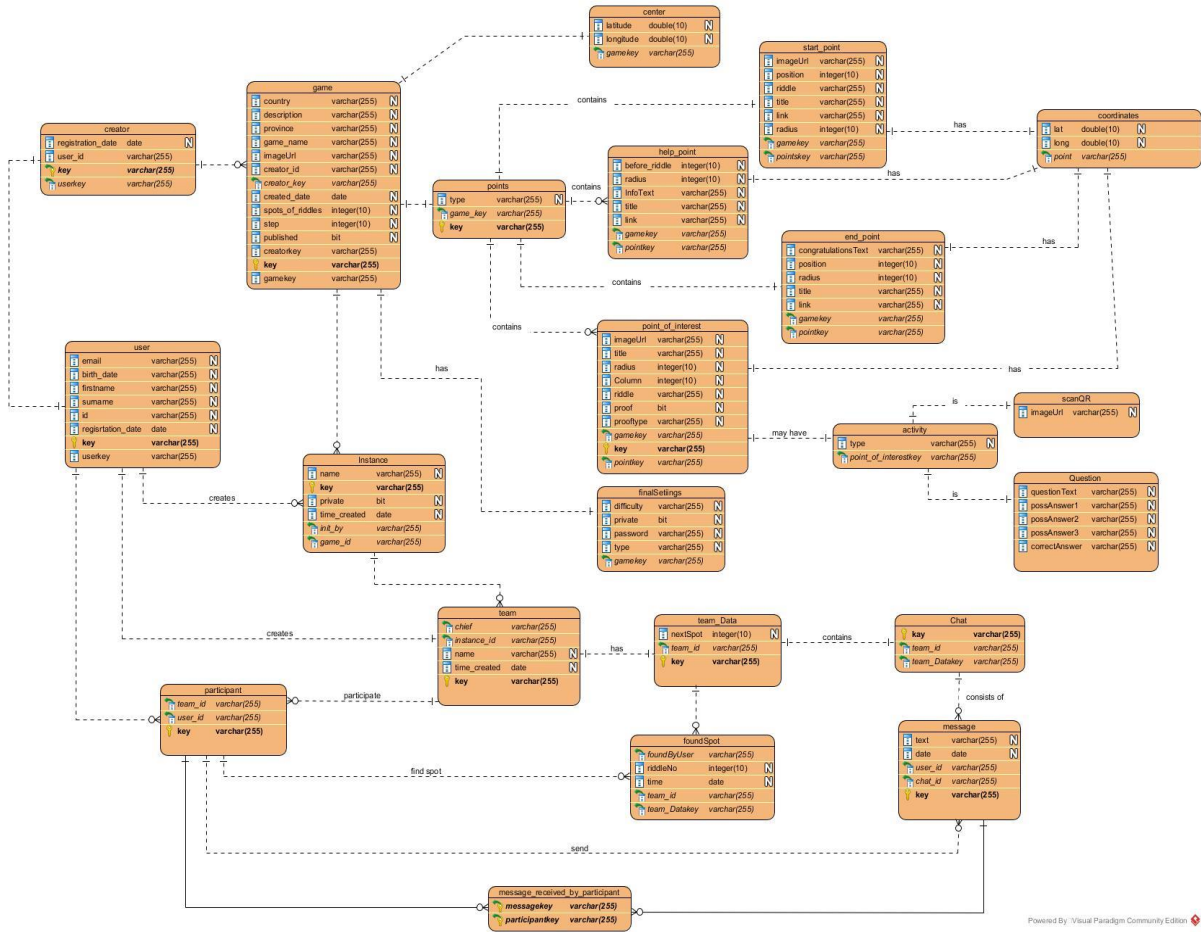
The basic entity is the game. It contains fields about basic information, such as the title, the description, the status of the deployment etc. It also has a creator id which refers to his creator. Each game consists of points. There are four types of points. Every point has a game id, which associate the point to a specific game. The types of points are the starting point, the point of interest, the help point and the end point. All points have coordinates, an Image URL, a title, a text for information of the point, and other fields depending on their type. Point of interest may also have an activity.

From the gameplay perspective there is the participant entity. The participant has a user id which uniquely associates him with a user, an instance and a team. The Instance entity is also uniquely associated with a user and has a field of time that it has been created, a name and an id. A team entity has an instance id, a chief id which indicates the creator of the team as also a name and an id. In a team many participants may participate, but a participant can be a member in only one team.

A Team data contain data that are associated with one team and have been produced by the participants. Team data contains chat data which refer to messages and timestamps send and received by participants. Finally, team data contains found spots which are used to store the spot that a participant has found.



y  
has



Powered By: Visual Paradigm Community Edition

Figure 17. Entity-relationship diagram

## Chapter 5: Treasure Hunt Implementation Technologies

The development of the system presented in chapter four is divided in two main sections, each one using different technologies. In both subsystems the base technology is JavaScript and frameworks which use JavaScript. The “Hide a Treasure” component is a web-based tool developed as a Single Page Application using the VueJS Framework. The “Find a Treasure” component was developed using Angular with Ionic Framework to achieve the mobile deployment with JavaScript and web technologies. The database and the storage are set on Firebase platform and make use of the firebase’s API.

### 5.1 JavaScript frameworks

Web 2.0 and site interactions and complexity have been accomplished by taking backend code, which was running on the server, and bringing this code in the front, running in the browser written in JavaScript. This complexity created numerous JS files combines with html and CSS files with no structure. This structure was given by JS Frameworks which have developed to solve this problem.

#### 5.1.1 VueJS framework

VueJS is an open source progressive JS framework for developing web apps. VueJS is created in such a way that the files of Vue can be integrated with any other JavaScript library or combined with backend scripting and frameworks. With core libraries Vue can support a full Web application. VueJS is based in reusable components, each one has his html, CSS, and JavaScript files, which can be set in the page layout.

A basic feature of JS frameworks and VueJS is the automaticity mechanism for updating the DOM and its elements. There are numerous directives and operations which a developer can use, to create interactive web pages and apps. VueJS has implemented loop structures, if statements etc. Core libraries have been developed as well to support different operations. Vuex is a library used to maintain a central core system of functions and variables in a Vue Web App. There is also a router library implemented to support page

navigation. A Vue application when is initialized, creates a Vue instance. This instance has certain life hooks which a programmer must consider, to adjust functions and operations and data changes [63].

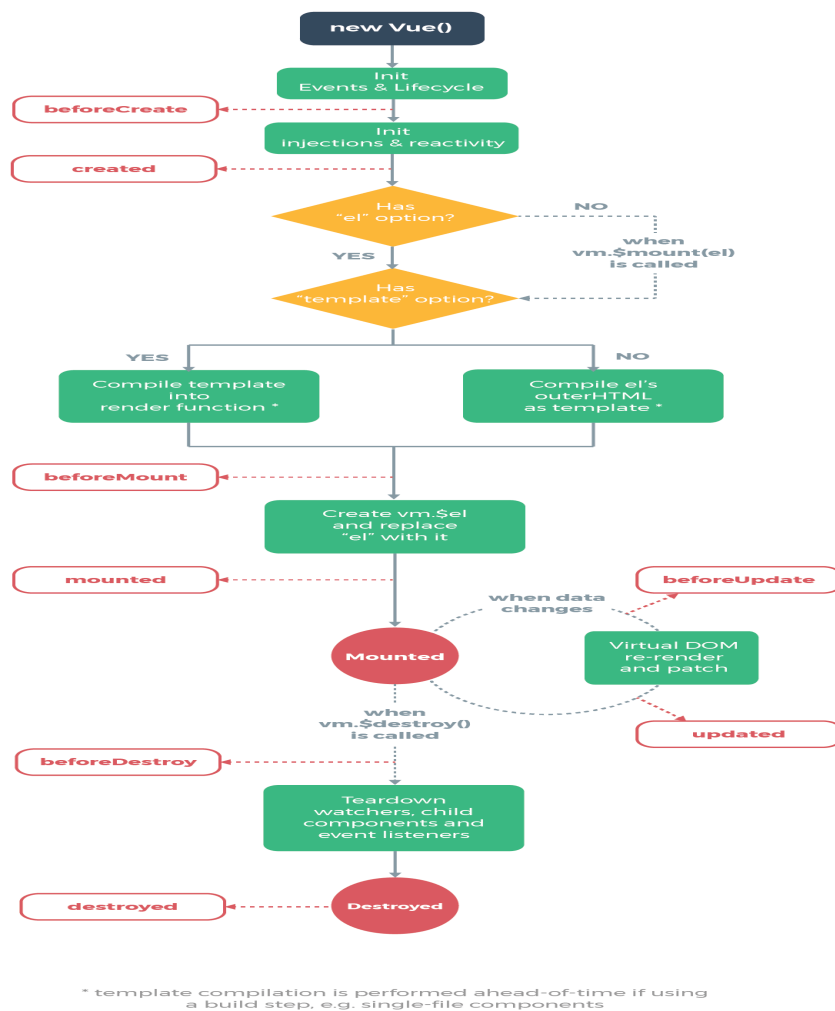


Figure 18. Vue Lifecycle (taken by 63)

### 5.1.2 Angular framework

Angular is another JS framework which is very popular. Angular also is used to develop web apps but is more focused on the procedures and operations of an application. It has multiple mechanisms to support state management, routing etc.

An Angular app is consisted by NgModules which are providing a compilation context for components. Components use services which are files with typescript code. Those services

contain functions that are not related directly with the view of the application. The main NgModule is the AppModule which is responsible for initializing the app. Templates are used to combine the html files with the angular procedure for modification of html elements in the DOM. The following figure presents the architecture of an angular app [64].

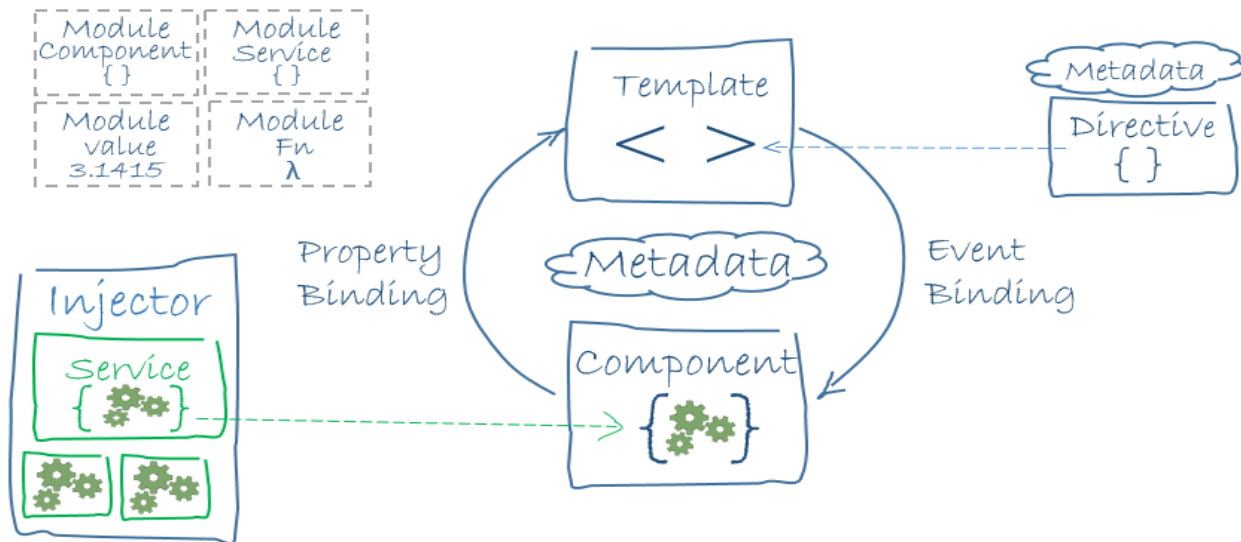


Figure 19. Architecture of an Angular App (taken by 64)

### 5.1.3 Ionic Framework

Ionic is a framework which enable the ability for mobile application deployment, developed with web technologies like html, JavaScript and CSS. Ionic is focused on how the user interface looks like, how the user interact with the app interface.

The structure of an ionic app is consisted by pages. Each page has a typescript file which describes its functionality. Ionic uses Angular framework with NgModules and services to consist the application's logic and html files with ionic components to conclude the app. The navigation between the pages works with the concept of a stack. Every application has a root page, and on this root page the next pages are set above like in a stack. Pages can be pushed and popped.

Cordova is responsible for the rest, for taking angular-typescript code and ionic view and produce an apk [65].

## 5.2 NoSQL Databases

NoSQL databases stands for “Not Only SQL” databases where the relations between data are not in the foreground and the data storage and manipulation is more concerned. NoSQL databases are used for big data analysis and storage, for saving data with no predetermined structure and model. Web 2.0 and the tremendous growth of content and data productivity by user’s activity, the need of highly scalable systems with million users, gave birth to the need for this new type of database [66].

A NoSQL database have some advantages over the typical SQL database with the complex table logic. Those advantages are referring about the efficiency in reading and writing data in high speed, the support of mass storage. Moreover, those types of databases are easily expandable and have a low cost.

The main data models in NoSQL databases are key-value data model, column-oriented database and document database. Key-value refers to a data model with one primary unique key which is associated with the value. Column-oriented database has tables to store and maintain the data, with no table association although. Document database look alike a key-value database but the main advantage is that the data is stored in JSON or XML format [67]. Some popular NoSQL databases are, MongoDB which has been written in C++ and Couchbase, written in C++, C and other languages [68].

## 5.3 Firebase platform

Firebase is a platform with developer’s tools for building apps. Some of the features provided by firebase are “cloud firestore” for storing and syncing data, authentication mechanism, backend functionality, cloud storage and real-time database. Furthermore, there is support for hosting.

Real-time database is a NoSQL database hosted on the platform. Every app uses an instance of this database. It uses the document-model database, where the data is stored as JSON. Real-time synchronization is supported among the client of the app which make use of the

database, so everyone can have access to the data at the same time. With the use of firebase API functionality there is no need for HTTP requests for getting data [69].

## 5.4 Maps

A key element in the implemented system are the map through which a creator design and preview a game, and the map through which a player can navigate. For the needs of this implementation were used two different map's APIs, OpenLayers and Google Maps.

### 5.4.1 OpenLayers

OpenLayers is an open-source library with customizable map layers. Using OpenLayers API a developer can display anything on a map, on certain position, have a coordinate system adjusted to the map image. Several functions, are supporting drawing on the map, taking coordinates in different formats by clicking on the map and much more [70].

The integration of OpenLayers with VueJS was made using VueLayers components library. This library provides an add-on component with a map and implemented functionalities as properties of this component [71].

### 5.4.2 Geo-location API by Google

Through Geo-location API and more specific Maps JavaScript API, an interactive map is embedding in the app. This map is customizable, can be added user's content on it. The zoom of this map can be categorized in levels. In the level one the map is displaying the whole world, in level five is displaying the landmass of a continent and on level ten, fifteen and twenty, cities, streets and buildings [72].

