EUD Software Environments in Cultural Heritage: A Prototype

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Abstract. This paper describes the prototype of a framework for designing interactive applications for cultural heritage sites by following an end-user development approach. The framework is devoted to all design stakeholders, i.e. software engineers, HCI experts, cultural heritage experts and visitors, and provides them with tailored design environments for contributing their expertise to shaping the final applications. The design is guided by application templates, which provide the rules for assembling the basic components, called building blocks, whose result is the final application.

Keywords: end-user development, meta-design, cultural heritage.

1 Introduction and Motivation

Since its early ages, information technology has been applied in the cultural heritage domain. Audio guides represented the first type of applications and are still in use in many museums worldwide even today. They provide access to audio descriptions of exhibits present in a museum. In the last decade, various improvements in the used technologies were brought forward. For example, RFID tags and infrared beacons were proposed in order to provide contextual information by identifying the position of the visitor in respect of the museum exhibits. Recent developments have investigated new ways in which technology can be employed to provide more engaging experiences at sites of cultural interest.

Previous work of our research group addressed multimedia educational games to be played at historical sites [1]. In Italy, schoolchildren aged 9-13 are among the frequent visitors of archaeological parks; in order to stimulate their motivation and curiosity, Explore!, a m-learning framework designed to facilitate history learning during visits to sites of cultural interest. This research highlighted three main issues: 1) the need to favor the reuse of existing resources; 2) the inherent difficulties in developing applications for multiple platforms; 3) the advantages in including domain experts and even end users in the design process. In fact, the efforts to create, convert in digital form and maintain the multitude of data related to cultural heritage assets are very high. This is especially true for applications for mobile devices supporting museum or park visitors, as contents have to be adapted to cater to different platforms, screen sizes, input methods, etc. Because of the frequently changing nature of exhibitions, both content and structure of the applications must be updated. This could be

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carried out by cultural heritage experts if they are empowered with the means to contribute to shaping software artifacts.

An important point of this research concerns the definition of a formal model, the Cultural Heritage Resources model (CHeR), which describes a generic visit experience to a site of cultural interest. It was initially designed to model multimedia resources, in order to facilitate their reuse [2]. However, there are many other types of visitors, who perform various activities at museums and historical sites, exploiting thematic itineraries, exhibitions, interactive installations, etc. In order to reason on all aspects related to different types of visits to sites of cultural interest, the CHeR model encompasses the stakeholders involved in creating the final applications, the digital resources to be presented, the different types of visitors and the relations among all such elements; it better defines the problem space, driving the design of new activities to be performed at cultural heritage sites.

A software framework comprising a set of design environments is in development to allow teams of different experts (software engineers, HCI and domain experts) to cooperate for creating applications according to the CHeR model. A prototype of one of the environments is presented in this paper. In [3] the authors present an EUD environment to assist curators in the design of museum guides. Although similar in concept, our approach, described in Section 2, has a broader aim encompassing all activities related to sites of cultural interest. Our prototype focuses on allowing its users to design such applications in an exclusively visual way by composing building blocks, i.e. elements that represent atomic features of a software application. The activities available in the CHeR are modeled through application templates that expose the available blocks and associated rules. These are described in Section 3; the environment is presented in Section 4. Section 5 concludes the paper.

2 Framework Design

A basic assumption of our approach to the design of interactive systems is that all stakeholders of an interactive system, including end users, are "owners" (or experts) of a part of the problem: software engineers are technology experts, end users are domain experts, Human-Computer Interaction (HCI) researchers are human factors experts, etc. We follow the *Software Shaping Workshop* (SSW) methodology, which prescribes that systems are developed according to a meta-design approach and involving all stakeholders [4]. The software engineers are not any longer the only system developers, but they act as meta-designers: they do not directly create the final systems, but they develop software environments, each targeted to a specific communities of stakeholders, in order to allow them to contribute to system design by bringing their own expertise [5]. The SSW methodology calls such design environments *workshops* to refer to the workshops of some artisans, like carpenters, where every tool suitable for their activity is available.

The communities of stakeholders involved in the design of applications for visiting cultural sites, as addressed by the CHeR model, are: Software Engineers, Human-Computer Interaction (HCI) experts, Cultural Heritage (CH) experts and Visitors. The design occurs in two phases. In the first phase, S*oftware Engineers* use an environment such as Microsoft Visual Studio® to design and develop the workshops for the

other communities of stakeholders. They also develop application templates, which provide atomic components and rules to combine them for creating final applications (described in the next section). They collaborate with *HCI experts*, who bring human factors to workshop design. In the second phase, all stakeholders through their workshops contribute to creating the final applications. In particular, *CH experts* contribute to the design primarily by providing proper content and by shaping software artifacts according to the purpose of the final application, e.g. a thematic itinerary in a museum or an educational game in an archaeological park. *Visitors* are the end users, i.e. the persons who will use the developed applications.

