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A trustworthy multimedia participatory platform for cultural heritage management in smart city environments

Zois Koukopoulos[1] · Dimitrios Koukopoulos[1] ·
Jason J. Jung[2]

Abstract Cultural heritage applications within smart city environments are becoming extremely popular to public authorities. The success of such applications lies on several factors like user-friendliness and data presentation as well as the amount and accuracy of cultural data they can offer to users, static or mobile, on-demand. This paper presents the design and implementation of a multipurpose, multidiscipline digital platform that manages, preserves and disseminates tangible and intangible cultural heritage information, in a trustworthy manner, appropriate for the everyday use in smart city digital environments. Platform's trustworthiness is mainly ensured by applying specific authorization mechanisms based on an extended role-based access control scheme. The platform integrates a mobile services module that can host and support smartphone applications for the direct collection, digitization and dissemination of cultural heritage content. Moreover, we make an attempt to address various stakeholders who benefit from such a platform. In this direction we have designed and implemented a series of real life usage scenarios. The proposed platform is evaluated against other online digital platforms that host cultural heritage content. Evaluation results suggest that the presented platform could become a participatory system that targets not only experts and artists, but also amateurs and enthusiasts of cultural heritage. This vast and heterogeneous user base could be the only feasible way to support data-hungry ecosystems like smart city digital environments, by providing cultural information at any time and place.

✉ Zois Koukopoulos
     zkoukopu@upatras.gr

     Dimitrios Koukopoulos
     dkoukopoulos@upatras.gr

     Jason J. Jung
     j2jung@gmail.com

[1]   Department of Cultural Heritage Management & New Technologies, University of Patras, 2 G. Seferi, 30100 Agrinio, Greece

[2]   Department of Computer Engineering, Chung-Ang University, Seoul, South Korea

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1 Introduction

In the last few years public authorities all over the world have been trying to use modern technologies in order to create a more digital-friendly environment for their citizens, expand their services and lower administrative costs [8, 22]. Traditionally organized cities are currently trying to keep up with the modern trends of Information Technology by integrating digital services aiming for their transformation to smart cities. Smart parking systems, e-government solutions through online portals, tourist information and guidance, local market promotion and the highlighting of cultural heritage points of interest are only some of the services that could be offered within a smart city environment [7, 11, 23, 27, 33, 34, 51, 54, 62, 67]. But these digital infrastructures hide a severe difficulty as they require vast amounts of data in order to become valuable, interesting and usable to their users.

Smart cities aim for making the use of their digital services a necessity for the everyday life of their citizens. When a user wants to use these services she/he must get an accurate answer every time. If this does not happen then the user will be disappointed with the service and the chance of reusing it or other similar services diminishes. One can thus assume that digital services offered to citizens within a smart city environment, should store vast amounts of accurate information [37, 49], should be available regardless of time and space and should be user-friendly and easy to use because they aim at an audience of non-experts in information technology. In [1] authors state that "Undoubtedly, the main strength of the big data concept is the high influence it will have on numerous aspects of a smart city and consequently on people's lives". This required mass of data is extremely difficult or even unfeasible to be gathered and digitized solely by professionals hired by the public authorities. The solution lies on the active participation of every citizen.

During the last decade, the evolution of smart mobile devices, smartphones and tablets, has changed the lives of individuals all over the world, making the dream of smart city environments more and more feasible. Such devices are a necessary digital companion for everyone nowadays as users can be informed about everything from everywhere at any time of the day. We can use this tool for our work, entertainment or transportation. All the information lies within our grasp. But this reality holds a second very important aspect. We do not have to be passive receivers of knowledge. We can also become active learners and contributors of valuable information. Each one of us, can use their smart device and record, digitize and share information. Mark Weiser in [76] pointed out that "There is more information available at our fingertips during a walk in the woods than any in computer system". In such a context, everyone can contribute small portions of information thus resulting in the collection of vast amounts of data.

But how can we motivate people to embrace the culture of digital participation? How can we urge citizens to contribute digital content in a form that could be reused by a system or another citizen? Individuals from nature do not tend to give knowledge and information to others in a structured way. Anyone can ask a stranger for directions on how to drive to a specific place but it is not that easy when it comes to Information Technology. An introduction of an online participatory digital platform that will trigger user participation and will guide users to contribute data in a structured manner, becomes a clear alternative for a viable solution.

The tremendous success of social media like Facebook, Twitter, YouTube and Instagram indicates that the culture of digital participation among the users is not an unreachable task. Such platforms allow users to generate waves of digital content with discreet guidance from the system itself. The observation of social media platforms can serve as a lighthouse for the design and implementation of online participatory platforms for smart city environments, especially because they are highly interactive, user-friendly, trustworthy and create the notion of a global community. But there is also a lacuna that we must not pass by. Social media support the human need for social networking which is not the case for other digital systems like e-government platforms. Individuals tend to participate easily in a means that provides digital social gathering in order to feel like members of a community but they may not care about the well-being of a system that informs them about carbon emissions from cars and fireplaces in their city. Moreover social media, from their nature, do not care about collecting and presenting accurate information to their users. But a digital platform within a smart city environment does not have that luxury as it should always collect and show qualitative information.

In this work, we propose Culture Gate, an online participatory digital platform for cultural heritage. The platform gathers cultural heritage information from its users, checks it for accuracy, organizes and presents it to the broad public in a friendly manner. It also provides the opportunity to users to search for cultural content. Culture Gate tries to confront all major issues that derive from its participatory nature while providing modern tools and services that make it an excellent system for smart city environments. The platform offers smartphone applications that present location-based cultural content on-demand or aid in collecting cultural data from outdoor or indoor locations and store it in a database or file server for further use (video, audio, photos, notes, annotations or gps data). Location-based services are an excellent personalized tool that we believe is mandatory for modern platforms. We aspire to create a fundamental digital platform that will receive cultural heritage information from different sources (scientists, artists, the public etc.), preserve and digitize it, organize it in widely accepted ways, author it with the help of well-known cultural heritage professionals and present it to the online users in a friendly, modern and innovating manner. By making scientific information public, we allow users to correct, update or enrich cultural content leading in more qualitative data.

