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INVITED PAPER

A Storytelling-Driven Framework for Cultural Heritage Dissemination

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Abstract This paper aims at introducing a new dissemination framework for cultural heritage (CH) making possible affordable solutions for small and medium museums to cooperate/collaborate in the creation of exhibitions. The framework also makes possible new data-based communication strategies able to combine content belonging to different cultural archives and accessed through an ontology-based integration and discovery mechanism, and fosters new data sharing and distribution policies that preserve intellectual property rights. The proposed dissemination model redefines the concept of digital storytelling with the aim of increasing the participation of domain experts in the dissemination of CH. The framework is designed around a graph-based architecture for creating attractive and engaging multimedia narratives that will be transformed in real experiences personalized according to the user's profile, interests and context of use. Recommender and digital right management services are provided to authors and users for helping them in the creation, personalization and navigation of stories and for guaranteeing the adoption of suitable sharing and distribution policies.

Keywords Digital humanities · Digital storytelling · Knowledge integration · Cultures of participation · Digital right management · Ontologies · Semantic · Virtual and augmented reality

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1 Introduction

Traditional dissemination strategies in the cultural heritage (CH) field push museums at organizing and producing increasingly high numbers of temporary exhibitions and show in order to attract new audiences and also to update permanent collections in order to retain regular visitors. While such dissemination strategies are the advantage of the museum, they require resources; without staff, it is not possible to mount shows and without a budget it is not possible to advertise and promote the displays that entice the public to visit.

For these reasons, museums are focusing on the use of new technology (e.g., digital media and social networking) in order to increase awareness and interest in their collections. On the one hand, the museum digitization movement that has been ongoing for over a decade since the beginning of the twentyfirst century is opening to the investigation of innovative information and communication technologies (ICT), and especially innovative data visualization techniques, for displaying, interpreting and promoting collections. On the other hand, the collection of these digital materials and the development of traditional and advanced ICT solutions, such as Web sites, mobile apps, multimedia installations, require significant funds and staff.

For example, big museums are investing in offering interactive experiences that range from more "traditional" smartphone tours via mobile apps to interactive gaming and even solutions based on virtual (VR) and augmented reality (AR) technologies[1] to enhance what visitors can see through 3D reconstructions or 3D models that are reproduced on top of real-world scenes by using smartphone apps

[1] For example, one of the leaders in the use of digital and mobile tech in museums is the Smithsonian (http://www.si.edu/).

or head-mounted displays[2]. These technology are not affordable by smaller museums [10] that are reducing services to the minimum because of budget cuts, which then result in loss of visitors. Moreover, the adoption of these technologies is resulting in physical museums becoming isolated and functionless. A strategy for helping smaller museums to survive is to offer solutions that aim at enhancing the cooperation and sharing of their CH in order to create attractive exhibitions that include real artifacts with digital reproductions from a network of integrated museums. Development costs can be reduced by supporting the reuse of the exhibitions' materials and by developing common technological infrastructures that can be adopted by several institutions.

Starting from these considerations, this paper proposes a dissemination framework that focuses on the visitor's experience rather than the technology itself. However, without the aids of advanced ICT technology, such goal cannot be achieved effectively and at affordable costs. Therefore, the challenges involved in the creation of an innovative dissemination framework can be classified into two dimensions: the use of advanced technologies and the enhancement of user experience.

Both challenges could be framed in a traditional strategy that museums adopt for helping visitors to interpret their collections: storytelling. In general, a story helps the visitor to interpret an artwork in the context of the life of the artist or the social and political context in which the artwork was created. Visitors can also tell their own stories, making connections between the artwork and their own concerns, knowledge and interests.

The digital storytelling framework proposed in this paper aims at supporting different type of storytellers in creating stories. The proposed framework is designed with the aim of evolving stories that conventionally are authored and experienced as linear chronological structures, in interactive experiences enabling actions in a nonlinear and unpredictable fashion. The stories are created by using narrative structures based on the use of directed graph in which nodes represent the main elements of the story, whereas the edges and the related sequence of nodes represent the narrative flow of the storytelling.

A node of the graph includes a set of different layouts, each one suitable for different devices (e.g., Web browser, mobile apps, multimedia kiosk) to use for accessing the multimedia contents of the story that are mashed-up from different archives of a network of integrated museums. In such framework, domain experts such as archeologists, historians or experts of art can become storytellers by offering their expertise to provide other users with adequate good stories. Such an approach enhances the storytelling process as communication model that museums might adopt to disseminate their CH by taking advantage by the participative contributions of domain experts. Moreover, the stories would be generated based on materials from different museums and cultural institutions, thus offering the opportunity to explore and navigate across heterogeneous and distributed multimedia heritages.

