InStory: A System for Mobile Information Access, Storytelling and Gaming Activities in Physical Spaces

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ABSTRACT
This paper describes the work carried out in the InStory project. InStory has the goal of defining and implementing a platform for mobile storytelling, information access, and gaming activities. The platform has a flexible computational architecture that integrates heterogeneous devices, different media formats and computation support for different narrative modes and gaming activities. The system is driven and validated by a set of story threads and narratives that are centered on the exploration of physical spaces. This exploration is combined with the perspective of sharing information between users and providing historic context. The project also wants to explore the social aspect of shared narratives and activities, with the idea that the technology can provide new innovative approaches to social participation in different types of events.

Categories and Subject Descriptors
H.5.4 [**Information Interfaces and Presentation**]: Multimedia Information Systems– *artificial, augmented, and virtual realities, hypertext navigation and maps, video*.

General Terms
Design, Experimentation, Human Factors, Languages.

Keywords
Mobile storytelling, mobile multimedia, spatial games, hypermedia, location based systems.

1. INTRODUCTION

The work described in this paper is set in a context where mobile devices and wireless networks provide the underlying platform for new forms of user interaction and participation. Mobile devices, such as PDAs, can be used in a non intrusive way in many situations including when navigating in the real world. These devices can be seen as a way to access information, but in a broader way, they can also be seen as a way to access a mixed universe that co-exists with the real world and where some interactions are possible. Most augmented reality projects require the use of cumbersome equipment, that although it could provide an interesting sensorial experience, it is too heavy and inconvenient to carry on in normal daily situations. PDAs although somewhat limited in terms of processing power and visualization capabilities provide a good starting point for designing usable mixed reality applications, where the PDA acts as the mediator or gateway between the physical world and the virtual worlds. These virtual worlds can be sophisticated 3D models or can be simpler and very much related to the experience that each user is having in the real world. We argue that proper design can avoid having extensive representations while keeping user engagement. Used accordingly to these principles, mobile networks combined with positioning techniques provide a new channel for a radically new form of cinematographic narratives that are navigable in space. Stories are received when navigating in the real world, using contextual information about the state or characteristics of the user. Traditional narratives, in their diverse forms, are a good way to convey knowledge about the real world. The ability to have constant access through mobile devices allows a new way of doing cinematographic narratives that can enhance the participants experience in a significant way.

There are many areas of application, ranging from tourism to education. The InStory project has the goal of defining an architecture and implementing a system for interactive cinematographic narratives and other information and entertainment related activities in mobile devices. The main topics that are addressed correspond to the fundamental problems in this type of systems:

- Definition of a flexible computational architecture that integrates heterogeneous devices, different media formats and different narrative modes
- Information presentation and interaction in heterogeneous devices, when navigating in the real world.
- System support for network and group management (namely ad-hoc networks and groups that are formed to participate in a given activity).

- Development of appropriate mechanisms for personalization and collaboration for this new channel of communication

The project is being developed in cooperation with Quinta da Regaleira, Sintra, Portugal. Quinta da Regaleira is a cultural heritage site that offers many opportunities for narratives, information acess and gaming activitities.

1.1 Quinta da Regaleira

Figure 1: Palace at Quinta da Regaleira

The town of Sintra, classified as World Heritage, is a key destination for tourists, and one of the town's highlights is the Quinta da Regaleira (Figure 1), an extremely beautiful architectural complex which includes an early twentieth century palace and a garden which symbolises initiation rites. The palace was built between 1904 and 1910, based on architectural designs by Luigi Mannini, who also designed the Buçaco Palace (now a hotel) also in Portugal. The stones and wood used in both buildings were crafted by the same team of craftsmen. The architect was also linked to the works of the Scala Opera in Milan and the São Carlos Theatre in Lisboa. Albeit having a semblance of a scene from opera, the Quinta da Regaleira has alchemical and sacred connotations. The garden includes labyrinthine galleries and subterranean grottoes, which can be accessed in three directions: from a spiral staircase which leads to a 15- meter deep dry well; an arcade with a stone footpath which is covered by a waterfall which flows into a lake; and finally a second dry well. The latter dry well (Figure 2) is 60 metres deep, and has 9 stairwells each with 15 steps. At the bottom of the well lies a Templar's cross inserted within an eight-pointed star. There is a chapel dedicated to the Holy Trinity, which contains another Templar's cross, upon which a triangle with an omniscient eye has been carved. Beneath the chapel is a crypt with black and white mosaic tiles, which provides access to a gallery connecting the chapel with the palace. The Quinta da Regaleira, which was purchased in March 1997 by the Sintra Town Council is currently used as the head office of the CulturSintra Foundation which is undertaking a vast conservation and rehabilitation program for promoting the palace in tourist terms. It is also organizing a series of cultural events.

