NOVA SCHOOL OF SCIENCE & TECHNOLOGY

DEPARTMENT OF COMPUTER SCIENCE

RICARDO LUÍS MONTEIRO PINTO

Bachelor in Computer Science

WEB OF STORIES
WEB AUTHORING PLATFORM FOR INTERACTIVE NARRATIVES

MASTER IN COMPUTER SCIENCE AND ENGINEERING

NOVA University Lisbon
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Web of Stories Web Authoring Platform For Interactive Narratives

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Abstract

Every place in this world has an identity that manifests itself through history, traditions, and culture. The way each locality has developed, its origin, and the stories people tell end up unifying the community. It is important to preserve the history, traditions and culture of each place.

This work involves the development of an authoring and content management tool that allows the creation of interactive narratives to be explored through a web application. These interactive narratives will contain pieces of knowledge and culture pertaining to the place it corresponds to.

Therefore the Web of Stories project was created. This project is divided into two components (web and mobile). The web component involves the creation and development of an authoring tool that allows the creation of interactive narratives in the form of itineraries that can be visited, as well as managing its contents. This means it involves the development of a web application, backoffice, database and a support server. This thesis focuses on web component.

This work was evaluated through a series of user tests, in order to assess its performance and the quality of each component in the created system.

Keywords: authoring tool, interactive narratives, storytelling, gamification, culture, web interface

Resumo

Cada lugar neste mundo, tem uma identidade que se manifesta através da história, tradições, e cultura. A forma como cada localidade se desenvolveu, a sua origem, e as histórias que as pessoas contam acabam por unificar a comunidade. É importante preservar a história, as tradições e a cultura de cada lugar.

Este trabalho envolve o desenvolvimento de uma ferramenta de authoring e gestão de conteúdos que permite a criação de narrativas interactivas a serem exploradas através de uma aplicação web. Estas narrativas interactivas contêm pedaços de conhecimento e cultura relativos ao lugar a que corresponde.

Por este motivo foi criado o projecto Web of Stories. Este projecto está dividido em duas componentes (web e móvel). A componente web envolve a criação e desenvolvimento de uma ferramenta de authoring que permite a criação de narrativas interactivas sob a forma de itinerários que podem ser visitados, bem como a gestão dos seus conteúdos. Isto significa que envolve o desenvolvimento de uma aplicação web, backoffice, base de dados e um servidor de apoio. Esta tese centra-se na componente web.

Este trabalho foi avaliado através de uma série de testes de utilizador, a fim de avaliar o seu desempenho e a qualidade de cada componente do sistema criado.

Palavras-chave: ferramenta de autoria, narrativas interativas, storytelling, gamificação, cultura, interface web

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Acronyms

API Application Programming Interface *(pp. 11, 42, 46)*

AR Augmented Reality *(pp. vii, 1–4, 7–10, 14, 15, 19, 20, 22, 45, 46, 52, 61)*

CHESS Cultural Heritage Experiences through Socio-personal interactions and Storytelling *(p. 11)*

CRUD Create, Read, Update, Delete *(pp. 41–43)*

CSS Cascading Style Sheets *(p. 45)*

DAO Data Access Object *(pp. 42, 43)*

DTO Data Transfer Object *(pp. 42, 43)*

FCSH Faculdade de Ciências Sociais e Humanas, School of Social Sciences and Humanities *(p. 2)*

FCT Faculdade de Ciências e Tecnologia, NOVA School of Science and Technology *(pp. 2, 46)*

GPS Global Positioning System *(pp. 7, 9)*

IAT Institute of Arts and Technology *(pp. 1, 2)*

IOS iPhone Operating System *(p. 11)*

POI Point(s) of Interest *(pp. vii, 3, 7, 16–24, 27, 30, 32–37, 39, 40, 43, 44, 48–51, 55, 61–63)*

REST REpresentational State Transfer *(p. 42)*

SUS System Usability Scale *(pp. ix, 48, 52, 53)*

UI User Interface *(pp. 11, 44, 45)*

1 Introduction

Culture can be defined as an identity of a place, and it is part of the identity of the people that surround it. So it needs to be preserved through generations. While culture needs to be preserved in time, the ways people convey it and transmit it are ever-changing and evolving. This project presents an innovative system to maintain the culture active and healthy using storytelling, AR and gamification with an authoring platform.

1.1 Problem and Motivation

It is important to preserve the history of each place and their people, as well as their traditions and how they have changed with time. Therefore the culture of each place needs to be preserved through generations. The way culture is communicated or passed to other people needs to evolve in order for it to continue living. Besides, now in the age where most information comes from digital sources like phones and computers, it is more important than ever not only to preserve history and culture but also to make it more available and presented in a way that makes people interact with the culture and history of the place they are visiting.

To preserve the culture of a place and its community, urban regeneration can be used. Urban regeneration allows not only the rehabilitation of a physical space, but also the development of the community that surrounds it.

To tackle the challenge of preserving and protecting a local culture, *Web of Stories* project was created. *Web of Stories* works by telling the history and stories that happened near and around the Institute of Arts and Technology (IAT) building in Trafaria by creating mobile interactive narratives for visitors and local community. Therefore, we developed this study together with IAT and the community from Trafaria [17].

This project is divided into two components (web and mobile):

- The web component involves the creation and development of an authoring tool that allows the creation of interactive narratives to be explored through a web application, as well as managing its contents. This means it involves the development of a web

application, backoffice, database and a support server (that is also used by the mobile version of the app).

- The mobile component [2] was developed in parallel, in the scope of a different thesis, with the creation of a mobile application based on AR and interactive narratives allowing local exploration and navigation through narratives in a space along with interaction with different types of data, like texts, images, sounds and video. These interactive narratives document the history, local culture and diverse activities in the community.

1.2 Context

This master dissertation was developed alongside *T-Factor*, an European project which has the mission of reverting the abandonment of historical zones, making them more attractive to citizens and visitors. This is accomplished by creating opportunities for local businesses to expand and also create and grow local cultural activities. *Web of Stories* is one of those projects which its main goal is to boost this cultural heritage and culture-relevant innovation in Trafaria [17].

IAT is being helmed by the partnership between Faculdade de Ciências e Tecnologia, NOVA School of Science and Technology (FCT) and Faculdade de Ciências Sociais e Humanas, School of Social Sciences and Humanities (FCSH). The mission is to serve local and global society through knowledge, research and innovation with a social and economical impact in people's lives. This partnership lead to the creation of IAT, a strategic platform that will help in accomplishing this mission, which will also be a hub that connects and values technology and art. IAT intends to develop and create products, organize events and services [1].

Just like mentioned before, this project is focused on Trafaria and its community. Trafaria is a village close to Lisbon, and it is an emblematic site, having buildings that are more than 400 years old (the first buildings were built circa 1565). One of the most emblematic symbols of Trafaria is a fort, built in 1683, which is currently the site where IAT is being built. It was eventually demolished and rebuilt again as a prison until 1974. It has been abandoned ever since. The local economic activity is focused mostly on fishing, local commerce and restaurants, with high unemployment and precarious jobs, but with *T-Factor* and this project we hope to contribute to the area and community of Trafaria [17].

1.3 Main Contributions

The main contributions of this thesis are:

- **Web application:** The creation of a web application to keep the culture and history alive with the help of innovative ways to interact with it. The focus of this web application is the authoring tool that allows the creation of items like itineraries. By

making use of technologies like AR, storytelling and gamification, the user will be kept motivated to find more and explore the richness of the place they are visiting. Therefore preserving the cultural heritage of the community.

- **Server:** The developed server that provides tools for users of the application to browse, play and create itineraries. These routes take advantage of innovative ways to keep the users engaged with gamification and storytelling as mentioned above.
- **Authoring tool:** The server also provides an authoring tool, which enables the user to create itineraries, places/POIs and events. All of these can use narratives and gamification incorporating several types of multimedia content and AR.
- **Research Results:** Another contribution is the advancements in the study of areas such as authoring tools, AR, storytelling and gamification as tools in the development of applications.

1.4 Document Structure

This document is divided in the following chapters:

- **Introduction:** This chapter introduces the problem to be tackled as well as how we are going to face this challenge. It introduces the project that we will be focusing on and the respective components that will constitute the solution to the problem presented.
- **Related Work:** This section explores similar work with this project, in which their information and studies were helpful during the development of the work.
- **Development Of The Project:** This chapter details how the project was developed, the web application, the server, and the technology that was considered and the ones that were used during the making of the software.
- **User Tests:** This chapter explains the process for assessing the project through user tests. It explains how these user tests were made and the results from it.
- **Conclusions and Future Work:** A short reflection on the work that was made and the developed project.

2

Related Work

This chapter is comprised of four sections: storytelling, gamification, AR and Authoring. The first section is about how storytelling can be used as a tool to improve learning and motivate users to learn more. We also talk about gamification as a tool for storytelling. Similarly, in the next section, we talk about how AR has influenced this type of applications and systems. In the last section we talk about various authoring tools, their goals and how they work.

2.1 Storytelling

There have been many cases in which storytelling was used together with technology to achieve a number of goals, whether in education [22], keeping in touch with loved ones [30], among many others. In fact, not only are technology and storytelling by themselves already powerful tools that can change and shape society, but they also can be used together for many more purposes.

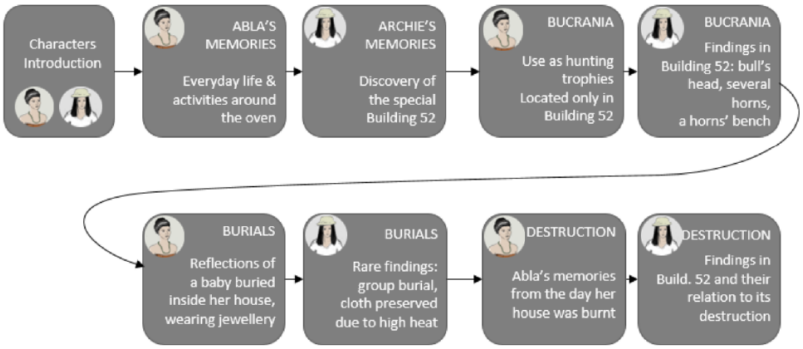


Figure 2.1: Example of a structure of a story [18]

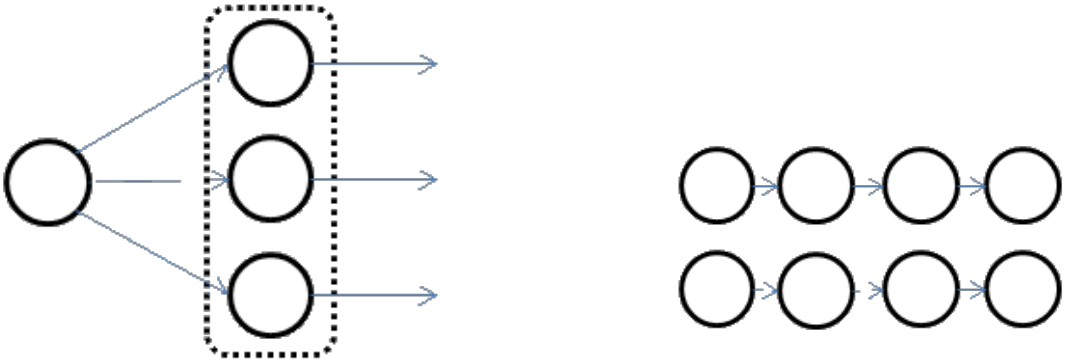
A. Katifori et al [18] used storytelling as a way to deliver an audiovisual content to promote learning about culture and interaction between users, which they found out has improved the users' experience. They also defend that the story should come first before the technological considerations, making the application all about the experience of the

user. An example of a story used in the software they created, figure 2.1, would involve two fictitious characters who tell the story of the place where the users are, and the artifacts found there, through both character's narrative, providing two different perspectives on the topics being discovered in the experience.

Location aware fiction is a type of story that presents its content or narrative to the users on their specific geographic location. This type of fiction can be used to increase the immersion in a story. According to C. Hargood et al [15], the distinction between location aware fiction, tour guides and games can be blurry - the most important feature of location aware fiction is delivering a story. Tour guides focus on giving just location description and information relative to the local culture and history. In case of games, they are more focused on delivering a gamified experience of the application.

A story can be made by an ordered sequence of connected nodes in a graph. Alternatively when creating a branching narrative, it is possible to create a sequence of nodes that diverge and split based on the users' interaction with the story's interface, or even just a collection of nodes that can be explored in any order. For example, concurrent nodes can be explored, just like their name says, concurrently with each other.

Parallel thread of nodes are sequences of nodes in the same route that can be explored independently of each other as a result of a branching that happened earlier in the route. Alternative nodes are nodes that overlap each other, however, their contents differ from each other and have different triggers for being active, for example while one is active on a certain day of the week, another one is active on a different day. There are also unlocking nodes that are off the path that are activated by achieving certain conditions in the route. These types of nodes could be used for secrets and easter eggs [15].

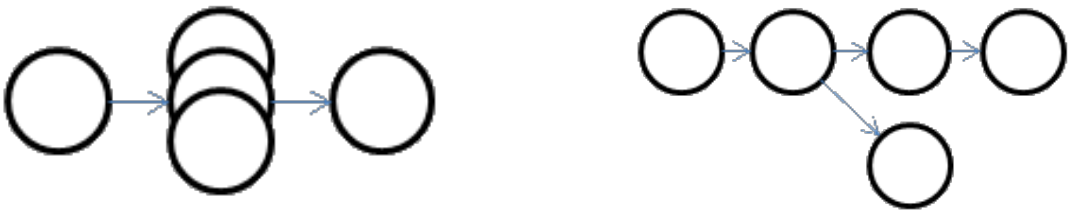


(a) Concurrent nodes (b) Parallel thread of nodes

Figure 2.2: The many types of nodes, part 1

These many type of nodes are illustrated in the figures 2.2 and 2.3.

Storykit [8] has also used storytelling for education. It found success with education across all levels, including success with children with special learning needs. The goal of *Storykit* was to understand the ways in which mobile storytelling can be used to improve



(a) Alternative nodes (b) Unlocking nodes

Figure 2.3: The many types of nodes, part 2

literacy and their personal expression. Just as described in the paper *Let Them Talk!* [18], *Storykit* has also found that interaction between people while using the application has improved their opinion and enjoyment of the application.

Storybox [30] has used storytelling to keep grandparents and their grandchildren in touch thanks to this kind of technology. This technology has been used to share stories about their lives, crafts and arts children have made, written messages, audio samples. It uses a box structure and a mobile phone to create the stories with audio and images taken from it, as seen on figure 2.4. It was verified that more messages, greetings and other factors in general would lead to a considerable amount of increasing willingness to share events between the parties using this system. Not only has increased the communication between grandparents and their grandchildren using this system, but also the number of times the grandparents were visited by their families and grandchildren.

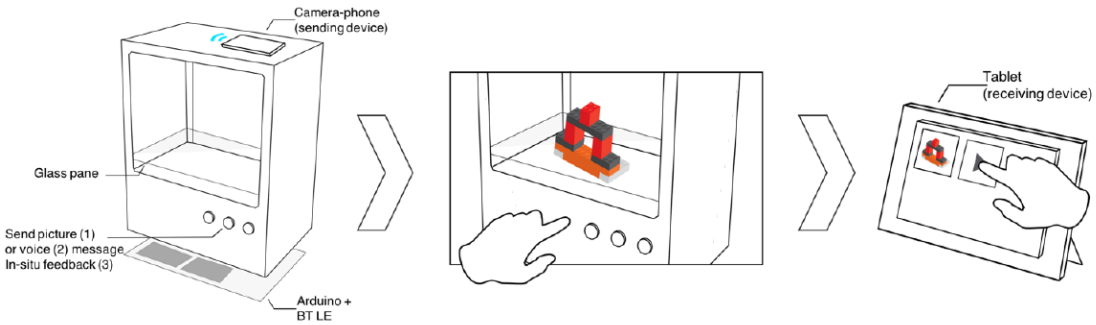


Figure 2.4: *Storybox* architecture and interaction [30]

InStory [14] is a platform for mobile storytelling with gamification support on the stories created in the app. The stories created in this app are centered on the physical exploration of the locations that are presented in the storyline. These stories are told based on the navigation of the user in the actual location in the real world, and using this way not only to tell the stories but also to present them, is a good way to convey knowledge. In combination with the exploration, they also use another user driven component that works by sharing information between users in order to provide historic context, while presenting a new innovative way for social participation in different types of events.

Culturacores [25] is a website directed by the Açores government, in order to develop its local tourism and preserve its culture. It curated some itineraries built upon some famous local personalities. So that people can learn about not only the local history of the places they visit during the itinerary but also the personality associated with it. Each itinerary is available in both English and Portuguese. Each itinerary is also accompanied by a chronology of events related to the famous personality of the itinerary.

On a similar level, *casafernandopessoa* [12] also made an itinerary for people to follow around Lisbon where each POI tells a little bit about the Portuguese poet Fernando Pessoa and his relation to the corresponding place. Each of these points are also accompanied by an excerpt of a poem by Fernando Pessoa.

The *Lisboa Romana* project [20] also puts storytelling in its geo-location through technology. It uses locations around Lisbon to tell the history of what happened around those places during the times when it was occupied by the Roman empire.

Another project that uses storytelling with great effect is *byAR* [11]. This project intends to pick up stories to create narratives that can be connected to AR and other technologies, like animations, 360 content and 3D objects. They have done projects with the *Museum of Archeology and Ethnography of Elvas* where they focus on the history, the people and the time. These topics and the museum's content are presented through narratives using objects, illustrations, and animations. They also developed a project in Arraiolos village in Alentejo where they built an interactive totem in the main square. Through this totem the users can see a 3D model of the village on the 14th, 16th and 20th centuries. They also have a 3D model of how the local castle, now in ruins, used to look like. It is also possible to view 3D character animations telling the story of Arraiolos during those three centuries. This totem can be viewed in figure 2.5.

Figure 2.5: Totem by *byAR* in Arraiolos

Another project made by this group is *BispoGo* where it aims to gamify the users' journey through Vila do Bispo, challenging the user to conquer 50 POIs. They even have a mascot modelled in 3D named Windy that accompanies the user during their voyage. An example of the AR provided by this app can be viewed in figure 2.6.

They also had a hand in producing *Regaleira App 4.0* that uses POIs, AR and Global

Figure 2.6: 3D mascot of *byAR* being used in AR

Positioning System (GPS) in the app to guide visitors. *Regaleira App 4.0* was analised further [3]. During their analysis they took note that most of the visitors, specially children, were excited about the inclusion of AR in their visit to Quinta da Regaleira. In general, the project was a success, becoming a benchmark for innovation in tourism. However, some of the downsides noted in the application were that there was no social aspect of the application allowing users to share their experience on the internet. Another downside is that while most people were excited to try the AR presented by the application, some of them commented about the quality of the models not being perfect and without personality and thus breaking immersion.

2.2 Gamification

Gamification is becoming prominent in applications with the intentions of keeping the user engaged with their activities in the application. This technology is usually directed to a younger audience. *Let Them Talk!* [18] is a story based experience that promotes social interactions in digital storytelling settings. The authors also defend that gamification can also be used to promote group interaction.

Some of these applications, like *Can You See Me Now* [7], have merged location sensitive applications with gamification, like location aware games [15] which are systems that possess game mechanics connected to to player context and, can also have AR experiences associated with the games as well.

Luiro, Elina et al [22] have developed a mobile game that uses elements of local history and cultural heritage in its stories and content. The game's stories have been curated by history experts on the topic, where the users have to visit historical places in person to advance in the story. In terms of game design, it was a more casual game that anybody can easily play without any previous experience with low time commitment, so that anybody who wanted to try the application could get into it. It was developed using the *unity3D* game engine, and the game environment was based on *OpenStreetMap* data. They describe

that the main challenge in making such game/application like this was finding the balance between historical accuracy and an interesting storyline.

In order to deal with geo-location, *InStory* [14] uses a combination of technologies. When there is WiFi the *Ekahau* system is used. The *Ekahau* system calculates the position of the user based on the signal's strength, which is obtained through triangulation of the Wi-Fi signal. *Ekahau* can be used by the clients and the server user interface to locate elements in an environment. Additionally, for outdoors, GPS is used. Nevertheless if those two methods fail the user has to explicitly state where they are. The interface used in the game can be seen in the figure 2.7.

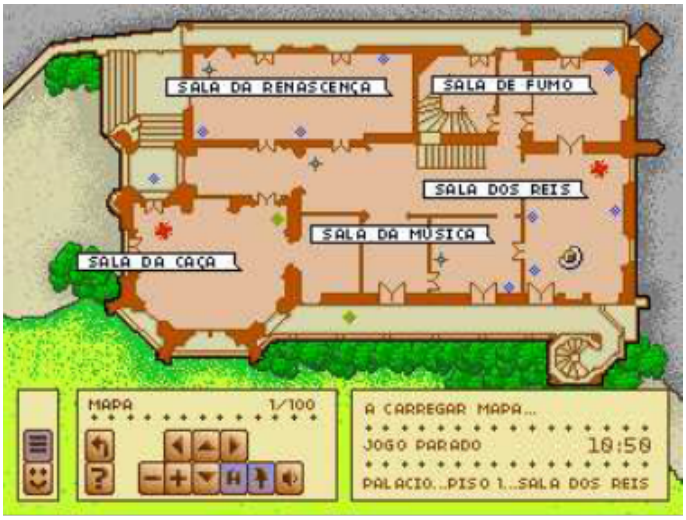


Figure 2.7: *InStory* game interface [14]

According to Zimbello, Agustina M. et al [35], an alternative to GPS location techniques for geo-location is the use of QR codes. These can be placed in a specific location to trigger an event in the application. QR codes can also be used in a story setting by generating as many of them as there are nodes in a certain story. Each one of them corresponds to a location, which corresponds to the respective node of the story.