The goal of storytelling thus becomes the one of disseminating integrated cultural heritage, enhancing and promoting the cultural knowledge itself instead the single museum collections. Such goal entails however addressing a new challenge discussed in Sect. 3: How to safeguard narratives and the resources of which they are composed, from a privacy and intellectual property right (IPR) point of view.

Another important challenge of our storytelling-driven dissemination framework concerns how to transform a narrative into a real experience that the users can live while being in the museum or by a remote device. The aim is to immerse the users in the storyline through the use of innovative technology. To address such challenge, each graph representing the story, created by a domain expert, can be navigated in different interactive environments generated according to the user's wish and context of use and so rendered in a Web application or instantiated in real spaces through the use of location-aware and immersive technologies. In the latter case, the story can be accessed by exploiting VR or AR solutions for intermingling real objects with the virtual environment for real-time interaction. The implementation of these immersive and multimedia solutions may work toward filling the gap of traditional museums which are unable to offer adequate interactive stages for visitors and artifacts. By adopting affordable devices for VR and AR that are currently available on the market museums will have the possibility to exploit storytelling strategies for providing visitors with exciting immersive and articulated experiences, avoiding the problem to offer innovative technology but with very poor and uncared content.

Our affordable storytelling-driven dissemination strategy will provide economically less endowed museums and cultural institutions with the opportunity to increase their visitors' interest through the use of innovative and technologically advanced solutions.

The rest of the paper is organized as follows. Current ICT solutions used for CH dissemination specifically the ones based on storytelling strategies are introduced in Sect. 2. The storytelling-driven framework is then discussed in Sect. 3, with particular emphasis on the motivations and requirements at the base of its design. Section 4 summarizes the paper and describes an implementation of the proposed framework.

[2] Examples are the 3D virtual showcase for the archives of the Italian fashion house Valentino (http://valentino-garavani-archives.org/) and the exploration of 2000 years of Paris' history by means of an interactive 3D model created by the 3DExperience company (http://paris.3ds.com/).

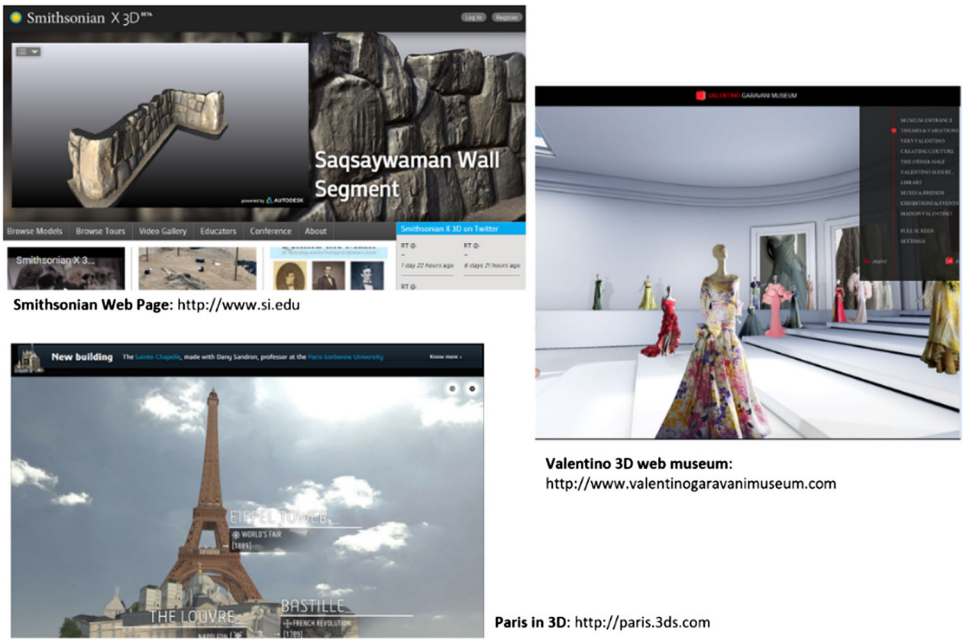

Fig. 1 Web applications using 3D technologies for disseminating cultural assets

2 Technologies

Today, more and more museums, archeological parks and cultural institutions are exploring innovative uses of ICTs to enhance their visitors' experience. Such a pervasive use of ICT solutions within exhibitions and installations aims not only at enriching the first-hand visiting experience, but also at creating remote experiences for those who cannot get physically there.

These interactive, educational and engaging experiences range from more "traditional" smartphone tours via mobile apps to interactive gaming and even VR and AR. For example, one of the leaders in the use of digital and mobile tech in museums is the Smithsonian technologies. The Smithsonian (see Fig. 1) has an array of mobile and Web apps that allow museum visitors to interact as they go through an exhibition or to remotely experience the exhibition.