## Chapter 6: The Treasure Hunt System

Chapter 6 is discussing about “Treasure Hunt” system in a case study. Through a scenario system’s functionality is being presented. Each section describes a certain procedure that a user must follow to fully make use of system’s capabilities. The exhibit of a history classroom is designated for this purpose.

### 6.1 Representative scenario for the “Treasure Hunt” System

To illustrate the concepts described so far and to provide insight to our system we will describe a representative scenario emphasizing the main aspects of our system. The reference scenario is summarized in Exhibit 1.

***Exhibit 1:** Mr Kostas is a history teacher at Heraklion of Crete. His city has a Venetian fortification and there are one of the best-preserved fortifications of Europe. Their goal was to protect the coastal city from invaders, fact that is proven by the Siege of Candia that lasted for 21 years (1648–1669) and it is the second longest recorded siege in history. They were first built by the Byzantines although they started being shaped to the way they look today, after the conquest of the city by the Arabs (Saracens) in 824. A full reconstruction of the walls took place after the island of Crete fell into Venetian control in 13th century. The content of Mr Kostas’s first-class lesson is “The Fortification Gates” and includes text, images, videos and URLs. Mr. Kostas want to find an alternative and creative way to enlighten his students with the history of the Fortification of Heraklion. He thought to design a treasure hunt at the walls and through riddle content to achieve the learning goals of the course. Mr. Kostas select to approach the teaching of his class by using the “Treasure Hunt”, an authoring tool for creating location-based treasure hunts, enhanced by mobile technology. He has to use the “Hide a Treasure” web platform to create his game and a play instance of the game. The next day during a school trip the students download the mobile app “Find a treasure”, select the game of Mr. Kostas and participate at the created play instance of the game. Students are divided in four teams. Each team has a leader and every team member take certain duties. Students start the treasure hunt from the starting point and proceed to the next points by solving the riddles. Each riddle demands research and learning material study to be solved. The game ends when all teams solve the last riddle and found the treasure.*

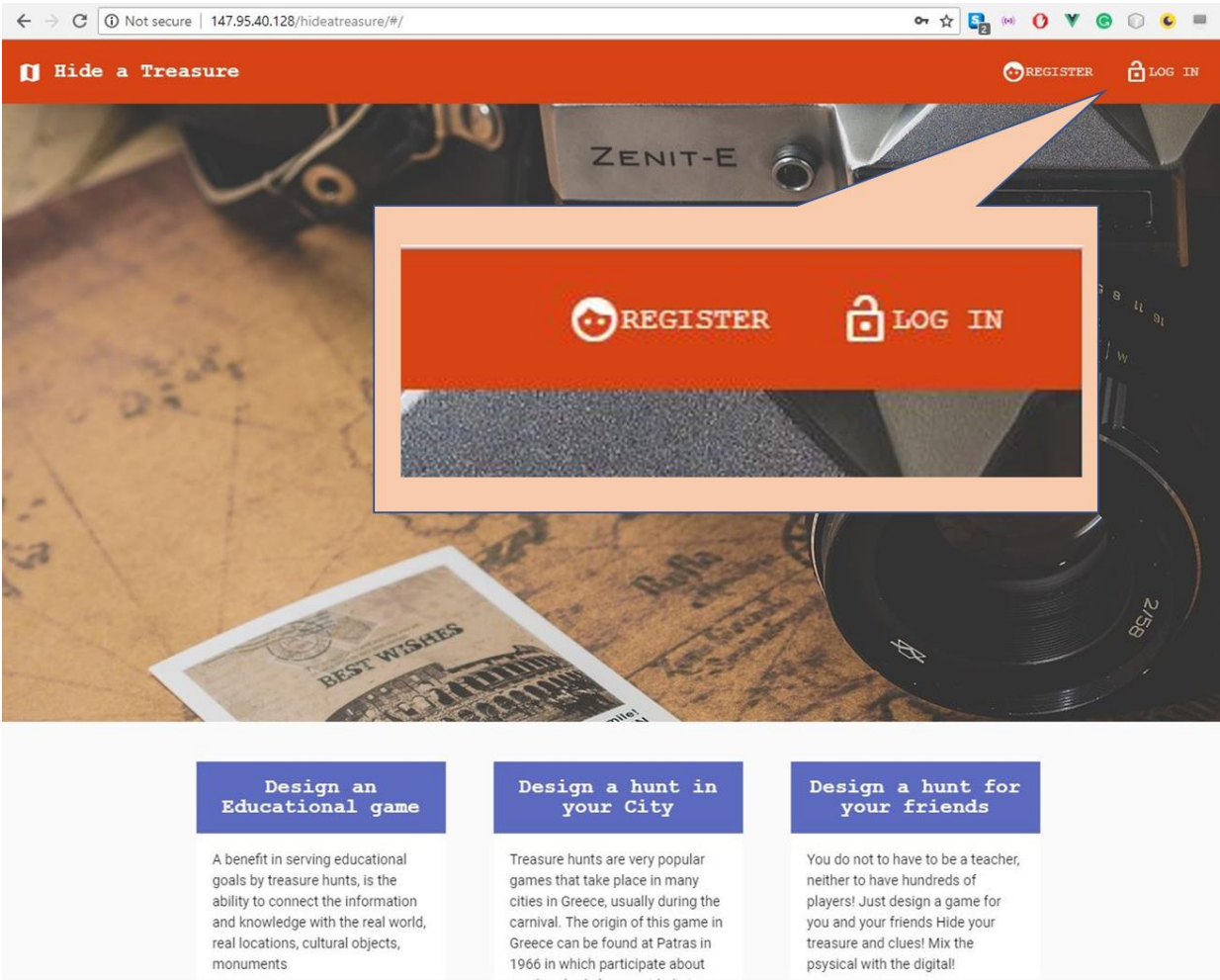


Figure 20. "Hide a Treasure" home page

## 6.2 Register in the "Hide a Treasure"

Registration to the system is a main requirement for every user to proceed. The home page at the web platform has a navigation bar which is set accordingly to the login status of the user. If the user has not been signed in the navigation bar has only two elements which lead the user at a registration form, or at a log in form, as shown in Figure 20. The form of registration requires from the user to insert personal information, as also an e-mail and password which are used for the log in credentials. Figure 21 presents the user interface for the registration and Figure 22 shows the JSON for the users which is stored in the database.



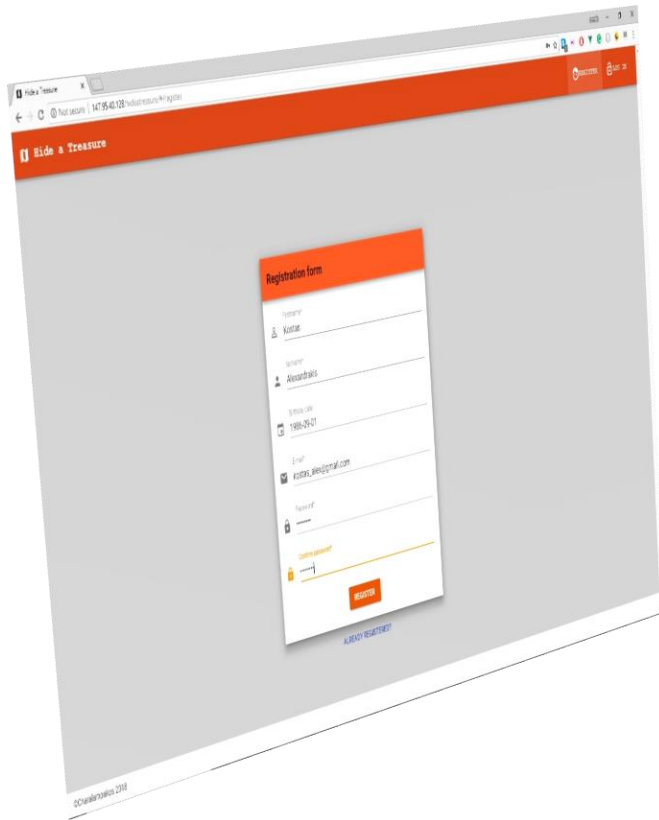


Figure 21. "Hide a treasure" Registration form

```

users
├── -L4Fkbnv7YtJFuEtZ5nT
├── -L4LAMRiwor88ozYV2dK
├── -LFwyNgVAa3Sj4jvZKA7
│   ├── birth: "1989-12-25"
│   ├── email: "papadak@gmail.com"
│   ├── firstname: "Kostas"
│   ├── id: "9DJqqiGKPjNq6y51T4mk5I5fuH"
│   ├── registration_date: "2018-06-26T16:42:24.409"
│   ├── status: "false"
│   └── surname: "Papasakis"
├── -LGyzG4VHMmNcVJxz5b
├── -LKzrunFkNjG4of4yNxP
│   ├── birth: "1990-03-25"
│   ├── email: "orest@nile.com"
│   ├── firstname: "Orestis"
│   ├── id: "0jCqvRuBCNLX7Qh1f8ovNfcmq"
│   ├── registration_date: "2018-08-28T09:31:27.326"
│   ├── status: "false"
│   └── surname: "Charalampakos"
├── -LLTmE050GLqwDgA1PJF
├── -LLU9cY74R0zLGjacRa
└── -LLVkkI58sywaCL2cSVd
  
```

Figure 22. Common Database document for users

When a user is successfully logged in he can use the system functionalities. Navigation bar settle for a logged in user (see upper right corner of Figure 23) and navigation buttons are shown. The round button has the first capital letter of user's e-mail and by clicking it a dropdown menu is presented. The dropdown menu contains to button links, one navigates the user at his profile page, and the second logs the user out.

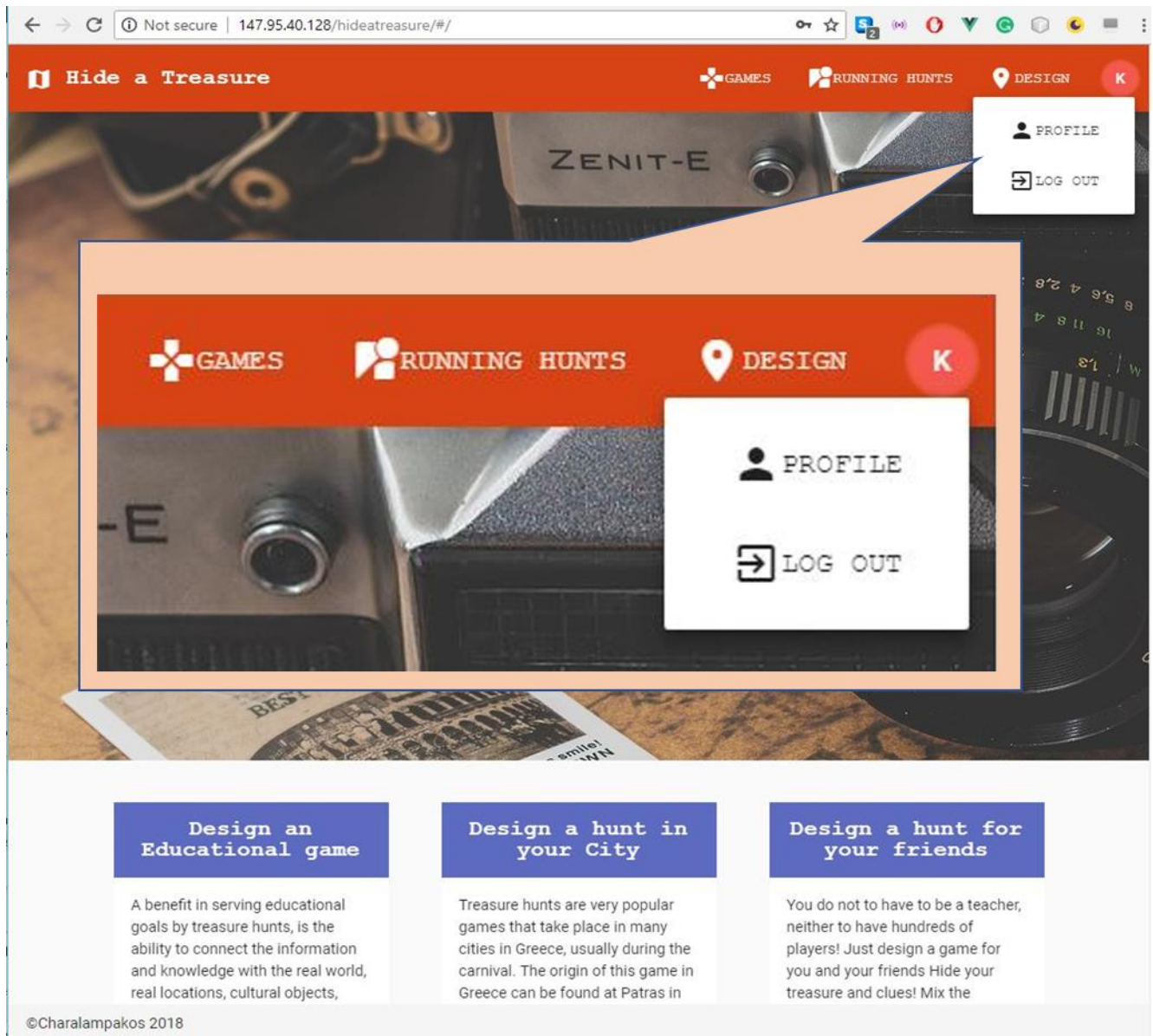


Figure 23. "Hide a Treasure" Home page for logged in user

### 6.3 Sign In, User Profile and log out

During sign in process a new user object is created with the user's data from the database. Every user has a first name, a surname, a birthdate, an e-mail, a status and a registration date. Each user has access to his personal information and profile data through a profile page. When a user selects to log out its user-object is destroyed, and the system returns to the main home page. The Figure 24 presents the described above, profile page.