Hargood et al [15] defend that location aware tour guides seek to inform and engage the users in their surroundings and are often accompanied by a historical narrative of the location in the story the user is currently following. One example of this kind of application type is the *Louvre Tour*, developed with the *HIPS system* [9] and *REXplorer* [5]. Hargood et al [15] also defend that location aware guides can be considered educational apps, since these can focus more on the educational part of the application than just the process of exploring a space like these educational tools [4].

2.3 AR

Just like gamification, AR has become more relevant in today's age. AR takes advantage of the many sensors present in the device to give the user a bigger sense of immersion

with the app they are using. It has also been used particularly well when combined with gamification, just like the famous apps *Pokémon GO* and *Harry Potter: Wizards Unite*.

There have been attempts to introduce AR to tourism before. For example, *Historiar* [16] which is a startup from Tunisia that uses AR for cultural tours. AR has also been used in apps for education and culture while using methods like geo-location demonstrated by Luiro, Elina et al [22] where a user follows a route proposed by a map in the app in order to progress in a game presented by the application. While progressing in the game the user will pass by local landmarks and learn about them. They also used 3D models in the routes of the games that the user could find. These 3D models of buildings and important landmarks can also be used to enhance the experience in AR apps. They were used as a way to provide the user a better understanding of the location they were in. They also used 3D models of characters, both high-poly and low-poly, for the stories used in the app. These characters were also created by using 2D element art.

InStory [14] defends that these technologies that use storytelling are an innovative way to tell stories since these applications can sense their location and adapt accordingly. The authors indicate the main components that make this possible are: mobile devices, location technology, outdoor and indoor location devices, wireless networking, service technologies and content creation. These applications must adapt to the available resources, the characteristics of their own mobile device, and the user requirements.

Zhang, Qimo et al [34] also use AR for physical and narrative navigation. They developed an app that to accomplish that goal uses AR flags to guide users to the physical locations of the story they are navigating through. This can be seen in figure 2.8. They also defend that combining AR with location-based data makes the user feel more connected and immersed in the story. For this they used *Unity3D* and *AR Core*.

Figure 2.8: Narrative Navigation prototype [34]

There is also been AR used with social networks, like in location-based social networks [33]. These enable users to connect with each other with geo-tagged social multimedia content connected to a location related to the user. The users can upload their own geo-tagged content and view other users' content through AR form on a 3D model with real-world coordinates.

2.4 Authoring

Authoring systems or tools allows users to create multimedia objects or software, which could be as simple as creating text documents or as complex as a graphic design tool [28].

Authoring tools have been used in storytelling apps like in Cultural Heritage Experiences through Socio-personal interactions and Storytelling (CHESS) [13]. Their authoring tool was used to create stories, and it allows users to create and edit a visual representation of a story using multimedia content, combining text, video, images and audio with established templates. Their interface can be seen in figure 2.9.

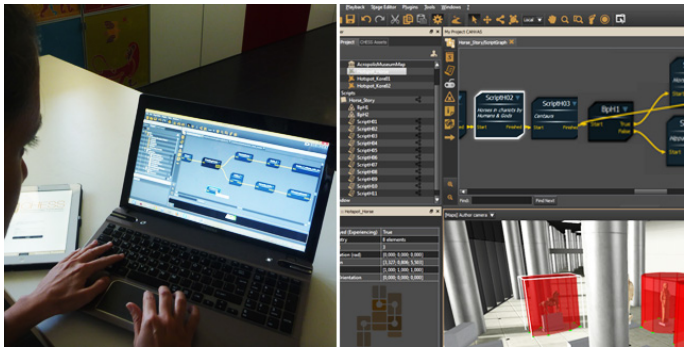


Figure 2.9: CHESS's interface [13]

Storykit [8] also has an authoring tool which lets their users create their original stories or modify a sample story with their own photos, drawings and audio. Users can also edit stories that they have created. It has an interface that makes the creation of stories possible with full-screen views and dialogs. The edit mode allows users to add text, sounds and images, and to draw/paint and take pictures directly from the device's camera. However it does not support videos due to lack of support by the iPhone Operating System (IOS) Application Programming Interface (API) at the time and due to long upload times required for uploading videos in their stories.

InAuthoring [6] is an authoring environment for *InStory* [14] which allows users to create and personalize their own stories/gaming activities. The authoring process in *InStory* can be described as:

- Creating components.
- Geo-referencing components (when needed).
- Associating multimedia content to components.
- Establishing connections between components (when needed).

InAuthoring [6] comprises of two frameworks: **InAuthor** (graphic story and/or game editor) and **InContent** (for creating screens with multimedia content and User Interface (UI) elements). One of the observations made by the developers and researchers working on *InAuthoring* was that it was impossible to give everyone the possibility to create activities

suited to their needs, since then they would need programming/advanced computer skills. An example of the *InAuthoring* interface can be seen on figure 2.10.

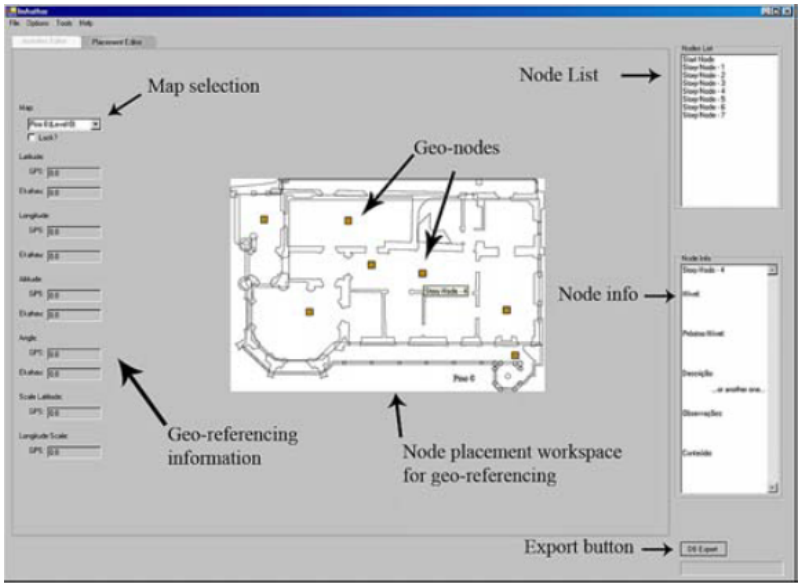


Figure 2.10: *InAuthoring* interface [6]

The stories created in *InAuthoring* are composed by nodes forming a graph, with various types of nodes, such as the **start node** (starting point of the story - this node also contains information about the entire story/game), **spatial inner node** (geo-referenced node which contains information about a scene or a task) and **inner node** (similar to spatial inner node except that it isn't geo-referenced) and there could also be an **info node** (geo-referenced node that simply holds the description, information and the contents of a file).

Geografia [27] is an authoring tool that gives the user the possibility to create a virtual environment describing their local history. Just like in *InAuthoring* [6], each story is a node graph. In *Geografia* each node is geo-referenced so that when the user is near the location it plays multimedia content like digital slideshows, images, text, audio or videos. Community curators upload their content onto their server. Their platform consists of a library for storing and editing nodes and their content, a website for off-site viewing and testing, a mobile app for on-site viewing. With this project they observed that there was an increased level of engagement with students while creating a tangible narrative that they could showcase. Teachers also noted the benefits in education/learning while creating assets specific to town's location and their history.

myhelsinki [32] is a project that focuses not only on developing tourism but also to help people from abroad that want to work or study in Helsinki. The website shows all sort of content from itineraries to events and even possible business ventures. All of the website's content is curated by the locals as their personal recommendations. It also doesn't include paid brand endorsements or sponsored content. It even has content based on interests, like for example architecture or arts, curated by local specialists on the subject.

visitcascais [29] is a website made by the Cascais Visitors and Convention Bureau to promote the tourism in Cascais. It has content related to gastronomy, culture and activities. It also has some routes created by them, each of them personalised to better accomadate its theme. For example, the farms route, besides the itinerary, it also includes information on the type of flora and fauna that could be found in the trail, as well as the warnings and dangers that could happen during the treking.

3

Development Of The Project

The *Web of Stories* project was created to help preserve the culture and history of Trafaria, a place located in the outskirts of Lisbon. The main concepts of this project were gamification, storytelling and AR, in order to enrich the touristic experience of exploring new places.

It was decided that the user experience should be driven mainly by interactive narratives. And for that matter, an authoring tool was developed to build these. These interactive narratives can come in the form of itineraries, places and events, that the user can explore.

Web of Stories is a larger project that combines two components: the web application and its mobile counterpart (figure 3.1). The mobile component was developed in the scope of another thesis. However, since it was developed in parallel with the work done on this thesis, its design choices were also taken into consideration. Our main focus was the web component, which includes the creation of a web interface, backoffice, database and support server (which is used by the mobile component as well).

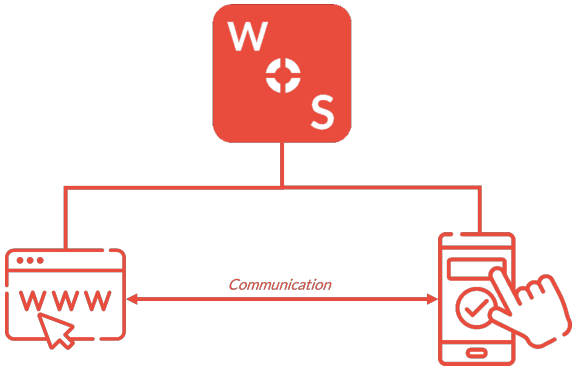


Figure 3.1: Web and Mobile Counterparts

This chapter aims to detail the solution that was adopted during the development of this thesis. It describes in depth about the visual design (how the application looks visually), the architecture of the entire system, the technologies used, and so forth.

3.1 Design Process

In this section it will be discussed how this project was designed, from the initial stages to the final results (figure 3.2). It is also explained the iterative process of the development of this project, more in specific related to the web application, the server, and database of *Web of Stories*.

Initially, *T-Factor* (section 1.2) had proposed a project in regards to the location of Trafaria, in the outskirts of Lisbon. The objective was to promote tourism using AR, storytelling and gamification.

After establishing the goals for the project, there was a brainstorming of ideas and research in order to figure out the best way to accomplish this project. Finally a blueprint of the project was conceived involving itineraries that tell narratives. These narratives are interactive in a way that involves gamification for the users.

The first tangible work done on this project was prototypes and mockups made with Marvel [24]. These prototypes brought together the ideas and information that were obtained until the moment. These were target of scrutiny in order to see what worked and what didn't work.

After finalizing the development of the prototypes, and having a better view and understanding of the work to be done on this project, we moved on to the next step: creating a more realistic application.

During the development of the application some events were held in Trafaria to showcase the project to the people of Trafaria. These events were used to gain feedback from the locals on the project. This feedback was used to improve the application on the following iteration.

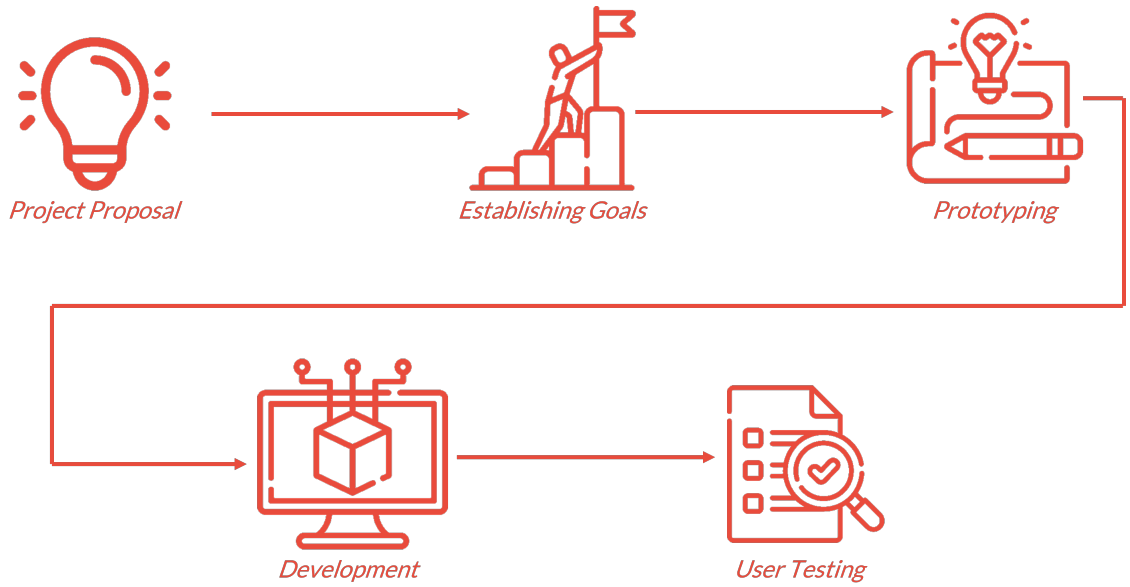


Figure 3.2: Development Map

During the final stages of the development, we tested the application with potential users in order to evaluate the quality of the experience to please the general crowd. Afterwards we analysed the results of the tests, and drew conclusions that could influence the future of this project.

3.2 The Main Entities

During the stage of obtaining ideas for the realisation of the project, we began by making an overview of the elements that could constitute our application. After this selection we explored their possible attributes and contributions to the system. These are depicted here in the way they appear in the current version of the project.

3.2.1 Itineraries

Itineraries are the main focus of the web application. These are routes that describe interactive narratives that are told by linking POIs (which forms a graph) that can be physically visited in their rightful place by users using the mobile application. The content of each POI should be focused on the history and culture of the places and people that the itinerary focuses on. Thus all its information should reflect that. Creators of itineraries can use the tools at their disposal to create an interactive narrative using elements of the history and culture, enriching the play-ability of their itineraries.

These itineraries can be of two types: linear or non-linear. The **linear itineraries** are, as the name suggests, a group of POIs that are connected in way that each point will direct towards just one other POI (making so that the user only has one possible path to take while doing this itinerary, as can be seen on the figure 3.3). On the other hand, the **non-linear itineraries** introduce an element of choice. A POI can lead the user to multiple other POIs. In this case the user, using the information shown by either the application, the story being told by the itinerary, or their surroundings, may choose the point that interests them the most. Thus making each itinerary's journey a more personal experience. This can be seen on the figure 3.4.

On a deeper level, the itineraries are constituted by its general information (the information that constitutes the profile of the itinerary), its location information (the content that serves to describe the geo-located portion of the itinerary, i.e the locations that the user travels to) and other information that doesn't fit in either category.

The general information is comprised of name, description, region, estimated time and distance, among others. This is the information that the user has a more direct access to when browsing itineraries in the application.

The attribute **name** is the title of the itinerary. This should be relevant to themes, stories or culture of the places the itinerary is representing.

The itineraries should have a short **description** of what the itinerary encapsulates. Creators of itineraries are encouraged to use this space to tell a narrative that is going to be

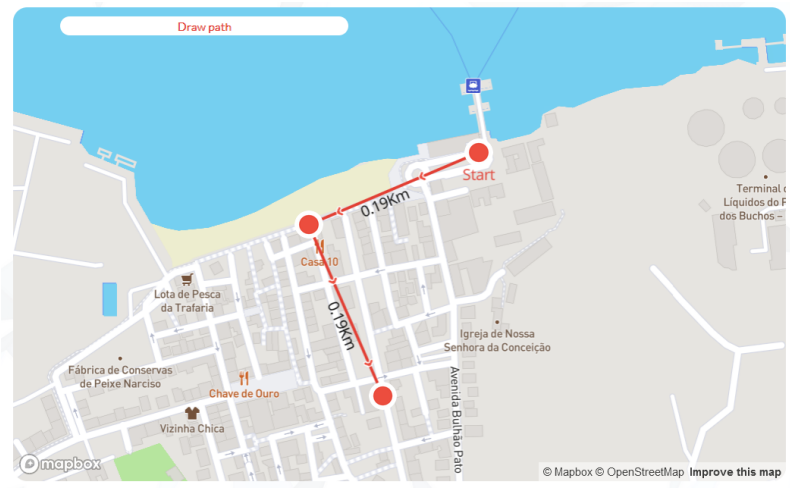


Figure 3.3: Example of a linear itinerary

Figure 3.4: Example of a non-linear itinerary

told by travelling through the itinerary. The narrative can be continued in the description of the itinerary's POIs.

An itinerary is associated with a **region**, that is the general location in which the itinerary is centered. This can be used to facilitate searching for itineraries near the user. Notice that the region attribute is considered general information and not location information because this attribute is just the name of the region where the itinerary is located and not something to do with physical location that requires the use of the map.

Both the **estimated distance and estimated time** are self-explanatory - the distance that the user is expected to travel while doing the itinerary and the time it is expected to take. These parameters are also used for sorting itineraries while browsing, in case the user wants a short or a long itinerary both in time or distance, for example.

In order to encourage the user to perform the routes, one of the aspects that our application would focus on is gamification. For this, one of the aspects that was used was the attribution of **points/score** to the user, which would be visible in their profile. These could be obtained upon completion of itineraries. Therefore, these points should

be established fairly when the user is creating an itinerary, making it another attribute of the itinerary.

When the routes created are listed in the application they need a **thumbnail image** that represents them. This image should be relevant to the themes presented in the itinerary. This type of information is represented as a media file. During the development of the project another media file type component was added to the itineraries to make them more compelling, the **award files**. These are files that the user will gain access as a reward for completing an itinerary. Just like the points/score, these are also used for gamification purposes.

Another attribute that emerged during development was the idea of **tags**. These are presented as a list of descriptors or interests that are related in some way to the itinerary. This is used in searching for itineraries based on a specific interest the user has.

Each itinerary has a **creator**, and that creator is associated with an ID. This connection is represented in the itinerary just by the ID of the user who created it.

The location information relates to the attributes that have in one way or another something to do with the physical location that they are associated with.

The user while using the mobile application travels along **nodes** represented on a map that are created in the web application. These are the group of POIs that constitutes the itinerary, more precisely, the main part of the itinerary with a real world component. Each node corresponds to a POI, and these are saved as an object called **itinerary nodes** which contains a reference to both the POI and the itinerary. The POIs are connected between each other forming a graph of points that the user will travel to. In an itinerary there cannot be an isolated POI from the rest of the network of POIs.

The order of these nodes are represented by an attribute called **node sequence**. This is a group of objects that denotes the ordered sequence in which the nodes are meant to be travelled. A node sequence is a group of items, where each item has a reference to a pair of nodes (a node indicating the beginning of the sequence, and a node indicating the end of the sequence), and a description (*desc*) as well. The description can be used to give information to the user while they are trekking this specific part of the itinerary.

When the user starts traveling an itinerary, the point from which they depart is called the **start node**. For every itinerary there needs to be one, and only one, starting point, and for this node, we save both the ID of the POI and its coordinates.

Below is a simplified representation of how nodes are interconnected within the itinerary, namely the attributes *nodes*, *start node* and *node sequence* (figure 3.5).

$$nodes : A, B, C, D$$

$$startNode : A$$

$$nodeSequence : (A, B, desc1), (B, C, desc2), (B, D, desc3), (C, D, desc4)$$

At the time, when the concept of the routes and the information they contained was being improved, two other attributes were consequently added: path lines and map style.

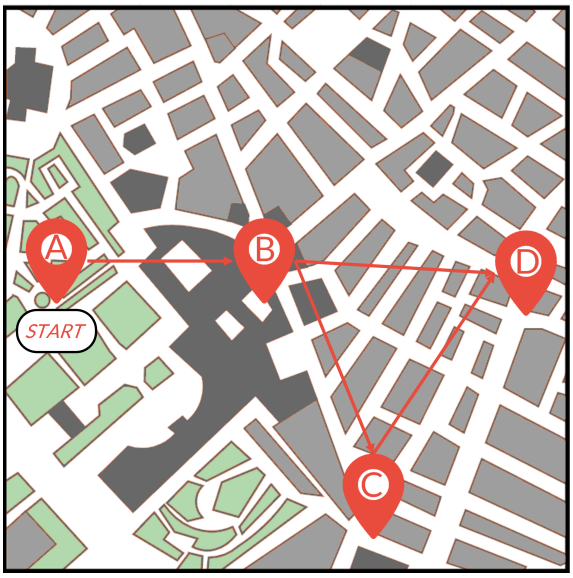


Figure 3.5: Example of node sequence

Each itinerary has a group of suggested paths on the map that the user can take while trekking between and across POIs - these are called **path lines**. These are saved using *MultiLineString*, a type of geometry that is made to represent various lines made of various vertices, thus making it possible to generate multiple paths the user can take.

When it came to the attribute **map style**, unfortunately it ended up not being used in the web application. However, it is still saved on the server in case there is further studies in this project. This attribute represents the visual style the map takes while journeying this itinerary. This attribute could be used, for example, to enhance the user experience while using the mobile app between POIs following a specific map for an itinerary.

Notice that we have a *start node* but we don't have an *end node*. This is because we consider that every node that doesn't have a way out is an end of the itinerary. If any node in the itinerary isn't in any start node attribute of the node sequence, then that node can be considered an *end node*. This permits us to have itineraries with multiple endings.

If there are multiple endings to an itinerary that means that there are multiple paths you can take. We made sure that the way we built this sequence of nodes accommodates that (each node can lead to as many other nodes as possible).

In addition to general information and information related to location, the itineraries also have additional information. Each itinerary also has four booleans (**file type booleans**) denotating the types of files present in the itinerary (to see if it has images, audio files, video files or AR files). These are used for filtering and searching itineraries, in case a user wants to experience an itinerary that definitely uses, for example, AR.

3.2.2 Points of Interest (POIs)

A POIs is a point in the map with given coordinates and that resembles a physical geographical location that a user can go to. The main purpose of the POIs is to serve as a

localised hub of content and information about the place it refers to. Their information should be relevant to the history and culture of its location. POIs have coordinates tied to a specific location that the user can travel to and upon reaching the POI the user will have access to its information.

POIs also have associated media files, which can include AR features, that can be used to enrich the interactive narrative of the itinerary. This interactive narrative is used to enhance user experience of the history and culture of the POI they're in.