Other institutions are focusing on the use of VR and AR technologies. These are probably the most interesting and most likely to be successful technologies for museums simply because they enhance what visitors can see; 3D reconstructions or 3D models are overlapped to real scenes using smartphone apps or head-mounted displays (such as Oculus rifts, Google Cardboard or Gear VR. See Fig. 2). Examples are the 3D virtual showcase for the archives of the Italian fashion house Valentino (Fig. 1) and the exploration of 2000 years of Paris' history (Fig. 1) by means of an interactive 3D model created by the 3DExperience company. A further ongoing project, developed by the Landmark Entertainment Group, aims at creating a virtual reality amusement park in China that will include a virtual zoo, a virtual aquarium and complementary components such as an interactive museum

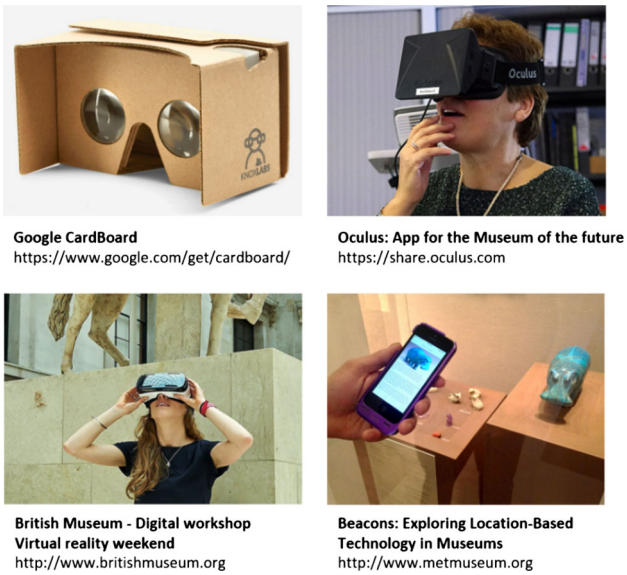

Fig. 2 Examples of innovative technologies in museum field

and a digital art gallery. Other solutions offer the possibilities to live experiences using sensor-based platforms (e.g., LeapMotion[3], Kinetic[4]). For example, the American Museum of Natural History in New York[5] allows visitors to step into motion sensor-based platforms and to pilot two different species of pterosaurs through a virtual landscape.

Cultural institutes (including the Metropolitan Museum of Art of New York—see Fig. 2) have also been recently giving

[3] https://www.leapmotion.com/.

[4] https://dev.windows.com/en-us/kinect.

[5] http://www.amnh.org.

attention to "Beacons," a Bluetooth low-energy technology that addresses the need for a low-cost, easy-to-implement solution for indoor location-based services. This technology offers the possibility to build location-based experiences and share them with others. If a museum places some beacons in its galleries, any bluetooth compliant device can detect and use them for content access.

Independently from the adopted ICT technologies, the adopted solutions typically aim at impressing and amazing visitors. However, besides their cost, a problem of these technologies, and the reason why in some cases these solutions fail, is that they are passive and promote a top down and prescriptive approach to communication. A visitor will initially happily use such technologies and implicitly agree with the aims and educational objectives behind their adoption. At the beginning of the visit, visitors will likely be very interested and intrigued, but very often after the first impact and a short use of these technologies, visitors loose interest and curiosity with the result that the cultural, historical and artistic importance of the heritage is not really understood and appreciated.

To solve this problem, we believe that next-generation culture dissemination processes are to be designed around two important communication aspects: user involvement and knowledge sharing. Museums, especially the smaller ones, need to focus on dissemination strategies able to support an active involvement of the visitors during their visits and of domain experts, such as scholars, archeologists, historians and experts in the art of creating and organizing the content to disseminate. Visitors want to live interactive and attractive experiences according to their profiles, interests and contexts of use. Domain experts want to take part in the dissemination processes in order to provide well-grounded information but, at the same time, disseminated culture in an engaging way. They both want the possibility to navigate across a diverse heritage from different institutions and fields of interest. The active participation of different cultures and the possibility of sharing knowledge and contents from different sources can enable the design of new affordable solutions. Affordable dissemination strategies (in terms of costs, time, performance and usability) will provide economically less endowed museums and cultural institutions with the opportunity to increase their visitors' curiosity through use of innovative and technologically advanced solutions.