Figure 2: Templar Well

1.2 Paper Structure

The paper is structured as follows. The next section presents related work, including mobile information access, mobile storytelling and augmented reality. Section 3 presents the overall system architecture and the main components are described. The following section presents our proposals to use the system, including gaming and storytelling activities. The paper ends with some preliminary conclusions and directions for future work.

2. RELATED WORK

Storytelling is one of the oldest human activities. It supports education, entertainment and cultural dissemination. For thousands of years, storytellers have been improving their art according to technological advancements - moving from cave walls through stone tablets and papyrus to paper and the printing press. More recently, digital technologies and the advent of the Internet allow the creation of new types of narratives and the wide spread of stories across the world. Many digital storytelling related projects concern mainly with social and educational aspects, studying the digital technologies as a mean to approach people, to promote collaborative learning and cultural dissemination. These projects allow people to share experiences and stories, to train their writing and self-expression skills and to learn how to use and explore digital technologies.

The center for digital storytelling (http://www.storycenter.org/) has managed and participated in a number of large scale programs of Digital Storytelling, assisting institutions in creating their own ongoing workshop, production, celebration and publication processes. The paper [5] presents the use of digital storytelling in community development settings to promote reflective practice and foster connections in communities of learners. Through digital storytelling, individuals learn to tell a story, and in doing

so, become more effective actors in collaborative work environments. In [6] it is proposed a storytelling approach to organize, re-use, and share captured video material, thereby enabling interactive re-experience. A prototype storytelling system is described, based on 3D game engine technology and a tangible user interface. This system allows new ways of organizing and re-using the video material in an interactive and non-linear fashion.

The emerging mobile technologies took storytelling a step forward. Today, digital location information is available, allowing the applications to sense their location and adapt accordingly [7]. The main technological components of mobile, location-based, multimedia systems are: (1) Mobile Devices; (2) Location Technology; (3) Outdoor and indoor location devices (4) Wireless Networking; (5) Service Technologies and (6) Content Creation, which determines the attractiveness of the complete system. In [12] it is presented an overview of the basic techniques used for location-sensing and a taxonomy of location system properties, including a survey of research and commercial location systems that define the field and show how the taxonomy can be used to evaluate location-sensing systems. The paper [13] analyzes the means of representing spatial information. Different location model types and some of their extensions are presented and compared.

Several experiments have been made concerning location-based systems. TOI - Traveller's On-line Information System was one of the first mobile context-aware multimedia geo-referenced information system to be conceived [29]. It has an extensive set of functionalities useful to a visitor of a large city. The information system is built upon digitized maps, and hypermaps are used to provide the user with spatially referenced multimedia information. Georgia Tech developed the CyberGuide [10]. The MIT Laboratory for Computer Science developed a location-support system for in-building, mobile, location-dependent applications [9]. The National Central University has prototyped a location and context aware tour-guide system [8]. Lancaster Univ. and Univ. of Arizona developed a system that provides an electronic handheld guide to Lancaster [11]. The ability to adapt a service to the user needs is gaining widely acceptance in several areas, including interactive mobile multimedia applications. Mobile applications must adapt dynamically to the available resources, the characteristics of mobile devices, and the user requirements [14,15,16]. Several activities are exploiting reflective approaches at the middleware level [22]. Another significant trend has been the development of coordination support functionalities for mobile computing. The exploitation of group abstractions [23] seems a promising research direction. Persistent tuple spaces, inspired in the Linda model [24], have been developed in several middleware systems, such as LIME [21], TSpaces from IBM [27], and Jini/JavaSpaces from Sun [25,26]. Jini provides additional functionalities to manage a community of services, offering a lookup service and an asynchronous event notification mechanism. Tuple spaces have also been related to group abstractions.