Similar to how the attributes of the itineraries are organized into general information and location information, the POIs also have the same arrangement. They also have information about the media files (file information) that are associated with the POIs.

Most attributes can fit into general information. These are: name, description, thumbnail image, the date of the last update, and the ID of its creator.

First and foremost the **Name**, which is the title of the POI. This should be relevant to the place they correspond to. Then we have the **description** As the name says, it is a short description of the place this POI refers to. The description should mention cultural and historical facts relevant to the location of the POI. This can mention narrative elements of a bigger narrative being told throughout an itinerary. This however makes the POI less reusable in other itineraries. This factor will be at the discrepancy of the moderator creating this POI.

A POI also has an image to represent the POI when browsing them. The chosen image should be relevant to the POI and/or its location.

It is also saved on the server the date when the last changes occurred to the POI in the system (**last update**). This attribute is only used for administrative purposes.

Regarding the location information, it only has one attribute, which is the **coordinates**. This represents the physical location (longitude and latitude) of the POI. These coordinates are saved in the form of a geometric data type point.

We also save the file information (information related to the media files of a POI), like the media files themselves, the order in which they are presented and the manner in which they are displayed.

We store the **media files** that the POI contains. These are the main content of the POIs. A POI can have any number of media files of any type. There is more information on them at their dedicated section, section 3.2.3.

We keep the importance of the order in which the files are presented as a boolean, and if it is in fact important we also save the order of the files. The **file order** is The order that the files are presented in a specific POI. This may enhance the experience of the user. The order is represented by an object that saves the file ID and the files' position in the file sequence of the POI.

A POI has a **content type** that affects the way the files are presented to the user when viewing this POI on location through the mobile application. However, if the user desires, it can be changed on the mobile application when seeing these files. As of this moment there are two ways to present the files: *gallery* and *list* (figure 3.6).

- **Gallery:** Similar to how current smart phones display their gallery of photos and videos. The user has to click on a grid of thumbnail images to see the corresponding file and its info. This option should be used when the order of the displayed media files does not matter.
- **List:** The user can scroll through the file and their info in a sequenced manner (similar to how Facebook displays their feed). This option should be used when the order of the displayed media files matters.

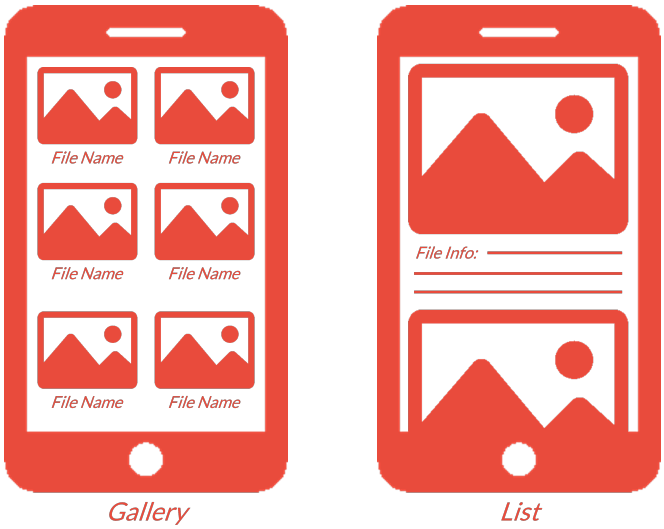


Figure 3.6: Display file options: Gallery and List

3.2.3 Media Files

The media files are an important element of the application's user experience because they contain the core content for interaction within the application itself; they are used to enrich the narratives built into the itineraries, and in turn make the history and culture more engaging to users.

Media files can be of many types, like image or audio, among others. The multimedia content of the application are presented as media files that the creators of POIs, places or itineraries will upload to the app.

A single media file, besides the actual file, also contains a title (**name**), a short **description** explaining the content of the file, and a **subtitle** that just like the description should also be used to explain the contents of the file, except this one is displayed just under the file it belongs. So creators should use this attribute for crucial information that the file in question needs for context purposes. In order to give credit to the original creator of the file, in case it doesn't belong to the user that uploaded it, and to properly reference where the file came from, we have the attribute **reference**.

Just like the ones used in POIs and itineraries, media files also have a **thumbnail image**, which is is an image that is meant to represent the file.

The media files have another attribute that we have labeled **teaser boolean**. This boolean attribute is used to represent the visibility of the file. If it is true then the file is visible to people who visit the page of the itineraries or POIs even if they are not on the location that file refers to. However, if it is false then the file is only visible when the user is on the location of the POI to which the file is attached. It is called the Teaser Boolean, because when this attribute is set to true the file can be used as an incentive for a user to do an itinerary, or to visit a place that has this and other related files.

Last but not least, each media file has a **type**, which is the type of the file that is to be uploaded. Each type has their own set of attributes that helps better represent each one of them. The types that *Web of Stories* currently supports are the following: a simple *image* file, a *text* file, an *audio* file that can be used as audio guides or to play music that is culturally relevant to a location (it can also be used for sound effects to improve immersion). We also support video files like a simple and regular *video* file, a *360 video* that, as the name implies, can be viewed in 360 degrees, using the phone's sensor in the app, and it also supports *Youtube videos* that can be relevant to possible locations and itineraries.

One of the most prominent components of our application is the integration of AR. This makes the user experience when performing itineraries even more immersive. And this is incorporated in files of various types:

- **AR Geolocated:** A 3D object file can be seen using AR. The event that triggers the object to be visible is to be near a specified location, in this case the coordinates of the POIs this file is attached to. The 3D object will be shown when the camera of the mobile application is pointed in the direction of those coordinates.
- **AR With Marker:** Just like the previous file type, this file can be seen using AR. However, the event that triggers the visibility of the 3D object is now a marker. The marker is an image that can be specified while uploading this file. The marker should be something that can be seen on the POIs that this file is in. The 3D object will be displayed on top of the marker image once it is detected.
- **AR With Plane:** Exactly like the previous file types in terms of AR. The trigger for the visibility of the 3D object now is when the mobile application detects a plane. Once it detects a flat surface the 3D object will be shown on top of it.

And finally we also have another type of media file, a *3D object*, that can be viewed on its own or used in one of the AR media files.

3.2.4 Places

Another asset of the *Web of Stories* application is the places. These are similar in many ways to the POIs - both have similar information (with some exceptions that are explained in the following sections) and both have media files. However, places are not connected to an itinerary and can be visited individually without traversing an itinerary.

These actually contain a POI and another attribute, the region's name in which the place is located. This is used to facilitate searching purposes.

3.2.5 Regions

These are the possible regions that the items (itineraries, POIs, and others) of *Web of Stories* can be located.

While places, or POIs have a concrete geographic location defined by specific coordinates, regions are more abstract in the sense that they refer to a wider area where they can cover several locations such as Trafaria or Lisbon.

So far regions are comprised of its name, and a boolean representing if the region is featured or not. Until the most recent version of the application, these regions play a very small role in the grand scheme since it was a very late addition - however these have a great potential for further development, for example, a featured region means that its items would be highlighted, and/or it could be used in partnership with events making sure to attract more attention to its location, among other ideas.

3.2.6 Events

A user can search for events taking place in a given location, which can encourage the user to travel to the event location. These can be festivals or exhibitions in museums and such. At the event's location they can also interact with other facets of the application such as performing itineraries or visiting places, further encouraging the use of the *Web of Stories* application.

This entity is similar to *places* with the exception of the time restraint, since events only occur for a limited period of time. This time restraint is characterized by the attributes **start date** and **end date** for the respective dates of the beginning and ending of the event. Events are also comprised of most of the same attributes of a *place*, such as: name, description, thumbnail image, region and coordinates.

3.2.7 Users

Another very important element for any application, and this one is no exception, is the userbase. This application targets people who are interested in traveling, people who are above all adventurous and always open-minded, willing to get to know the local culture and go exploring. Users are any person that registered an account on the system. The accounts are authenticated by their username and password. On a more technical level, these users can have one of the following roles:

- **Player:** The most basic type of user. They can perform the basic features of the application like browse and traverse itineraries, among others.

- **Creator:** This type of user can do everything a user with the role *Player* can. They can also create items, like itineraries, for the application. Not all users can be creators since there is a layer of curatorship and moderatorship on the items created on this application. This moderatorship can also be used to prevent malignant behavior from potentially harmful users and even a protection against spam from users.
- **Admin:** This type of user is the most powerful in the application, and just like the name implies, they are charged with the administration of the application, like delete users and itineraries and also upgrade or downgrade users to other roles.

This **role** component of the users is represented as an attribute. besides this one, the user entity also contains the attribute **progress** This attribute relates to the progression of a user at a specific itinerary. For example, a user can save their progress on an itinerary and later return to it at a specific POI. The progress saves the IDs of the user in question, the itinerary they're travelling, and the POI they were currently on.

When it comes to **statistics and gamification** we store a number of attributes that can be used as either for keeping statistics on each users' involvement with the application or as a gamification tool, and some can even be used for both purposes. These are the number of created items and the created items themselves, like POIs, itineraries, events, the number of items visited and files accessed on locations, which can be used for both statistics and gamification. This number could be used to create some form of friendly competition as ranking boards. For gamification purposes the user also saves the points and files that have been awarded to them on completing itineraries. Later these attributes could also be used in some sort of a more social component of the application between users.

And finally we also save the **last update**. This attribute saves the last time there was an update on the user's info. While it isn't shown in either the mobile or web application, this attribute can be useful for administrative purposes.

Now that the main entities of our project have been established, we move on to the creation of the first sketches of the application.

3.3 Prototypes

At the start of the development of the *Web of Stories* project various prototypes were developed in order to test the best way to build the website. This served to visualize how to achieve the goal of creating an authoring platform for the *Web of Stories* application. These prototypes allowed to check the best disposition of the content in each page, which pages were important to keep and which ones were redundant and could be disregarded, for example, in favour of a more optimal approach by either not including them or putting their elements in another page.

For this type of prototyping the technology used was Marvel[24]. This was used to build a mockup version of what the website would be like. In this mockup website it was

possible to navigate between a few pages and simulate browsing a list of itineraries as well as simulate the creation of an itinerary. At this point not all features of an itinerary had been conceived so this representation of the process of creating an itinerary was revealed to be naive in comparison to the completed project. However, the basis for the process of the creation of itineraries was conceived during this phase of the project.

These prototypes were tested with some users in order to gain feedback on what should be most desirable qualities according to the users. With these tests and the feedback received from them the *Web of stories* interface was changed in order to accommodate and fix some of the problems mentioned during the testing phase. More information on the prototype can be seen in the annexed document I.

A comparison between the initial version of the prototype and its current iteration of the application (figures 3.7 and 3.8).

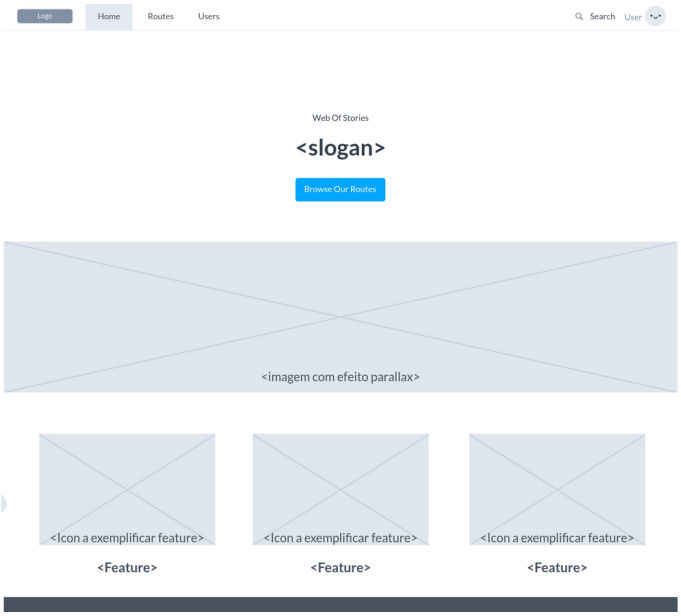


Figure 3.7: Initial Mockup

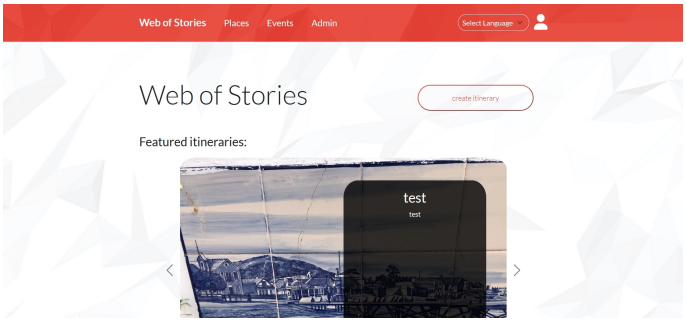


Figure 3.8: Current Iteration

The visual design of the application has gone through some iterations, evolving towards a more sophisticated and dynamic system. While there were some changes when it came to the visual component of the application and in some steps in the process of

browsing and of creating items, we still kept the original goals of the project in mind until the current version of the application.

In order to help us with the evolution of the design of the application, we contacted the designer, Carlota Terenas. The visual design and iconography made by her really helped not only in terms of presentation but also when it came to make the app more understandable.

The visual design progressed from the classic blue and white design used in the prototype stages of the application, to the now more modern and slick design, which also reflects the *T-Factor*'s logo colors, as can be seen on the figure 3.9.

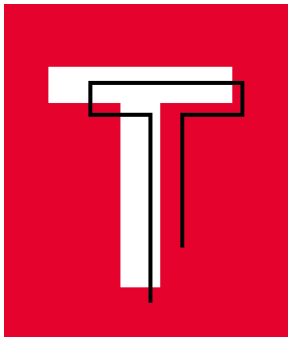


Figure 3.9: *T-Factor* logo

After creating a functional prototype and testing it with users, we obtained feedback that would be useful later in the development of the final application. Now that we had an idea of how the final application would look, we moved on to the development phase of our application taking into account the observations that were raised during the prototyping phase. From this point on, the frontend of the application was developed in parallel with the backend.

3.4 Web Application

After having a clear idea of what we were aiming for, we started the development of the application *Web of Stories*. As already mentioned, this is divided into two components (mobile and web), and in the scope of this dissertation only the web component was developed.

The goal of the web application is to serve as a hub for browsing and creating the items to be used on this application, for example itineraries, places and events, that users can visit using the mobile application.

For this process of creating these elements, which are fundamental to the user experience, **authoring tools** were developed. These are the mechanism that permits the creation of objects in an application. In our case, the *Web of Stories* project, we designed specialized interfaces that would permit the user to create numerous items that would construct interactive narratives that could be experienced in the mobile application. In our application there are three types of users (section 3.2.7) but only two of them, *Admin*

and *Creator*, have the power to use these tools. This is to add a layer of moderation to the application. We'll explain the process of creation of each specific item that composes these narratives on their specific subsections (Create Itineraries, Create Places, Create Events and Create Media Files).

The web application is focused on being used off-location, at home or, if the user is visiting Trafaria, on the place they are staying. Nevertheless despite not being used to play the itineraries, like the mobile application, it has mechanisms to visualize and create them and all of their components.

Some other internal design choices for this project was the use of gamification and storytelling. Itineraries use **gamification** in order to keep users engaged not only with the application they are using but also the environment they are in. Some aspects of how gamification is being used are, for example, a point system and alternative paths. Using gamification, according to the information in chapter 2, will improve awareness and also the inheritance and spreading of the local culture. **Storytelling** is another important factor of this project, which is going to be incorporated in some of the itineraries created by users. It works by creating narratives that can be attached as multimedia content in the POIs of the itineraries. Just as mentioned in the chapter 2, this can help further engage the user in the app, and since stories are a good way to convey knowledge, these can also help spread information about the culture and communities in the stories that are told.

From this point on, the next subsections will detail how the web application is built and how it works.

3.4.1 Navbar

When the user opens the web application on a browser, it redirects to the homepage. Upon opening the homepage, the user will see on top of the page the navbar (figure 3.10). The navbar is the main mode of navigation between pages, leading to all the other main components of *Web of Stories*. Therefore, it is visible on every page of the application. In order for the user to be able to locate himself in the application, the button of the respective page in the navbar is highlighted.

On the rightmost side of the navbar, the user, according to their status in the application, will have the option to log in or register, and if they are already logged in they can log out. Upon logging in the user can also visit their own profile from the icon on the top right.

If the user logged in has the role *Admin* they will see another option on the navbar named *Admin*. Clicking on this option will redirect them to the admin page - this page will be explained in more detail later in the subsection 3.4.10.

Right next to the profile icon is a dropdown where the user can select the language for the application (figure 3.11). Right now there's only Portuguese and English available but this can be expanded to more languages easily due to the technology used, in this case i18nexus (more is explained about this technology on the section 3.6).

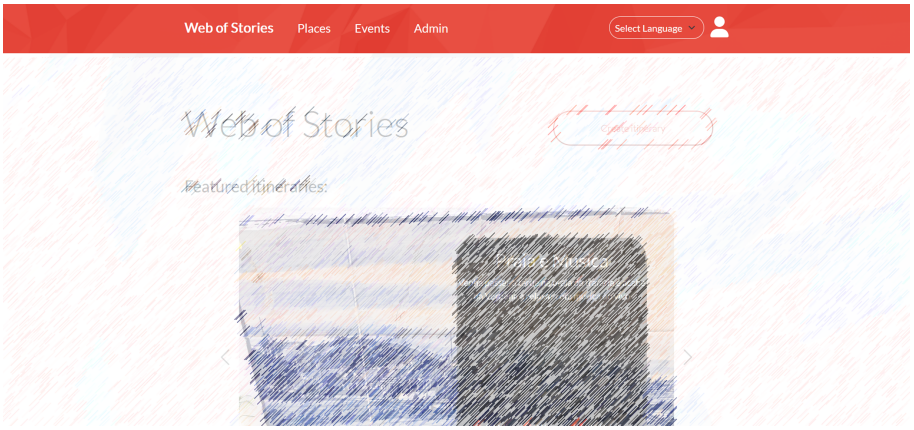


Figure 3.10: Navbar

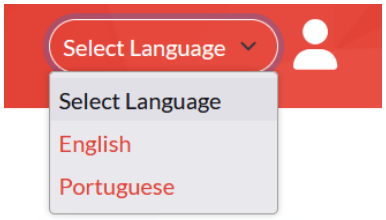


Figure 3.11: Language selection

3.4.2 Login/logout

Users can register for accounts in the application, so they can have their own profile, and they will be able to play the itineraries on the mobile counterpart of the application while using most of the web application's features. However, browsing itineraries can still be done when logged out.

When the user clicks on the register button a pop-up will appear with the form requesting the user to input their registration information. This information is just the username and password, though in the future we may also ask for the user's email in case the project intends to communicate updates or news via email with its users. Upon registering, the user will receive a notification warning that the user was registered with success.

On the other hand, when the user clicks the login button a similar pop-up will appear asking for the login information. Upon submitting, the user will be notified of its success in logging in. Now when the user clicks on the profile icon, instead of the buttons being *register* and *login* they are now *profile* and *Logout* (figure 3.12). The first will redirect to the logged in users' page and the later will end the users session, redirecting them to the homepage.

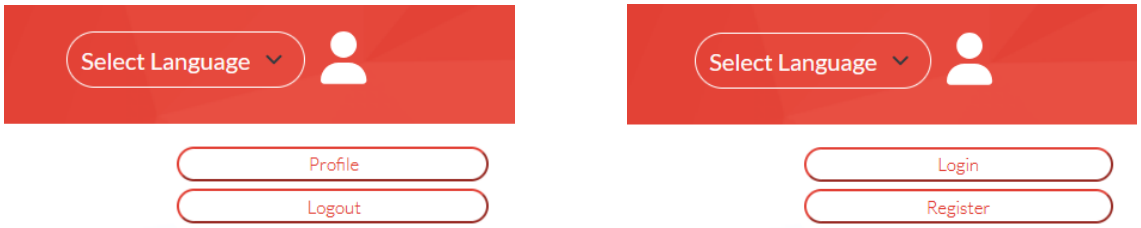


Figure 3.12: Logging in menus

3.4.3 Homepage

Our homepage is used as if it were a hub where the itineraries of the application are located, these being the major focus of the *Web of Stories* project.

Below the title, the user can see a carousel cycling through the featured itineraries (figure 3.13). These are the itineraries the admins think deserve a spotlight, be it for an event or their quality or any reason they see fit to feature them. On the carousel the featured itineraries will display their title and description, and with their respective icons their estimated time to complete, estimated distance, and the score in points the user will receive upon completion of this itinerary. All this information is displayed on top of the itineraries thumbnail image, this one occupying the entire space reserved for the carousel to better catch the users' attention.

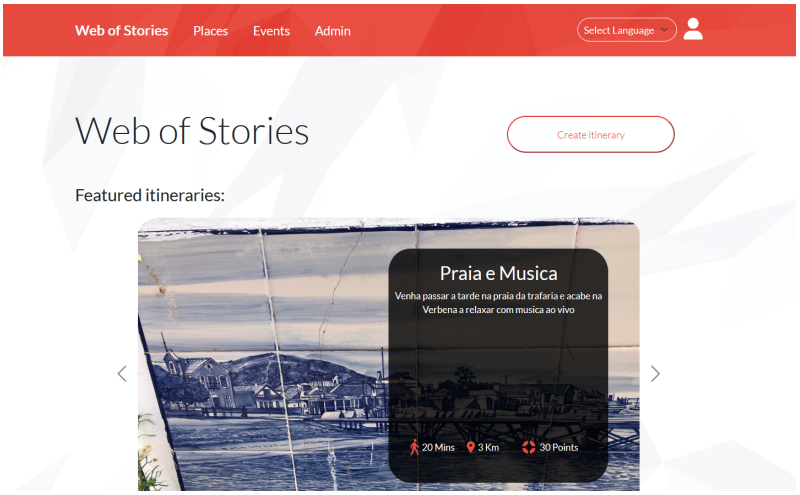


Figure 3.13: Carousel with featured itineraries

Below the featured itineraries is the main method of browsing the itineraries. It is displayed a list of all the itineraries and above it is a search bar where the user can search by the itineraries' title (figure 3.14). On the left side is the sorting options. The default sorting option is sort by the time it was created from the most recent to the oldest, bringing an highlight to the more recent itineraries, instead of having the same itineraries always on top of the search bar. Other sorting options are: sort by travel time, this one sorts it by shortest travel time to longest travel time; sort by travel distance, same as sort by travel time but with distance instead; and finally sort by the total points the user gets

upon completion of an itinerary. This one sorts the itineraries from the ones that provide the most points to the ones that have the least. The browsing, sorting, and searching is mostly the same for itineraries, events, places and users, barring some minor changes, for example on the sorting options.