The main concept at the base of the dissemination framework proposed in this paper aims at defining a new idea of virtual museum that makes possible for museums to open their archives and to interconnect in order to create a network of cultural institutions supporting open and shared culture. This concept of virtual museum stems from the need of a communication strategy able to combine contents from different cultural archives and to increase the users' curiosity for arts and understanding of CH. From our point of view, storytelling represents the right choice for helping visitors to approach specific cultural contexts through engaging narratives. At the same time, storytelling is a useful solution for providing domain experts the ability to devise new strategies for shaping, accessing and studying CH in their own research field.

In recent years, several CH projects focusing on the use of narrative methods and storytelling tools have been launched. However, such projects have largely been designed for use in museums or heritage buildings, where visitors typically stand in front of an object such as a painting, or in a "historic" room. For instance, the CHESS[6] project attempted to integrate interdisciplinary research in personalization and adaptivity, digital storytelling, interaction methodologies and narrative-oriented mobile and mixed reality technologies with a theoretical basis in museology, cognitive and learning sciences [17]. However, the two case-study prototypes developed as part of such project were huge and focused on modern museums: the New Acropolis Museum in Athens and the Cité de l'Espace—a gigantic science theme park with four million visitors per year. The sophisticated technologies developed are more suited for large-scale CH sites than for their smaller counterparts. Similarly, the ARtSENSE[7] project, deploying AR techniques to enhance viewers' appreciation of art in a museum setting, requires far more elaborate equipment than what is available to small museums. The art-E-fact [12] project aimed at creating a mixed reality installation about art. An ontology was developed as part of such project for describing works of art from several viewpoints (e.g., esthetic, technical) using the Protégé ontology tool [8]. Artists entered information about the featured works of art which was then used in the mixed reality storytelling installation. As discussed in the survey by Garzotto [6], other research efforts have focused on engagement in story exploration and authoring in 2D or 3D environments, e.g., FaTe2, [7]; Teatrix, [16]; Wayang Authoring, [21]), mixed reality environments [19] or mobile technology [18].

Another area closely related to the creation of interactive experiences in CH is the field of Interactive Digital Storytelling (IDS), where systems provide users with renditions of stories and allow them to alter the course of the presented story. Of particular relevance is the research undertaken by the IRIS Network of Excellence[8] [3] focused on authoring systems for interactive storytelling; research efforts in this area continue to grow [15]. For IDS, the template-based approach is commonly used in authoring tools to support the concept of separating content from presentation. For

[6] http://www.chessexperience.eu/.

[7] http://www.artsense.eu/project-overview/artsense-system/.

[8] Overview of authoring tools form interactive storytelling, http://iris.interactive-storytelling.de/AuthoringToolDescriptions.

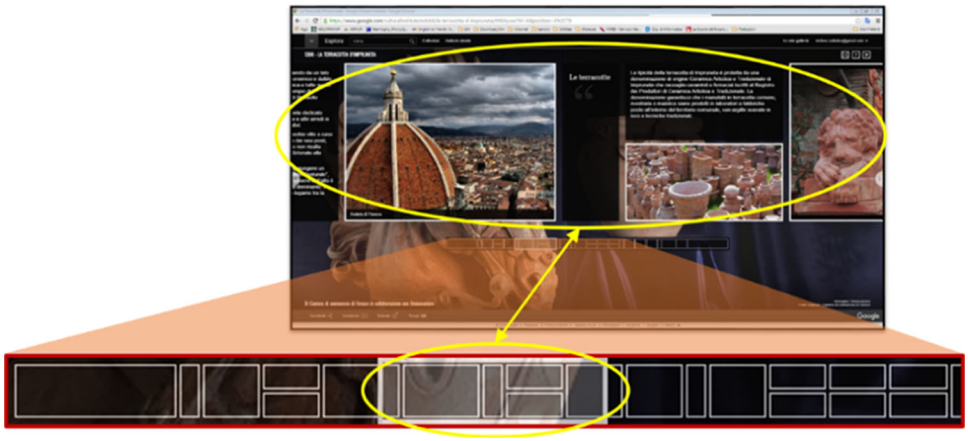

Fig. 3 Google Cultural Institute. Use of layouts in creating a virtual exhibition. The layout used for displaying the images and text is zoomed at the *bottom* of the figure (surrounded by a *circle*). The zoomed part of the figure shows the complete set of layouts used in this exhibition

instance, the authoring tool StoryTec[9] ([9,13]) is aimed at nontechnical users, utilizing visual approaches to authoring, and the tool was applied in the context of several projects (e.g., INSCAPE[10], U-CREATE[11], 80Days[12]). A typical use scenario of a template-driven storytelling tool is when archeologists want to present some of their findings in a playful way; in such case, they can insert findings in a predefined story structure, without the need of game design knowledge. IDS can be also used by teachers to combine different resources created by archeologists into a single learning unit.