A very important aspect that we must not oversee, in participatory digital platforms is security, privacy and ownership of data [73]. When a system asks users to contribute information several issues might arise in the above areas. It is universally true in the digital domain that in order to entrust a system, users, experts or not, should be persuaded that their contribution should not be accessible or manipulated by others without their permission. Platforms that offer crowd-sourcing services should ensure controlled access into cultural content stored in their databases. Furthermore, a part of platform's potential users, especially scientists and professionals, would like to exchange information with their colleagues privately. Participatory systems should implement mechanisms to ensure that private communication is supported. On the other hand, the complex issue of handling intellectual property rights is of great importance. It is easier within a smart city environment to establish some rules about user contributions in order to minimize future conflicts, but overall the platform cannot deal with any possible threat so it should provide to its users full responsibility about their actions. Moreover, Culture Gate tries to relieve the fear of users that their content contribution will be accessed and manipulated without their permission applying suitable authorization mechanisms. In particular, we extend role-based access control model to impose limitations to the access of cultural content.

Culture Gate stores and presents cultural information concerning all major cultural disciplines like archaeology, architecture, history, literature, museology or theatre. It can be used for a variety of purposes ranging from education and commercial exploitation of cultural heritage sites and monuments to digital preservation of existing or newly discovered cultural content. In this direction, we propose a series of usages targeting a number of real-life management, preservation and dissemination scenarios in cultural environments. It also provides the opportunity to store intangible cultural content when it happens otherwise such content would be lost. The platform can be accessed from all electronic devices that have an Internet connection like desktops, laptops, smartphones and tablets. Moreover it supports the integration of third party software. Experts that create software applications concerning cultural heritage, like serious games, could integrate their creations to Culture Gate and gain access to a targeted audience.

But the most important aspect of Culture Gate is the goal to interconnect a vast and heterogeneous population of scientists, artists, educators, curators, tourists, enthusiasts of cultural heritage or simple citizens of a smart city, in a community. Besides the cultural information, the platform will provide ways to lead users to interact with each other in order to create a vivid online community. It is very difficult to unite different individuals in a single community. To surpass that obstacle, we attempt to encourage the creation of small sized communities with their own scopes. Such micro-communities will constitute the larger community of Culture Gate.

Culture Gate opens the way towards a unified platform, appropriate for smart city environments, which will provide cultural heritage digital services online with the participation of a large audience of users, both experts and amateurs. Cultural heritage is a field that never hesitated to use the technological breakthroughs in procedures like collection, digitization, preservation, data organization and presentation, dissemination and exploitation of cultural heritage information. So it provides an ideal starting point for building a system compatible with a smart city environment. On a different level, the target of the proposed platform is to create a social impact that will encourage the commercial exploitation of its content for the benefit of cultural organizations, local communities or tourist industry.

We attempt to evaluate our platform strength comparing it with similar applications (focusing on cultural heritage online platforms that store information from several disciplines) that have been introduced to the broad public in the last few years [12, 29, 35, 71, 72, 78]. Evaluation results suggest that Culture Gate is, to the best of our knowledge, a first attempt towards an online digital platform that supports the idea of content contribution by the users, has an international scope, uses mobile applications, is open to the public, can store tangible and intangible cultural content and uses interactive means to engage users the longer with the system.

2 Related work

The set of smart electronic devices that are connected to the Internet collecting and exchanging data, constitutes the Internet of Things which is the basic fabric that leads to the transformation of traditional cities to modern smart cities. IoT realization poses a series of challenges but also can lead to unimaginable mental, cultural, political, bartering, educational, technological and spiritual breakthroughs to everyday life of people [70]. Several frameworks, architectures, platforms, tools and systems have been proposed to the scientific community which guide or

implement the realization of smart cities through the IoT [15, 42, 64, 69, 79]. In [42] authors proposed an information framework for creating a smart city through the Internet of Things and utilized their idea to a noise mapping case study that illustrated a new method for existing operations that can be adapted for the enhancement and delivery of important city services. An industrial use case of IoT appears in [64], showing the vision of making sustainable IoT solutions by employing a model driven software development approach based on code generation for multi-protocol web service gateways. [79] demonstrates the CloudThings architecture, which integrates the IoT with Cloud Computing, while [69] also attempts a convergence between IoT and Cloud Computing by proposing a platform for using cloud computing capacities for provision and support of ubiquitous connectivity and real-time applications and services for smart cities' needs. WoTKit is a tool for developing IoT mashups demonstrated in [15].

Cultural heritage is also a field that tries to exploit the advantages of IoT solutions. [40] uses IoT technologies to achieve culture preservation and revitalization of smart towns. SmaCH uses multimedia and communication services to transform indoor Cultural Heritage sites into smart environments by utilizing IoT technologies like Wireless Sensor Network (WSN) with Wi-Fi and Bluetooth technologies to identify, locate and support visitors equipped with their own mobile devices [19]. Talking museum uses IoT technologies in order to make objects of a museum exhibition able to "talk" during users' visit and capable of automatically telling their story using multimedia facilities [4]. In [18], authors, in the pursue of designing a smart museum, present an IoT architecture and a case study of a temporary art exhibition of sculptures in the Maschio Angioino Castle, located in Naples, Italy. A clear indication about the power of multimedia content among users' preferences, appears. But as stated in [2], IoT systems cannot successfully realize the notion of ubiquitous connectivity of everything if they are not capable to of truly including 'multimedia things' since multimedia content is easily comprehendible and is highly appreciated by users. This observation leads the way towards the Internet of Multimedia Things (IOMT). Authors continue by defining IOMT as a paradigm in which smart heterogeneous multimedia things can interact and cooperate with one another and with other things connected to the Internet to facilitate multimedia based services and applications that are globally available to the users. IOMT could find a lot of applications within smart city environments like tourism and education, but also in digital cultural heritage management and dissemination.