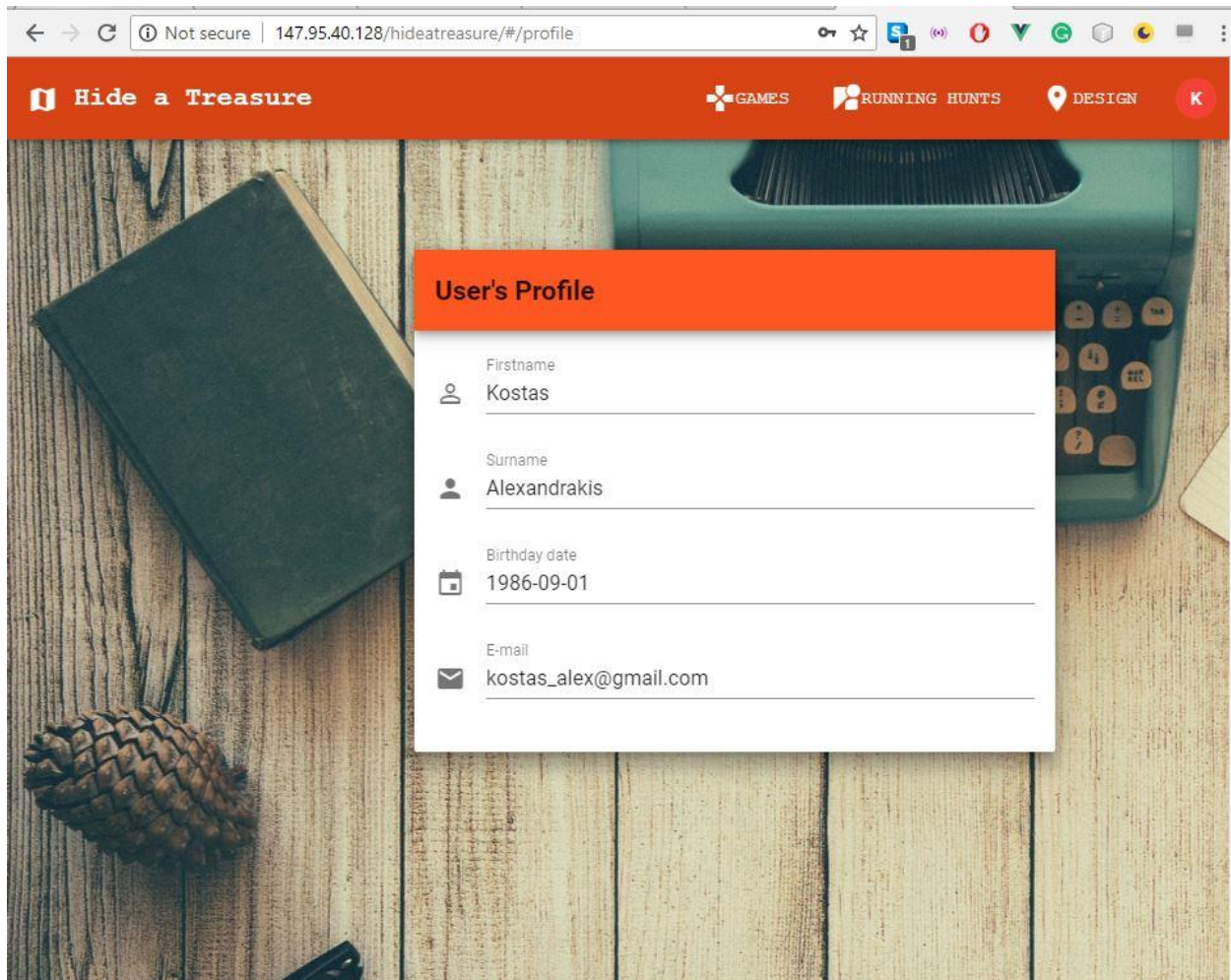


Figure 24. "Hide a Treasure" Profile Page

## 6.4 Design a Treasure hunt

A signed in user can proceed to become a creator by designing a new game. Each creator has a dashboard with his games (Figure 25). A game has two main states, the editing state and the completed-published state. All creator's games are presented in the page "My treasure hunts". Through this interface a creator can (a) create a new game, (b) access an existing game for editing purposes, (c) preview his published games and (d) delete them. When a game is published, it can only be previewed or deleted, and no other change can be applied because any change may affect a running game.

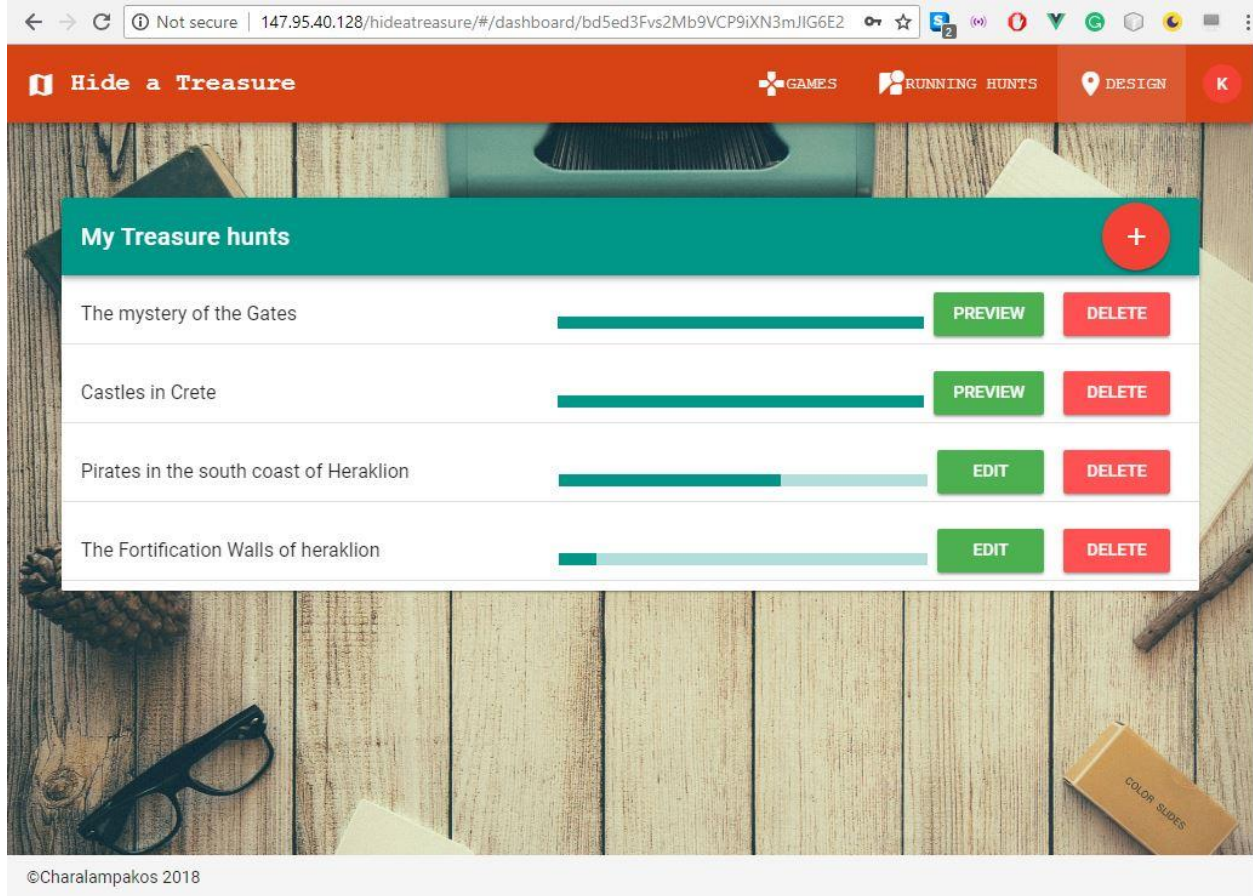


Figure 25. "Hide a Treasure" dashboard

By clicking the button for the creation of a new game, a form is presented (see Figure 26). More specific, the creator must set the desirable name for his game, the country and the province where the game is located. A description text field is also part of this form. The description may contain a small introduction of the game, and some basic hints about his storyline. It is part of the public information of the game that any user can read. Moreover, tags such as "Education", "History", "Tour" etc. are used to categorize the game based on his purpose. The last field requires from the creator to upload an image which will be used as the cover image of the game. The form has action buttons, a "cancel" button which dismiss the form with no other action taken, and a "save" button which save the given data and enables the next steps for editing the game.

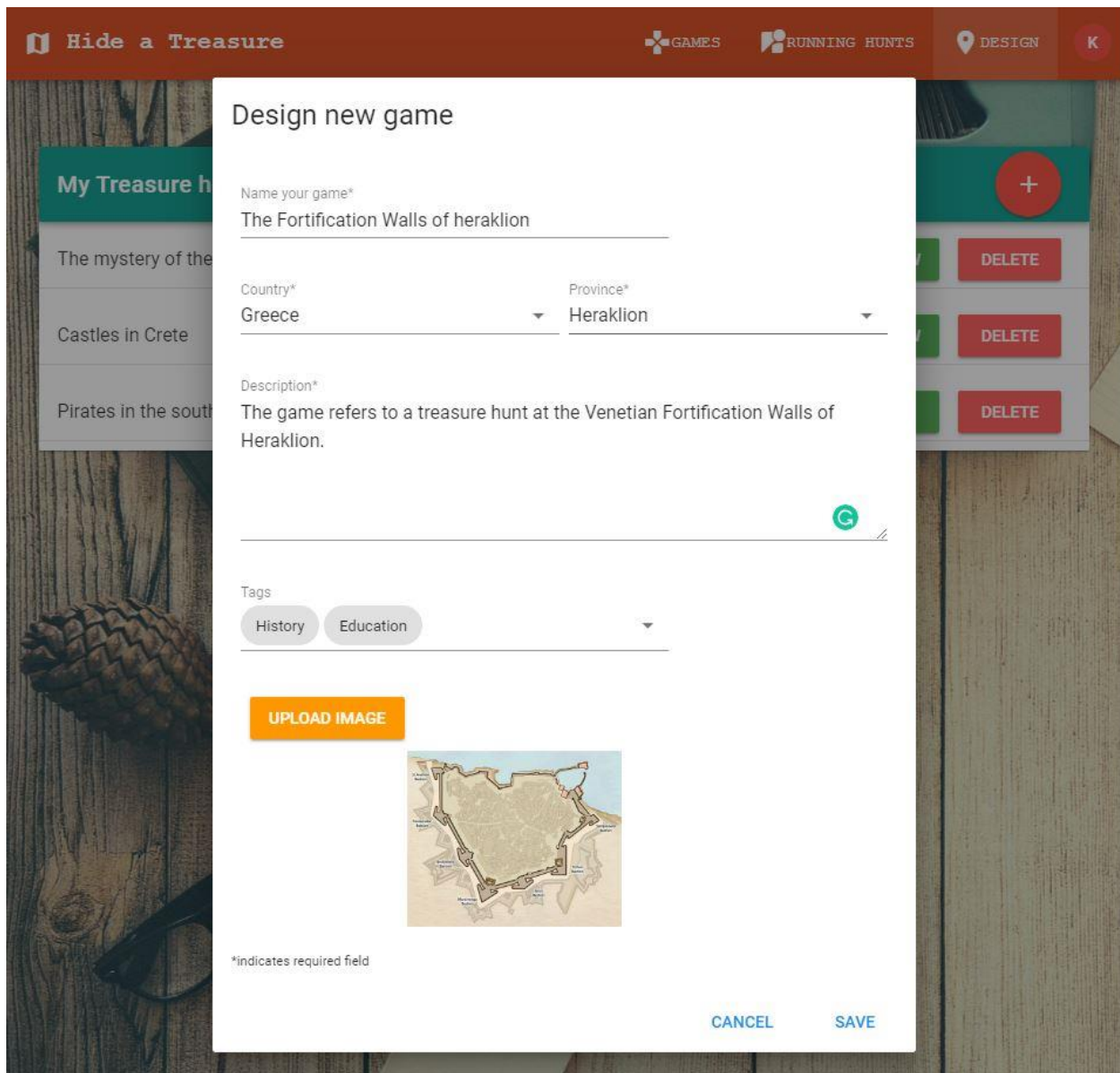


Figure 26. "Hide a Treasure" Create a new game

When the initial form with the basic static game data have been set (see Figure 26), the game creator can proceed to the next creation step which includes the assignment of the game interest points. This game creation step is realized via a "design map" page which provides the creator with an interactive map and a basic toolbar with four buttons namely the Start Point, the Interest Point, the End Point, and Help, each one referring to a different type of point. The point buttons are enabled and disabled accordingly to the game creation workflow with the start-point button to be the only one enabled at first. When the start-

point has been set the buttons of end-point and interest-point are being enabled and the start-point is being disabled. When a creator set an interest-point or an end-point the help-point button is being enabled. Figure 27 presents the sequence in which the buttons are activated.

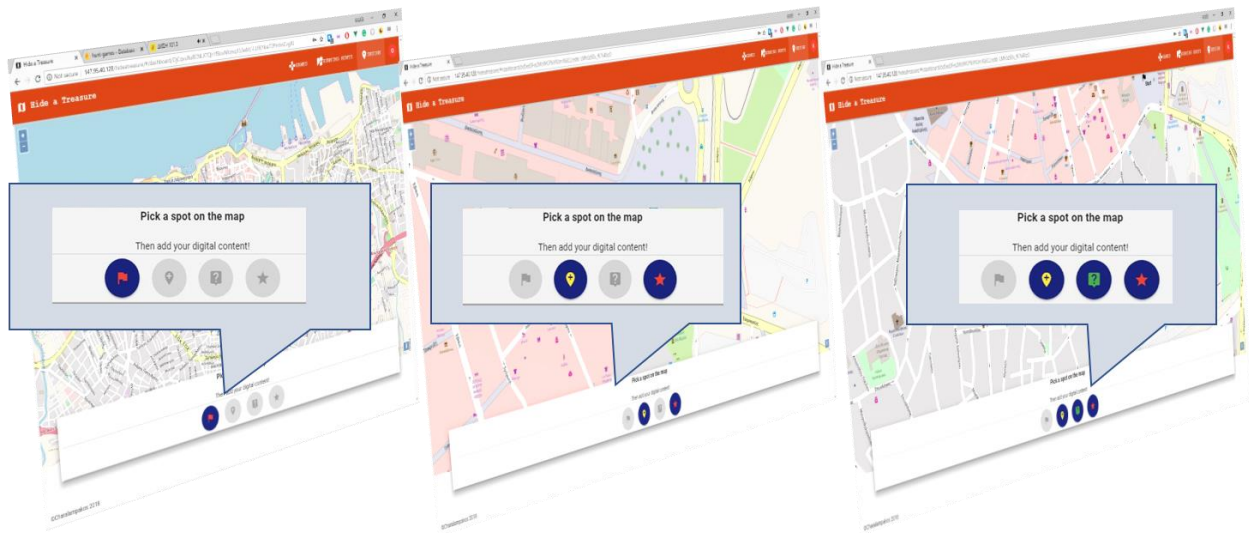


Figure 27. "Hide a Treasure" Design a game toolbar

With a button-point selected the creator can click on the map at his desired location. Then, a form is appeared, in which the creator of the game can set the digital content of the point. The coordinates of the selected spot are taken from the map and passed in the point's form in a read-only field. The point-form has fields accordingly to its type.

Start point is the first point of the game and contain information that give player the appropriate evidence to continue. In the start point's form (see Figure 28), the creator must set a title and a cover image for the specific spot. Moreover, the form contains a text field in which the creator must fill the text of the riddle which leads to the next point of interest. There is optional a field for video or other URL relative to the content. Starting point also has an active range area in which, during the gameplay, its content is being displayed to the players.

Point of interest has a similar form. It also contains a title, a text field with the riddle's text, and an upload image mechanism. Furthermore, like in a starting-point form an optional field refers to URLs, as also an active range area (see Figure 28).