Although stories vary in many ways, a storytelling template can help one to frame his/her own story. Aaker and Chang [1] propose the formula *Story = Situation/Desire—Complication/Obstacles - Solution/Outcome* for describing a possible template of a story. This is a typical example of template, that is, a plot structure that can be used for writing a narrative, but is not always suitable for presenting a story in the CH field. "The evolution of agriculture technology" or "A beginner's guide to Impressionism" is examples of stories that cannot be explained by using a narrative or an adventure plot. In this case, it is better to consider plot elements as part of a layout that can be followed for describing the pathway of a story. For example, Google Cultural Institute[13] (see Fig. 3) is "*an effort to make important cultural material available and accessible to everyone and to digitally preserve it to educate and inspire future generations*." In such institute, the author of a digital exhibit can choose among a set of available layouts for presenting the content of his/her collection. As shown in Fig. 3, a layout is used for arranging the multimedia elements and for allowing viewers to scroll through the exhibit.

The main problem of the layouts used in Google Cultural Institute is the constraint to use a linear structure. Such constraint makes impossible interactive experiences for viewers as such interactive experiences would require the system to support nonlinear visits through the contents. For this reason, it is critical that systems supporting CH story authoring provide authors with authoring tools able to exploit a graph structure from allowing them the possibility to devise different pathways through a story.

Finally, some recent, albeit limited, attempts have focused on developing multi-user collaborative authoring tools (e.g., CrossTale by [4,11]). The design and evaluation of such tools are still at the beginning, as well as the scope and context of application. Clearly, such tools need to be fully developed and extended to address the identified shortcomings (e.g., limited adaptivity). Work is needed to develop more powerful authoring tools with advanced technologies, such as VR/AR, for more positive experiences that engage users.

According to these considerations, the novelty of the storytelling-driven dissemination framework proposed in this paper is the capability to involve a variety of users groups with different backgrounds. Such capability is critical in order to develop a usable, useful, desirable and flexible (and even playful) authoring tool for interactive digital collaborative storytelling and storylistening. As described in the next section, by exploiting a graph organization for CH information, the dissemination model provides savvy users with an open interface for storytelling, resulting in more freedom for creativity and enhancing interactivity in the presentations of narratives.

3 Storytelling-Driven Framework

As discussed in the previous section, the main weaknesses of existing methods and tools concern two important aspects of

[9] http://www.storytec.de.

[10] INSCAPE—Interactive Storytelling for Creative People. FP6, IST, IP.

[11] U-CREATE—Creative Authoring Tools for Edutainment Applications, FP6, CRAFT.

[12] 80Days—Around an Inspiring Virtual Learning World in Eighty Days.

[13] https://www.google.com/culturalinstitute.

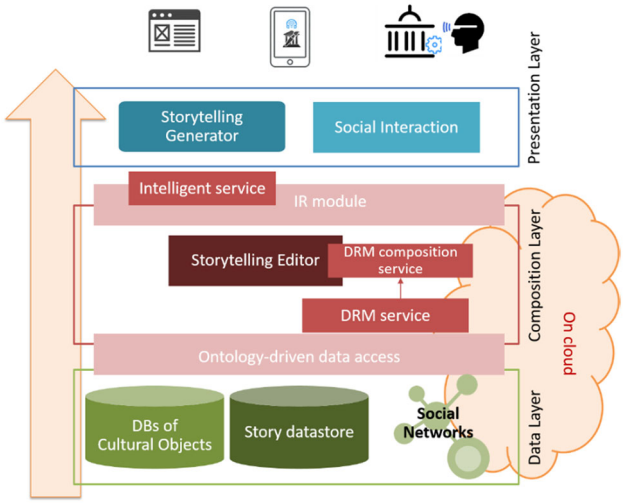

Fig. 4 Architecture of the storytelling-driven framework

CH dissemination: the involvement of visitors and domain experts, and the sharing of knowledge and contents.

Exploiting the storytelling paradigm, the proposed dissemination framework is based on the architecture presented in Fig. 4. The framework aims at providing users with an advanced dissemination strategy based on a storytelling engine able to transfer data from the data layer to the presentation layer by interoperating the systems used for retrieving data with the tools used for presenting stories customized according to users' profiles, interests and contexts of use.

According to the architecture in Fig. 4, the main components of the storytelling-driven dissemination framework are:

1. The *data layer* for the integration of heterogeneous and distributed cultural data using a semantic model based on a cloud architecture able to scale according to the museum's needs and dimension.
2. The *composition layer* for providing domain experts with the possibility of creating professional stories by using a graph-based authoring tool.
3. The *presentation layer* for providing users with stories that can be accessed through a personalization of the story structures defined by story authors. This instantiation is performed according to user's profile, wishes and context of use.
4. The *recommender and data right management services* for suggesting authors possible multimedia cultural material that can be used for creating stories and for recommending users a suitable personalization of stories and navigation strategies. Both types of suggestion are provided according to precise sharing and distribution policies for guaranteeing the privacy and intellectual property preservation of the content.

