Allowing Lay People to Manage Smart Objects in the Cultural Heritage Domain

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I. Extended Abstract

Cultural heritage is a legacy of the past to be transmitted to present and future generations to help fostering their cultural identity. Information technology can support greater awareness and appreciation of historical content. In particular, the Internet of Things (IoT) has emerged as a very promising technology able to enhance the access to CH collections. IoT systems are based on distributed software services that, through the Internet, enable the access to functionality and data provided by physical devices. These are the so-called smart objects [1], i.e., devices generally equipped with sensors (able to detect different types of events occurring in an environment) and/or actuators (able to enact some actions determining a state change in the environment or in the IoT system itself). Through this technology, it is possible to create smart visit experiences offering to visitors of CH sites objects that they can bring with themselves, touch and manipulate for experiencing the site by receiving personalized information [2-4]. The interaction with such tangible objects favour emotions and engagement, improves understanding, thus increases the appropriation of CH content [2]. Some works in the literature recognize the benefits of physical manipulation and action as an additional channel for conveying information, since they activate real-world knowledge and improve memory [5, 6].

Providing visit experiences tailored to various categories of visitors is a need that emerged in several studies in the CH domain [7-11]. In order to accommodate this need, fixed, pre-packaged applications have to be replaced by software systems that flexibly allow domain experts, e.g., CH curators and guides, to tailor the applications that might be later used by visitors for a more engaging visit. End-User Development (EUD) paradigms supporting smart-object composition are needed, in order to allow lay people to define the behaviour of smart objects without requiring programming skills is the main barrier that limits the social and practical benefits of IoT. EUD is a research field that focuses on enabling people, who are not professional developers, to tailor their interactive applications by modifying or even creating software artefacts [12-14]. EUD fits very well the requirement of letting users customize their systems to support personal, situational needs [12-16]. Very few contributions in the literature address the possibility of enabling CH experts to shape-up smart visit experiences to be proposed to visitors. One prominent approach is the one proposed by the meSch project, which aims to enable CH professionals to create tangible smart exhibits enriched by digital content [17, 18].

A system that allows domain experts to flexibly combine the functionality of IoT devices has been developed [19]. The system offers a visual design environment that enable even non-programmers to define Event-Condition-Action (ECA) rules that automatically detect events generated by some devices and actuate some actions on the same or on different devices, in order to determine their behaviour. However, differently from other scenarios for smart object configuration, smart visit experiences may consist of the incremental activation of different rules that progressively involve new objects and that in the end lead the final user to discover new content. In addition, smart visits to CH sites require, more than other domains and smart-experience scenarios, to augment the semantics of smart objects. This is because smart visits have an intrinsic richness of content that cannot be conveyed to visitors by simply considering technical properties of smart objects. As an example, semantic properties that CH experts can define might refer to the historical features of artworks exhibited in a museum (such as historical age, related events, etc.). The introduction of new abstractions for expressing properties, which can help define relations among different objects and conditions on rule activation, makes explicit the role of the objects themselves not as isolated elements to be programmed, rather as components of an articulated scenario related to the discovery of some content. Semantic properties have been encoded into a new version of our system for the design of a smart visit experience [20]. The system is used by CH experts for the definition of ECA rules that, for example, enable specific smart objects to react in a certain way when they are close to artworks holding these properties. In the initial design phases, the activity of identifying semantic properties provides a means for conceiving how the smart resources will be exploited to convey some content or, more in general, to support the visitors' tasks in the smart environments. This is done by focusing on concepts of the cultural domain the visit refers to, rather than on low-level events and actions that characterize smart object technologies. In the following phases, domain experts exploit the semantics to define, in a simpler way, rules determining the behaviour of smart objects.

To better understand the notion of semantic properties, let us consider the example of a professional guide who is designing a smart visit to a museum that hosts an exhibition on the tools used during the archaeological investigation process. The exhibited tools are already equipped with QR-codes or RFID tags that visitors can scan to obtain additional information by using a personal device given to them before the visit starts. The guide enriches the archaeologists' tools with properties such as "Usage phase" (with values: *source collection*, *excavation*, and *stratigraphic reconstruction*), "Exposition room" (with values: *source collection room 1*, *excavation room 1*, and *stratigraphic reconstruction room*) to indicate the museum room where the tool is exhibited, "Audio file" (with values indicating names of soundtracks) to specify the audio to be played on the visitor's personal device when the retrieved tool is the right one. The guide "freely" defines these properties and their values, without any constraint (syntactic or semantics) on the type of properties to be

specified. After defining properties, the guide specifies the ECA rules controlling the behaviour of the smart objects.

Assigning properties to objects has two main advantages when creating ECA rules. First, the language adopted to define the rules is closer to the domain-expert language. For example, the variables used in the rules are exactly the properties previously defined by the professional guide, i.e. the smart visit experience designer. Second, the properties introduce abstractions that favour generalization. Without custom properties, several rules would be defined for each single device.

Summing up, our approach promotes smart objects as components of a smart experience that can bring with themselves evident connections with the semantics of content for which they facilitate the access. This gives to smart objects a new flavour, not only as technical devices able to sense and control the environment, but also as components that can be seamlessly integrated with the surrounding content, as they bring with themselves properties that facilitate the specification of goals for content appropriation. As such, they can better stimulate the creativity of CH stakeholders, such as CH site curators and professional guides, as smart-experience designers: if the smart objects make evident the relationship they have with the content, these stakeholders can better identify how to adopt such devices to convey the CH-site content to visitors. The additional semantics can make it easier for smart-experience designers to identify and manage the different elements to be considered and set up when defining cross-interactions of multiple devices.

Our approach for allowing lay people to manage smart objects is at the basis of the project "EMPATHY: EMpowering People in deAling with internet of THings ecosYstems". EMPATHY aims at developing new concepts, languages, methods, and tools to support people in creating and tailoring IoT context-dependent interactive applications for their needs. In this perspective, the project also addresses security and privacy concerns. It also focuses on how to support end user developers in easily identifying and fixing errors that they might have unintentionally introduced in their developed applications. The theoretical contribution of EMPATHY will guide the design of a platform able to support domain experts to tailor context-dependent IoT applications, in order to adapt applications for their activities in a productive way. Beside CH, the project results will be validated in other two relevant IoT application domains, namely ambient assisted living and education & learning) in order to show the generality of the approach.

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