Figure 3.14: Itinerary list with sort and search options

In our application all users except those with the role *Player* can create itineraries. To do so, if the user has the role *Creator* or *Admin*, they will see a button, on the top of the homepage, prompting them to create an itinerary. This will redirect them to the dedicated page (however if a user that doesn't have either of those roles tries to access that page they will be immediately redirected to the homepage).

On the pages for places and events a similar page layout is set up, but for their respective entities. These pages are accessed through the navbar items. The sorting options will also be specific for the entity. These pages have a dedicated list for their items where the user can search and sort. They can also redirect to the respective item creation pages just like in the homepage.

3.4.4 Itinerary/Places/Events Profile Page

Each entity also has their own profile page for each instance of the entities' type. Each of the entities' profile pages, be it an itinerary, an event, or a place, is divided in three sections:

- **Map information:** In this section, it displays a map with the relevant information for the page the user is on. In the case of an itinerary, it shows the POIs that belong to the itinerary, as well as the paths and connections between them. In the case of events and places only their location is displayed.

- **General information:** This information is displayed as a card with textual information just below the map.
- **File information:** This section has a list of files displaying their name and type. The files displayed are the award files in the case of the itineraries' profile. The files on the places' profile are the ones that are visible when a user reaches its geographical location. However, events won't have this section, since they don't have files to display.

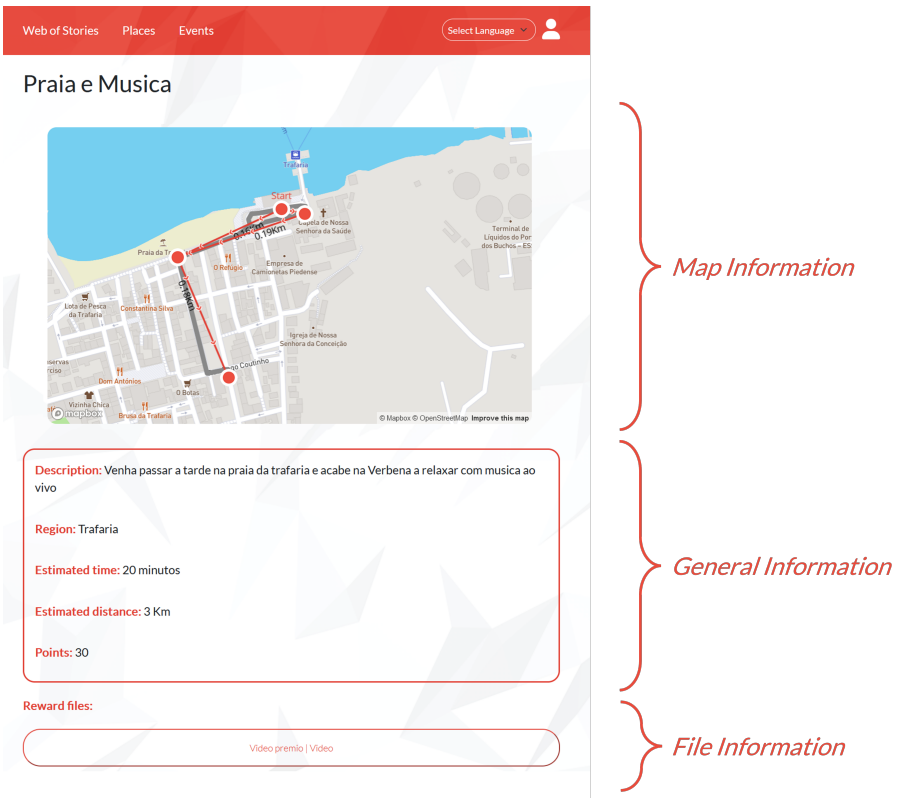


Figure 3.15: Profile Page Composition

3.4.5 Create Itineraries

The itineraries are the more complex items to create, and are also the main focus of the application. The user can find the option to create the itinerary on the homepage, being redirected to the specific page upon clicking it.

The way these itineraries are created is also inspired by the authoring section of the related work chapter (section 2.4). Such techniques mentioned in there that are used in this project are geo-referencing components, associating multimedia content, various types of nodes and an interface more appropriate for creating narratives.

In order to gamify the application, nodes are connected in a way that allows a story to be told in multiple ways. A node can be connected to multiple nodes, making so that

a user playing through a story has to choose which path in the story to take, each path having different consequences on the story being told, as seen on figure 3.16.

Figure 3.16: An example of an itinerary

Between the nodes the user will be guided by a path. This path is the recommended trek the user should walk between the POIs in order to experience the itinerary the way it was intended. The path being taken by the user will be in real time and on-location. This is represented as a grey line on the map, as seen on figure 3.17. Since the user, who is playing through the story, has the choice of which options to take while advancing in the itinerary, it keeps them engaged with the choices made, their outcome, and how the story is influenced by them.

Figure 3.17: Itinerary with path

Upon entering the page to create an itinerary the user will see a map and a form under it. This map can be seen on figure 3.18.

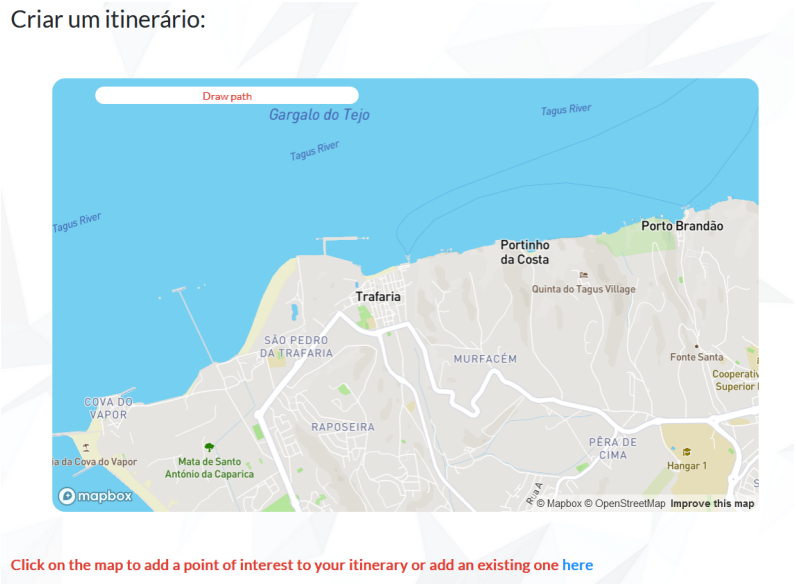


Figure 3.18: Create itinerary: Map

Under the map is a subtitle that informs the user that they can click on the map to create a new POI or choose an already existing one. When a user clicks on the map, it will prompt the user to create a POI, replacing the form for creating an itinerary, to be filled with the info of the POI to be created. Once submitted, the POI are displayed on the map with an icon, and more of those can be created. If a user wants to choose an already existing POI, they can click on the prompt in the subtitle to do so. This will open a new pop-up window where the user can search for the POI they are looking for. Once they submit the POI they want, it will show up on the map. When clicking on one of the POIs' marker a menu with the following options will appear, as can be seen on the figure 3.19.

Figure 3.19: Create itinerary: POI menu

- **Add Connection:** Upon selecting this option the user will be prompted to select another POI. This can be cancelled by right clicking a node on the map. When the user selects another POI, it will create a connection between the initial POI and the one that was just clicked with a direction from the initial POI to the one that was

selected. To have a valid itinerary to submit, all POIs should be connected to each other.

- **See Info:** This will replace the form of the itinerary with information on the selected POI.
- **Mark As Start:** Once the user clicks on this option, this will mark the respective POI as the beginning of the itinerary. This will also be marked on the map, so the user can always know which POI is marked as the start of the itinerary. If this POI is removed from the itinerary, the mark will also be removed, and the user needs to select a new starting point.
- **Remove From Itinerary:** This removes the POI from the itinerary. Any connections this POI has in this itinerary will also be removed. As stated previously, if the POI marked as the start of the itinerary is removed, then the user has to select another POI as the new start.

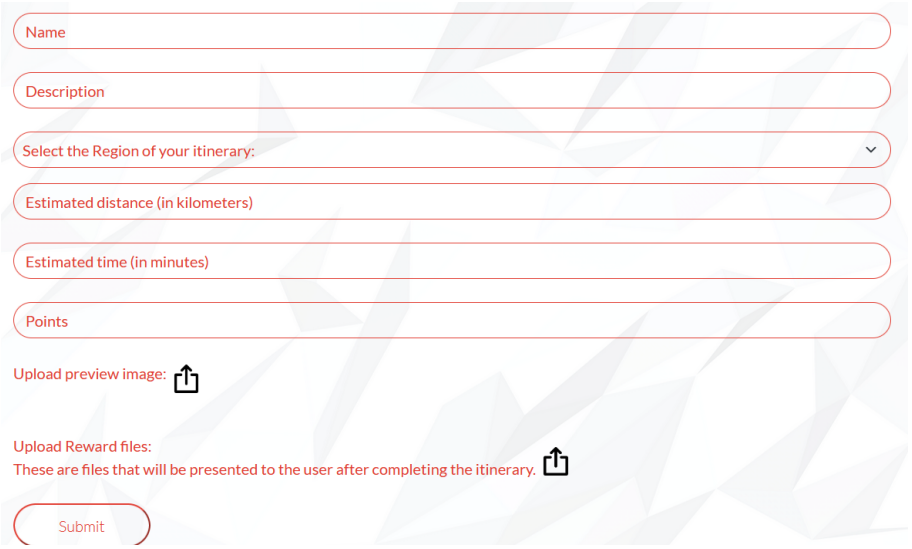


Figure 3.20: Create itinerary: form

Below the map is the written form the user will have to fill with information regarding the itinerary (figure 3.20). Two of the items the user will have to fill in themselves is the estimated distance and the estimated time. These correspond, respectively, to the expected distance a user will traverse and the time a user will take to complete the itinerary. Initially it was thought these could have been automatically calculated by the application. However, due to the nature of multiple paths of various lengths, we couldn't guarantee any kind of average or calculated number that would be representative of the actual user experience. Nevertheless these values would be useful when deciding which itinerary to choose. Therefore we still save an estimated distance and time, but it has to be the creator of the itinerary that has the responsibility to choose a value for these attributes, which may

not be accurate but should be fair to the user experience. The same train of thought was used when attributing the points given to the user upon completion of the itinerary. Since there is no accurate enough way to measure how much an itinerary is worth in points, it is the creator who should decide on a fair amount of points to be awarded on completion of this itinerary.

Below the written form are the buttons to upload a thumbnail image and award files. When opening the thumbnail selection button in the form, the user will be presented with a form similar to the one for uploading files, except this one only contains images. The itineraries, places/POIs and events can only have one thumbnail. If a user tries to upload a second thumbnail that will only replace the one currently selected.

When submitting an itinerary, the application will check for the following restrictions:

- The itinerary must have a name, a region selected, points, estimated time and distance.
- The itinerary must have at least two POIs. That's the minimum amount of POIs an itinerary should have.
- The itinerary must have a POI marked as the starting point. It shouldn't be possible to create an itinerary without a start.
- The itinerary must have all its nodes connected.

After successfully submitting an itinerary the user will be redirected to the homepage. There the user can verify the creation of the itinerary, by searching the list of itineraries for it.

3.4.6 Create Places

The process of creating a place will also create a POI. To create a place a user must navigate to the page labelled *Places* in the navbar and click the *Create Place* button. Upon opening the page, the user will see a map on top of the form to be filled with information about the place. This map is interactive and wherever the user clicks, that's where the place will be located. That's how the application knows the places' coordinates. Below the map, the user is able to see the form to be filled in with information about the place. This can be seen on figure 3.21.

3.4.7 Create Events

This is very similar to the process of creating a place. However, when creating an event, it will not create a POI. The user must navigate to the *Events* page and select the *Create an event* button to go to the respective page. There, just like when creating a place, the user will select on the map the location of the event and write its information below it, including when the event starts and when the event ends. This one can be seen on the figure 3.22.

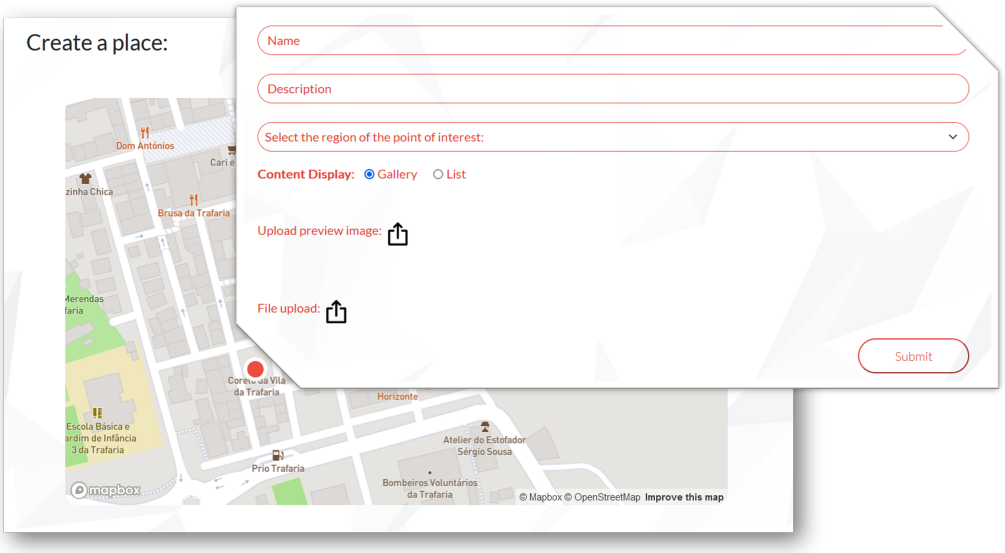


Figure 3.21: Create place

Figure 3.22: Create event form

3.4.8 Create Media Files

When creating and uploading a file for the application the user will have to fill in a form. This form is adaptable according to the file type chosen. This is because each file type has its own data to be saved. For example, an image doesn't need a thumbnail image to be chosen, since itself is its own thumbnail image.

The user can choose the file to upload from the user's file system. The rest is as simple as filling in the text form with the correct information for the file you want to save and submit. In order to upload a file for the application, the user will be prompted to fill in the form with the information of the file (this form is opened when clicking on the respective icons that can be seen on the figure 3.21). When creating an itinerary, a place, or a POI, the user will have the opportunity to create files for the items they are creating or use already existing files. The existing files are displayed on a searchable list that a user can browse. Each file on that list displays its title and file type. The upload file form can be seen on the figure 3.23.

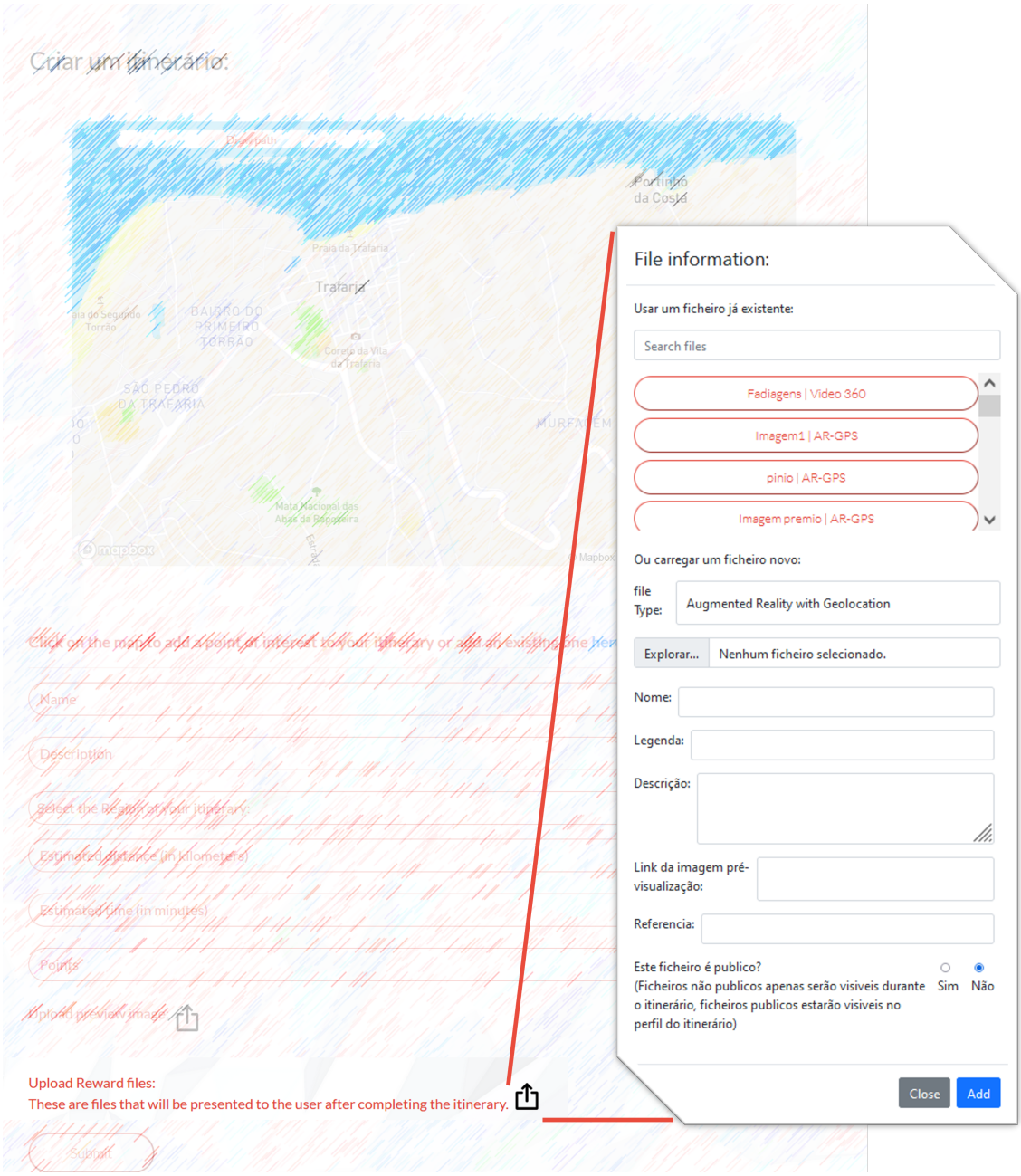


Figure 3.23: Upload file form

3.4.9 User Profile Page

The users' profile page is built different from the other profile pages. Just like in the previous pages, the users' name is shown on top, however under it is their role and their accumulated points by completing itineraries. Below that section is the general information of the user. This section is itself divided into multiple clickable and expandable cards where it is stored information related to itineraries, POIs, places and files, like how many they've visited or created. This can be seen on figure 3.24.

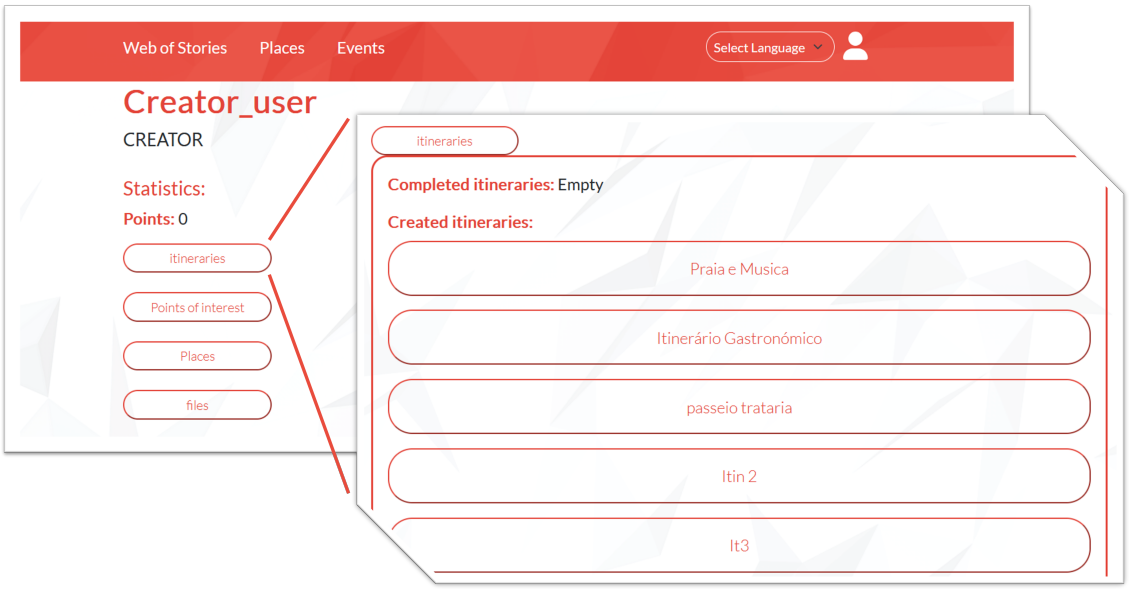


Figure 3.24: User Profile

3.4.10 Admin Page

Users with the role *Admin* will have an extra page, previously mentioned in the navbar paragraph. This page is dedicated exclusively to admin operations, making this the backoffice of the web application. Users with any other role than *Admin* won't be able to access this page since the application checks the logged in user's role in order to display the button to access this page.