3.1 Data Layer

A cloud platform is at the base of the architecture presented in Fig. 4. The use of a cloud infrastructure is motivated by the fact that museums do not want to heavily invest in computing equipment and software and prefer to incur costs that depend on the effective use of the computing infrastructure. In our framework, the cloud infrastructure hosts the archives containing the CH data of each museum, the social networks created around the CH, the stories developed by using the Storytelling Editor and all services provided by the composition layer. The main component of the data layer is the ontology-driven data access that is used for accessing external repositories ("archives, scientific collection, museums, art galleries, visual arts") and connecting them to the composition layer of the architecture. By introducing a mediator component at the bottom of the cloud infrastructure, it is easy to allow new institutions to join the network of interconnected museums and thus access and use the facilities provided by the system. The data access layer uses a conceptual reference model (e.g., an ontology) that describes the concepts according to which artifacts and narratives are stored and classified in the different external repositories. Such reference model is crucial in order to enhance the interoperability among the different institutions. It also supports a uniform access and retrieval of the artifacts and narratives developed by stakeholders, thus making possible their reuse and repurposing according to users' needs and inputs.

3.2 Composition Layer

Through the use of the ontology-driven data access, the composition layer supports the community of domain experts in creating stories. By using a Storytelling Editor, the author can retrieve relevant material (texts, images, video, other stories) to use in composing the narrative. This information discovery mechanism does not search the actual objects in the collections, but uses the descriptive metadata of the objects. The metadata are part of the ontology used for modeling the concepts and relations of the knowledge base composed by archives integrated at the data layer.

These metadata are also used for describing the content of the stories (e.g., themes and sub-themes). By using a layer structure, the Storytelling Editor helps domain experts in creating stories. The story structure is created by using a directed graph in which nodes represent the main elements of the story, and the edges and the related sequence of nodes represent the narrative flow of the storytelling. The graph is structured in such a way that from a node it is possible to move to another node by following different storytelling paths. Structures can be newly created, selected, adapted or merged by using the graph operations.

For each node, the author has to define its layout and the related multimedia content, that is, the combination of images, sounds, videos, animations and/or texts that represent an element of the story. The layouts can be selected from a set of layouts suitable to represent content in a Web page, in a screen of mobile apps or in the screen of a multimedia kiosk. For each multimedia item, the author can provide different versions, for example, images at different quality, texts suitable for different purpose (e.g., short text for a brief overview or long in-depth text), animations accessible via Web or by using VR/AR devices. Existing multimedia items are retrieved by the system via the ontology-driven data access service according to the keywords associated with the story structure. The final stories are created by the users by selecting suitable layouts according to their requirements and devices used to access the stories. The multimedia content of each node will then be instantiated according to the user's profile or wishes.

The organization of the story elements can be specified with the graph operations provided by any of the graphical environments[14] that have been proposed for the design of graphs and charts. These environments offer solutions based on JavaScript libraries for creating customisable graphs or charts. Independently from the libraries used for creating the graphs, the main feature of the Storytelling Editor is to provide authors with a set of operators for creating nodes and edges and for enabling the connection of different story structures by joining nodes of different graphs.

In Fig. 5, a mock-up of the Storytelling Editor is shown. Section A shows the graph editor that the author can use for creating the structure of his/her stories. Section B shows a set of layouts suitable for creating Web pages. In this scenario, the author is creating stories to be presented in Web applications. Finally, Section C shows the canvas used for composing the elements of the first part of the story (the first node). In the figure, the author has dragged and dropped a picture and has been writing a text and added an audio.

3.3 Presentation Layer

At presentation layer, the user will customize the final story to be accessed. The customization phase will help the user in selecting the suitable options offered in the story structure according to his/her context of use (at home by using a browser, at the museum with a smartphone, at the museum by using multimedia installations) or profile (approximate duration of the storytelling, level of detail of the information to provide).

[14] D3.js—Data-Driven Documents: http://d3js.org/; Google Charts: https://developers.google.com/chart/; ChartJS: http://www.chartjs.org/; n3-charts: http://n3-charts.github.io/line-char/.