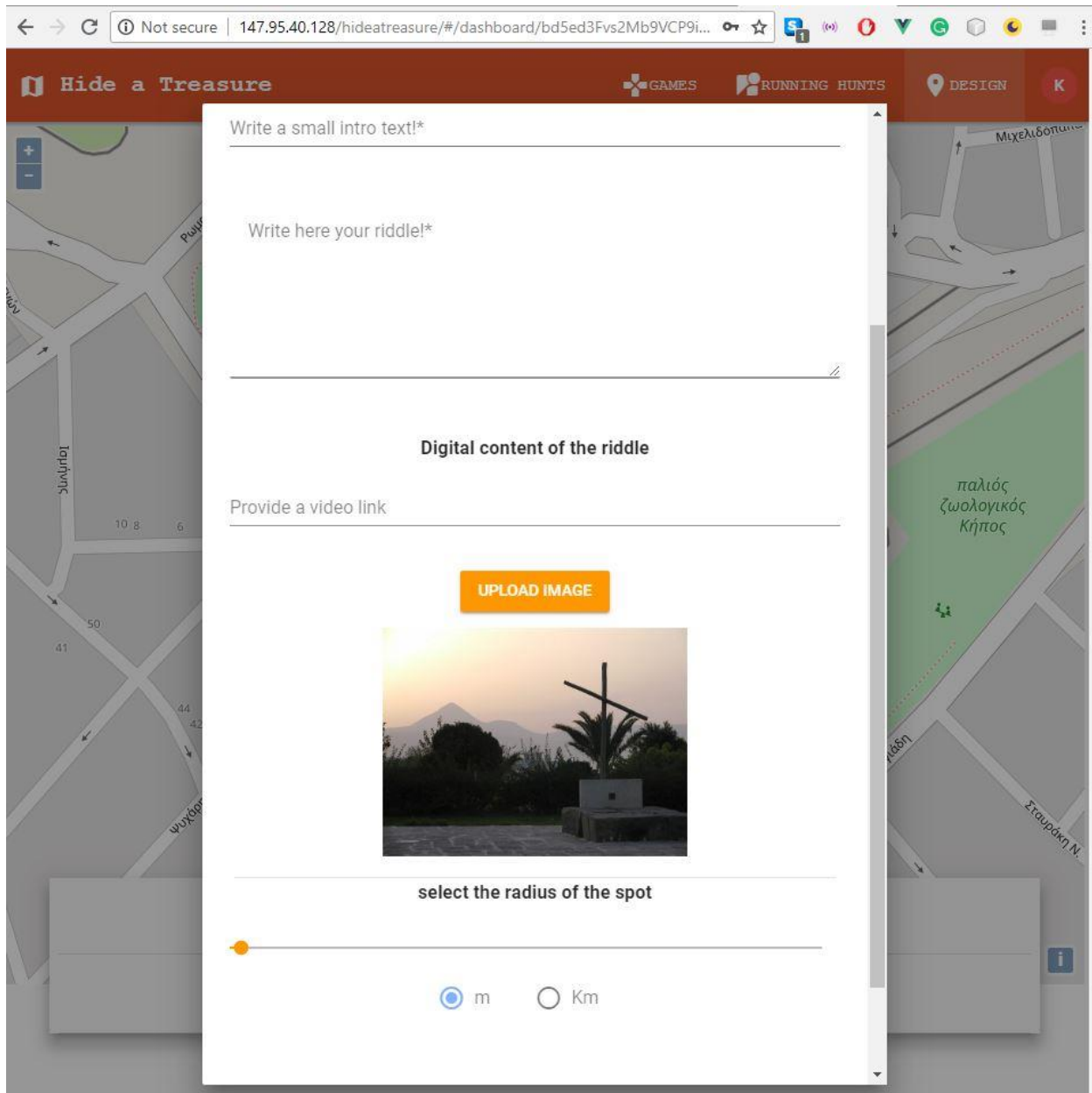


Figure 28. "Hide a Treasure" point's digital content and settings

Points of interest include one more feature, the request of an activity, which contain the selection of setting a question in the certain spot. In Figure 29 a question is set on a specific interest point. The question activity consists of the text of the question, three possible answers and the number of the correct answer. A creator can set as many interest points as he wants without a limitation.

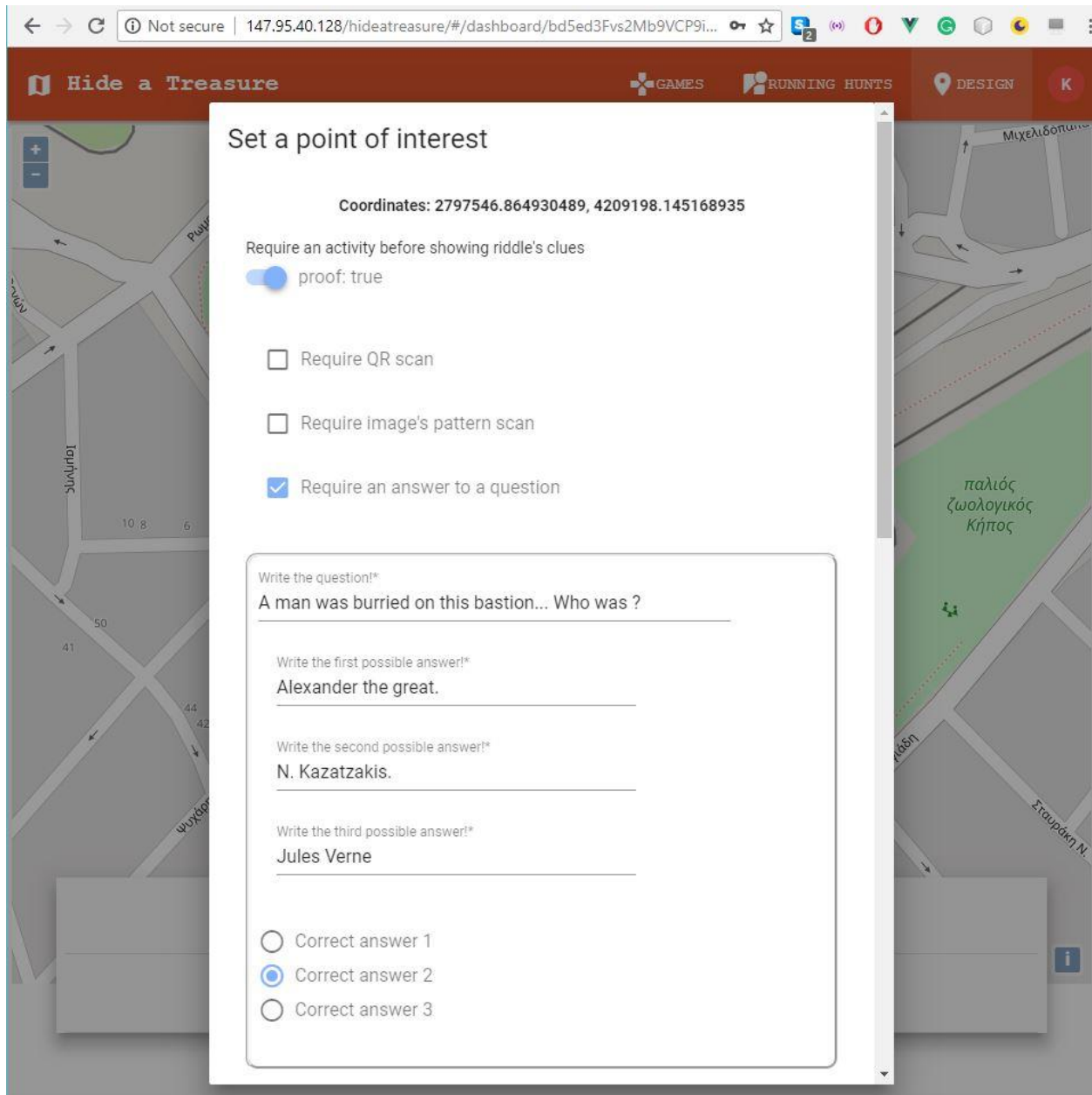


Figure 29. "Hide a Treasure" Setting a question on a point

Help-point refers to a certain interest-point or the end-point. Help point's form has the same fields as the interest point without the option of the activity. The content of the text is differentiated and adapted to the help that the creator wants to provide. Help point form has an extra field which is a dropdown menu with the available spots to associate the help as it is shown in Figure 30. Help points can be unlimited but they have to refer to a specific point of interest, or at the ending point.



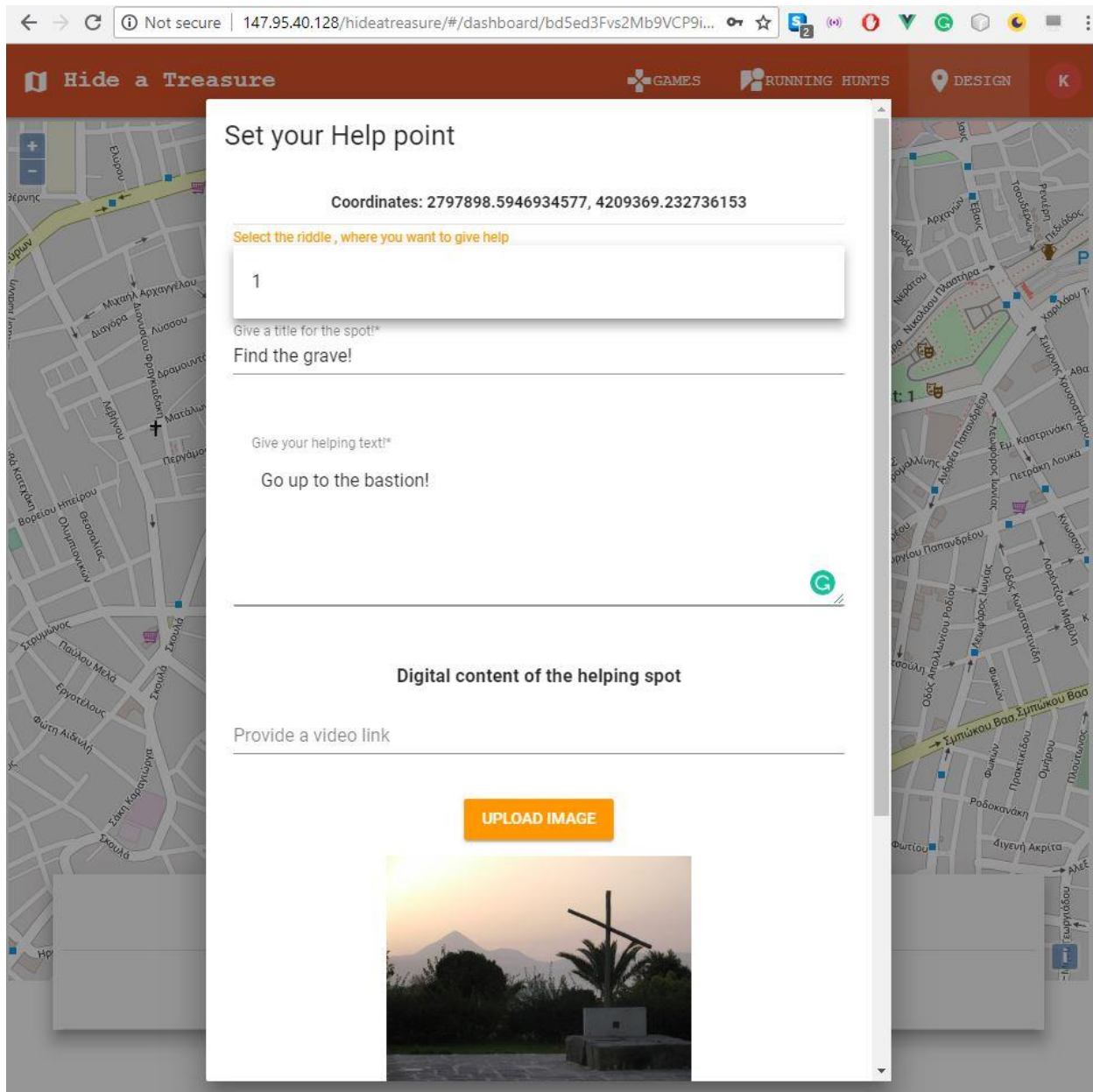


Figure 30. "Hide a Treasure" Set a help point

The end point's form has also the basic structure of every point's form. The text in this occasion is a congratulation and farewell message.

When a point-form is filled, and the creator save the point, a JavaScript object of the certain type is created with the data that the user has entered. Then, the object is pushed in the game's document database. The Figure 31 presents the pushed element in the NoSQL document database.

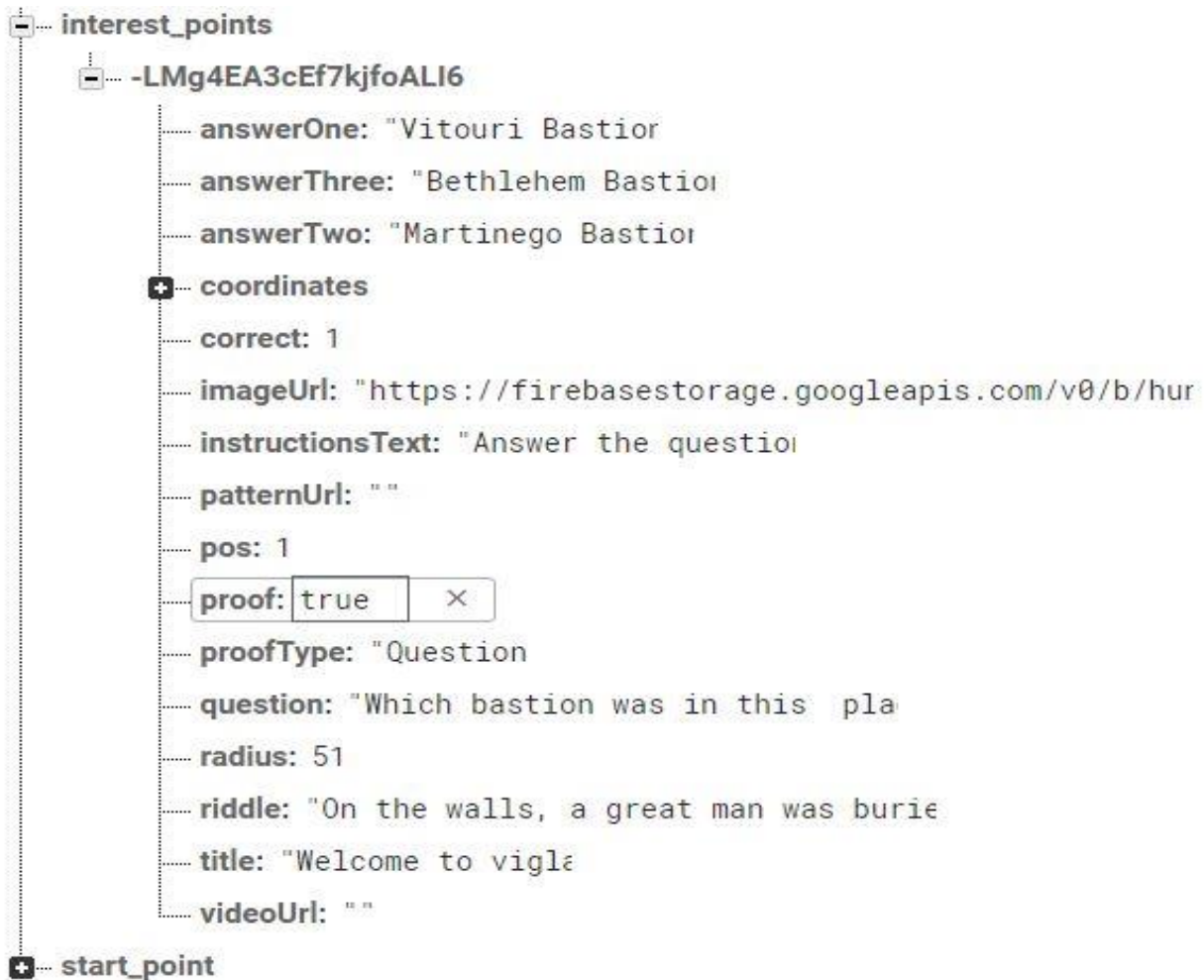


Figure 31. Game Database

The last action that a user can take during editing, is the deletion of a set spot. Every spot that has been set on the map is clickable. When the spot is clicked, an information window pops over with the digital content of the spot, his active range area and a button which deletes it. Figure 32 illustrates the info window of a spot and the delete button.