Combining the above sectors, many excellent applications, tools and frameworks have been proposed to support cultural tourism, cultural education and cultural heritage management within smart city environments using rich multimedia content [3, 10, 17, 20, 23, 27, 28, 55, 62]. [27] presents a framework for personalization of cultural tourism in smart cities. Venice Connected is an online portal that mainly seeks to preserve Venice's immense cultural heritage, to safeguard the environment and the natural resources, and to promote the economic interests and the welfare of the local community as mentioned by the Office for Tourism of the City of Venice [62]. CESARSC is a framework for creating cultural entertainment systems with augmented reality in smart cities, which is primarily destined to the field of mobile tourism [23]. Or.C.He.S.T.R.A. project's mission is to provide technological solutions for tourists and inhabitants aimed at appraising the cultural heritage of the historic center of Naples [10]. A platform for cultural education and lifelong learning is presented in [17] that blends together augmented reality and gamification. Authors in [17] state that by engaging learners in cultural subjects, the cultural heritage is delivered to next generations and remains alive. [28] presents a digital game that supports cultural learning among immigrants. Storify is a digital curation

platform that explores how curation works in the classroom [55]. SNOPS is a smart city environment for cultural heritage applications that supports multimedia information [3], while [20] highlights Multimedia Cultural Heritage and proposes an integrated approach to support cultural content enrichment.

Multimedia content is present in another smart-city-environments-friendly tool, mobile applications. In order to be appealing to users, mobile applications tend to extensively utilize modern multimedia content. Most of such applications address the audience of indoor or outdoor mobile users integrating location-based services. In the field of cultural heritage we find many excellent efforts deployed during the last 15 years [6, 21, 32, 50]. MobiDENK is a location-aware information system used in historic sites of interest and provides location-dependent multimedia information, by locating the user and showing position and path on an interactive map thus offering visual navigation support [50]. SMART VILLA, along with SMART BIBLIO for ancient books, SMART ROOM for particular rooms and SMART GARDEN for surrounding historical gardens, is an information system developed to access cultural heritage areas of interest and was particularly related to mobile and safe cultural access in the context of Villa Mondragone [6]. Another excellent mobile application that combines location-based services and multimedia content is SmARTweet an application that exploits several location-based services and technologies to realize a smart multimedia guide system able to detect the closest artworks to an user, make them able to "tweet" and "talk" during tourists' visit and capable of automatically telling their stories using multimedia facilities [21]. The issue of effective utilization of cultural heritage sites, via mobile technologies and multimedia content, is addressed in [32] where a prototype appears offering local heritage tourist paths downloadable onto mobile devices.

In the course of time, it became more and more clear that special purpose systems and applications do not attract or satisfy modern digital users. It is not very efficient to design a system that can only be used in a single cultural heritage place. Why not integrate such a special purpose solution to a wider infrastructure that could attract more users. The need for holistic solutions appeared. Digital platforms, offering a wide variety of services and integrating applications from different sources, provide a notable solution as they are by nature general purpose systems. Many excellent efforts have introduced various cultural heritage digital platforms to the scientific community [12, 29, 39, 44, 71, 75, 78]. Cultural heritage multipurpose digital platforms have been an important matter of research and implementation in, at least, the past decade [7, 29]. EUROPEANA is a project funded by European Union that offers a multidisciplinary platform which operates as an aggregator connecting more than 2500 cultural heritage organizations across Europe. The majority of cultural heritage platforms targets an audience of specialists [39, 71], while some of them address amateurs and enthusiasts of cultural heritage too [12, 35, 72, 78]. The KORA platform, an open source digital repository for cultural heritage, can be used only by archaeologists, curators and managers of cultural heritage and not by amateurs [71]. IPERION CH [39] interconnects cultural heritage researchers and Cultural Heritage Informatics Initiative [25] thus addressing only to scholars. On the other hand, MQUADRO [78] promotes the user generated cultural information, even if the users are amateurs. Several other crowdsourcing efforts have been recorded so far throughout the Internet that can be classified in various categories: correction and transcription platforms and projects, contextualization, complementing collections, classification and co-curation [60]. In regards to the served discipline, there are cultural heritage digital platforms that are multidisciplinary [12, 24, 25, 29, 35, 39, 71, 72, 75, 78] and platforms that mainly concern a unique discipline [56], taking into account that a discipline is not isolated from all

the others. Additionally, there are platforms that host discussions and export guidelines for further research [25, 39] while others contribute and present scientific evidence [24, 44, 56, 71, 72, 75]. This scientific evidence could refer to tangible [35, 78], intangible [72] cultural heritage content or both [12, 71].

Some platforms try to exploit the idea of open participation encouraging users, both experts and amateurs, to contribute cultural heritage content [35, 72, 78]. User-led content creation is a topic that has arisen in the recent years, with great success [16]. Users not only contribute in data collection, but, also, help in system improvement by providing feedback for its functionality. As the number of users rises, such platforms are rapidly enriched with new content that needs to be audited, especially if the content is provided by amateurs. As stated by C.L. Liew [52] the key for the success of such a system is the "establishment of a culture of participation that takes place not only at design time, but also throughout use time of a system". Attracting large numbers of users, both experts and amateurs, guarantees the success of the platform. A smartphone based participatory crowd management platform that is deployable to smart cities is introduced in [31].

Contemporary digital platforms need to take into account current technological advances. Several platforms integrate mobile services [35, 75, 78]. MQUADRO offers a dedicated tablet application [78]. Mbira lets users create mobile experiences and presents cultural items within a rich, interactive map interface [75]. Muse hosts native iPad apps for digital libraries with cultural heritage content [35]. Location-based mobile applications for cultural heritage have been deployed the last few years, following the tremendous explosion in the use of smartphones and tablets around the world. These applications can be in the form of serious games like "Gossip at Palace", a location-based mobile game that integrates a storytelling approach used primarily in museums [66] or "Ghost Detector" an application that serves as an educational location-based museum game for children [59]. Other applications try to exploit the notion of participation like "stedr" a mobile and social storytelling application that narrates stories about the history of an outdoor location [30]. An important aspect discussed in [74] shows that location-based mobile applications transform users from passive receivers to active learners, an observation critical for the success of participatory cultural platforms [52].

An important aspect of security in cultural heritage platforms is the application of authorization actions to the users when they attempt to access content. This goal can be achieved by applying access control models like role-based access control. An authorization model specialized for multimedia content stored in musical heritage archives is described in [48]. In [46 a role-based access control scheme is applied on multiple files on digital art projects. In [47] an extension of role-based access control is applied on smartphone devices for protecting multimedia content which is disseminated though multimedia guiding services in a cultural environment.