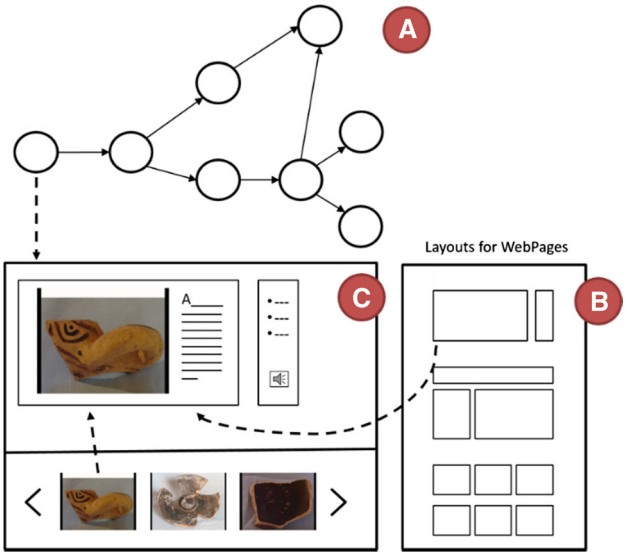

Fig. 5 A mock-up of the Storytelling Editor

The Story Generator is the main component of this layer and is endowed by an adaptive story player module. The goal of this module is to allow one to instantiate a story structure in a real experience adapting it according to the user's profile and wishes in different modalities including:

- *Mobile digital experiences*, based on the use of mobile digital devices (tablets, smartphones), of their components (GPS, compass, accelerometer, data connection, camera), and functionality (mobile applications). Narratives, essentially based on territorial anchorage (with multimedia content geolocation inserted by the author of the story structure) will drive to users in real environments providing them multimedia information linked to the visited spaces, contextualized according to the narrative plot. Other narratives, based on gamification strategies, will be transformed in adventure games. For example, a treasure hunt in which real and virtual items and information should be collected for, at the end, winning an award.
- *Multimedia digital experiences* aiming at developing the narrative for view on several devices, presenting complementary uses and technological solutions: PC, laptop, tablet, smartphone, TV, interactive scenography, multitouch screen, etc. Such transmedia approach enables a continuity of use around content with adapted design and to immerse the user in an original narrative universe. For example, in an in-loco storytelling the visitor can see a fragment of an artifact and by using a kiosk can try to recreate a virtual reconstruction.
- *Immersive digital experiences* based on blurring the borders between fiction and reality. The transformation into narrative is continuously operated and poses the user in a particular situation, in which the difference between

the story told and the experienced reality becomes more and more tenuous. The narrative universe defines the experience in which the user is immersed. Immersive experiences would be typically based on the use of VR and AR technologies able to enhance what visitors can see through 3D reconstructions or 3D models that are reproduced on top of real scenes by using smartphone apps or affordable head-mounted displays such as Oculus Rift, Samsung Gear VR or Google Cardboard.

Finally, another component of the presentation layer is the social interaction service that is used for endowing the story player with a social network for exchanging knowledge (experiences, ideas, comments, evaluations about stories or content) among the different communities of users.

3.4 Recommender and Data Right Management Services

The final component of the architecture presented in Fig. 4 concerns two services supporting authors in creating stories, helping users in customizing their experiences and at safeguarding the stories and their concepts according to some access policies.

3.4.1 Recommender Service

The procedure for creating stories relies on the analysis of a given situation and author's behaviors for suggesting the material to take into account in the generation of the storytelling. According to the authors' interests and wishes expressed by using a set of metadata, the recommender service provides suggestions about how to access the data layer and how create a story in the Storytelling Editor. The problem of accessing and classifying a high number of data to use for generating new stories can be approached by using suitable machine learning techniques. The addition of new stories to the training set has the potential to improve classifier's performance. The outcome of this recommender service is to suggest how to access the most relevant subset of data to use for creating new stories according to the author's preferences, profiles, behaviors and contexts of use. For improving the suggestions, this service can also integrate social intelligent computing functions. The social network of storytellers is important for sharing and exchanging knowledge, and the social network developed may potentially grow to a very large scale. Such social network of storytellers can be equipped with an intelligent algorithm to analyze the structures of large-scale social network of storytellers through the use of graph analysis techniques. This allows to analyze various collaborative dynamics and behavior patterns in the large-scale social network of storytellers. The results can help to understand the attributes and behaviors of individual members, the collaborative and interaction model between members, as well as identify the properties belonging to communities as a whole.

The recommender service can be used also for suggesting how to create stories by providing indications about possible concepts, relations or parts of other stories that need to be included in the current story. The set of narratives created by other authors can be analyzed for identifying the features that make possible a proper characterization of the concepts described in these narratives and for defining the metadata that could be associated with each narrative or at parts of narratives.

Moreover, the service also helps users who want to create a visit. In this case, the recommender service suggests how to customize the story structure by taking into account the device to use, the user's profile and interest, the narratives previously visited and related feedbacks, rating, impressions that the members of the community have generated when they have discussed about the narratives in our social network. Moreover, the service can also suggest possible paths to follow in the story structure.