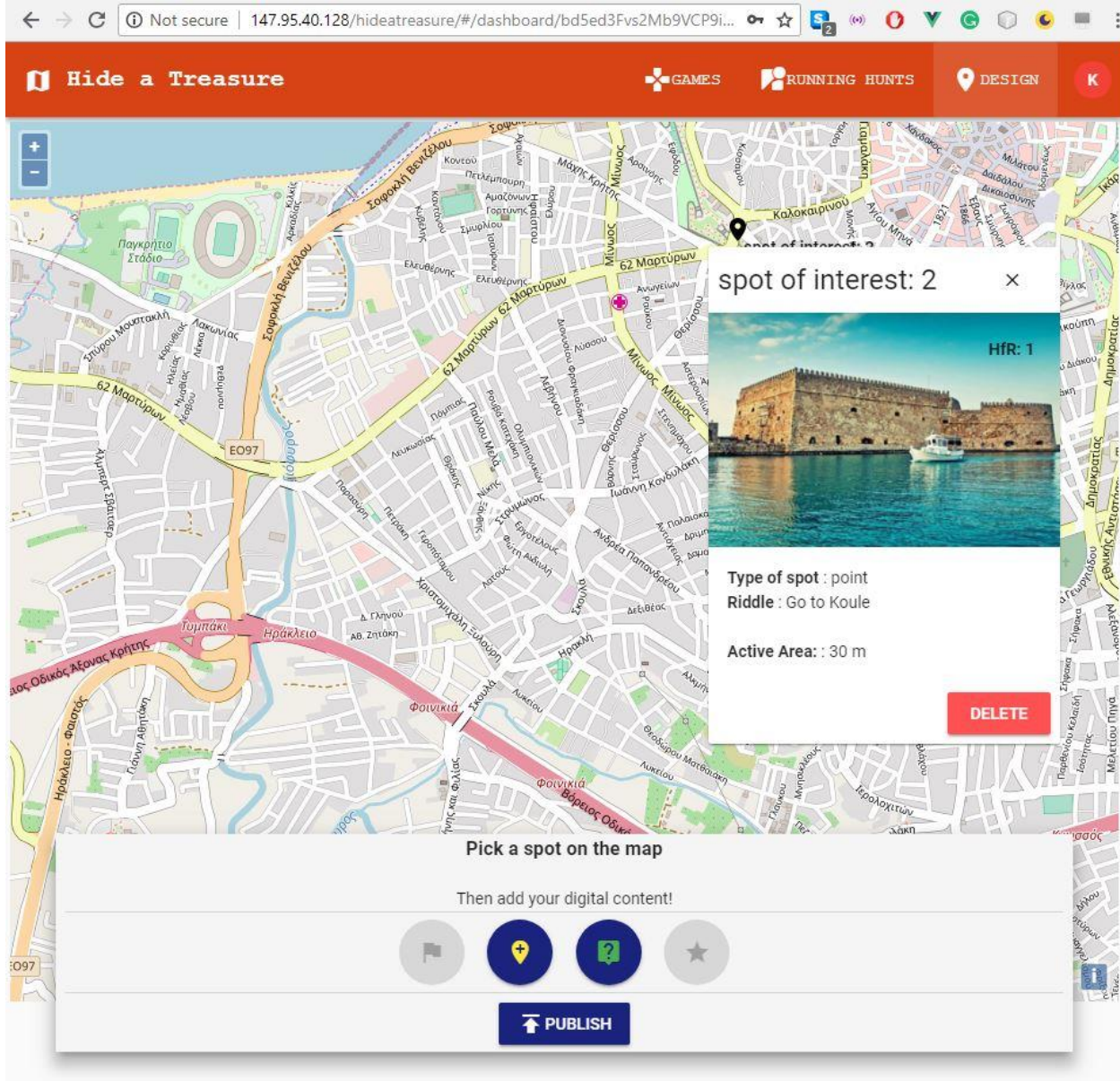


Figure 32. "Hide a Treasure" delete point

When the basic points for a game has been set the publish-button appears (Figure 32, Figure 33). The basic points of a game are a start-point and an end-point. Without those two points a game cannot be published.

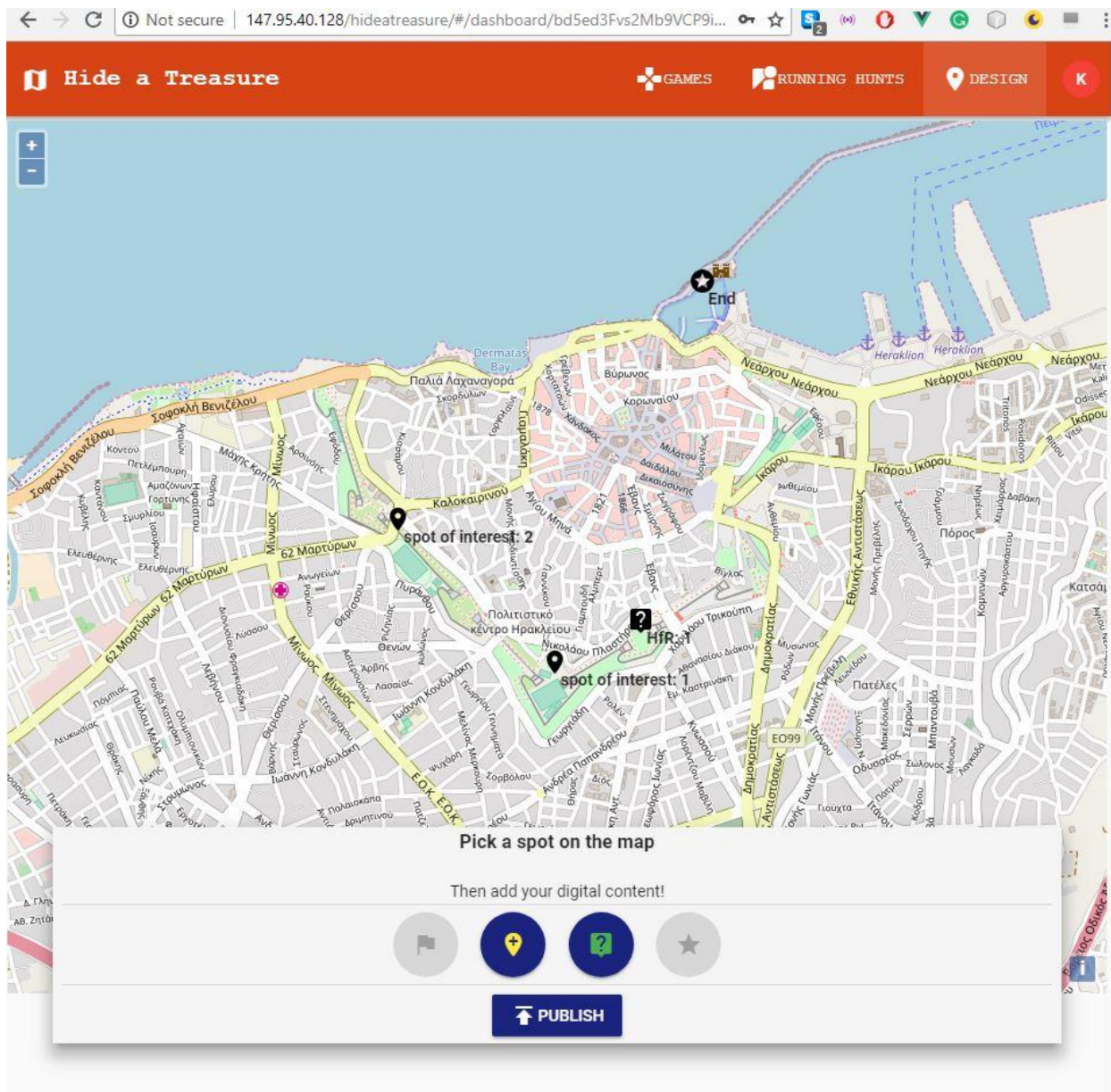


Figure 33. "Hide a Treasure" Design map with publish button enabled

Final settings of the game are presented when the creator hit the publish button. Basic fields in settings are the private or public state of the game and the password, the type of the game and the difficulty (Figure 34).

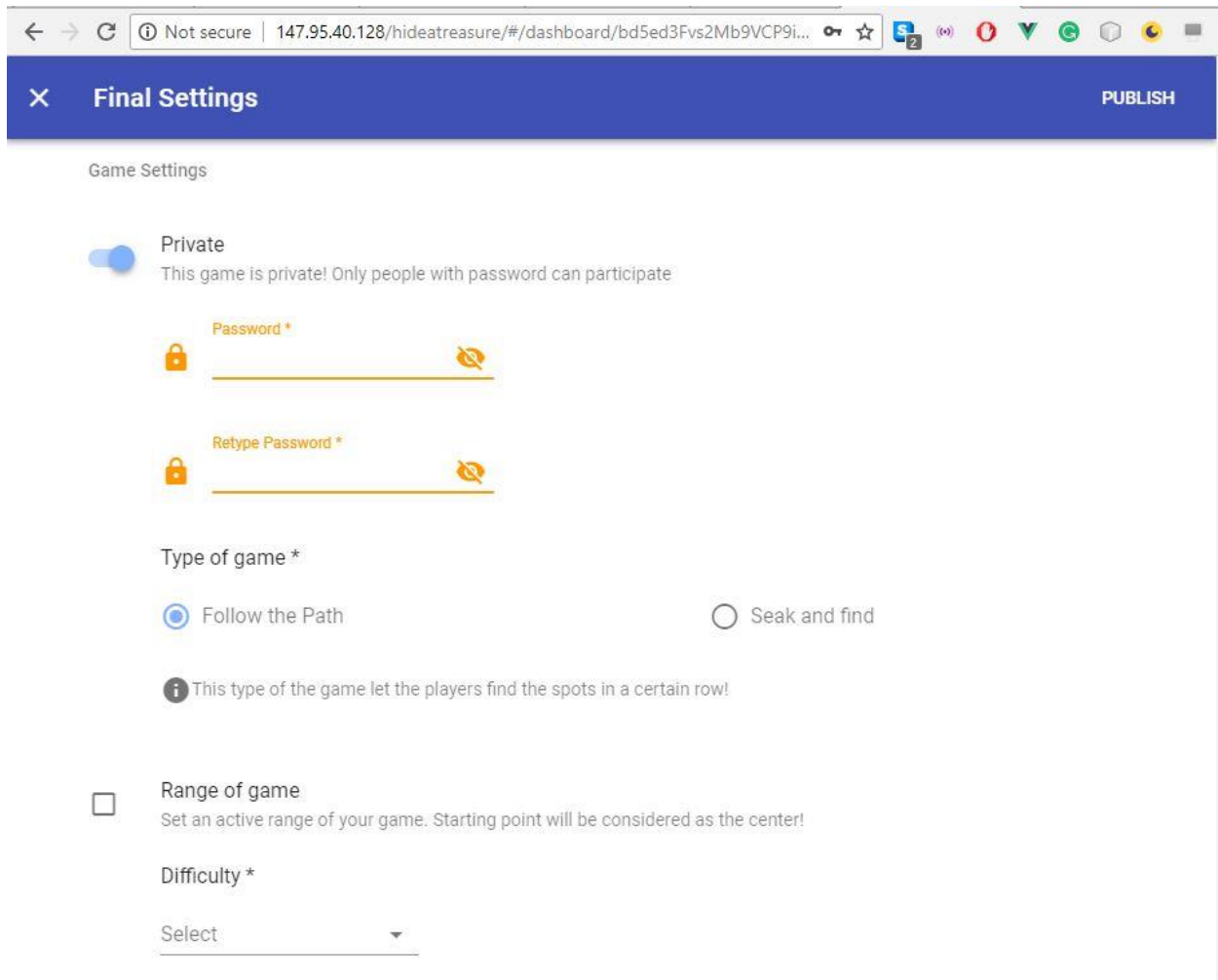


Figure 34. "Hide a Treasure" final Settings

## 6.5 Preview the designed game

When a game is published the creator cannot make any changes. The only procedure with this game is to be previewed. The game is accessible to every user of the web platform, if the game is public, or only to the creator if the game is private. The preview page contains a map with the points of the game. Each point is clickable and when is clicked an information window with point's content, pops up. Furthermore, game's basic information, settings are displayed in the bottom of the page. Figure 35 presents the preview of a published game.