3 Research methodology

The design and development of an online participatory digital platform poses a series of challenges that should be addressed before or at the early stages of system implementation. The implementation should on the one hand meet the requirements for a system that is technically feasible, qualitative and on budget, and on the other hand be understandable and acceptable in terms of its scope, by a targeted audience, in our case people that care about cultural heritage.

In order to guide the procedure of implementing an interesting and modern system, IT experts could get the appropriate feedback from focus groups like cultural heritage professionals or amateurs that are willing to search for cultural content online. When designing a digital system for cultural heritage a bizarre obstacle of psychological nature appears. On the one hand there are the IT experts, professionals that know how to build both complex and simple systems that implement many different services and offer lots of capabilities. On the other hand, there are experts of cultural heritage or simple enthusiasts that cannot or do not want or care about utilizing all services offered by an online platform. The main interest of such an audience is to simply search or manage cultural information. In most cases, those two groups fear each other and do not communicate properly and effectively. This gap between the mindset of two so different sides could result in a system that despite its high efficiency wouldn't be acceptable or useful to its target audience. Therefore a high level of communication between information technology experts and cultural heritage stakeholders is essential to achieve the goal of building a platform that would be useful to its users.

In our research methodology, we tried to tackle this devious problem, by giving a higher focus to end-users' skills, requirements and expectations than making the platform as high-end as possible. We are primarily interested in creating a useful system rather than a software masterpiece that will disappoint and be ignored by its users. According to our approach, the term "skills" refers to each user's level of new media literacies (NML) comprehension [41] and "requirements" refer to each individual's actual needs when using cultural heritage content. "Expectations" is a term that bears an emotional connotation and refers to each user's formulated aspect of how the platform should work before they actually start using it. This is very important, because individuals tend to accept a situation if it fits their pre-determined perspective. If a user thinks that a platform provides cultural content, then she/he should find cultural content there or else it will be ignored.

Before starting designing our system, we formulated focus groups and discussed about the services that an online platform for cultural heritage should offer, without guidance from us or setting predefined issues. These focus groups consisted of experts in cultural heritage management, like academic professors, post and pre-graduate students of cultural heritage disciplines. During our meetings, we managed to extract some basic requirements that the system could implement, thus fulfilling the goal to approach user basic needs of such a system. The most popular requirements where:

- *rich cultural content from all major disciplines,*
- *understandable terminology,*
- *easy search and filtering of cultural content,*
- *easy navigation and usage,*
- *mobile-friendly services,*
- *interactive services,*
- *multimedia cultural content,*
- *fun activities,*
- *separation and highlighting of qualitative contributions,*
- *formulation of private groups that share content in a private manner,*
- *discussion area,*
- *personalized search and viewing,*
- *secure environment for user contributions*

The above user remarks came to confirm numerous notes, about system requirements, found in the scientific literature that is dedicated to online digital platforms. Nielsen in [58] indicated that a user interface must reflect "simple and natural interface" design and "speak the user's language" (for example, the terminology should be based on users' language) thus confirming requirements for an understandable terminology and for easy navigation and usage. MINERVA project [13] presented some criteria that should be taken into account for improving the usability of cultural web applications like quality of content (for example, consistency, completeness, conciseness, accuracy, objectivity), design of functional layout, consistent use of graphics and multimedia components, as well as provision for navigation tools and search mechanisms. These criteria support requirements for rich cultural content from all major disciplines, easy search and filtering of cultural content, easy navigation and usage, multimedia cultural content and separation and highlighting of qualitative contributions. Nam in [57] comes to confirm requirement for a discussion area, by pointing out the user aspiration for participating in digital discussions, about their city's problems and issues without guidance from city officials or experts. In [63] authors raise the role of security, in digital collaborative environments and in particular, the social aspects of security and the importance of identity, in central position thus confirming requirement for a secure environment for user contributions. Authors in [9] dedicate a whole survey to point out the importance of personalization in cultural heritage digital environments, validating the requirement for personalized search and viewing. A work presented in [65] confirms requirements for interactive services and personalized search and viewing by indicating the use of personalization and interactive services in cultural heritage digital systems to attract and engage visitors, in the case of a museum collection. In [36] authors argue about how important it is for a digital system to offer mobile-friendly services, through dedicated smartphone applications or by implementing a responsive design for their desktop versions, thus confirming requirement for mobile friendly services. Enabling the use of private collaborative groups (a requirement for formulation of private groups that share content in a private manner) appears in several research works that deal with issues of privacy in collaborative environments and their high importance in online digital systems [14, 38, 43]. The requirement for integrating fun activities to a digital platform is confirmed by several academic works [45, 61, 68] that highlight the importance of the "fun factor" in user satisfaction.

The next step was to formulate groups of individuals and test their NML skills, by distributing a questionnaire, in order to find out what a user can do and how she/he comprehends digital content. Again we used as a sample, academic professors and students of cultural heritage. The questionnaire proposed in [53] was used, to give us an indication about potential users skills in understanding digital content.

With the unavoidable limitations and assumptions, the above procedures gave us a useful overview of the design goals that the system should implement to match the skills of potential users and a thorough understanding of what would make such a platform interesting and engaging for end-users. The next step was the design and implementation of a first version of the system [26]. We uploaded the beta version of the platform in April 2016 and immediately organized and conducted another experiment to measure platform's level of response to user expectations. We chose a group of random individuals, that may or may not have a direct connection to cultural heritage and explained to them thoroughly platform's scope and implemented services. Then we gave them time to ask questions and answered their inquiries. Afterwards, we let users access the platform for half an hour and interviewed them about their impressions. From their answers we tried to understand if the platform actually offered what they expected and if it indeed fulfilled its scope.

Based on the results of the expectations evaluation we made some adjustments to the platform's content, to make it more acceptable and on May 2016 we launched the platform online. Since the first launch, we have been constantly measuring users' behavior with the help of Google Analytics tool and making adjustments to platform's services in order to make it easier, more interesting and more attractive to its users.