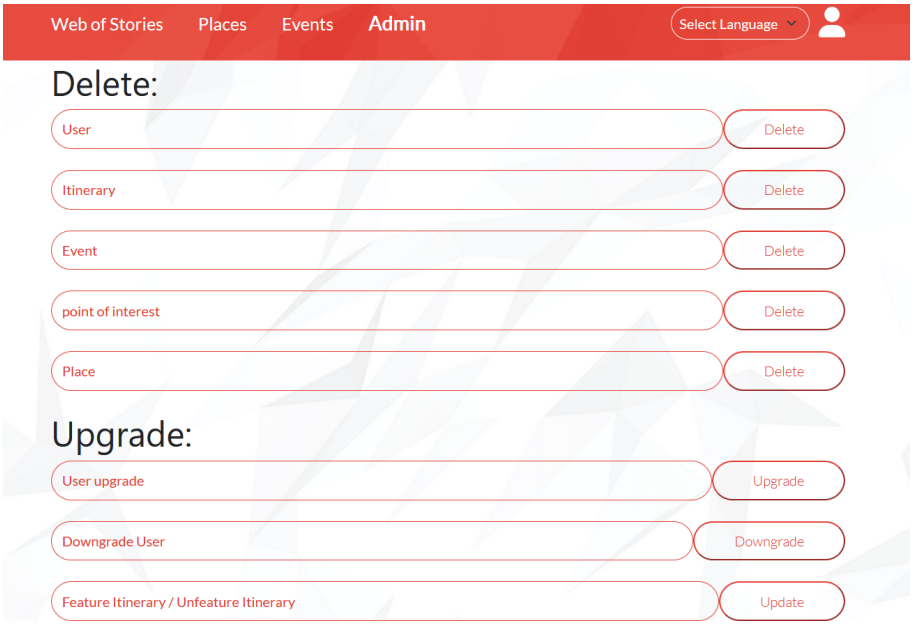


Figure 3.25: Admin page

In this page there is a list of simple forms where the *Admin* can insert an ID of an entity to delete them. Below the section to delete the users there is the *Upgrade* section as seen on

the figure 3.25. In this section the *Admin* can upgrade and downgrade users, which means promoting users with the role *Player* to *Creator* and *Creator* to *Admin* and downgrade them respectively. In that section the *Admin* can also feature and remove itineraries from the homepage's carousel.

3.5 Architecture and Server

As mentioned before, this project is divided between the mobile and the web counterparts. This thesis is focused on the latter one. Besides the web application, the work being done on this thesis will also focus on the server and database.

Represented in the figure 3.26 is a diagram detailing how both parts of the project (mobile and web) interact. The web application is meant to be used off-location. Since it's mostly used for either browsing or creating entities, it doesn't need to be used on a specific location. Both the mobile application and the web application need to have access to a server so that both of them can get the content they need to present on their respective interfaces. The server in turn stores and accesses the content on the database.

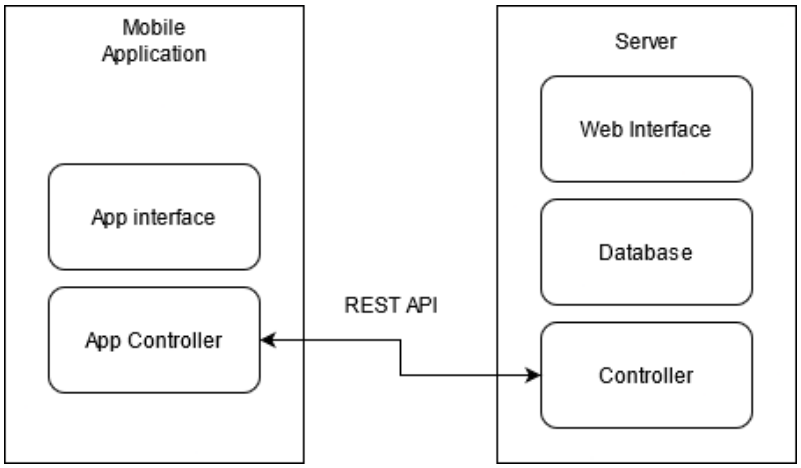


Figure 3.26: Interaction between both parts of the project (mobile and web)

3.5.1 Architecture

Regarding the architecture of the system, that is, the way in which the elements are interconnected between themselves, what the relationships between them are and how they operate, we began by idealising a fairly general scheme that was gradually adjusted to the needs of the application.

Initially the vision of the entities that comprised the workings of this project (users, itineraries, POIs, etc), were intended to interact with each other as seen on the diagram on figure 3.27 (further on it will be shown a more updated version of this scheme).

Some notable items missing on that diagram, comparably to the final version of the application, are events and places. Places were added to the application so that the user

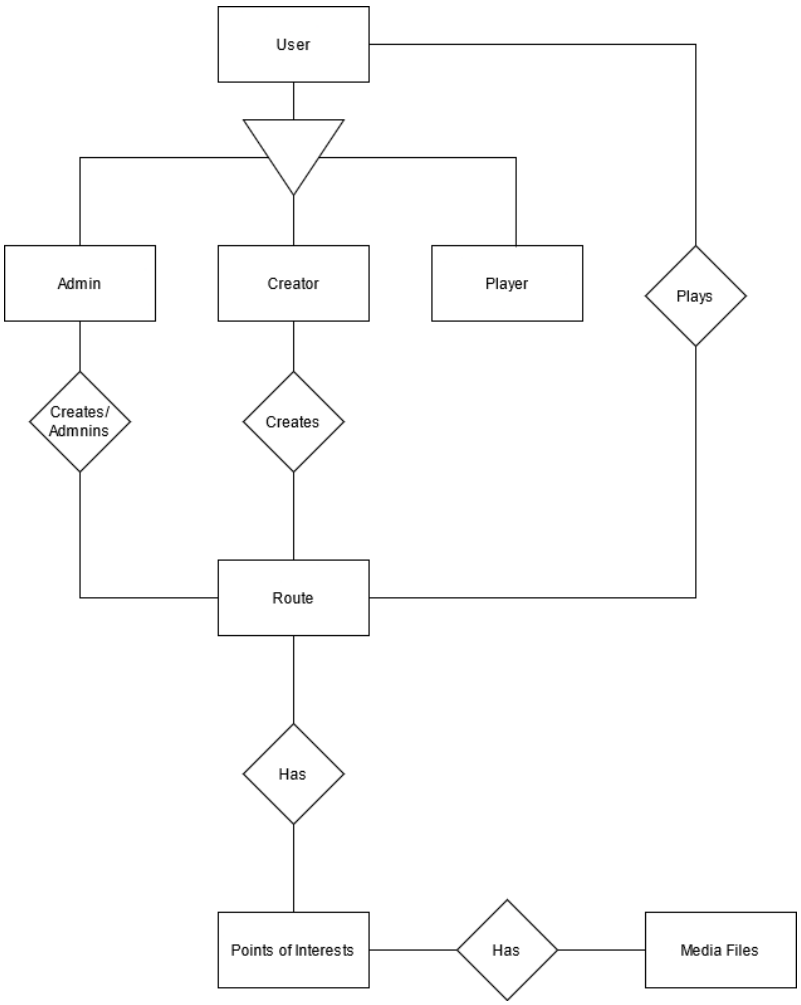


Figure 3.27: Initial Entity Relationship Diagram

could visit individual places without committing themselves to follow an entire itinerary. While visiting a place, the experience should be similar to when visiting a POI while doing an itinerary. In succession, events were made to be similar to places but restricted to a specific period of time.

Another aspect that was different in the initial vision of the system was that only POIs had media files; as the development of the application progressed it was decided that not only the POIs should have media files associated but also itineraries, places and events.

Regarding the way the system addressed the users, during development instead of having three different user classes (as can be seen on figure 3.27), we have decided to contain all of these types of users in just one user class by using a *role* attribute to distinguish between them. This can be seen on the updated version of the application, as can be seen on the diagram on figure 3.28. The same can't be said about the media files class - this one had to be divided into each file type having its own class due to each file type having various different attributes from each other.

Figure 3.28 shows a class diagram demonstrating an updated version of a the system.

A more detailed version of the diagram can be seen on annex III, with all the attributes present for each entity.

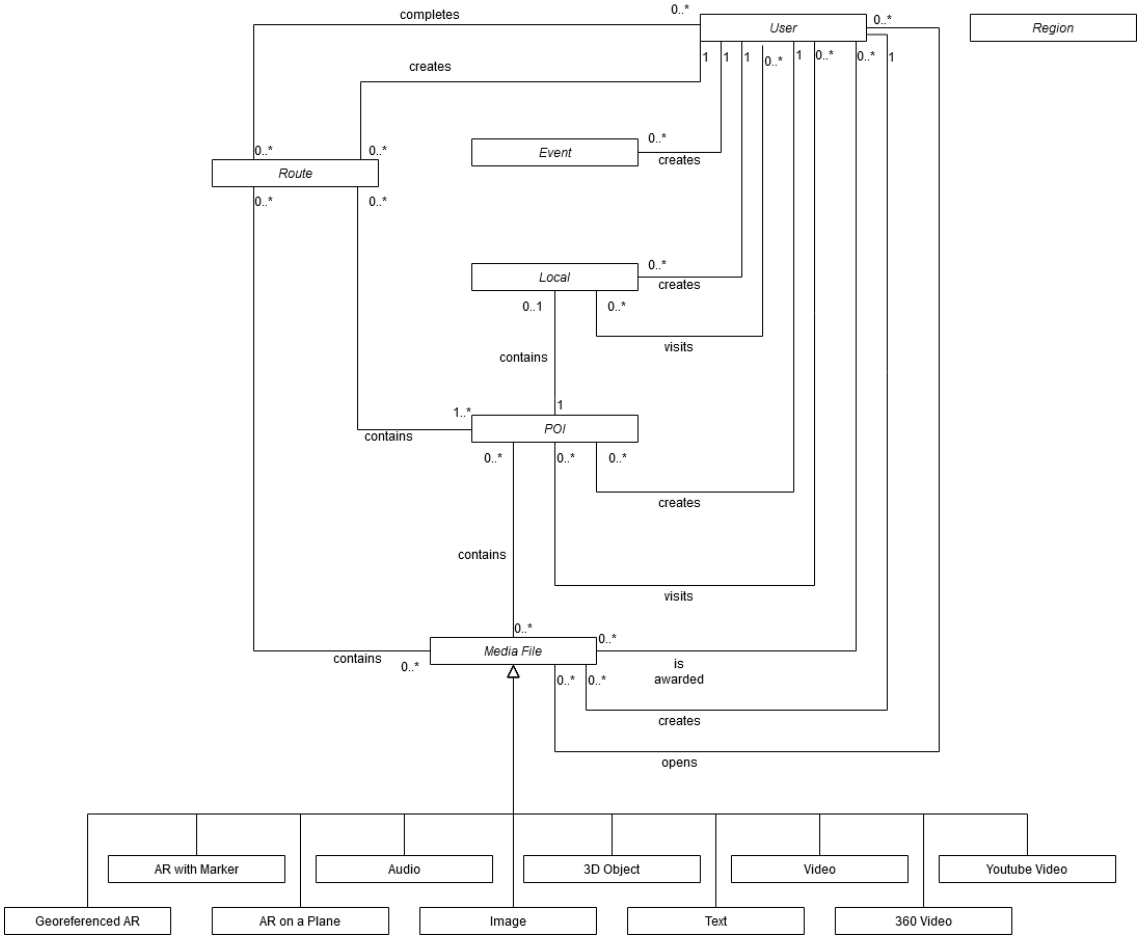


Figure 3.28: Class diagram of the system

On figure 3.28 you can also see a sole class not connected to the other classes. The Region class was created as a class and not just used as an attribute in other classes, because it is expected to be able to select one or multiple regions to be featured, and have the itineraries and places of those regions to be highlighted in that space, while those regions were featured. That feature could be made in the future, but so far it hasn't been developed yet.

3.5.2 Server

Initially a basic version of the server was made, where each class had only the Create, Read, Update, Delete (CRUD) operations available. The server and database was iteratively developed during the elaboration of the project, becoming increasingly more sophisticated to the desired aspects of the application.

For the server we have decided to build a local server instead of a cloud based server, since the application will be mostly used on used on site. Also, this option allows more

control over the services the application provides and also its own safety. It should also be more efficient and cheaper to rely on local server on location than the service provided by cloud based servers, since this project will not rely that much on the advantages of having a cloud server, like the better accessibility in any location.

A REpresentational State Transfer (REST) API is used to communicate between server and the interface of the application (both web and mobile). This API was made with the help of Spring, which provides infrastructure support for developing Java applications, and Spring Boot, which is an extension of Spring widely used to build REST APIs. Both Spring and Spring Boot bring significant advantages for this kind of application, making it easier to maintain, and to develop.

The server architecture can be represented by the components described in figure 3.29. That figure also represents how those components are connected with each other, and how they interact with each other.

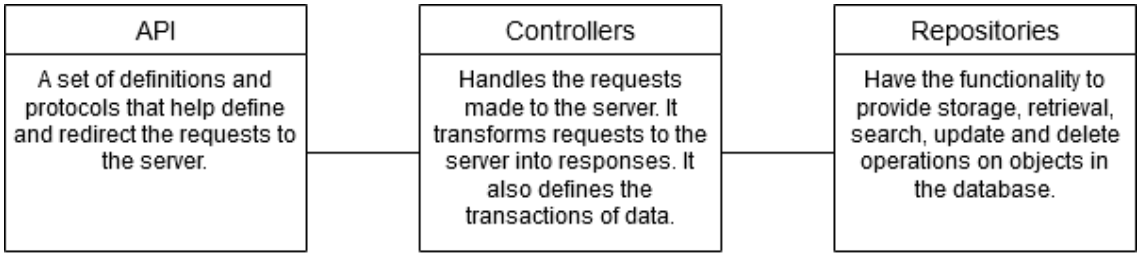


Figure 3.29: Server Architecture

3.5.3 DAOs and DTOs

The entities of *Web of Stories* are represented as Data Access Object (DAO) and Data Transfer Object (DTO). DAOs being the objects that communicate with the database and the ones that suffer from CRUD operations, and DTOs are objects that contain the data. These are the ones the server receives and sends on their requests. The DAOs are transformed into DTOs, and vice versa, in the controller layer (which focuses on giving, receiving and transforming data). In this system each entity is identified by a unique number called ID.

3.5.4 Controllers

The controller layer focuses on giving, receiving and transforming data, depending on the type of operation, and saving it on their respective repository. Most of the operations here are CRUD operations, in fact, each entity has all the CRUD operations in their respective controller. More specifically each controller has a method to create an instance of their respective entities, get a list of all instances of an entity in the database, get an instance of an entity given an ID, update the info of an instance of an entity given its ID and the information to update on the request's body, and finally remove an instance of an entity given its ID. Each controller also has a private method to transform the corresponding

entity's DAO into a DTO. Next we will specify the controllers used in the application as well as some specific methods for each entity that don't exactly fit in with CRUD methodology.

- **User:** Besides the previously mentioned CRUD operations, in this controller there are also methods involving the login of the user, including the actual login operation, getting the logged in user's information (depending on the device the user is using), and logout. There is also a method for saving a user's progress when trekking an itinerary. This is used in case the user needs to stop following the itinerary (for any reason the user deems fit) and later the user can come back and finish the itinerary. There is a method to update and save the user's info when it passes by a POI. This is used to update the user's statistics. There is also a similar method to this one but for when a user completes an itinerary. There is also separate methods to set the numerical gamification points for the user. Finally, there is also another method to change the role of a user. This feature is protected so that only administrators can use it.

- **Itinerary:** The itineraries' controller has the CRUD operations. However, when retrieving an instance of an itinerary, it also retrieves its POIs, all its POIs' files, and the files that are awarded to the user upon completion of the itinerary. This was made in order to minimize the amount of requests to the server, in an attempt to eliminate needless calls to get POIs, media files, and others.

- **Media File:** Even though there is an entity for each file type, there is only one controller for all media files. This means that all CRUD operations in this controller are meant for all types of files, with the exception of the method to create text files and Youtube videos, due to the nature of not uploading an actual file and instead its contents being filled in manually by the user in the form on the web page.

- **Others:** For the following controllers only the CRUD operations were implemented, keeping them simple and easy to extend and simple to use: POIs, Events, Places, and Regions.

3.5.5 Repositories and Database

We needed a place to store in the long term the entities that make up the system, and to be easily accessed by the web application. The server saves its entities on repositories, and these repositories represent their respective tables in the database.

Each entity, with its own attributes, has its own repository. Each instance of an entity is identified by its ID in the database. This ID is generated at the object's creation making sure that there isn't any repeats of IDs between objects.

We had to carefully check each entity in order to see what would be the best way to store them in the database. During this process, some relevant aspects were highlighted.

While creating itineraries, users can create new POIs, or use already existing ones. And these POIs can be reused between different itineraries. An advantage of this aspect is that it prevents the creation of unnecessary single-use POIs, which helps unclutter the database from redundant POIs.

In regards to the entity *place*, the main difference between this one and a POI is that for a *place* a user doesn't need to be trekking an itinerary to visit them. Because of this distinction they are saved in a different table in the database to facilitate queries made to it. Still, places can be used as POIs for itineraries. Therefore when a user creates a place, they also create a POI.

Events are also similar to POIs, in the way that they have the same general information with few exception. This way, the database saves, for the events, almost the same amount of general information as a POI besides the attributes that define the time at which the event takes place. For that purpose we just save the beginning date of the event and the date of its closure.

Given the nature of media files being of different types and having their own set of attributes, we created a class for each one of them. Even if we have all these classes, we can group all the common attributes in one abstract class representing all files. But in the database the files can't be stored that way, therefore we had a dilema: should the files be stored all in one table independently of the file type, or each file type would have its own table to store its data. If all the files were stored in one table there could be a lot of unused space in that table due to the uncommon attributes between file types. However, if each file type was stored at their own table, each request to the database searching for all types of files would be complicated and would also need to visit each file table individually. We've ended up deciding to store all files in one table independently of their type. This is because, in the case of this application, all requests to the database involve getting files independently of their type (the only exception being images, when a user is searching for thumbnail images to add to a POI or itinerary they are creating).

3.6 Technologies

Several technologies were used to develop the application and it was necessary to make a brief comparison study between the various possibilities.

For the web application's front-end, we considered the following technologies and frameworks, which have been compared as follows [31] [26]:

- **React:** A JavaScript library that helps build user interfaces. It is used for the visual layer of a web application, more specifically in single-page applications and reusable UI components. However, React has a few drawbacks. It has left Object-Oriented Programming, which steeps the learning curve for users who are used to this kind of programming, this might in turn discourage some users and steeper the learning

curve. Most libraries are loosely coupled that means there can be a struggle to cross-check for dependency issues.

- **Vue:** A progressive framework for JavaScript used to build web interfaces and, just like React, to build single-page applications. Besides web applications, it can also be used for mobile and desktop applications. Vue has a very small learning curve and despite being the most recent of these frameworks, it has a very extensive documentation. However, Vue is also the least popular of the frameworks presented.

- **Angular:** A framework that just like React and Vue is used to build single-page applications. It is written in typescript. Its data binding and dependency injection mechanisms make it so the code is made by the developer in a shorter amount of time. However, Angular's performance is slower comparatively with React and Vue. This can be because it is also the heavier of the three. Angular has also a steeper learning curve than the mentioned alternatives due to the many structural components. Angular comparatively to React and Vue is less flexible, making so that developers have a harder time to adapt to it.

We ended up using React for the development of the front-end, due to it being the most lightweight of the ones considered, but also the one with which I'm most experienced. The fact that we can reuse the UI components helps speed the development of the project, making React a faster alternative than the others. All of this made React the best choice for the development of the *Web of Stories* web application.

In addition, Bootstrap, an open-source framework which contains Cascading Style Sheets (CSS) design templates for many elements of the users' interface (making it easier and faster to build), was used to complement the building of the front-end of the web application.

Taking into account the importance of the use of geo-location and the visualization of itineraries graphically, we had to take into consideration the technology to best accommodate these features. Therefor, we investigated the following technologies:

- **Google Maps Platform:** It is built by Google. Possibly the most used map technology in the world. It can provide map features like routes, markers and some others to web and mobile application, however it does not natively use AR technology.

- **Openstreetmap:** A free map technology with crowdsourced content. It has many features (i.e. map features) similar to Google Maps, like routes, markers and other specifications to web and mobile applications. It also does not use AR technology in a native way. Openstreetmap is used by various companies like Facebook, Apple, Amazon, Uber, among others.

- **Mapbox:** It was built as an alternative to other map providers like the two mentioned above. Just like those it can be used for routing and navigation applications. However,

Mapbox can be more easily used for AR applications. Mapbox is used by National Geographic, CNN among others.

Since Mapbox is more adaptable for AR applications it was the mapping technology of choice during the development of this project. Mapbox is also being used by the mobile counterpart along with the web application.

As our application needed a specific back-end for its geo-located features, we have pondered if the server should be localized, which means it would be deployed and accessed by users on a single location, or on the cloud, using services like Firebase, Google Cloud Engine or Microsoft Azure. However, since the nature of this project is more specific to a single location, i.e. Trafaria, the choice for a localized server seemed more advantageous and in turn easier to manage than the cloud alternative. However later, in further work on this project, it can be expanded to be applied globally.

Postman was used to help the development of the server. This technology was used to test the API while the server was being developed.

When it came to the database used in this project, it was built with the help of the relational database management system MySQL, which allowed us to build a relational database of our system using Spring, and Spring Boot. MySQL provides every tool needed to build the database for this project and it is also faster, and simpler to operate than the alternatives like PostgreSQL.

In order to deploy the project on the server at FCT, we used Docker. Docker is a set of platforms that is used to develop, ship and run applications. Our application was deployed with the help of a dockerfile and two containers (the database/MySQL container and the *Web of Stories* server/frontend container). For these two containers to interact with each other it was also necessary to create a network that both the database and the server/frontend container could interact and share information with each other.