Barbara Barry, in her Master Thesis [20], defines a specific storytelling process, which she calls "Transactional Storytelling". Transactional Storytelling is the construction of story through trade and repurposing of images and image sequences. This proposal designed "StoryBeads" as wearable computers for mobile construction of image-based stories by allowing users to sequence and trade story pieces of image and text. "StoryBeads" are modular, wearable computer necklaces made of tiny computer "beads" capable of storing or displaying images.

Related research also contemplates the user interface field, where innovative works has been done. BITS (Browsing in Time and Space) interface allows users to navigate and explore a complex virtual world, interact with the objects that comprise it and make annotations indexed in time and space [28]. The 3D story cube [17] explores the application of a cube interface to the field of interactive storytelling. This interface considers 3D graphics and sound as well as 3D manipulation and 3D sense of touch as means of interaction with a multimedia story.

Exocog experiment uses the Internet as a game and storytelling medium [19]. It tells a story by manipulating the content of a set of seemingly real Web sites and explores how the special characteristics of the Internet can affect and change the nature of creating, telling, and experiencing stories (www.exocog.com). Users unfold the story by incrementally, disclosing pieces of information about the story's plot and characters throughout the game sites. They figure out how the information fits together in the world of the story and thereby understand how the story is progressing. The requirement of action by the reader places these events somewhere between games and storytelling.

At MIT, a system for creating and participating in context-sensitive mobile cinematic narratives is being developed [4,18]. It enables users to experiment Mobile Cinema, taking them on a journey through the physical world while pieces of a story (in the form of media clips) appear on their handheld according to their movements and location. The system includes tools to define the story sequence and to place that story in physical spaces. This system has directly inspired our present work. We intend to build upon the concepts of this system and extend it with additional mechanisms for collaboration, logging, information access and other types of activities including games that have different computational requirements. The InStory project also builds on previous work on the ANTS (Augmented Environments) project [3] and hypermedia mechanisms for mixed reality worlds [1,2]. The architecture used in InStory is an evolution of the one that was adopted in the ANTS project. The hypermedia mechanisms are used to support context aware access to the information items.

3. SYSTEM ARCHITECTURE AND MAIN MODULES

The system architecture, divided between client and server, is depicted in Figures 3 and 4. This architecture is modular and it can be extended to handle other mobile collaboration, information and gaming activities. The architecture considers several clients and a main server (that can also be distributed in several components, if needed). The clients provide the user experience and our main version is currently a PDA implementation. Other planned versions including mobile phone versions and an augmented reality version, using AR goggles and a wearable computer.