4 System design

4.1 Design goals

Culture Gate architectural design tries to achieve a series of goals to be able to support, effectively, the wide range of services that offers to its users. These design goals are crucial for the platform's normal operation. More specifically:

- *Security*: The architecture hosts a secure environment for users to interact with the system and upload their contributions. The system forbids unauthorized access to data for users that do not have the sufficient rights and permissions. Additionally, key elements of the system, like database and file system are not directly accessible by end-users.
- *Scalability and adaptability*: The architecture permits the addition of new services easily. This is very important because users' needs change very quickly and the system could become outdated if it cannot offer the desired functionalities. Furthermore, it allows the modification of existing services in order to be more interesting to the users and the removal of others that users do not use because they are obsolete or outdated. These modifications do not affect the performance and overall efficiency of the system.
- *Moderation*: As the system becomes more and more popular, maintenance workload increases rapidly. The design permits platform's project team members to easily implement the daily tasks that are required for maintaining the system.
- *Concurrency*: The system by design is able to support a high level of concurrent traffic without problems in performance. Users can utilize every service concurrently without loss in performance or stability.
- *Performance*: Platform's design offers high performance, speed and low response times. Users expect fast loading of webpages and instant use of services.
- *Low cost*: The platform is designed in such a way that both the initial implementation of the system and the everyday maintenance to be low cost in money and resources. This is very important because expensive platforms tend to have shorter lifecycles than others that are more cost effective.
- *Mobile users*: The architecture allows the integration and use of mobile applications. Users enjoy immediate responses and direct digitization and sharing of information.
- *Third party software*: The system by design can easily integrate third party software, like an implementation of a serious game. Users are able to enjoy services from various artists and experts.

4.2 System architecture

The main characteristic of Culture Gate architecture is that it is modular. The platform consists of several different modules that all work together harmonically in a single system. Modular architectures support most of the above design goals. In particular, a modular architecture supports the creation of a secure environment because it isolates important parts of the system from the end-user. In such architectures, also, it is very easy to add, modify or remove services without affecting the performance of the system and also to integrate third party applications. Moreover, a modular architecture is very easy to be maintained because administrators can perform the necessary moderation activities to each module separately without affecting the operation of the other modules.

The platform architecture provides support for the implementation of several services, both for static and mobile users. It consists of three main modules: the Web Server (WS), the Online Web Portal (OWP) and the Mobile Services Module (MSS). Figure 1 demonstrates platform's architecture and different modules. The three main modules work together harmonically and provide an easy, friendly and modern way to collect cultural data, tangible or intangible and display them to the broader public.

The main idea behind the proposed architecture is simple. Users install a dedicated smartphone application, supported by MSS, on their mobile device and use it to collect data which they send immediately to the web server. Web server collects data from every connection and stores it in a database as records, while files are stored in the file system. Simultaneously, users that access OWP, submit information that is also stored on the system database and in the file system. Apart from content collection, other users access OWP and a different dedicated smartphone application supported by MSS, to read content from their devices (desktop, laptop, tablet and smartphone). The web server handles such requests sending end users the requested content. Several modules and technologies implement Culture Gate architecture:
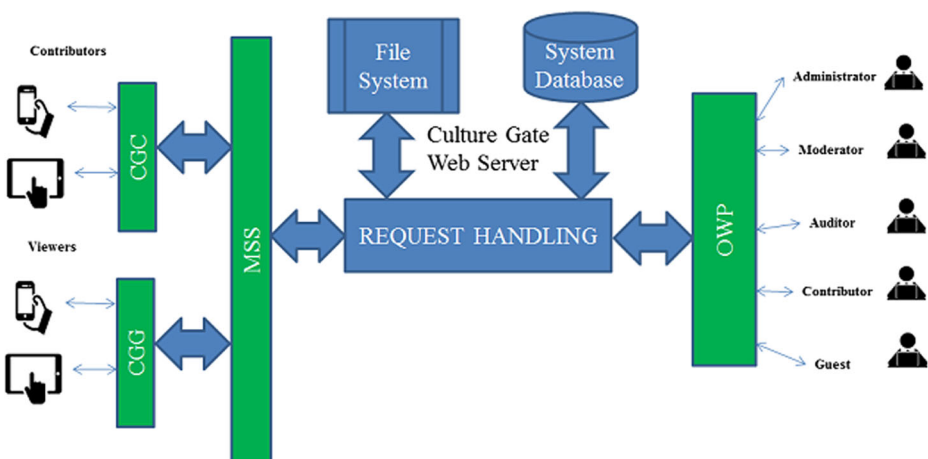

Fig. 1 Culture Gate architecture

WS is the heart of the system as it interconnects all modules together. This virtual machine has the ability to get and post data from remote machines that have access to the internet, interact with the database and file system and send the requested material back to the user screen. It consists of three components:

- *Request Handler*: This module is a software suite that consists of several programs and scripts. It is the only communication gateway of the web server with the rest of the system. Internally, request handler communicates directly with the file system and system database in a bidirectional manner. It stores or retrieves files from the file system and inserts or selects records from the database. Externally, request handler communicates directly with MSS and OWP. It does not allow MSS and OWP to have a direct communication with the file system and the database. Request handler implements scripts that get data from MSS and OWP content contributors, performs insert/update/search/delete operations to system database, creates responses to send encoded data to CGC and CGG users and displays user requested content.
- *File System*: All files are stored in the platform file system. The files vary from php, html, xml scripts and apache files to directories with audiovisual material from users' contributions (CGC and OWP). This system is isolated from all the other modules, except from the handler, which is the only module that has permission to interact with the file system.
- *System Database*: Stores all information concerning application data and cultural data, contributed by the users. A database administrator is responsible for administering the database.

OWP is a web interface that gives users the capability to submit data, using various online forms, to the platform database, but also operates as the main window of the platform to the broad public. OWP disseminates cultural information in several ways, most interesting of which is the presentation of cultural data on a geographical map as pins of interest. Every tangible or intangible cultural item (like document, interview, event, digital picture of artifact or building, dance or music recording, narration), that has been collected or submitted, can be represented as a pin of different color on a geographical cultural map based on the item's discipline (archaeology, architecture, folklore, museology, music, literature, theatre, history, libraries). Moreover, through OWP, users that are artists or professionals of information technology can present their artwork like 3D representations, serious games software or timelapse videos to everyone. Additionally, OWP is used primarily from platform's project team members to implement the daily maintenance tasks needed. From this module users can engage in online conversations about cultural heritage issues, through the hosted discussion forum or check for cultural events in their area. Furthermore, users can access OWP to download the platform's dedicated mobile applications.