Our application aims to improve in a certain way the tourism and the perception of the history and culture of a certain place. Ideally the application could also be used by tourists coming from all over the world. So the language in which our application was written should not be an obstacle for the users. For that we used another technology, i18nexus, capable of translating the website from Portuguese to English and vice-versa, making it more accessible to all. i18nexus uses Google Translator to translate between languages. The translations can be edited to fit the users' wants and needs. This technology also makes it easier to expand the languages the application is available in. However, for the context of this thesis only English and Portuguese were chosen as languages for the application - the supported languages can be expanded in future works.

Once the application was created the next step was to evaluate it. Therefore user tests were made in order to evaluate the application and also to gain feedback on what could

be improved. These user tests were the final step of the development of this iteration of the application. More on the user tests is shown on the next chapter of this document.

4

User tests

During the final stages of the development of the *Web of Stories* web application, it was devised some user tests in order to evaluate the performance of the application. A number of aspects were evaluated, for example the quality of the interface, the process of creating places/POIs, uploading a file and creating an itinerary, in turn evaluating the authoring system of the application. There were 15 participants in total performing these user tests.

4.1 Metodology

Each user test was comprised of 3 steps that the user needed to take:

- First the user read a short document detailing information on the *Web of Stories* project, like its background, its goals, and its content. This information was essential to give the user who was partaking in the test context on what they are going to be testing, as well as, what is expected of the application. This document is attached at the end of this paper (annex II). In that document it was also described the tasks the user was going to be performing. These can be resumed to:
  - creating a place/POI.
  - creating an itinerary using POIs that are already on the system.
  - creating an itinerary using new POIs, but without uploading any new files to the system.
  - creating an itinerary using new POIs, but uploading new files to the system.
- Next the user was hands-on on the application. During this part of the test, there was communication between the user and the developer in order to answer some question the user might have. During this step the developer was also taking notes on the current test.
- Finally the user answered a questionnaire. This involved questions about the user, while maintaining their anonymity. It also used the SUS questionnaire, as well as some general questions about the quality of the user experience during the test.

4.2 User Test Performance

Each user test lasted from 30 minutes up to 1 hour. Every single task asked for the users to do was completed successfully. Nonetheless the users had the freedom to explore the app freely and use it to create all sorts of possible items (POIs and itineraries mostly).

During these tests, it had been noted that in the beginning of each test the user had difficulty creating whatever item was asked of them to create and navigate the application in general, however by the end of the test most users could use the application as expected, creating items easily and with speed. It means that the application has a learning curve that is easy to overcome by most users, however some guidance might be necessary for some users to fully utilize the authoring tool to the fullest.

While observing the users completing their tasks and using the application, some notes were taken on the users behaviour and some talking points during the test. Some of the most common ones were:

- Difficulty in correcting mistakes. Most of the users had this problem when creating an itinerary, more specifically when interacting with the map. This is something that should be improved on future iterations.

- Difficulty in distinguishing between the line connecting the POI and the line determining the path for the user. As shown in figure 4.1, the users would try to connect the POI using the line meant for designing the trek of the users.

Figure 4.1: Itinerary showing the line connecting the POIs (orange lines) and the line showing the user's path (grey lines)

- Most users had more difficulty understanding the 'file upload' form of the application (figure 4.2) than the other forms. Most users didn't understand the 'reference' item on the form. This is to give credit to the original creator of the file that was uploaded since uploaded files can be re-used by other creators. Most users also skipped the

'file type' item despite being the first one on the form. Indicating that in the future this form might need to be re-worked. This can be fixed by forcing the user to fill in that form item before submitting.

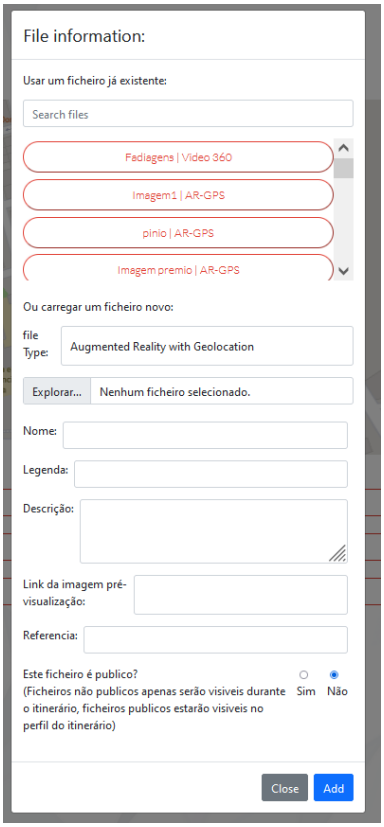


Figure 4.2: File form

- A considerable amount of users, one third of the users to be exact, didn't know how to add already existing POIs. Despite the subtitle on the map with the indication, it needs to be changed in order to be more visible.

- When filling the form most people couldn't get what the item labeled *points* was referencing. When asked what they thought it was, most said that it was the number of POIs in the itinerary they were creating. Only after an explanation it was understood it stood for the points awarded to the player upon completing the itinerary on the mobile application. Indicating that this component of gamification might have gone unnoticed. This item needs to be changed on the next iteration of the application, like an image of an *i* (i.e. information) and when a user hovers the mouse over it displays the information on what these points are.

- During a user test, one of the users mentioned this app, or an app like this, could be really useful for archaeology. This could be an interesting facet to explore in a future iteration of the app, or this app could serve as inspiration for similar apps more related to the field of archaeology.

- In general, most users didn't know what the *content type* item of POI form is referring to, even with the *gallery* and *list* options present. More clarification on this affecting how the files are displayed on the mobile app is needed.
- Due to the size of most itineraries created, and the focus of the app being on the region of Trafaria, most of the itineraries created were less than a kilometer in length, therefore in the parameter determining the estimated distance should be in meters and not in kilometers. That way, the estimated distance should be more useful to the user when making these shorter itineraries without sacrificing its usefulness when trekking larger itineraries.

The web application was tested on all sorts of web browsers and operating systems. The browsers tested were Firefox, Edge, Chrome, Safari and Opera and it worked as intended on all browsers except Safari. When testing on the Safari browser the only small but noticeable difference was the size of the *create itinerary* button - this one was much larger than intended, other than that it worked as expected. It was also tested on the most popular operating systems, like Windows, Linux and macOS, and the operating system didn't make any difference to the performance of the app, it worked as intended on all of them as expected.

One of the participant was Sandra Henriques, a travel writer who has written for Lonely Planet among others. During her test she gave insight on desirable features and aspects that users of this kind of application could want, and also insight on the impact of this kind of applications and possible desirable innovations. Such insights include the importance of curatorship in tourism as a way not only to enhance the experience of visiting a place but to expose its history and culture to a major audience, specially if its curated by locals with knowledge about the real history of those places.

On gamification, unfortunatelly she wasn't very confident on this facet of the application while she recognize its use in appealing to the younger audience. It could get in the way of the more cultural/learning experience by making it just about the game and not about the history and culture. She warned not to get these aspects in the way of each other but make them coexist.

On the aspect of attracting possible users to using the application, she reinforced the curatorship, speaking on the success of applications that focused on that aspect be it in curatorship for a specific audience. There have been successful apps that have this kind of curatorship, for example, apps that focused on curatorship made specifically for women or the LGBT+ community or others due to lack of trustworthy sources for safe spaces for each community. Those applications have proven to be not only successful but an asset for either the community and the establishments that work closely with these communities.

Another way this curatorship could help would be to associate travel writers/vloggers. This way the app could use the influence of these to expand the application's user base and vice versa. The writers/vloggers could use the application to expand their audience. Another perspective on this is that it could help expand tourism to other more unknown

aspects of local culture that aren't considered a tourist trap, catching the audience that seeks counter-culture. Therefore, this could also help spread the tourism to not just go and overcrowd the same touristic places, like Pastéis de Belém for example. In fact, curatorship helps to appeal to niche communities, for example having an itinerary made by a famous local architect would appeal to people interested to architecture, like in the *myhelsinki* website [32]. This logic could be applied to any sort of niche and interest, be it in Portugal or international, in this way appealing to anyone with that particular interest.

When it came to each itinerary, she stood out the fact that you could make multiple paths for one itinerary, thus making each itinerary more appealing for more people since anyone could explore in the way they prefer. She also found the inclusion of AR very important since there is so few application of this technology in Portugal today, and the ones that exist are pretty successful, like the one at Quinta da Regaleira [11].

4.3 Questionnaire results

The final part of the test was the questionnaire that every user had to fill. This was divided into four groups of questions: questions about the user (user profile), SUS [10], task quality, and general questions. In this section it is analysed the data gathered from the questionnaire.

4.3.1 User profile

During this section of the questionnaire a few questions were asked to the users about themselves.

Relative to age, most users were in their twenties, from 22 to 26, having only 2 tests of people who were older 44 and 51 respectively, making it an average of 26,8 with a standard deviation of 8,27. When it came to gender, two thirds of the participants who tested were male and the other third female. A little more than half of the people tested, 53%, had a masters degree, while 40% had a bachelor's degree, and only 1 person had high-school level education. On a similar note, 53% of the users had previous experience developing software.

4.3.2 System Usability Scale

The SUS is one of the most frequently used questionnaires to measure the usability of an interface, and it's been proven to be a reliable tool in the evaluation of the usability of applications [23]. The SUS consists of 10 questions with a scale of 5 options that go from Strongly Disagree to Strongly Agree. Each question has a weight of 10 points and the total score is 100.

In order to calculate the SUS score, first you must subtract 1 from the odd-numbered questions, since these have a positive connotation, or since there is 5 of them you can subtract 5 from the sum of the points of those questions. By doing this you ensure

the minimum is 0 and after multiplying by 2.5 you ensure the maximum is 10 for each question.

For the even-numbered questions, these have a negative connotation. You subtract from 5 the score of each question, or since there is 5 of them you can subtract from 25 the sum of the points of these questions, ensuring the maximum is 10 for each question after multiplying by 2.5, for the same reason as before.

Simplified the formula looks like this:

$$X = \Sigma(the\ points\ for\ all\ odd\ numbered\ questions) - 5$$

$$Y = 25 - \Sigma(the\ points\ for\ all\ even\ numbered\ questions)$$

$$SUS\ Score = (X + Y) \times 2.5$$

The resulting SUS score is a number from 0 to 100. This number serves as a measure of usability performance of each user. The average score is 68, therefore we can evaluate each score resulting from the users' answers to the questionnaire according to the table 4.1.

Table 4.1: SUS score grading

SUS Score	Grade	Adjective Rating
>80.3	A	Excellent
68 – 80.3	B	Good
68	C	Okay
51 – 68	D	Poor
<51	F	Awful

Two more components that could be extrapolated by the SUS component are learnability and usability [19]. Learnability can be calculated by just using question 4 and 10 (*I think that I would need the support of a technical person to be able to use this website.* and *I needed to learn a lot of things before I could get going with this system.* respectively), by subtracting 1 to both scores and then adding the result of those 2 subtractions, and multiplying it by 12.5. The resulting number should represent the learnability of the system. While it is reliable, unfortunately the score is given in intervals of 12.5, so the maximum might be 100, but the next biggest score is 87.5, making it have a considerable degree of inaccuracy.

For the usability you do the same process except you use all questions except 4 and 10. However instead of multiplying by 12.5, it is multiplied by 3.125. The results obtained for the SUS score, learnability and usability can be found on the table 4.2 and on the graph on figure 4.3. As can be seen, the score on most tests as well as the average are above the average SUS score. The results on the learnability and usability are also high values. While the usability result is close to the SUS score, the learnability result is very high,

which supports the idea that the application being fast and easy to learn for newcomers to the application.

Table 4.2: SUS score, learnability and usability

User	SUS Score	Grade	Learnability	Usability
1	55	D	37,5	59,4
2	72,5	B	75	71,9
3	75	B	87,5	71,9
4	87,5	A	100	84,4
5	60	D	75	56,3
6	75	B	100	68,8
7	80	B	87,5	78,1
8	72,5	B	100	65,6
9	97,5	A	100	96,9
10	92,5	A	100	90,6
11	80	B	100	75,0
12	60	D	100	50,0
13	65	D	75	62,5
14	75	B	87,5	71,9
15	72,5	B	87,5	68,8
Average	74,67	B	87,5	71,46

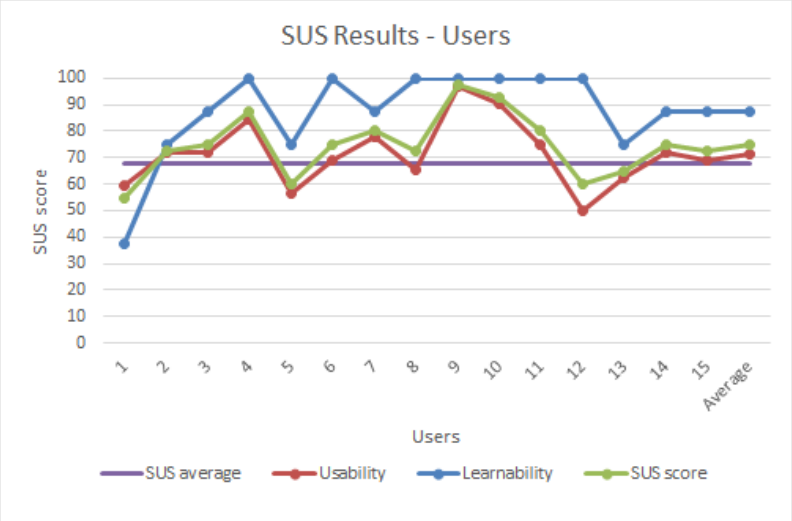


Figure 4.3: Graph of SUS score table

4.3.3 Creating an Itinerary

This section had the objective to identify the steps on the process of creating an itinerary that could be improved or that the users already felt comfortable while creating an itinerary. These questions are also answered on the *Likert scale* of 1 to 5 (1 being *Strongly disagree* and 5 being *Strongly agree*).

On figure 4.4 it can be seen that most, if not all, users had an easy time finding access to the page designated to create an itinerary.

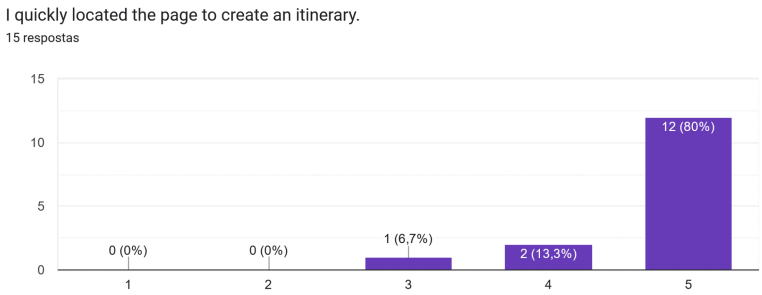


Figure 4.4: Graph *I quickly located the page to create an itinerary.*

According to the graph on figure 4.5, most users also had an easy time understanding how to add information to the itinerary they were creating.

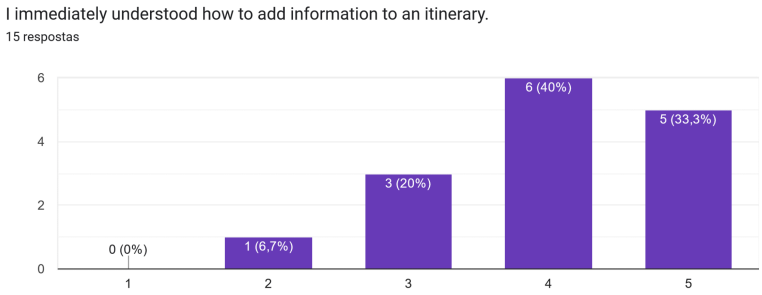


Figure 4.5: Graph *I immediately understood how to add information to an itinerary.*

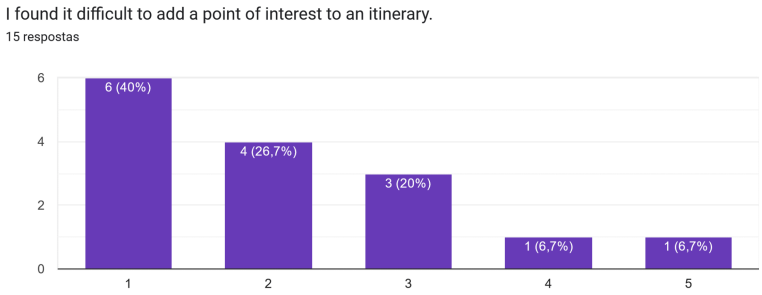


Figure 4.6: Graph *I found it difficult to add a point of interest to an itinerary.*

Most people didn't find difficult to add a POI to the itinerary they were creating. This can be seen on figure 4.6. On that note most people also understood immediately how to do it, represented on figure 4.5.

When it comes to adding media files to a POI, most people also didn't find it difficult to do as can be seen on the graph on figure 4.8.

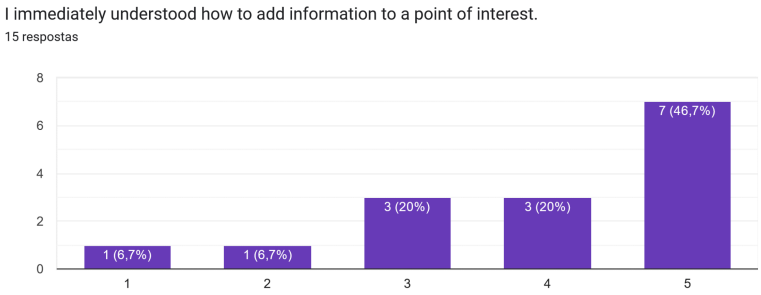


Figure 4.7: Graph *I immediately understood how to add information to a point of interest.*

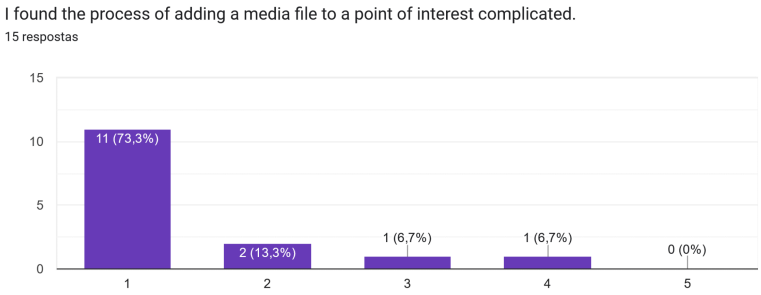


Figure 4.8: Graph *I found the process of adding a media file to a point of interest complicated.*

Figure 4.9 shows that the users found it easy to add information to the media file they were uploading to the system.

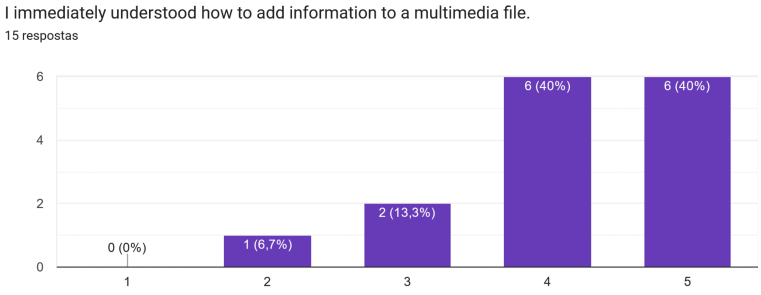


Figure 4.9: Graph *I immediately understood how to add information to a multimedia file.*

Finally, on figure 4.10, the users didn't find it difficult to find the itinerary they created in the web application after they created them.

Unfortunately, most users found the process of correcting mistakes while creating an itinerary from bad to okay, as can be seen on figure 4.11. Which means this is an aspect that should be changed in futures iterations of the website in order to improve the user experience on the application. This could possibly be fixed by adding a button that retraces the steps of the user while they are creating an itinerary.

According to figures 4.12 and 4.13, most users didn't find like there was neither too much content for each itinerary nor too little.

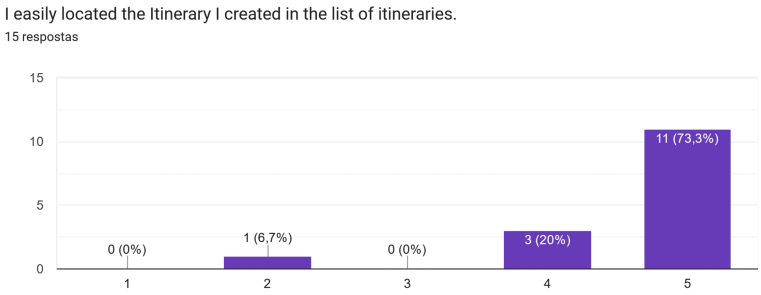


Figure 4.10: Graph *I easily located the Itinerary I created in the list of itineraries.*

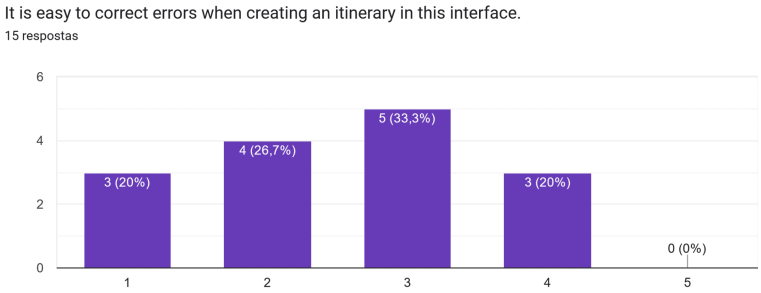


Figure 4.11: Graph *It is easy to correct errors when creating an itinerary in this interface.*

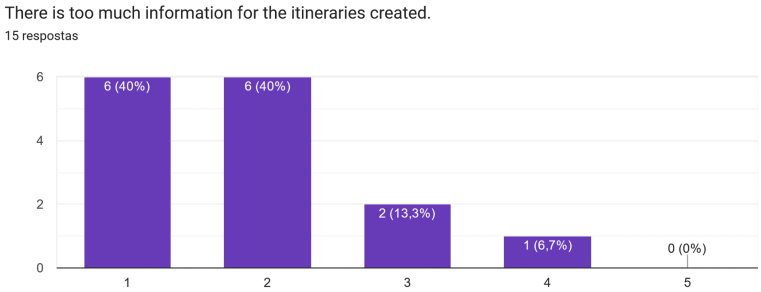


Figure 4.12: Graph *There is too much information for the itineraries created.*

4.3.4 Other Questions

The last section of the questionnaire was reserved for general questions, all of them have written answers personalised by the users, with the exception of 2 multiple choice questions. These 2 multiple choice questions were about the aspects the user liked the most and liked the least considering the creation of the itineraries, as shown on figures 4.14 and 4.15. On these 2 questions each user could select up to 3 options. By analysing the graph in figure 4.14, 4 of the options in that question were highlighted as the better components by more than 50% of the people that answered that question. These options are:

- "Complex itineraries can be created with alternative paths."