3.1 Client

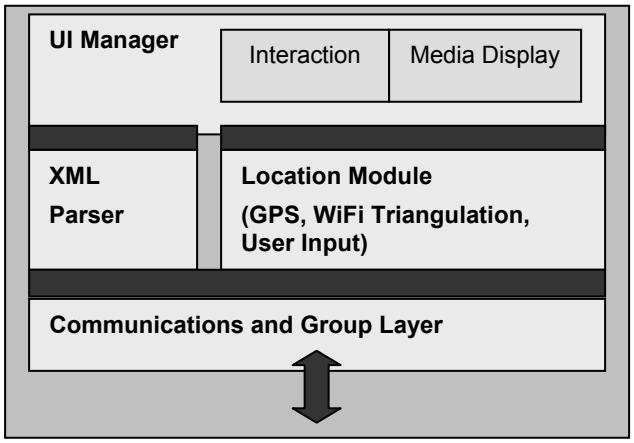

Figure 3: Client Architecture

The client application (Figure 3) includes several modules, including one for displaying information in different formats (currently text, images, audio, and video). It also includes a communications module that allows to transfer the information using the HTTP format. The user interfaces are specified in XML and, as such, an XML parser is also included (TinyXML). Furthermore, the client includes mechanisms to precisely locate the user in physical spaces. We are using a combination of differente technologies to ensure the best results: when there is WiFi network coverage we are using the Ekakau system (www.ekahau.com) that, based on the strengths of the signals, can find the position of the users. Additionally, and mainly for outdoors, we are using GPS. If these two methods are not available, and as a fallback, the user explicitly states where she is. We can have a variety of user interfaces in the client, which can be oriented towards information, storytelling, or gaming. The client also integrates a module that is responsible for the interaction with the Group Service component of the server (see below). This module gives the client application the ability to manage group services, such as join a group, communicate with other members of the group, access the specific information associated with that group and leave the group. Each client can be member of one or more groups.

3.2 Server

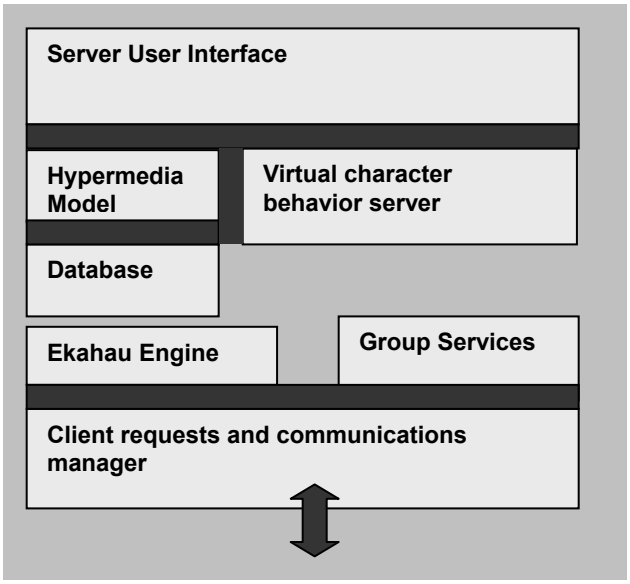

Figure 4: Server Architecture

The server maintains all the information about users and items in the system. It also supports the location mechanisms, the progression of stories and other activities, and it includes user interfaces to show and modify the current status of the objects. The main components are described in the next sub-sections.

3.2.1 Client requests manager

This module processes all the requests sending the information to the database, e.g. when a client requests to enter the system or when there is a location change. It is also this module that interacts with the Hypermedia Model and Virtual Character Behavior Engine, described below, requesting the information that will be returned as XML files with the contents that are to be displayed in the user current position. Upon processing the requests an XML file is sent to the client with all the necessary information for the client system. This module includes a queue of client requests. It is managed as a first in first out queue to handle all possible requests (In, Out, Pos) from the clients. “In” is the request to enter the system, “Out” is the request to leave the system, and “Pos” is the update position request.

3.2.2 Virtual Character Behavior Engine

This module maintains information and a set of rules that determine the behavior of the characters based in the user position and previous actions/history. Each character has a (time/space) script that will define how the character contributes to the story

and in which spatial locations the interactions happen. This script will consider the narrative temporal evolution and will provide for each time/location several media segments that can be used as alternatives. It is a timeline with several parallel media segments. The computational representation of the characters will also maintain the interactions with the users of the system, so that each character will not repeat itself. As an example, when a user interacted with the system and received a media element with the introduction of a virtual character, that part should not be repeated for the next interaction.

3.2.3 Database

The database is a repository that maintains information about users. This includes login information (username/nick/password) but also logging the results from different interactions with the system. It also contains information about the virtual characters, used by the Virtual Characters engine.

3.2.4 Ekahau Engine

This is the server (www.ekahau.com) that enables the position tracking of all users. It uses a WiFi triangulation method to calculate a (X, Y, Floor) position for each user. It is used by the clients and it can also be used by the server user interface, in order to display the position of each element in the environment.