3.4.2 Data Right Management Service.

The possibility to open museums and cultural institutions' archives for creating common and comprehensive CH data sets goes together with the need to protect data and stories with adequate sharing and distribution policies for the management of the intellectual property rights (IPR). For this reason, our framework includes a service that supports innovative strategies for specifying proper data right management (DRM) actions and IPR policies, specifically oriented toward the access and reuse of CH contents. During the design phase of a story, by using the DRM Service, the authors can access CH data from integrated archives; however, such accesses must comply with the IPR policies specified for these archives. At the end of the design phase, by using the DRM composition service, the Storytelling Editor defines the license to be associated with the stories that can be generated using the structure created by the author (or more authors) according to the digital copyright owned by the author(s). When a story is accessed by using the IR (information retrieval) module, the user can access the content according to his/her use licenses. Such licenses specify the number, type and quality of the images, sounds, videos that the user can access.

4 Conclusions

The paper describes a storytelling-driven framework for CH dissemination that aims at providing affordable solutions for small and medium cultural institutions to cooper-

ate/collaborate in the creation of exhibitions. The framework supports a new communication strategy able to combine content belonging to different cultural archives and accessed through an ontology-based integration and discovery mechanism, and fosters new data sharing and distribution policies that preserve the intellectual property rights of the involved institutions. The framework is designed around a graph-based content representation that is the key for creating attractive and engaging multimedia narratives that can be easily transformed in real experiences personalized according to the user's profile, interests and context of use.

An implementation of this framework was carried out in a context of a project focusing on information integration and access for a community of CH professionals in order to develop a comprehensive information system for the Etruscan civilization. This implementation was part of the T.Arc.H.N.A.[15] (Towards Archaeological Heritage New Accessibility) European Project. The aim of T.Arc.H.N.A. was to offer a holistic view of the Etruscan CH, physically located in different cultural institutions, by leveraging knowledge representation techniques. The proposed solution aimed at defining a semantic mechanism for retrieving data from a variety of knowledge sources through a well-defined ontology. The ontology was used both for integrating museum databases and for proving a knowledge representation of a given Etruscan CH. In this context, the ontology was designed on the base of the standard reference model for CH—the CIDOC Conceptual Reference Model [5]. The CIDOC-CRM ontology represents a suitable basis for a common CH description language and for supporting conceptual modeling activities in each cultural context. The T.Arc.H.N.A. approach, built upon CIDOC-CRM, is based on an ontology layer that focuses on interoperability of information systems and databases and abstractly defines concepts and relationships. It hides the specificities of domain-specific languages or the intrinsic features of a well-determined cultural context, in this case archeological heritage. Further details are reported in [2,20].

Another outcome of the T.Arc.H.N.A. project has been to establish a methodology for addressing the problem of knowledge accessibility and the sharing of experts' perspectives. Through the use of a Narration Builder tool, the archeologists can write stories according to the historical, artistic and anthropological meanings they want to disseminate. Narration Builder was developed to support authoring activities by helping the authors in selecting the information that constitutes the subject of the narration. The process of specifying a story consists in three main phases:

(i) *Search relevant objects* By making use of the ontology layer, the archeologist searches the artifacts which are relevant for the narrative. Relevant information can either directly retrieved from the databases (e.g., I want to specify a narration of all decorated potteries) or indirectly retrieved through the ontology (e.g., I want to specify a narration on the Etruscan God of marriage).
(ii) *Select relevant objects or concepts* Among the information retrieved from querying the data sources, the next phase is to select the data the story will be linked to.
(iii) *Specify the story text* The last phase is the specification of the narrative. The stories are stored in the ontology itself; the authors can access them to revise the text or change the associated objects or keywords.

The T.Arc.H.N.A. Project represents an example of instantiation of the storytelling-driven framework proposed in this paper. Further activities need to be undertaken in order to extend the proposed solution with recommender and DRM services and for evaluating them in real contexts of use.

An implementation of the DRM service was carried out in the context of another project [14]. This project has developed the building blocks for the implementation of tools helping a user to visualize his/her own resources (or the resources created by the communities she/he belongs to), to compose resources and to generate related licenses. The tool relies on a formal model that is compliant with the MPEG-21 REL (Rights Expression Language) for the representation of licenses as collections of grants.

Future work includes extending the framework to deal with large-scale data sets, to incorporate novel data analytics techniques specifically defined for tasks such as user sentiment analysis and to incorporate novel IoT technologies. Finally, the application of the proposed framework to STEM education and to collaborative scientific explorations is another important research direction.

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