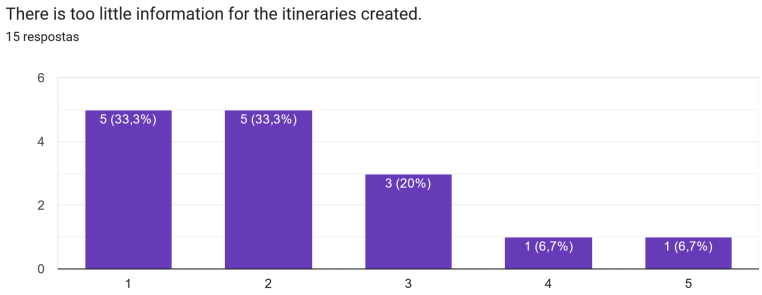


Figure 4.13: Graph *There is too little information for the itineraries created.*

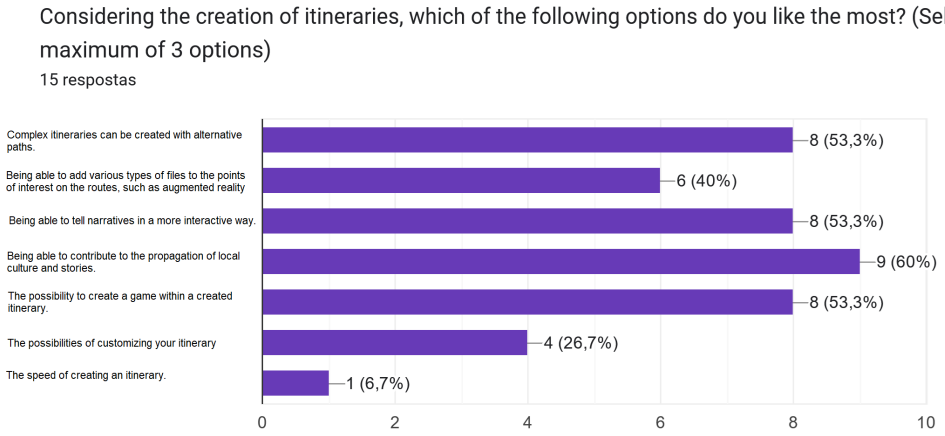


Figure 4.14: Graph *Considering the creation of itineraries, which of the following options do you like the most?*

- "Being able to tell narratives in a more interactive way."
- "Being able to contribute to the propagation of local culture and history."
- "The possibilities to create a game within a created itinerary."

With 60% of the people answering *Being able to contribute to the propagation of local culture and history.* option, this seems to be the most favourable component of the itineraries created by this application. This component, in the perspective of the tested users, should, above the other components, be highlighted as the main focus of the development of the application.

On the other hand, regarding the question about what the users liked the least on creating itineraries (graph on figure 4.15), there wasn't a consensus in the way that no option had more than 50% of the users answering one of them. The two top answers, both only with 28% of the users voting for them were:

- "Being able to add various types of files to the points of interest on the routes, such as augmented reality."

- "The speed of creating an itinerary."

Despite only 28% of the tested users choosing these options, it is proof that these components should be improved the most, on the next iteration of the project, in order to catch up to the other components.

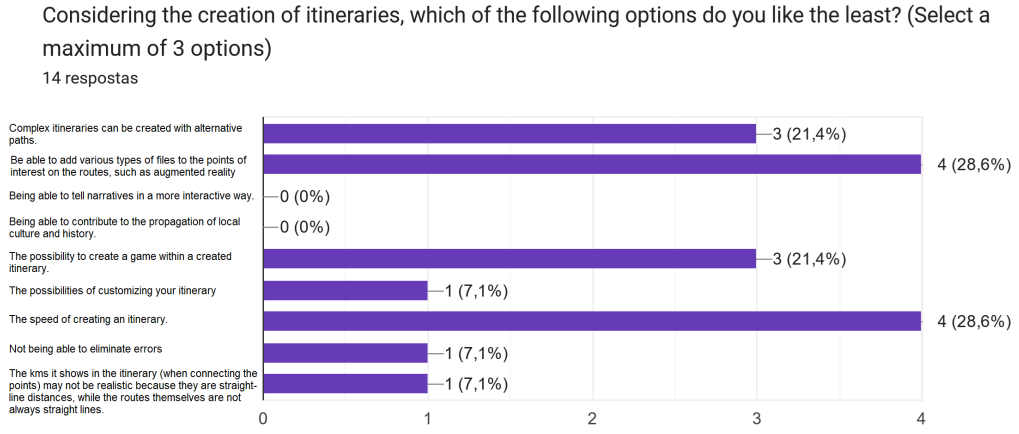


Figure 4.15: Graph *Considering the creation of itineraries, which of the following options do you like the least?*

When asked if there was a lack of relevant information on the itineraries that could be created on this app, the answer was an overwhelming *No*. We could interpret this as the itineraries, created with this application, could be considered complete in terms of the information they could contain. However, the option for expansion will always be there.

On the question, *What would you improve to make the itinerary creation process more efficient?* the most answered option is both in ways to correct mistakes made while creating an itinerary (figure 4.11 and in a tutorial of some kind designed for someone who is making an itinerary for the first time. A tutorial would definitely minimize the amount of errors made during the creation of an itinerary.

The aspects the users that tested the application highlighted as being the one they most liked on the application were, in no particular order:

- Gamification, or the ability to make a game out of itineraries created.
- The interactability and ease on the process of creating a complex itinerary.
- The accessibility of interesting content, be it, culturally or historically.

On the opposite side, when asked on what aspects of the applications the users liked the least the answers were mostly due to the complexity of the process of creating an itinerary, in the amount of forms that had to be filled, lack of ways to correct mistakes and the creation of a path for the itinerary. While this may sound contradictory to the answers of the previous question that say it was easy to create a complex itinerary, some

components of the itinerary may be complex in nature, like in the creation of a path (which during the test was the element most people seem to have more trouble with), while the itinerary in general was easy to create, especially if it isn't the first time creating an itinerary, as observed.

This can be confirmed on the next question which is if the user had felt any difficulty using the application. As most of the answers are directed to those aspects, others being in general correcting mistakes made during the process of creating itineraries.

Finally other comments left by users were situational tips on the design of the interface that should be considered while developing the following iteration of the application. One of the users commented that this application, or similar applications, could be very useful to archaeology or historians, in the way of mapping territory.

5

Conclusions and Future Work

On this chapter a reflection is made on the work that was presented and the project that was developed. Finally a discussion about the future work, including recommendations and suggestions to improve the project based on the ideas that were brainstormed during the development and also that were given as feedback during the users test.

5.1 Conclusions

This project revolves around the preservation of history and culture, using the Trafaria region as a case study, even though the results can be generalised to most locations, if not all; developing the community by enriching the local community with a way to not only preserve their story but also spread it to future visitors of the region through technology.

One of the objectives of this work was to create an authoring tool to create interactive narratives. These interactive narratives should revolve around the local culture and history. Considering the result of the developed work and the feedback of the user tests this objective was accomplished. These interactive narratives can be created in the application in the form of interactive itineraries, POI, places and events.

Another goal was the incorporation of AR in these interactive narratives. This was also accomplished as these types of files can be incorporated in the items created by this application.

Storytelling and gamification were also goals for the interactive narrative. Storytelling can be accomplished in the created itineraries, creating a story POI by POI. The gamification can be used through the complex itineraries that have multiple paths, and also the points that the user gets when completing itineraries.

Regarding the evaluation of the application, the project was positively received by most users during the test phase. The results of the tests and questionnaires reveal that the application is easy to learn how to use and has an ease of use in general be it through observation and through the questionnaire that was answered by the users.

The feedback presented also revealed some aspects in the application that were lacking or in need of an improvement. These will be elaborated further in the next section.

5.2 Future work

During the development, unfortunately not all of the aspects of the application were developed to perfection. This could be observed during the user tests of the application.

Despite the positive feedback of the users that tested the application, there were some observations made either during the users' test on the application or on the answers of the questionnaire left by the users that make clear some possible improvements.

Also during the user test, some observations made by some users enlightened some new perspectives and new ventures this application could take in future iterations.

All of these observations are going to be listed here as possible improvements and new features that could be implemented in future iterations of the *Web of Stories* application:

- What most users that tested the application mentioned that should be improved upon was correcting mistakes when creating items like itineraries. There should be an easier and clearer way to correct mistakes. In future iterations of the project for each step of creating an item, be it an itinerary, POI, place or event, there should be a simple way of going back on a mistake that was accidentally made during their creation, like a button that steps back the last action.

- There was also a lot of difficulty in distinguishing between the line that symbolises the connection between the nodes (orange line) and the line determining the path the user should take (grey line) while creating an itinerary. This can be improved by either the more drastic option, that is the complete removal of the path line and reworking that feature completely, or a more simple solution like giving the user information on how to add each element of the itinerary, like a tutorial.

- In addition to the previous item on this list, some users answered that a tutorial could be very useful to first time users of the application. Analysing the results, this can be confirmed as some users had a hard time creating their first itinerary. However, the following itineraries created during the test were made faster and with ease. Nevertheless a tutorial still proves itself to be useful.

- The form to add a file to an item, be it an itinerary, POI and others, should be improved or altered, since this was the form that most users had a difficult time in understanding how to use, and what each form item meant, specially the *file type* and *reference* items on that same form.

- Another item that the users had trouble was finding out how to add an already existing POI to an itinerary. This could be fixed by the tutorial mentioned above on this list or on making the subtitle of the map, where this option is located, more visible.

- Making the gamification aspect of the application more visible. This could be achieved by making a ranking page, comparing the points of the users. Perhaps

not just points but number of completed itineraries, or visited places, among other aspects. Also when creating an itinerary making the aspects related to gamification more explicit, i.e the *points* item on the form, since there was a considerable amount of users that tested the application that didn't know what it meant.

- One of the aspects that a user said that could be a point of expanse for the application was in the realm of archaeology. While this may not be the objective of the application currently, it could serve as a sort of inspiration for possible features or possible future related projects to this application.
- More clarification on the forms of the creation of itineraries and POIs. There were some items on those forms that could be misunderstood or could be improved on, like making the *estimated distance* unit of measurements to meters instead of kilometers, or the *content type* of files on POIs, (there should be more clarification on what this later item should be).
- Have more focus on curatorship. For example getting in contact with travel writers, travel vloggers or other influential figures in tourism media in order to make the best content for the application, and also have more influential connections to the application.

While these topics have the potential to improve the *Web of Stories* project, when they have been implemented, further tests will be required not only to ascertain if these changes improved the application, but also how much they improved it.

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I

Annex 1: Prototype

Funcionalidades:

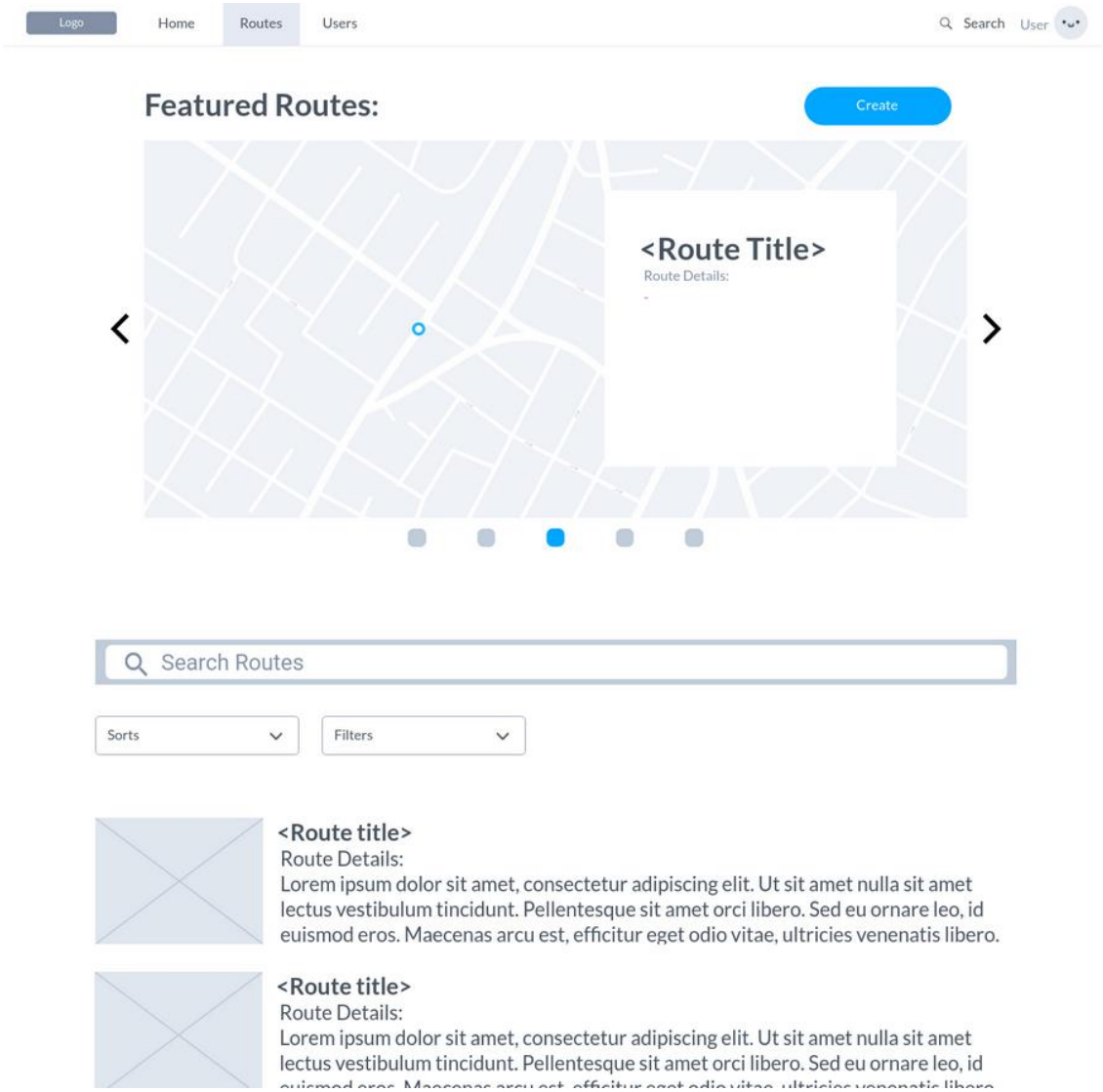
Criação de itinerários para serem explorados em tempo real na sua localização:

-Incluir no itinerário informação geral como a sua descrição, a sua narrativa (se este itinerário seguir uma história), tempo estimado para o completar entre outros.

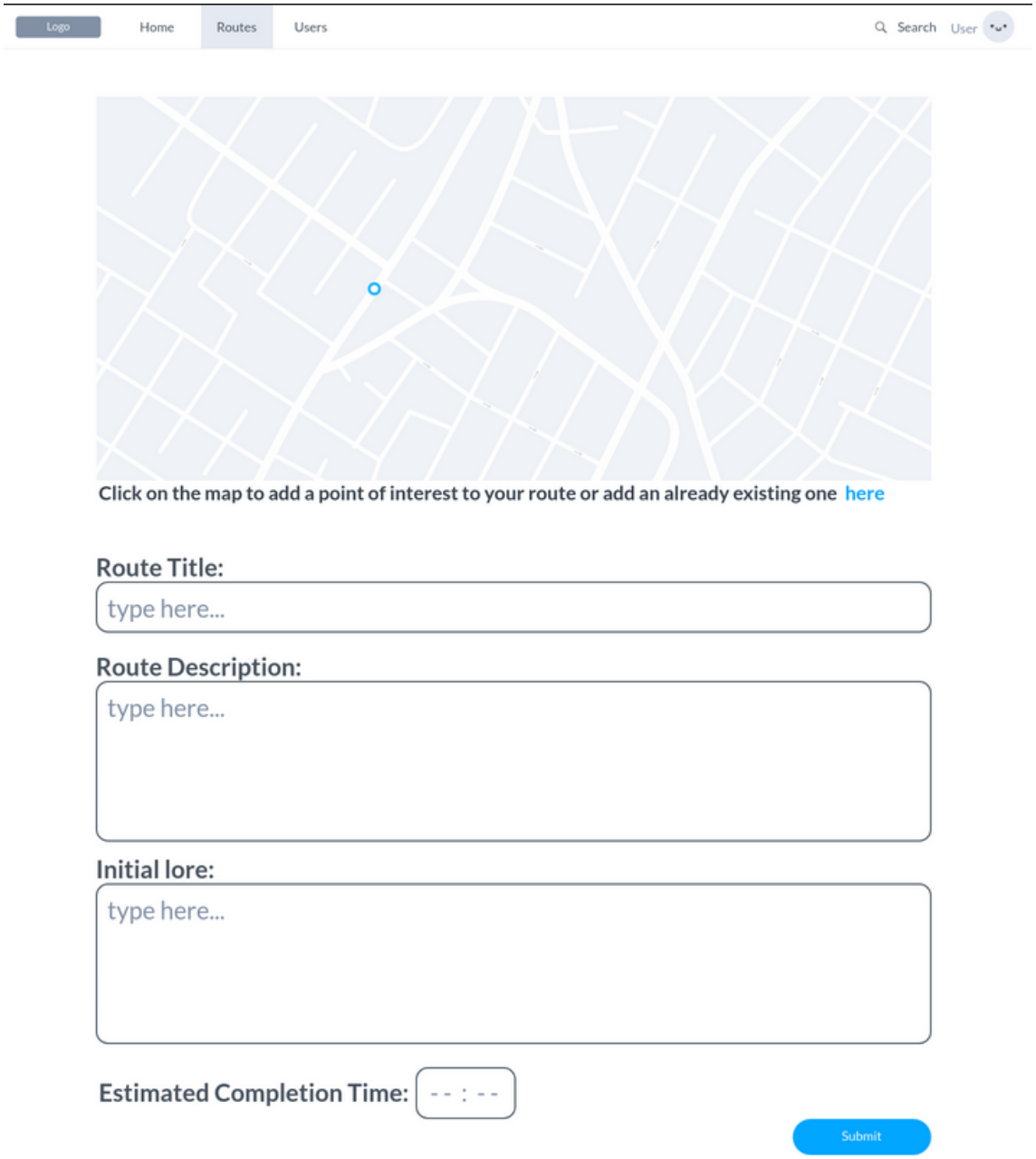
-Fornecer aos itinerários pontos de interesse com ajuda do mapa na página, ou a partir de pontos de interesse previamente feitos.

-Fornecer informação aos pontos de interesse criados no mapa como a sua descrição, esta pode seguir a narrativa do itinerário e ficheiros para partilhar conteúdo media. Os conteúdos submetidos nestes pontos de interesse têm como objetivo refletir a história ou a cultura do local em que se situa.

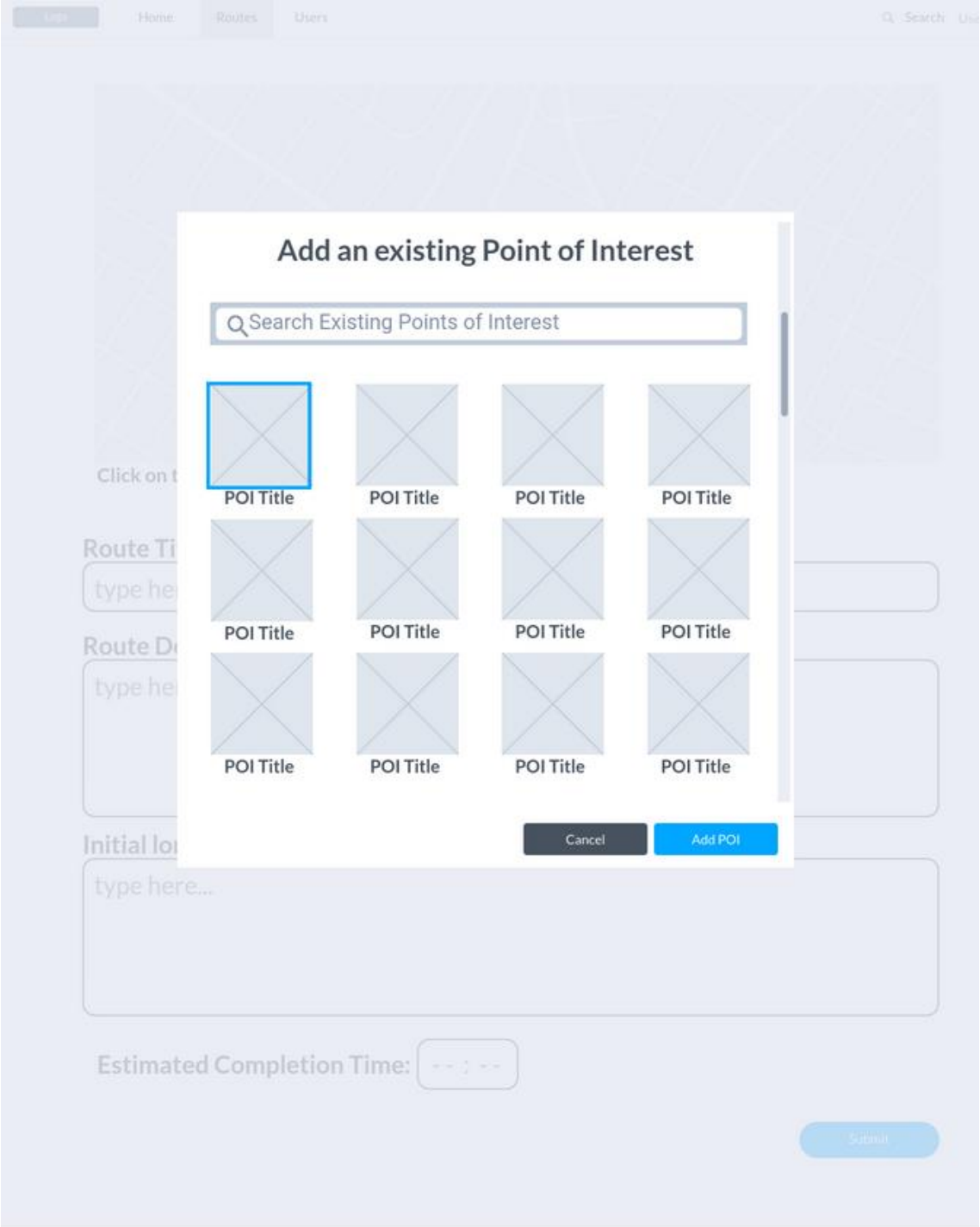
-Fornecer informação sobre os ficheiros dos pontos de interesse, como por exemplo uma descrição. Esta pode ser usada para descrever a relevância de uma imagem ou vídeo à região que está associada e a sua história.