3.2.5 Group Services

Group services handle the management of existing groups, providing all the group related functionalities. Some of these services are related to the functionalities of a specific group. This includes, for instance, filtering the database information that is made available to a specific group or defining special privileges to support access control. This module is also responsible for the management of new groups based, for example, on the client's actual position. More information and implementation issues about Group Services are presented in Section 3.4.

3.2.6 User Interface

This is the visible side of this application and it enables an overview of the system. It also gives mechanisms to interact with the users and change the virtual items that are positioned in the physical environment. The main functionality provided by the interface is described in the following:

- Tracking by User: Allows exploring the environment according to the point of view of a given user. This user position and orientation is tracked and the interactions with other users or objects are displayed.
- Tracking by Map: Shows an overview of all the users and objects in the system represented over a map of the physical space that is being considered.
- Sending Instant Message to one User: Allows to send a multimedia message to a given user.
- Sending Instant Message to all Users: Allows to send multimedia messages to all users in the system
- Viewing User's information: This includes information such as logging and history position.
- Group interactions including:
  - Handle user requests to join or leave a group
  - Sending information/messages to a group or to a group member.
  - Access to specific group functionalities.
  - View/update specific group information.

The current version of the user interface is depicted in Figure 5. It includes a map where users are represented as icons and a user list showing the status of each user.

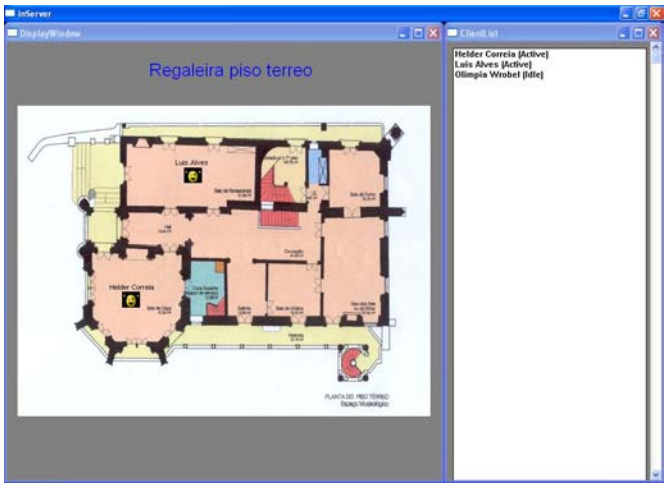

Figure 5: Server manager user interface

3.2.7 Hypermedia Model

Storing and displaying information is supported by a hypermedia model defined by a set of reusable components for application programming. The model includes the following types of components:

- Atomic: It represents the basic data types, e.g., text and image.
- Composite: It is a container for other components, including Composites, and it is used to structure an interface hierarchically.
- Link: It establishes relations among components.

Every component includes a list of Anchors and a Presentation Specification. Anchors allow to reference part of a component and are used in specifiers, a triplet consisting of anchor, component and direction, used in Links to establish relations between the different components of a hypermedia graph. The Presentation Specification describes the way the data is presented the interfaces. The model was designed to be used in different environments, including mobile and more sophisticated AR

environments. In the InStory project the internal representations are converted to XML files and sent over to the client.

The model supports the concept of events as anything that happens and that changes the information that is presented. There are three main types of events:

- Location of user in a space.
- Recognition of an interest point.
- User navigation or choice.

The position of a user in the space can also define an interest point. If the space has several subspaces (rooms, floors) moving from one to another will generate an event. Whenever an event is generated, new information is displayed, and the interface changes. In the physical space, where the user is, there are interest points that are detected by the system. When one of these points is detected new information is displayed in the mobile device of the user. When this point of interest is no longer detected the information ceases to be available unless this was a manual choice from the user. An information block that is displayed, as a result of an event, can be browsed by the user, thus originating a change in the content. Each navigation action made by the user creates a new event. All these events in the client are sent over to the server, processed in the hypermedia model and, as a reply to some of them, information is sent back to the client, using the XML files described in the next section.