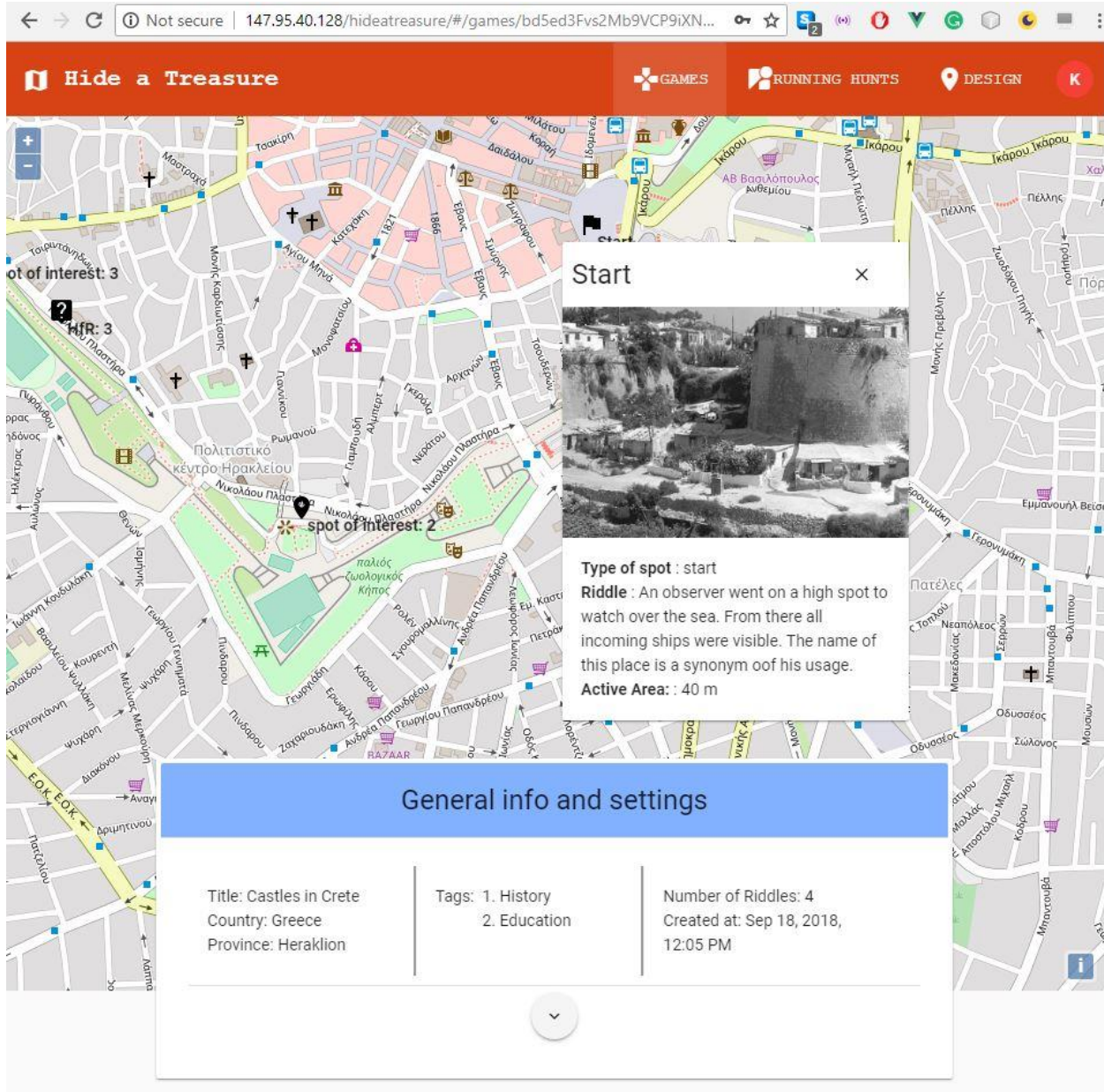


Figure 35. "Hide a Treasure" Preview game

## 6.6 Create an Instance from "Hide a Treasure" component

When a game is created and published an instance can be created. The instance stands for a discrete gameplay. An instance has a name and is uniquely identified by its creator and the time that it was created.

The creation of an instance can be done both from the web platform as well as from the mobile application. The need of creating an instance from both subsystems, stands on the

fact of the easiness at creating a gameplay on site by a smartphone or a tablet for a small group including the creator of the instance and at creating an instance from the web platform with the creator take the role of the observer in a more centralized and crowd game.

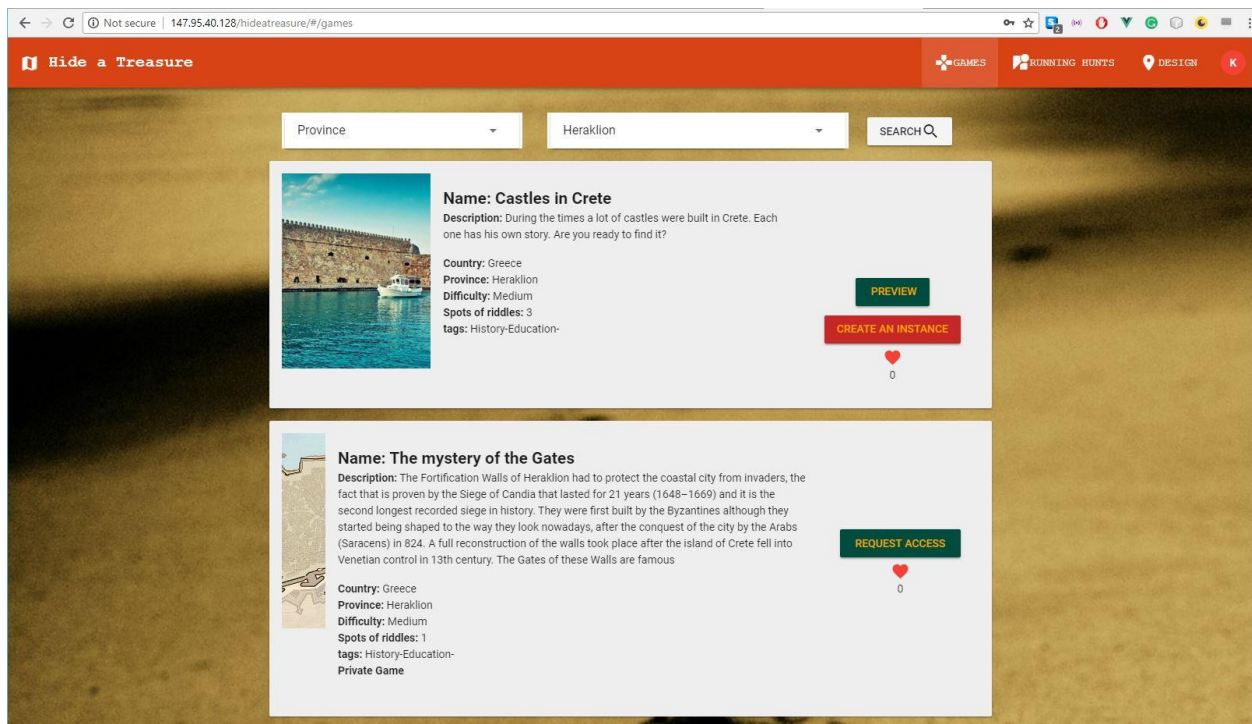


Figure 36. "Hide a Treasure" Published games

Figure 36 presents the interface through a user can create an instance. An instance form is displayed when the user clicks on the button "CREATE AN INSTANCE". In this form, the name of the instance can be filled. An instance can be private so only users with a code can participate. For this purpose, in the form there are the relevant fields (Figure 37).

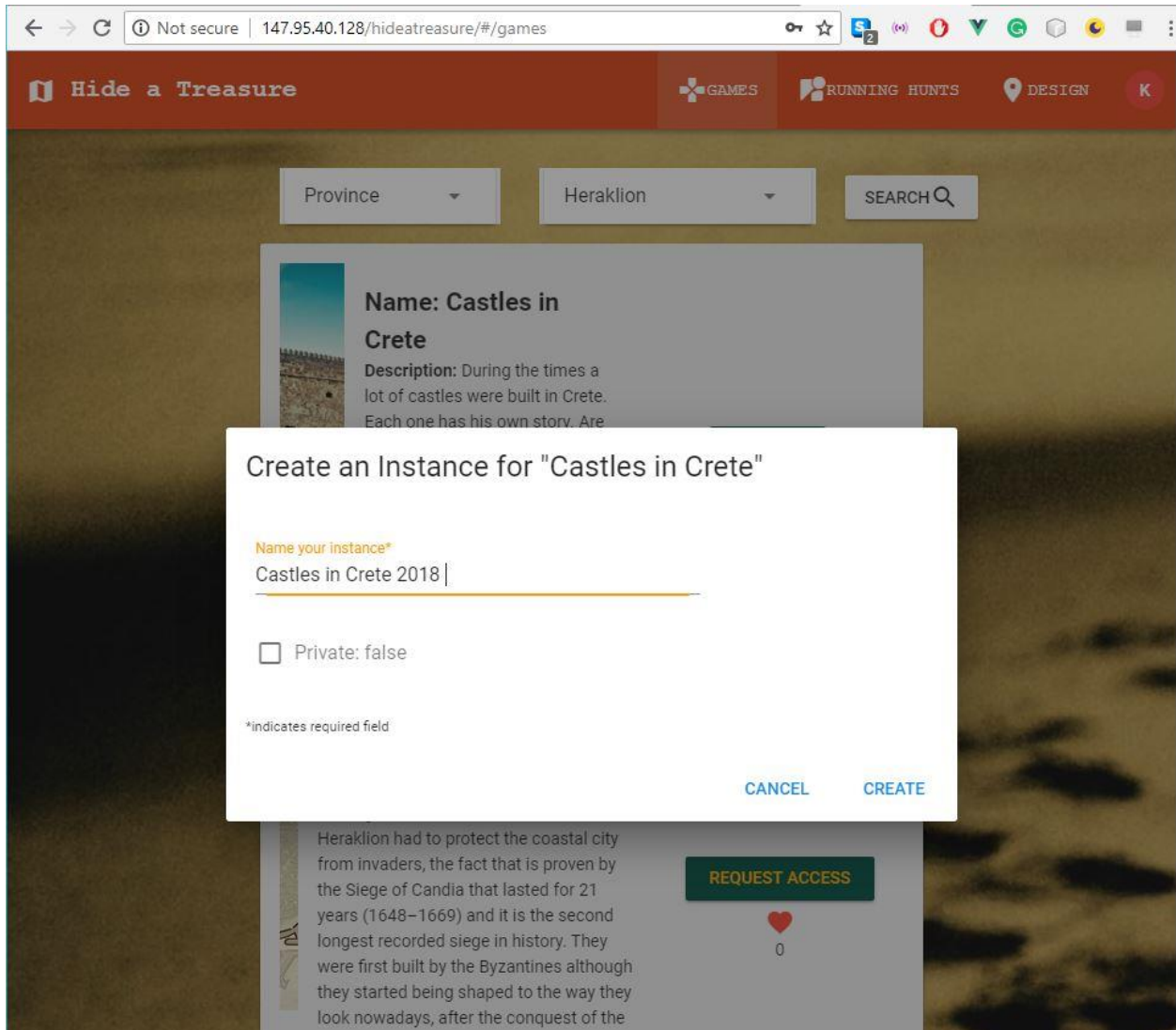


Figure 37. "Hide a Treasure" Create an Instance

## 6.7 Participate in an instance of a game

The designed game can be played through "Find a Treasure" component, a mobile application. The user must be registered and signed in to proceed (Figure 38 & Figure 39). If a user has been registered through the "Hide a Treasure" component, he can use the same credentials to log in.



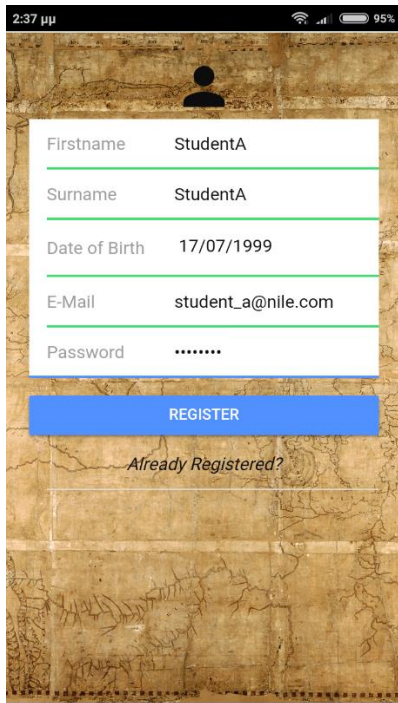


Figure 38. "Find a Treasure" Registration page

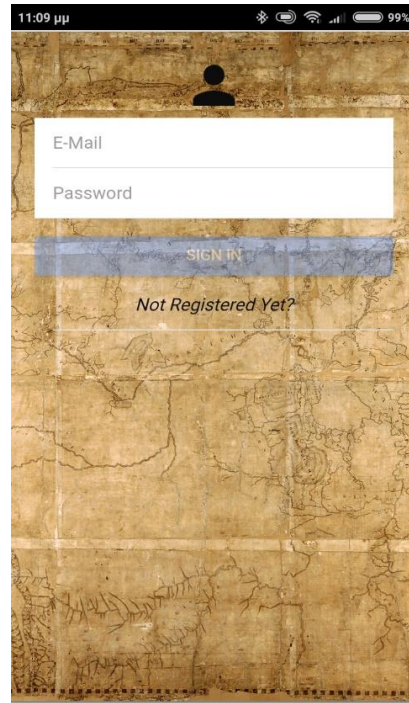


Figure 39. "Find a Treasure" Log in page

When a user register and sign in the application, a presentation of the published games are loaded from the database. The user can navigate through those games, read their description, preview the cover image, see the difficulty level, the number of riddles that consists the game and the relevant tags as it is presented in Figure 40 a & b. By clicking on the "PLAY THE GAME" button the available instances of the game are loaded and displayed on the screen. A user can create a new instance, by clicking on the red button in the bottom right corner or participate on an already created instance (Figure 40 c). An instance can be either public or private. If an instance is private a password will be asked, so the user can participate (Figure 40 d).