MSS aims at providing services for mobile users and has the ability to host several mobile applications. Currently MSS hosts two applications: (i) Culture Gate Collector (CGC), and (ii) Culture Gate Guide (CGG). CGC is a smartphone application that aids in collecting cultural data from outdoor or indoor locations and storing it on a database or file server for further use. CGG is a smartphone application that presents points of cultural interest that are located near the application user. The system uses GPS technology to locate user's location and presents all nearby cultural points. When the user chooses a cultural point, then the system presents all cultural information related to this point and provides an audio guide for his information. CGG gets all the needed information, from three different sources: OWP, CGC and Wikipedia [77].

Wikipedia is used only when Culture Gate does not have information for a location of cultural interest. If that's the case, Culture Gate automatically creates a new point of cultural interest with information provided by Wikipedia.

4.3 Users

Culture Gate uses an extended role based access control model. The system classifies users as several roles/groups with different permission levels. A user can have multiple roles.

- *Administrator*: The system's super user who supervises every technical procedure, checks system integrity, assigns moderator roles to users, administers system database and file system. The administrator views all content (published and unpublished) and deletes users, if they upload offensive content and it is not modified even after warning.
- *Moderators*: Users who are members of Culture Gate project team. A moderator assigns user roles, creates user private groups (after communication with a user that will become the group leader). A moderator views public and private content, checks for offensive content and warns or bans users if they upload such content.
- *Auditors*: Users who are not members of Culture Gate project team. An auditor has an account on the platform, views public content and private content only after assignment by a moderator. An auditor modifies content opaquely (this modification is visible to the end user as it is mentioned in the content page).
- *Contributors*: Users who have an account on the platform, view public content and private content from groups in which they are members, upload content and participate in forum discussions. A contributor can modify only the content she/he contributes.
- *Guests*: Nomadic users who view and search public content.

We should mention that platform users are classified as registered users (administrator, moderators, auditors, contributors) or simple users (guests).

4.4 Content organization and types

The system organizes uploaded cultural content, contributed by the users, in database tables illustrated in Fig. 2. The basic entity of contributed content is the digital cultural item (tangible or intangible) which is characterized by a series of attributes classified in three categories:

- *Content-based attributes*: include thematic ones like title, description, creator (like artist, group of people, institute), and discipline (field of cultural heritage the contribution belongs to),
- *Context-based attributes*: include contextual ones like featured image (contribution's most representative image), files (multimedia files corresponding to the contribution), location (region's geographical coordinates where the contribution was uploaded), digitization equipment (equipment used to collect the data), date (date and time of the contribution),
- *Model-based attributes*: include attributes imposed by the proposed model such as the permitted user operations, like authoring or content publicity.
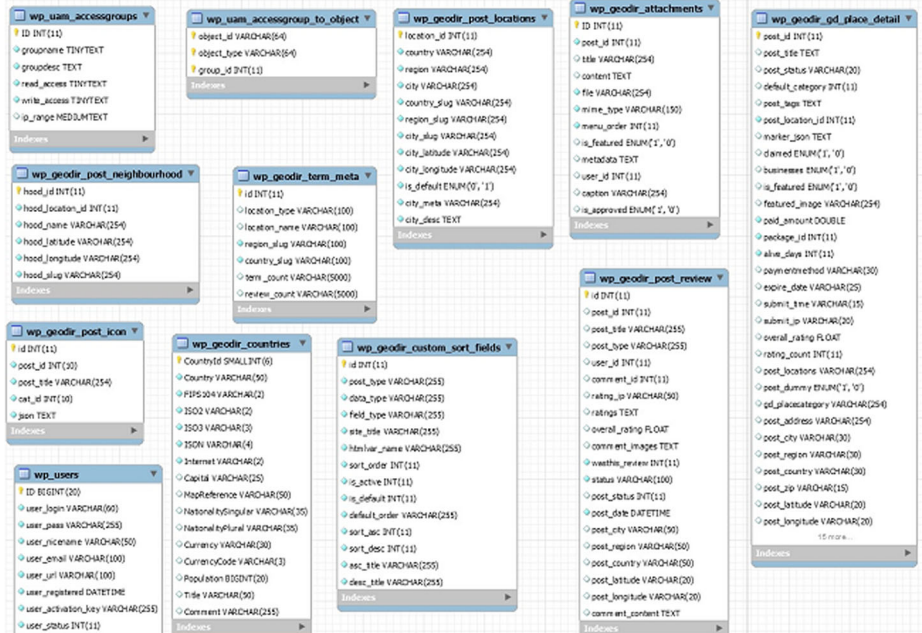
Fig. 2 Cultural listings table schema (MySQL workbench)

Platform supports different types of content (text, audio, images, video and multimedia). Text content can be content description, notes, event announcements, historical background information, theatrical plays and scripts, literary works or reviews and references. Images can be site and artifact pictures or depictions (like drawings, pictures, notes, sketch). Video can be animation or live activities like an excavation or a folk dance. Audio content can be narrations, storytelling, interviews and vocal guides. Multimedia files can be a full demo package with all kinds of data types.

4.5 Permitted operations

Depending on their role, users have various capabilities and can perform various operations, to add, delete, edit, search, view or disseminate content.

- *Add*: Contributors have complete ownership and responsibility over the data they upload. If the uploaded content is offensive then contributors will receive a penalty from the moderators or even a deletion from the system administrator. Both application and web interface display the same input fields and prompt contributor for the same information. The submit data screen is user-friendly and accessible to users with disabilities.
- *Delete*: A contributor can delete her/his own content.
- *Edit*: Contributors can modify their own content.
- *Search*: There are multiple searching levels for all users: (i) Simple searching: Users can search for cultural content providing keywords corresponding to content-based attributes (like title, description or discipline). (ii) Cultural map searching: A user searches cultural content through interaction with pins on a geographical map. (iii) Location-based

searching: CGG detects user's geographical position and proposes nearby cultural points in a user specified range.