3.3 Client Server Communication

As mentioned above, clients make HTTP requests to the server that in response sends XML files with the appropriate actions and references to media elements. Clients can make three types of requests: (1) **in** (usually the first request to enter the system), (2) **pos** (requests that indicate that the user has a new position) and (3) **out** (to leave the system). Each request also includes the identification of the user and the current position, which is summarized in Figure 6.

```
- req     (in, out, pos)
- user    (username)
- lat     (latitude)
- lon     (longitude)


Example:
server_url/index.php?req="in"&user="LuisAlv
es"&lat="20"&lon="40"

sever_url/index.php?req="pos"&user="LuisAlv
es"&lat="35"&lon="40"

sever_url/index.php?req="pos"&user="LuisAlv
es"&lat="60"&lon="45"

sever_url/index.php?req="out"&user="LuisAlv
es"&lat="25"&lon="45"
```

Figure 6: Client/server communication protocol

Upon receiving one of these requests the server returns an XML file as the one presented next, which is a very simple list of the media elements (URLs) to be presented. We are also investigating other alternatives, such as the use of SMIL, as the format to describe the presentations. Each media element can be positioned in the screen space and hyperlinks can be defined between media elements. In the example, an image is presented at position (0,0) that when activated gives access to other presentation described in the XML file “plantapisoterreo.xml”.

```
<content>
    <image x="0" y="0"
       url="saladosreis.jpg" />
    <link x="0" y="0" width="640" height="480"
       url="plantapisoterreo.xml"/>
</content>
```

Figure 7: XML file with interface definition

3.4 Group Services

Group services are a key component to support planned functionality in the InStory project and we are investigating several alternatives. We use a group-based approach for modeling the possible cooperation and coordination of the system mobile entities. There are two kinds of groups that are considered: (1) the explicit and (2) the ad-hoc groups. The first ones are explicitly defined groups that are specified by a system administrator (for example school students, visitors from the same country or similar situations). The other kind of groups, ad-hoc groups, can be spontaneously created (emerge) as a result of some kind of event, related to user specified characteristics (such as users with special interest in architecture or Templar symbolism) or even based on users current position.

The current implementation of this module is based on the Jini platform. The communication between clients and the Group Service module uses Java RMI (Remote Method Invocation). Currently only explicit groups are supported. The implementation is based on a lookup service were clients register or request services, a gatekeeper that manages the explicit group information, and a server which displays information about all registered users, the registered or requested services and the user groups. The development of the interface between the group services and the other system modules (mainly Ekahau position server and database) is still underway. The ad-hoc group manager is also under development.

3.5 User Contribution

The InStory system will allow users to contribute with new data to the story threads. An additional module has been designed and will be implemented to permit the upload of different types of data, including text or images. These data elements will be contextually integrated into the system and particularly into the story. User contributions may have different purposes, such as:

- Register their own experience while using the system, comprising the followed path and the relevant checkpoints;
- Intervene in the normal elapsing of the story (creation of decision points where the users may change the course of the story)
- Accomplish missions that have been assigned to the users during the story;
- Make ad-hoc annotations for future use;
- Leave messages to other current users of the system who may come behind.

4. INFORMATION, NARRATIVES AND GAMES

We are considering three main application scenarios that attempt to provide a compelling experience to the users and also test the different aspects of the computational framework that we are building. The activities that we are considering in the InStory project consider different layers: (1) information, (2) spatial storytelling, and (3) spatial games.