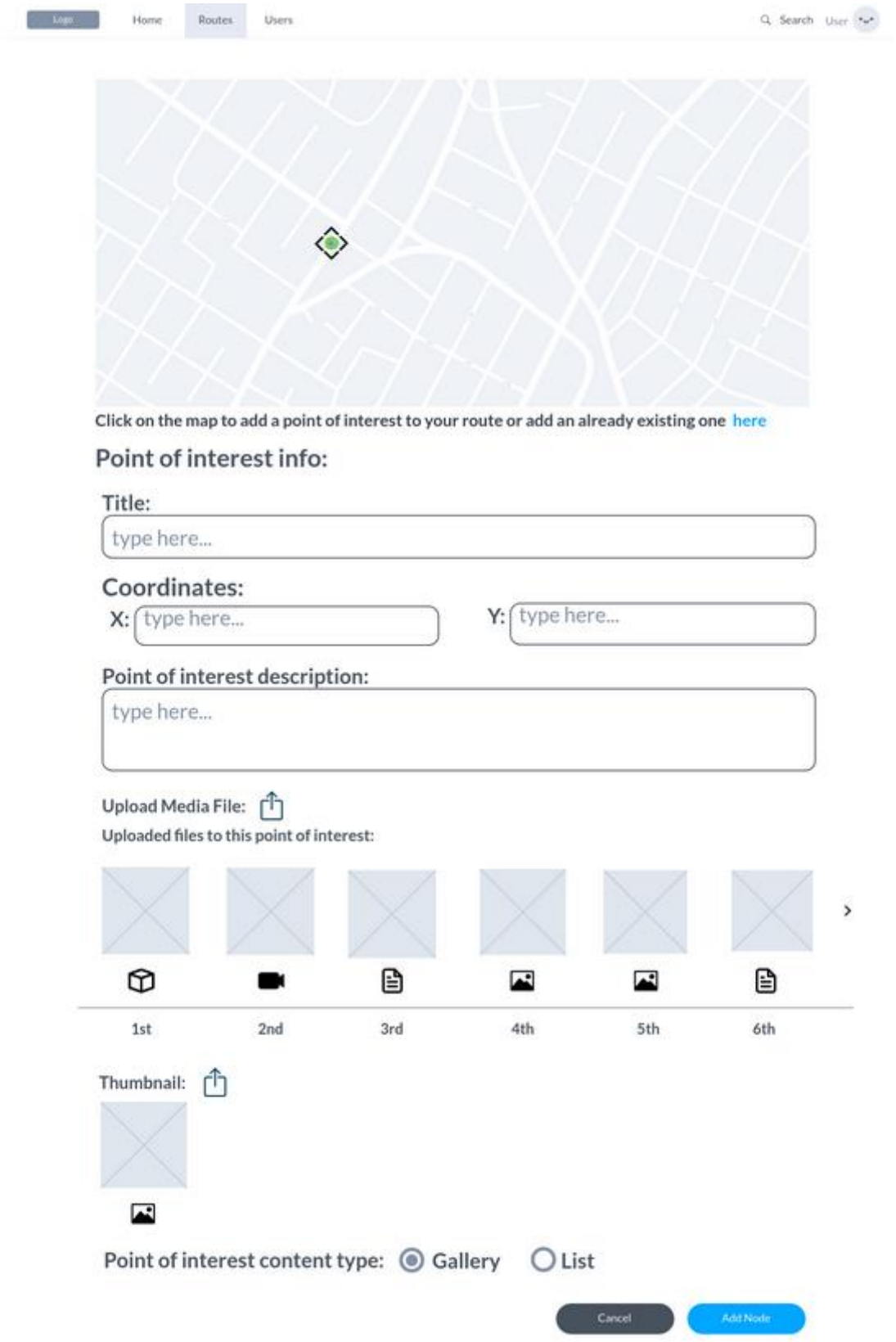
Página dedicada aos itinerários criados, onde utilizadores podem pesquisar e obter informação de diversos itinerários.



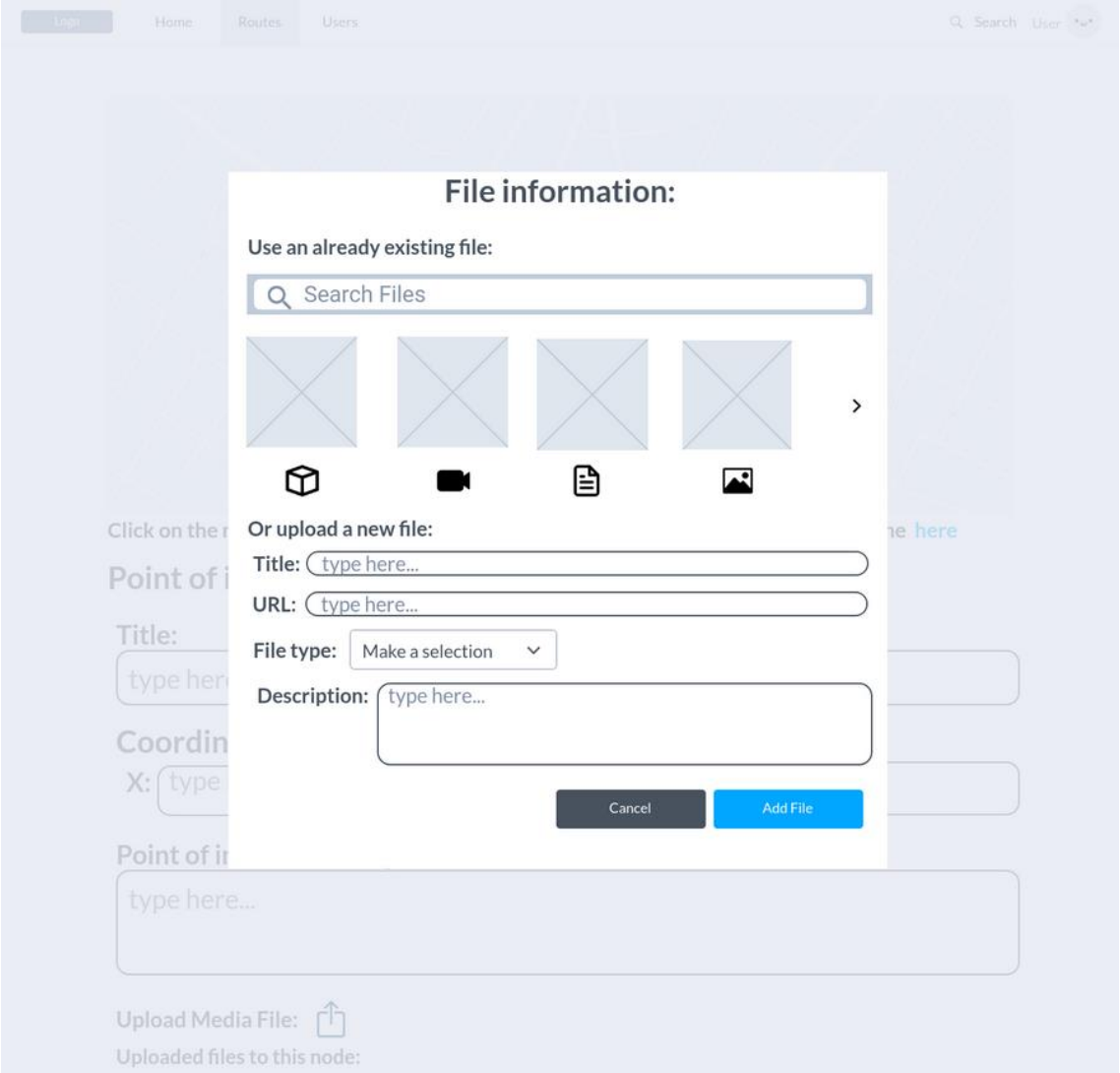
Página de criação de um itinerário, aqui pode se inserir informação do itinerário em si e adicionar pontos de interesse ao itinerário.



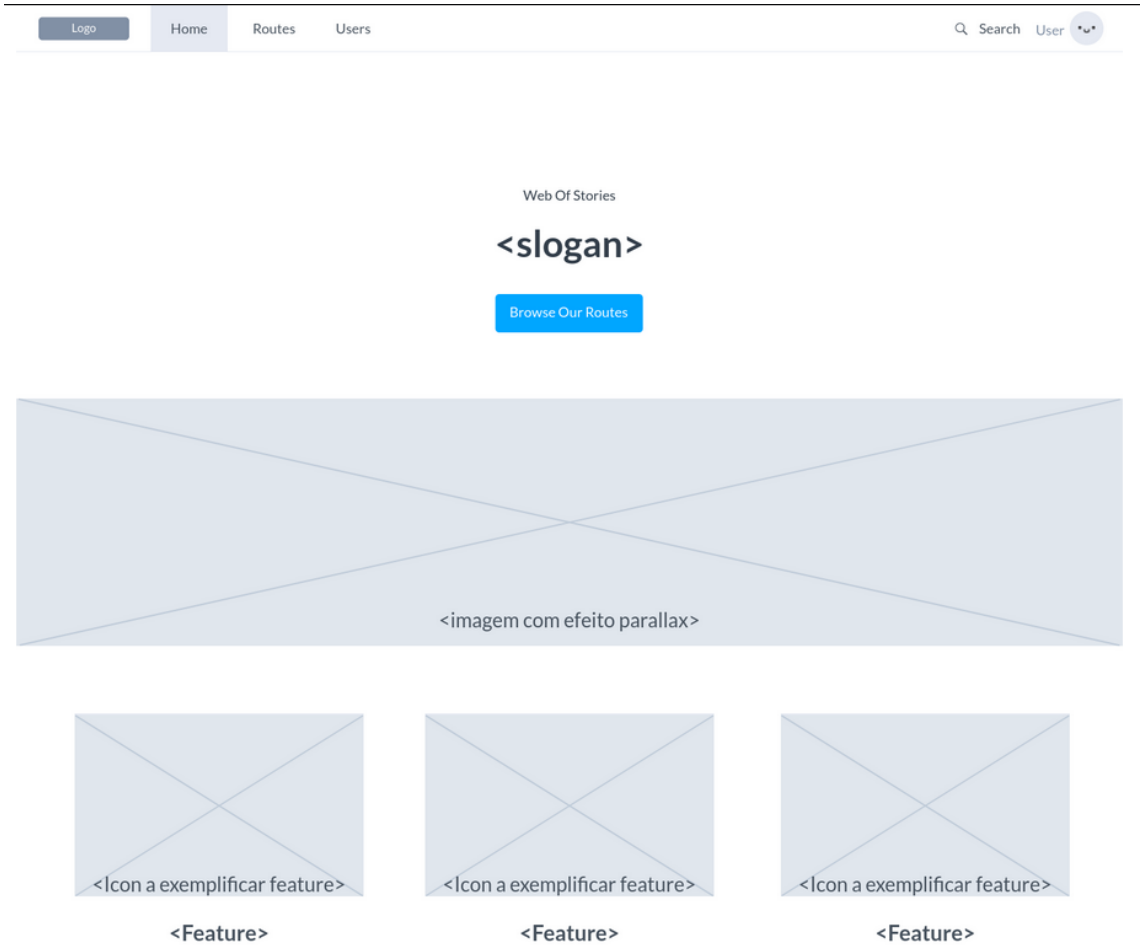
Ao clicar para adicionar um ponto de interesse já existente poderá escolher um a partir deste pop-up.



Página criação de um itinerário após dar a indicação para adicionar um ponto de interesse, aqui pode-se inserir a informação referente a esse mesmo.



Após clicarmos em adicionar um ficheiro ao ponto de interesse este pop-up irá aparecer para adicionar informação ao tal ficheiro.



Bónus: esboço da homepage.

II

Annex 2: User test document

Web of Stories – Testes de Utilizadores

Introdução

O trabalho de investigação que deu origem à aplicação Web of Stories foi desenvolvido no âmbito de um projeto da NOVA School of Science and Technology (Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa), em parceria com o projeto europeu T-FACTOR e o novo Instituto de Arte e Tecnologia da Universidade Nova de Lisboa (IAT).

T-Factor tem a missão de reverter o abandono das zonas históricas, tornando-as mais atrativas para os cidadãos e visitantes. Isto é conseguido através da criação de oportunidades de expansão para as empresas locais e também criar e desenvolver atividades culturais locais.

De acordo com as motivações do T-Factor e sua parceira, NOVA School of Science and Technology (Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa), foi desenvolvido o Web of Stories. Web of Stories é um projeto permite explorar espaços físicos dando a conhecer a cultura e história do local através de itinerários interativos, tendo como caso de estudo a Trafaria. Web of Stories inclui uma aplicação móvel que permite aos utilizadores percorrer os itinerários compostos por diversos pontos de interesse interligados. A estes pontos de interesse está associada informação de diversos tipos incluindo imagens, vídeos, áudio e realidade aumenta de forma a construir narrativas interativas sobre o espaço e comunidade local.

Web of stories inclui também uma componente web que permite a criação dos itinerários interativos e respetivos pontos de interesse a explorar através da aplicação movel. É esta componente web que aqui se pretende avaliar.

Testes de Utilizadores

Os objetivos destes testes são analisar a componente web da aplicação "*Web of Stories*", mais especificamente a ferramenta de *authoring* usada na criação de itinerários.

Ao criar um itinerário deverá ser possível ao utilizador:

- Incluir, no itinerário, informação geral como a sua descrição, a região a que se refere, a pontuação do itinerário, e os ficheiros que serão fornecidos ao utilizador como recompensa de completar o itinerário.

- Criar pontos de interesse para incluir nos itinerários a partir do mapa apresentado e associar-lhe a respetiva informação. Esta informação deve refletir a história e a cultura do local onde o ponto de interesse se encontra.

- Realizar o carregamento de ficheiros associados a pontos de interesse. A informação destes ficheiros pode ser usada para descrever a relevância do seu conteúdo relativamente ao local a que está associado.

- Associar pontos de interesse previamente criados ao itinerário.

-Associar ficheiros previamente criados a um ponto de interesse.

Utilizadores:
A criação de Itinerários deverá ser reservada a utilizadores especiais para moderar o conteúdo da aplicação. No entanto, no contexto dos testes de utilizadores, esta funcionalidade será

permitida a pessoas com mais de 18 anos com experiência em social media, nomeadamente na criação de conteúdo/posts.

Tarefas:

1. Navegar na aplicação web até à página de criação de pontos de interesse/locais.
2. Criar um ponto de interesse/local
3. Navegar na aplicação web até à página de criação de itinerários.
4. Criar itinerários:

   4.1 Criar um itinerário usando pontos de interesse previamente criados.

   - Deve utilizar os pontos de interesse apresentados no mapa da imagem em baixo.

Estes pontos de interesse são:

- Estação fluvial da Trafaria
- Verbena
- Praia da Trafaria
- Presidio da Trafaria

4.2 Criar um itinerário criando pontos de interesse novos, usando ficheiros previamente criados.

- Ao criar o primeiro ponto de interesse deve utilizar os ficheiros apresentados na imagem abaixo:

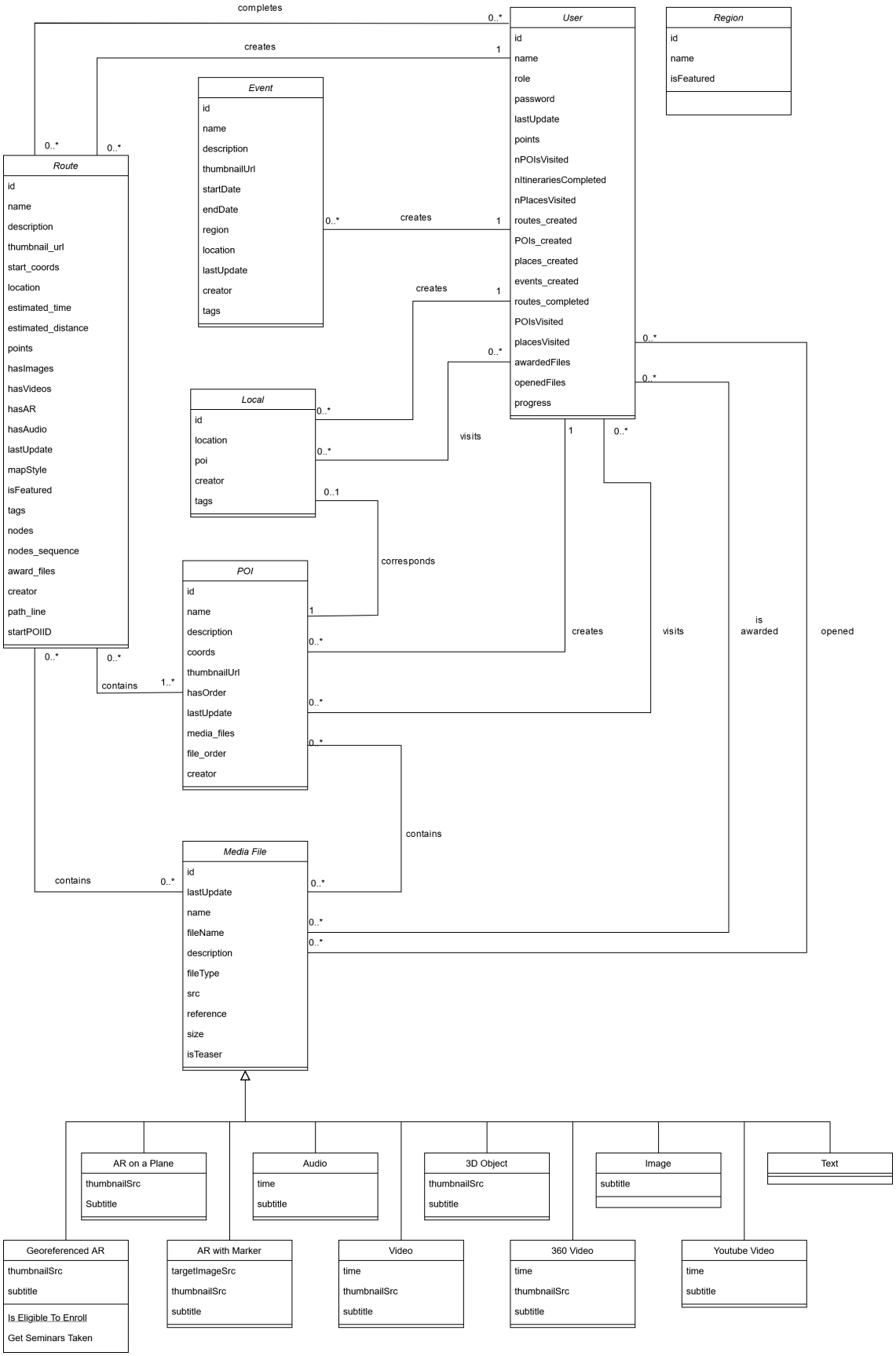
-Nos restantes pontos de interesse tem total liberdade de utilizar os ficheiros que queira.

4.3 Criar um itinerário criando pontos de interesse novos, fazendo upload de ficheiros novos para a aplicação. Aqui tem toda a liberdade sobre os pontos de interesse e ficheiros utilizados.

5. Ver listagem de itinerários e de pontos de interesse e encontrar os que foram criados.

III

Annex 3: Class Diagram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1
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hasAR
hasAudio
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mapStyle
isFeatured
tags
nodes
nodes_sequence
award_files
creator
path_line
startPOIID
Local
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location
poi
creator
tags
visits
corresponds
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id
name
description
coords
thumbnailUrl
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src
reference
size
isTeaser
AR on a Plane
thumbnailSrc
Subtitle
Audio
time
subtitle
3D Object
thumbnailSrc
subtitle
Image
subtitle
Text
Georeferenced AR
thumbnailSrc
subtitle
Is Eligible To Enroll
Get Seminars Taken
AR with Marker
targetImageSrc
thumbnailSrc
subtitle
Video
time
thumbnailSrc
subtitle
360 Video
time
thumbnailSrc
subtitle
Youtube Video
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2023 Web of Stories Web Authoring Platform For Interactive Narratives: Ricardo Pinto

NOVA SCHOOL OF SCIENCE & TECHNOLOGY