3 Application Templates

In software engineering, a template is any processing element that can be combined with a data model and processed by a template engine to produce a result document. In the context of the CHeR model, an *application template* formally is represented by a set of *rules* to assemble together basic elements, called *building blocks*, in order to define the final applications, i.e. those supporting the activities that can be performed or participated at cultural sites, such as: thematic itineraries, interactive installations, educational games, etc. Building blocks are atomic components who expose several functionalities (e.g. showing content, inputting data); they must be completed by inserting different types of multimedia resources (text, image, video, etc). Finally, it defines the devices that the application can be generated to.

Three application templates are available in the current framework, one referring to traditional museum visits (*Museum guide*), one referring to a learning game implemented on mobile phones (*Excursion-game*) [1], and the third one referring to a puzzle game, implemented on a large multitouch screen (*History-Puzzle*) [6]. This latter game is designed to be played by young students at an archaeological park. It proposes puzzles of the 3D reconstruction of historical monuments in the park. In order to solve the puzzles, students have to manipulate with their hands visual widgets shown on the screen representing either puzzle tiles or tiles with questions and answers. In Section 4 we will show how CH experts design a game using the History-Puzzle template. Once a designer (e.g. the CH expert) chooses an application template among those available in his workshop, its associated rules determine the building blocks (B rule) available, the permitted connections among them (C rule) and the multimedia resources that can be inserted in each particular building block (R rule).

A rule of type B can be defined as follows:

$B\colon AT \underset{allows}{\Longrightarrow} (E_0, E_1, \ldots, E_n)$, where:

- AT is an *application template*
- E_i is an element type

In the case of History-Puzzle, rule B is: *"For History-Puzzle application template, the allowed building blocks are of types: Puzzle, Questions and Answers"*.

A rule of type C can be defined as follows:

$C\colon (c_i, E, p) \underset{allows}{\Longrightarrow} \left(c_j, (E'_0, E'_1, .., E'_n)\right)$, where:

- c_i is a *connection point* of the *left-hand side* (LHS) element *E*
- *p* indicates whether the *connection point* allows 1:1 or 1:N
- c_j is a *connection point* of each one of the *right-hand side* (RHS) elements $E'_0, E'_1, .., E'_n$

An example of rule C is: *"From the source connection point c_i of a building block of type Puzzle (E), it is allowed only one connection (p is of type 1:1) to the target connection point c_j of a building block of type Q&A (in this case the set of elements $E'_0, \ldots, E'_n$ is the singleton E'_0)"*.

A rule of type R can be defined as follows:

$R: E \Rightarrow (k_0, k_1, \ldots, k_n)$, where:

- k_i is a constraint on the E and it is defined as k_i: (min_i, max_i, r_i)
- min_i is the minimum number of occurrences of resource r_i
- max_i is the maximum number of occurrences of resource r_i
- r_i is the type of resource (text, image, video, etc)

An example of rule R is: *"Given a building block of type Puzzle (E), each associated constraint k_i specifies that Puzzle accepts a minimum min_i and a maximum max_i number of resources of type image (r_i)"*.

Rules are designed to be extensible by software engineers as they are defined as XML files. In this way, interoperability with elements of future templates is ensured.

4 The Cultural Heritage Experts Workshop

The CH experts workshop offers a visual design environment (inspired by YahooPipes [6]), application templates, building blocks and multimedia resources to allow CH experts to collaborate to the design of applications aimed at visitors of sites of cultural interests. After logging in the workshop, the CH expert (e.g. a male archaeologist) has to choose an application template among those available in his workshop. Application templates, building blocks and multimedia resources are classified according to different visitors' profiles and devices they use.