- *Monitor*: Moderators and auditors can perform contributed content checking. Monitoring levels are: (i) Moderating: Moderators check for offensive material in contributed content and issues warnings. (ii) Authoring: Auditors check contributed content marked as "Needs Authoring" by its owner, for soundness and advice content owners for appropriate modifications. Authoring operation is anonymous, for objectivity reasons.
- *View*: There are multiple viewing levels for all users: (i) Cultural map viewing: A user views cultural content as pins on a geographical map. (ii) List viewing: A user views cultural content in a list of descriptive thumbnails. (iii) Private content viewing: Users that are members of a private group can view private content.
- *Disseminate*: Registered users can present their cultural heritage-related creations to platform's audience. Disseminating levels are: (i) adding cultural events, (ii) serious games, (iii) 3D representations/virtual tours, (iv) cultural applications for smartphones and tablets overview, (v) timelapse cultural videos, (vi) communication and feedback, (vii) discussion forum.

5 Operational design and services

Culture Gate platform in general is a collector, organizer and presenter of cultural heritage information. A detailed view of the operations that are taking place inside the system for selected user scenarios would be highly informative about the internal mode of system operation. The basic communication actions that take place among users and system modules for the satisfaction of user requests are illustrated in Fig. 3.
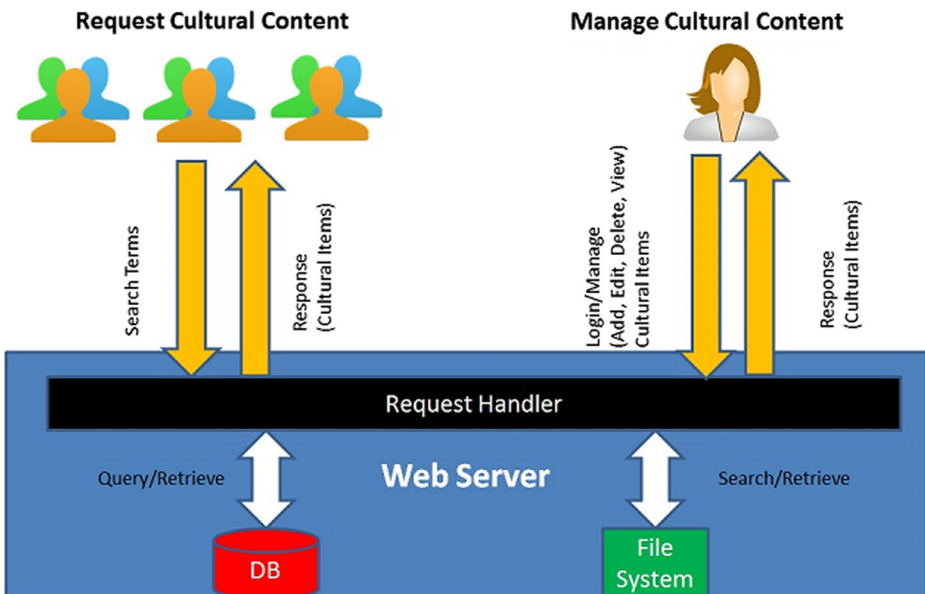

Fig. 3 Basic communication actions between user and system modules

- *User requesting cultural content*: Users can search for cultural content by utilizing the appropriate search areas. In each case, a user provides one or more search terms (geographical location, title, keywords, discipline) and sends her/his request to the system. The system receives user request and checks database and file system to locate the related records and associated files. If the system finds no cultural items (cultural point of interest, event, news, forum reply etc.) that correspond to user's search terms, it asks the user to refine the search. Otherwise, the system retrieves and displays the desired information. It is not required by users to have an active account of Culture Gate in order to search for cultural content.
- *User managing cultural content*: Only a registered user of the platform can manage cultural content. Users that upload contributions have full ownership over their content. In order to manage her/his content, each user must login to the system. The system retrieves all information associated with this user, by querying the database and searching the file system and demonstrates it in a list view. The user can access a cultural item contributed by her/him and view, edit or delete it. Also the user can visit the Add Listing screen (Fig. 4), Add Events screen and Add Reply screen to upload a new cultural item. The user can declare the content public (for everyone to see) or private (can be seen by her/him or a certain user group).

Fig. 4 Users contribute cultural content using the "Add Listing" screen

Below we explain thoroughly platform main functionalities classified in 3 categories with different scope: core, classification, searching and presentation, dissemination and user attraction. Core functionalities are not perceivable by the users but they are essential for the flawless everyday operation of the system. Classification, searching and presentation functionalities are the most obvious and interesting services for the users. Their use provides the desired information and gives meaning to platform's existence. Dissemination and user attraction services aim at fetching more and more visitors to the platform.

5.1 Core functionalities

a) *Registration*: The system allows users to create accounts and gain access to additional services, that are not allowed to simple guests of the platform. The most significant service that registered users enjoy is contribution of cultural information. Users that don't have an account on Culture Gate cannot upload cultural content, but only search and view it. It is highly desired, for a platform, to have more registered users than simple visitors because registered users tend to be more aware about the well being of the platform and also create an exploitable mass for commercial purposes. Every user can register to Culture Gate by accessing the User Registration screen. The user submits mandatory operational information like credentials (username, password), personal information like fullname and professional information like served discipline. Optionally, a new user declares her/his specialty and fields of interest. The system uses the specialty field, to establish if a user could serve as an auditor. User's fields of interest is used for the personalization service.

b) *Group formation*: Culture Gate provides the opportunity to its users, to create private groups in order to exchange content with other designated users. This content is not visible by users that are not members of the same private group. Every group has a group leader, which is the person that initializes the group formation procedure and a specific number of members. First, the intended group leader communicates with a moderator. The group leader provides a clear group description (like a class of students that implements an educational virtual tour to a museum) and a list of platform users who will serve as group members. The group leader is responsible for the content uploaded by any member of the group. Such content is private and restricted only to the group members for viewing. A group member that uploads private content must declare that the content is only available for the group members. A group of colleagues could create a private user group to share real-time content with each other. This solves many privacy issues that concern the vast majority of artists, scientists and curators.