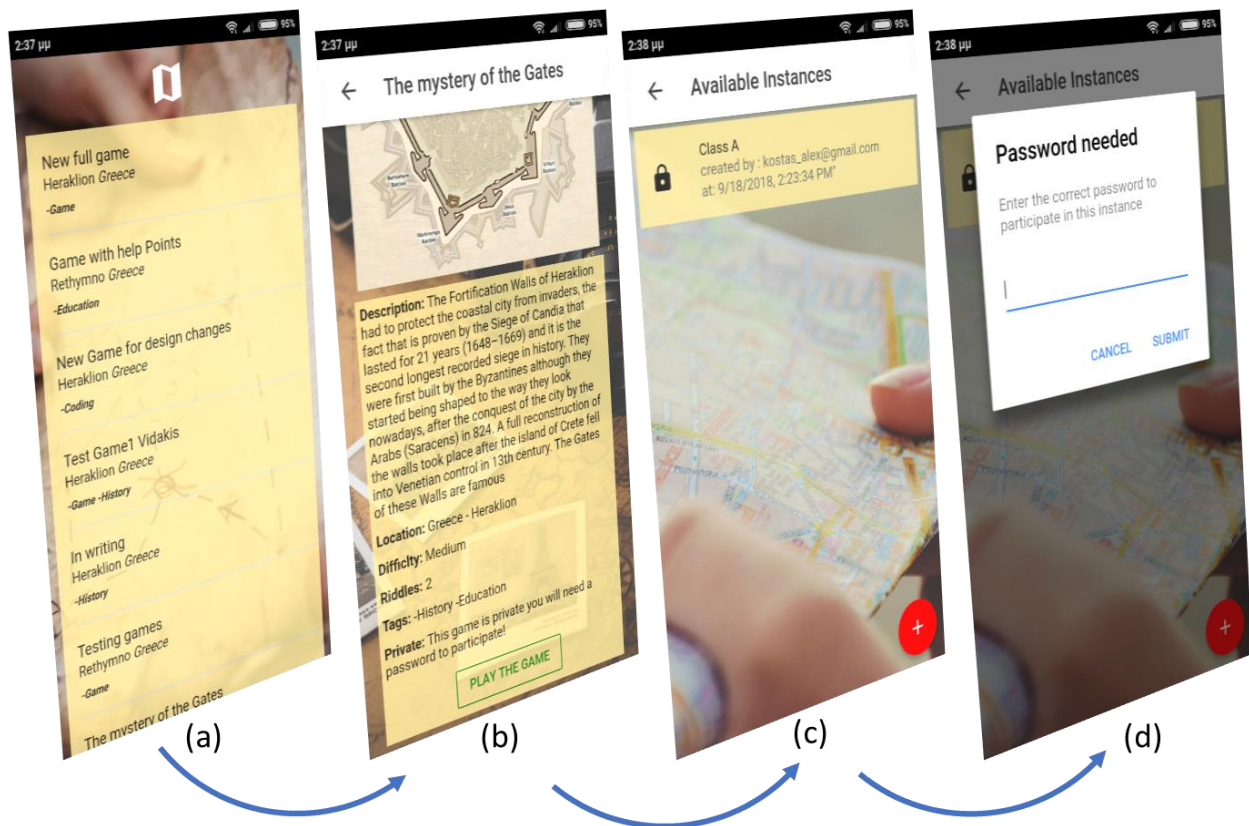


Figure 40. "Find a Treasure" Participate in a game's instance

Another key feature in this implementation is the support of team-gameplay. A team can be created in an instance. The creator of the team becomes simultaneously the team leader. In a team can participate every user who has access in the instance. Each user can participate only in one team. This procedure can be done only from the mobile application.

## 6.8 The Teamply

When a user participates at a game instance the created teams are loaded and presented. If there are no teams created, then the user can click on "CREATE ONE NOW" as it is shown in Figure 41 a. Each team has a name that the creator must fill in the form (Figure 41 b). Besides the name, the team has a leader, which is the participant who created the team and a timestamp with the creation time. Figure 41 c exhibits the created teams in an instance.



Figure 41. "Find a Treasure" Create a team

When a team has already been created a participant can become a member of this team. By selecting a team an alert window pops up with the option of joining the team (Figure 42 a). When the participant joins a team and click again on his team another popup window appears with a start option which enters the player in the gameplay. The described procedure is exposed in Figure 42 b & c.

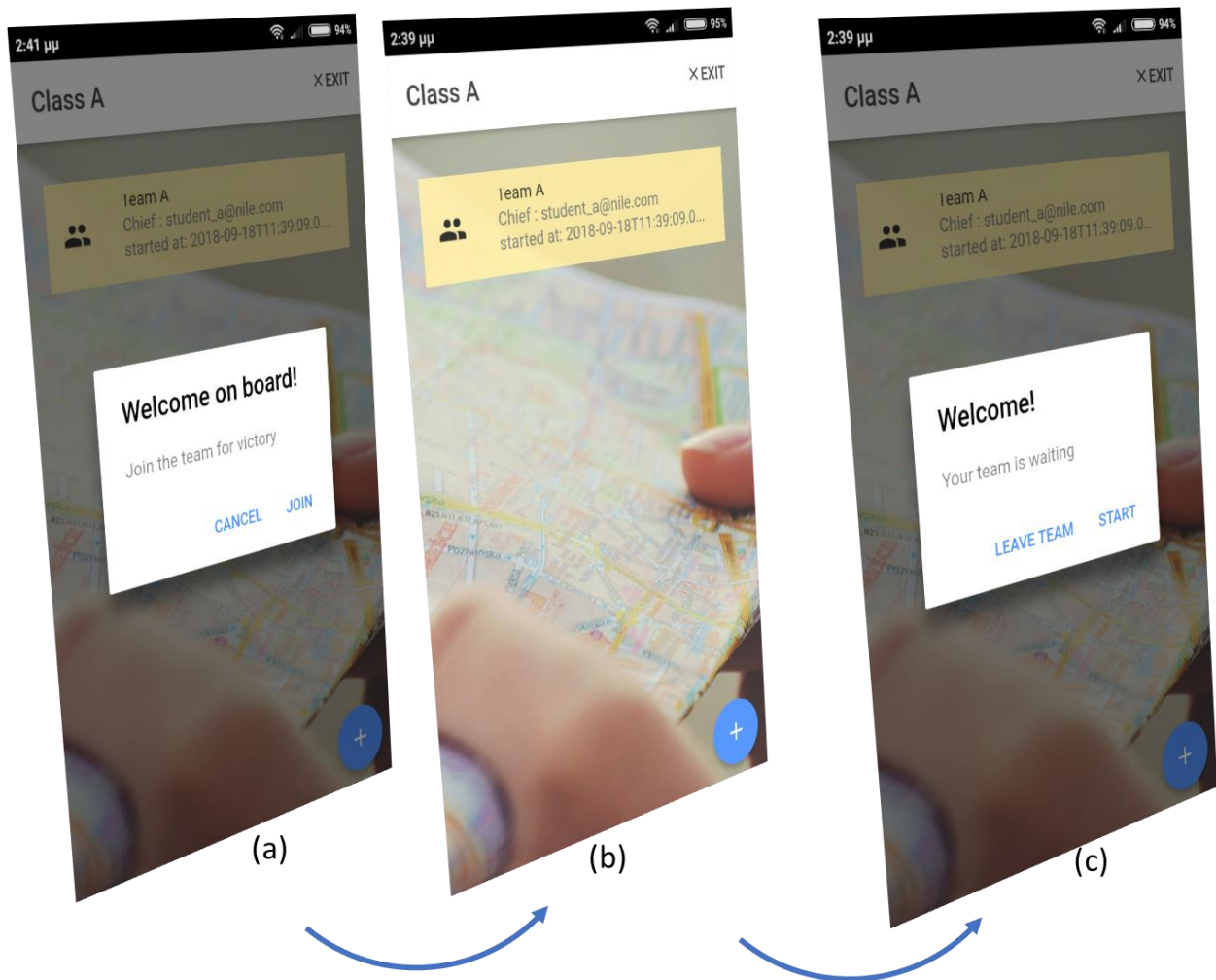


Figure 42. "Find a Treasure" Participate in a team

## 6.9 The Gameplay

The gameplay is displayed in three pages. As the players move around looking for the solution of the riddle, they have those pages for the digital representation of the gameplay. A map, the riddle's content and a chat among teammates are the tools that the app provides as it is shown in Figure 43.

The game's map is used by the players to find the starting point and receive the first riddle. When a new point is founded by a team player, the point is showed on the map with a distinct icon. By clicking on the icon any participant of the team can see information about the player who found the point and the time that it happened (Figure 43 a).

In content's page the digital clues of the riddle are being displayed. Through this page the player can read the riddle's text, see an image, follow a link to a video etc. When a point is being found by anyone in the team, this tab is being activated. Furthermore, this tab contains a top navigation bar which has an exit from the game button (Figure 43 b).

Chat page refers to a page displaying messages among teammates. Behind this page a chatting mechanism is implemented. Every player can send and receive messages by his teammates through this chat page. The send messages are displayed on the right side of the page and the received messages on the left as it is shown in Figure 43 c.

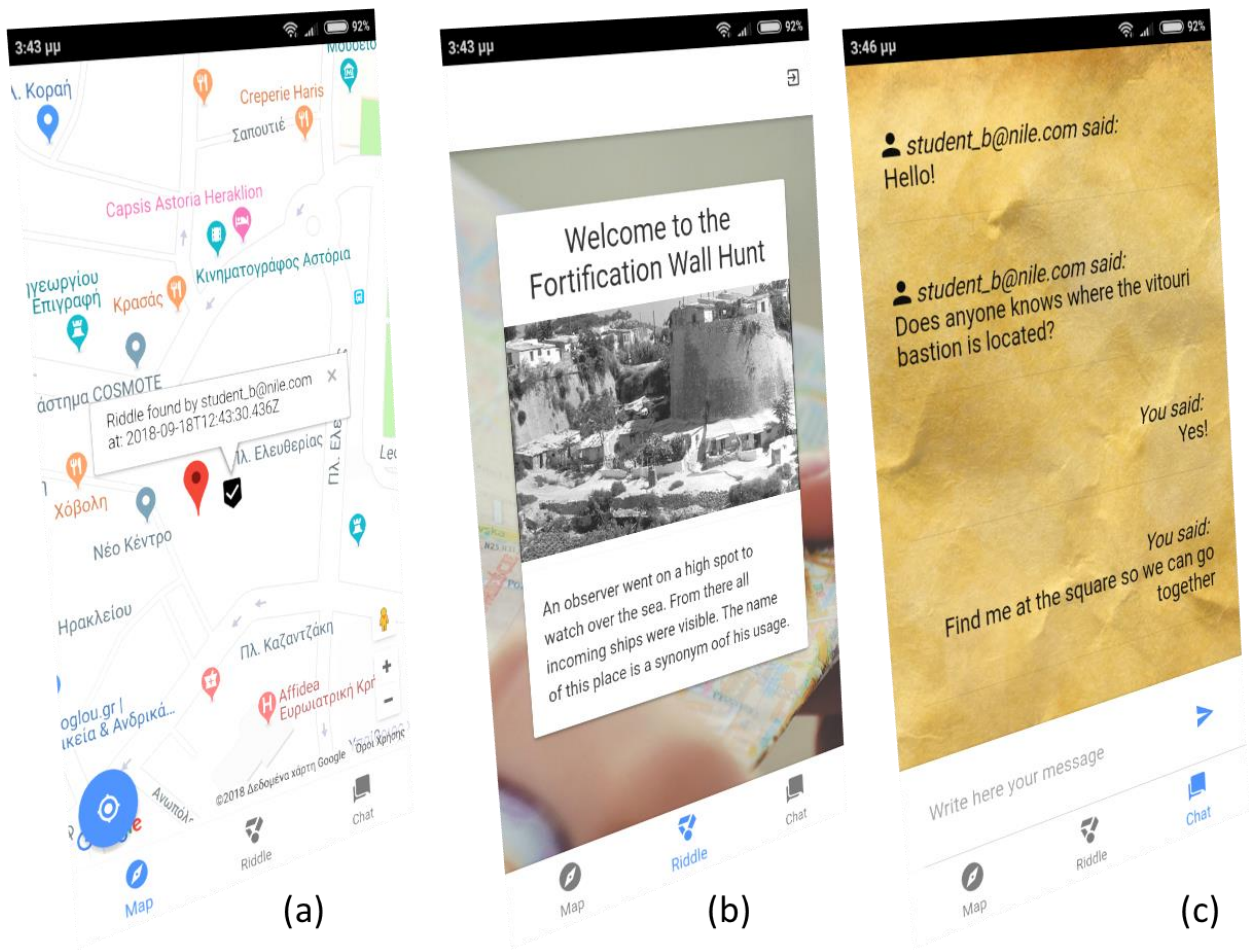


Figure 43. "Find a Treasure" Gameplay pages

## 6.10 Find a spot, answer a question, ask for help

When a player enters an active perimeter of a spot, a modal page notifies the player that he had found a new spot. If the spot has a question the user has to answer it to proceed. A fifteen minutes penalty is the cost of every wrong answer. When the player answer the question correctly can proceed and display the riddles content. The described procedure is displayed in Figure 44.

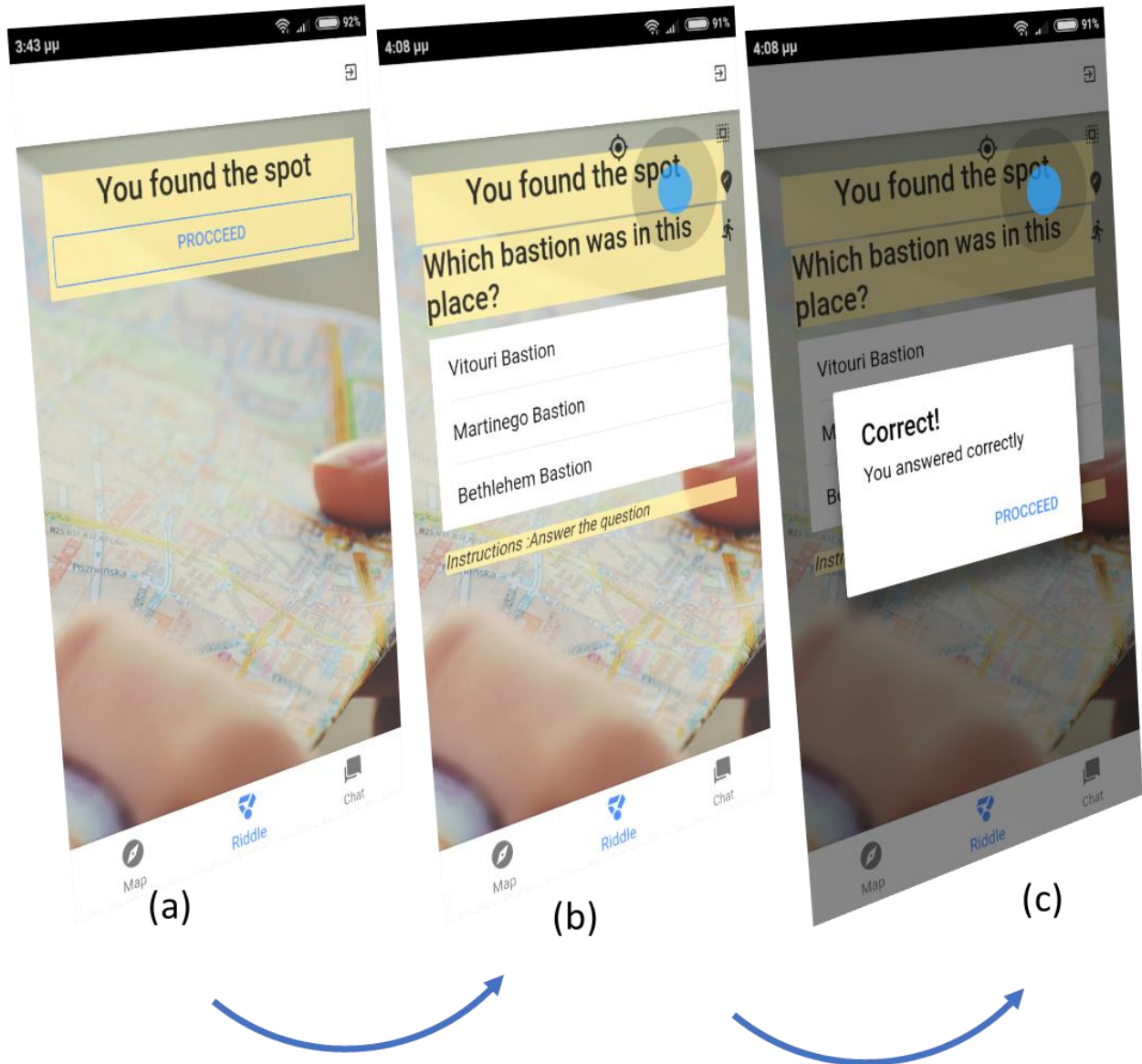


Figure 44. "Find a Treasure" Find a spot with a question

The team leader has one more feature in his map. He can request for help-point and if there is one for the current riddle, it will be shown on the map (Figure 45 a & b). If there is no help-point available for the certain riddle, a popup window appears (Figure 45 c). The use of a help-point cost a fifteen minutes penalty on the team.