Let us suppose that the CH expert wishes to design a History-Puzzle game for the archaeological park of Egnathia, in Southern Italy. In his workshop, he selects the History-Puzzle template; an interface, like the one shown in Fig. 1 appears with the *History-Puzzle* block (the root element of the game application) already in place. This element can be maximized by clicking on the button on the top right corner. The root element can be connected to the other elements available for the History-Puzzle template, which are listed in the Elements toolbar on the left side of the interface: Puzzle, Q&A (Questions&Answers) and Connector. The *Puzzle* element is a building block representing a single puzzle of the game, which is usually composed by several puzzles. In order to add a Puzzle, the CH expert drags this element from the toolbar to the main area of the workshop. Then he connects the Puzzle to the root element by drawing a line between the connection points of these blocks. If an element allows 1:N connections, a *Connector* element can be used to multiply that element's

connection points. In Fig. 1, three puzzles, Foro Boario, Fornace and Via Traiana have been connected to the root through a Connector.

The CH expert completes each Puzzle by defining the number of tiles in terms of Number of Rows and Number of Columns and by selecting the image of the 3D reconstruction, which will be automatically subdivided in tiles. To include multimedia resources, e.g. the Puzzle image, the CH expert expands the search panel at the bottom of the screen, where resources are classified by type (text, image, audio and video); filter buttons are used to include or exclude the corresponding category from the matches. Then he drags each resource on the accepting element; in the example of Fig. 1, he has added the Via Traiana image in the homonymous Puzzle block. When no resource is present, a watermark label informs users what kind of resources and how many of them the block accepts. When a resource of the wrong kind is dragged over, the cursor will change to indicate that the operation is forbidden.

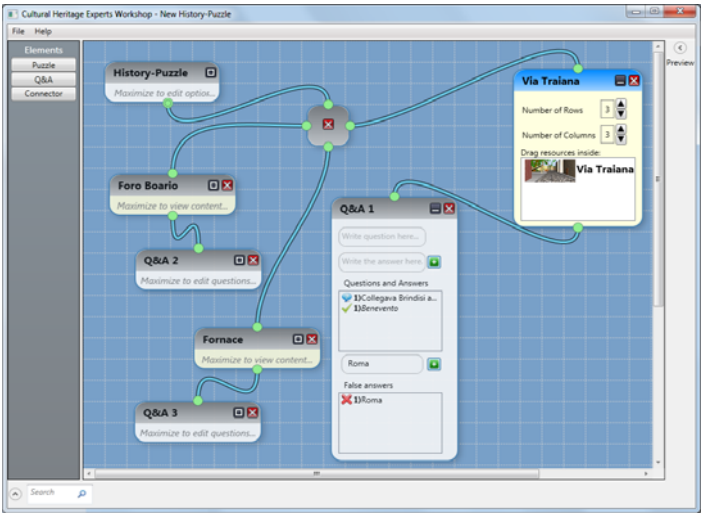

Fig. 1. The visual design environment in the CH experts workshop.

The final step is to connect every Puzzle block with a corresponding Q&A building block. First the CH expert drags the Q&A element in the working area and connects it to the associated Puzzle as he has previously done for Puzzles and root. Then he maximizes the Q&A block and types as many questions and matching answers as there are tiles in the connected Puzzle. In order to increment the difficulty of the game, more tiles than necessary can be shown: these additional tiles are created by typing false answers in the corresponding text area of the Q&A block. The preview panel on the right of the interface, when expanded, shows how the content will be presented on the application on the target device with the current presentation template. There are multiple templates for each allowed device in the application template. HCI experts can use their workshop to develop new presentation templates.

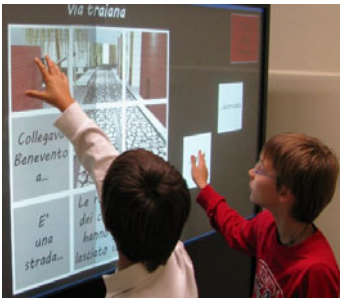

Fig. 2. Two young students playing with a History-Puzzle game

Once the game is ready, the *Export to…* command in the File menu of the CH experts workshop generates a collection of XML documents.

A host application running on the target device uses these files to show the application built in the environment with which visitors can interact. Fig. 2 shows two students interacting on a large multitouch screen with the resulting History-Puzzle developed for the archaeological park of Egnathia. Applications built in this way can be shared and modified once reloaded in the environment.

5 Conclusion

This research work has been motivated by the idea that the design of interactive systems requires a more active participation of all the involved stakeholders. In order to facilitate this process, a framework providing design environments tailored to each community of stakeholders is being developed. In particular, this paper has focused on cultural heritage experts, which play a special role having a deep knowledge both of domain and end users of the applications, namely the visitors of cultural sites. User studies evaluating the impact of the environment in the design process are currently underway and will be reported in a future work.

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