Figure 8: InStory client (Initial screen)

Figure 9: InStory client (Map interface)

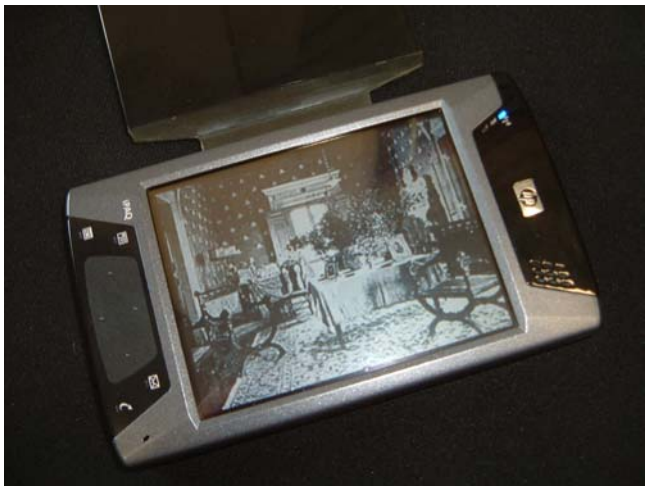

Figure 10: InStory client (Information access)

Considering the application scenarios, one of the important dimensions are the interactions between physical spaces, real persons and virtual characters that perform actions and also move in physical and virtual spaces. The computational system that supports these interactions needs to support location of the real and virtual participants and to support visualization of those interactions in graphical representations (maps and 3D models). Additionally, interactions between virtual characters and real users can be recorded with two main purposes: (1) replay of the interactions and (2) as a way for each character to tell different story element each time the user logs in. In this way the virtual characters will not repeat themselves and could present new media materials to the user, allowing the narrative to unfold.

Figures 8-10 depict the current version of the information layer of the system. This is the first layer that was built and supports the others). Figure 8 is the opening screen, followed by a map of one of the first floor of the palace at Quinta da Regaleira. Either using

explicit user interaction or location information (the Ekahau system) additional information is shown as represented in Figure 10. In this case for each of the rooms are shown pictures from the time when the palace was built (early 20th century). Further work to implement the other layers (narratives and spatial games) is currently underway. We are considering characters that have the role of virtual guides and that will be characters of the narratives that will take place in the physical space. These characters will be based on previous inhabitants of the physical setting where the project is being deployed, Quinta da Regaleira, and will consider the historical facts that are related with the place. A treasure hunt game is also being planned. This game will feature leads and virtual objects that have to be found by the participants of the activities. A preliminary interface is represented in Figure 11. It includes a version of the plan of the first floor of the Palace and navigation options. Considering the symbolic richness of Quinta da Regaleira, we are pursuing several story lines that deal with some of the representations and signs that are available, namely the Templar tradition and the Portuguese mythical tradition.

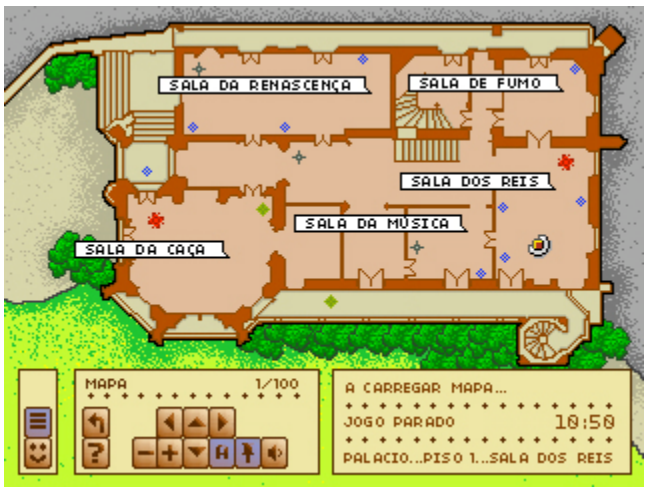

Figure 11: Game user interface study

5. CONCLUSIONS AND FUTURE WORK

Currently we have defined the overall architecture and implemented a first version of the system. The application scenarios described above are being implemented and tested. These application scenarios build on the collaborative and spatially distributed nature of the stories to provide the best experience to the user. The personalization aspects need to be refined and explored in richer ways. Additional user studies are necessary in order to verify if we are taking the correct approach to build truly compelling interactive stories. Another dimension for future work deals with storing the interactions, as a hypermedia network. This has the advantage of allowing later replay, even after leaving the physical setting. The next version will integrate additional personalization features, more complex characters and narratives

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