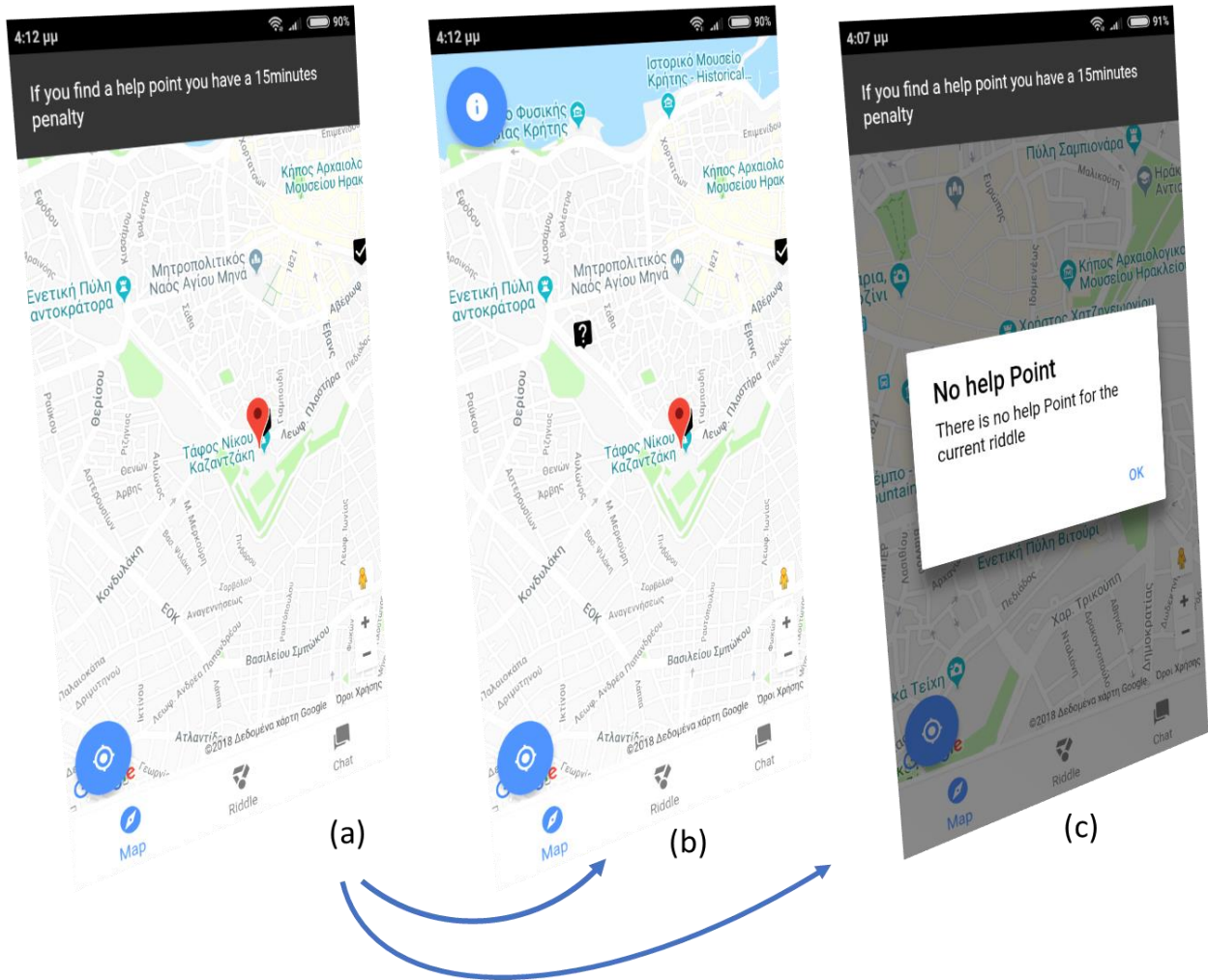


Figure 45. "Find a Treasure" Request for help

## 6.11 Overview of an Instance

The last feature of the presented system is an admin tool for observing the progression of a gameplay. The data which are a subject of observation are divided in three main categories, the instance's generic data, the data produced by a team and the data referring

to a point in the gameplay. Figure 46 presents the user interface in which generic data and team data are displayed.

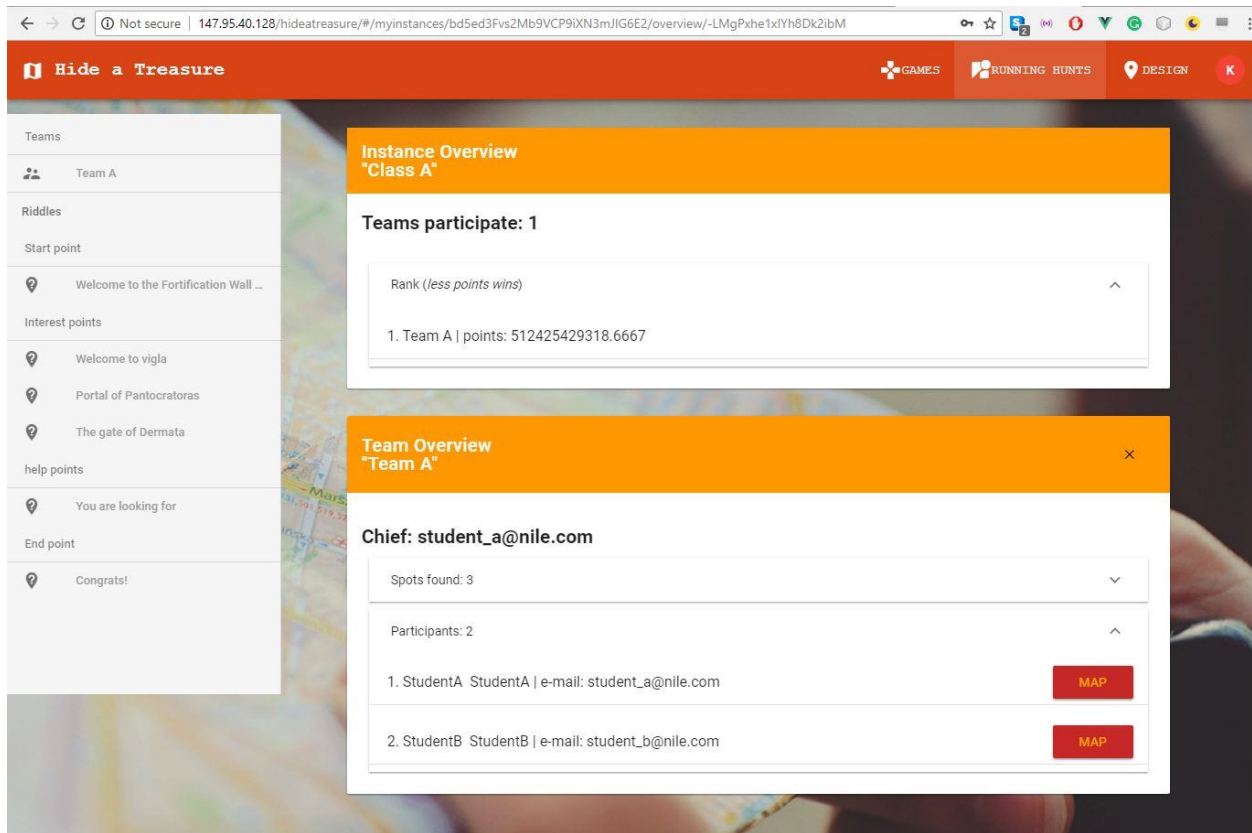


Figure 46. "Hide a Treasure" Instance Overview

Instances data include the number of teams participating, the name of those teams, the points in the instance's game and a rank among the teams participating. The rank is extracted by the time that a team found a point and which point was that in the points' sequence.

Team's data has the participants' information, logs of their position and the founded spots by the team. By selecting the map of a player, a dialogue with a map is presented with markers pinned in places that the player has been to. When a marker is clicked, an info window with the time that the player was there, pops up (see Figure 47).



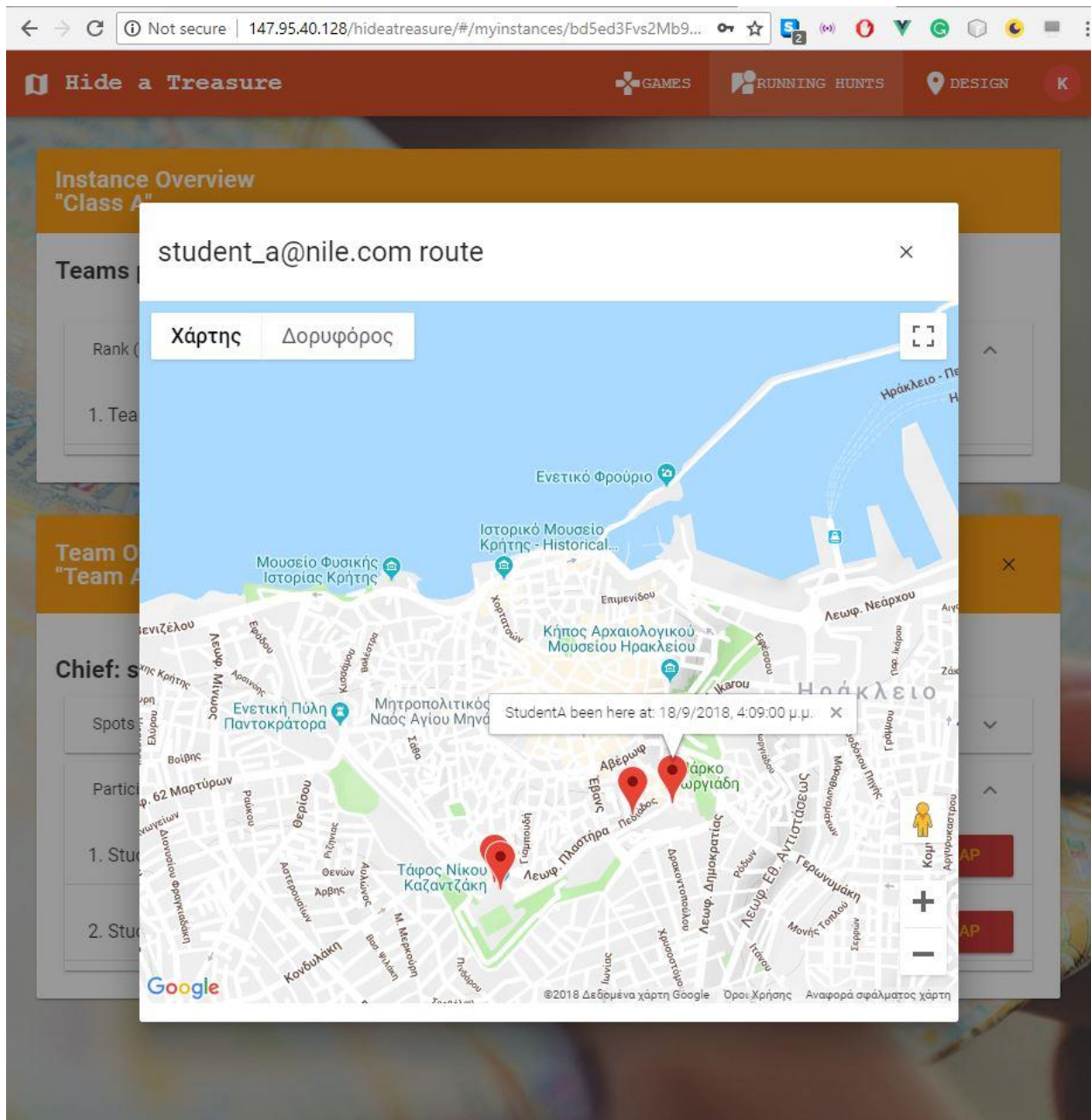


Figure 47. "Hide a Treasure" Player's route

Point's data contain the digital content of the spot and the teams that have found it. Those data are categorized and visualized (Figure 48).

Hide a Treasure

GAMES RUNNING HUNTS DESIGN K

Teams

Team A

Riddles

Start point

Welcome to the Fortification Wall ...

Interest points

Welcome to vigla

Portal of Pantocratoras

The gate of Dermata

help points

You are looking for

End point

Congrats!


### Instance Overview "Class A"

Teams participate: 1

Rank (*less points wins*)

1. Team A | points: 512425429318.6667

### Spot Overview "Welcome to vigla"



Spot content

Title: Welcome to vigla  
Riddle: On the walls, a great man was buried!

Figure 48. "Hide a treasure" Point's overview

## Chapter 7: Conclusions

The subject of this dissertation as it was described in the previous chapters is to present an authoring tool for location-based treasure hunts.

The basic argument of the thesis refers at the condition of minimizing the difficulty of a non-expert user in designing and developing treasure hunt through the presented authoring tool. The case study that is presented in chapter 6 try to demonstrate the easiness of the technical aspects of designing a game. Leaving aside the technical issues of a treasure hunt game development using mobile devices, we can focus at the learning structure, aspects and content of a game. Teachers and non-experts can use this tool to create rich in content treasure hunts with high learning qualities.

The second argument of the thesis is to search the impact of the mobile app implementation and the medium through which a learner or a simple player can participate in a game. Team support and collaborative tools like chat, enables participant's motivation in the game and increases the integration of a player with the activities provided by the game. The Treasure Hunt system as a completed authoring tool for location-based treasure hunts fulfill those requirements. Furthermore, it provides an admin tool for overviewing the gameplay's procedure, extract from this overview data about the players, their behavior in the game.

### 7.1 Future work

More extensive experiments should be done in order to further define the impact of using the described system. Future work should focus on testing the implemented tool in various groups of people and extracting conclusions about the engaging affect and the affect in the learning procedure.

Moreover, there are many areas of this work that can be upgraded and reconfigured. Augmented reality is an importance feature in location-based-games that this tool does not support. Adding a component which can support augmented reality features can increase system's functionality and importance.

Another upgrade can be done by implementing more activities at the points of interest. Digital activities, integrating with other games and tasks can be some of those other activities that are not yet supported.

At last, a gap that can be filled has to do with the analytics that are being produced by the gameplay. Learning analytics and the use of x-API protocol for in-game learning analytics can be added in the system to support this feature.

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