c) *Authoring*: Authoring service is the main mechanism that the platform uses to check contributions for accuracy. This mechanism does not check all users contributions but rather distinguishes and highlights the ones that are marked as "Authored". A contributor that seeks her/his content to be checked by an auditor and gain more reputation among other contributions, initializes authoring procedure by marking her/his content as "Needs Authoring". After a contributor request, content moderators choose an auditor to check the content and sends her/him an authoring request. The auditor is selected randomly and anonymously from a pool of auditors of the appropriate discipline. If the auditor accepts the invitation, she/he proceeds to the submitted content checking. Afterwards, the auditor sends the content back to the contributor with the proposed modifications. If the user wishes to publish her/his content as "Authored by an Expert", she/he is obliged to make the proposed modifications. If an auditor rejects the invitation, another auditor is chosen. This procedure is only available via OWP. The full scheme of the authoring procedure is shown at Fig. 5.
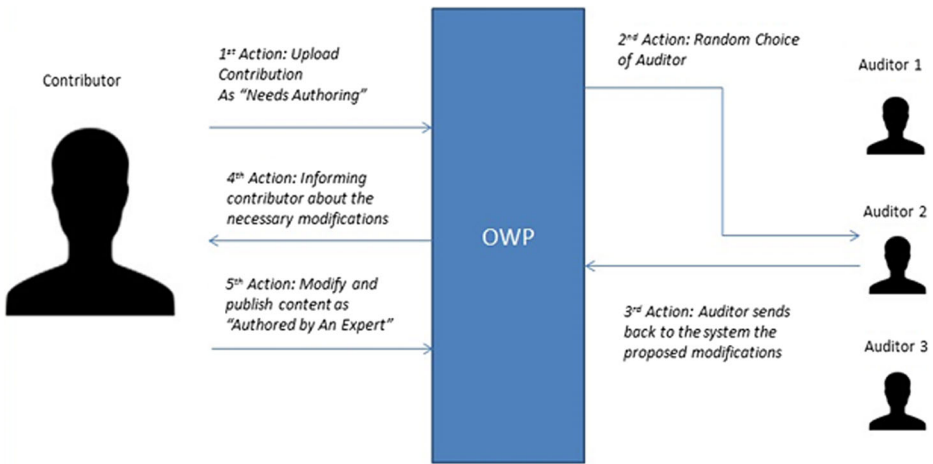
Fig. 5 Authoring procedure step-by-step

d) *Moderation*: Culture Gate uses a decentralized model to administer platform content and everyday use. The system administrator is the main responsible for creating a clear moderation plan with daily tasks and supervising its implementation. The administrator chooses the users that will become moderators from a pool of registered users that have shown interest for this role upon their request. According to the assigned duties (like monitoring disciplines or contributed content), the administrator gives every moderator the corresponding elevated permissions. For example, if a user is chosen to become a content moderator, the administrator will allow her/him to moderate contributions, create private user groups or ban users, but she/he will not be able to moderate content assigned to another moderator. At this moment there are several sections of the platform that are maintained daily by moderators. There are content moderators that monitor user contributions, private group moderators that create private groups after request and calendar moderators for the calendar of cultural events. Also, there are news moderators for finding and presenting cultural news from all over the world, forum moderators that supervise the online discussions and technical moderators that check the platform for technical problems. Moreover, there are smartphone application moderators that make sure CGC communicates correctly with the Web Server, feedback moderators that communicate with the users, design moderators that make adjustments to the platforms graphic design and integration moderators that help with the integration and normal operation of third party software to the platform.

e) *Security*: Authorization and registration procedures play a crucial role to the security and integrity of the system. Culture Gate uses an extended role based access control model to implement authorization. OWP supports five user roles with different authorization privileges to platform's content (administrator, moderator, auditor, contributor and guest). CGC supports one user role (contributor) as its only functionality is the collection of cultural information in real time. Each user role has different permissions to perform certain operations (add/edit/delete/search/view/disseminate). This functionality is the first step towards the creation of a trustworthy environment. The system administrator is the main responsible for the establishment of permission levels. Administrator determines the set of operations allowed in each role and along with the moderators, assigns every new

user of the platform to a specific role. As far as registration is concerned, user passwords are encrypted (PKI). System's modular architecture plays a key role for security. Database and file system modules are isolated from the users, malicious or careless, so they cannot interfere with their data. All necessary operations are being handled by the request handler module, which implements several programming techniques to encounter security breaches. Coding techniques used for security reasons are: Input Validation, compiler warnings heeding, simple security design, default denying, sanitizing data sent to other systems and using effective assurance techniques.

f) *Personalization*: Culture Gate prioritizes content shown to each user based on her/his fields of interest. When a user requests a cultural item the system returns items related to the user's interests as they have been declared during the registration process. The platform tries to reward users by operating a Point System which awards users with points based on certain actions aiming at distinguishing the ones that engage the longer with the system and contribute more information. Also, the system monitors the behavior of the more aware users and finds out which services they use most or which are not very useful to them in order to enhance the strength of the most interesting services or remove others that are outdated or obsolete. Also this feature could be a vital part of platform's exploitation plan since it could be offered to the users with a small fee.

g) *Accessibility*: Culture Gate is compliant to the WCAG v.2.0 AA standard [44]. This standard takes into account that users with disabilities should have an equal opportunity to access site's content.

5.2 Classification, searching and presentation functionalities

As contributors upload cultural content (cultural heritage information, multimedia content, cultural events, cultural news, cultural artwork, forum topic replies, feedback) the system stores, organizes and demonstrates it to platform visitors in a user-friendly manner.

a) *Data classification*: While data collection procedures take place, the system performs simultaneously another vital function, data classification. Every contribution is considered from the system as a cultural item. When a user uploads content, from data submission screens, she/he makes a series of choices that assign semantics to each new contribution (Fig. 4). An example could be the scenario where the user chooses to upload cultural content that belongs semantically to the discipline of archaeology, let's say a picture of an ancient artifact in the Acropolis museum with accompanying notes. A contribution can belong to more than one category in a certain classification. For example, a user contribution can have significance in both Archaeology and Museology disciplines. Moreover, if a user uploads a cultural event on the Cultural Events Calendar (Fig. 6), the system classifies the contribution as a calendar record. If a user uploads content like a 3D representation, the system classifies that contribution as an artwork (such information is shown in artists corner section). Similarly, cultural news information is classified in the appropriate section and forum replies are classified as forum material.

b) *Data presentation*: The system uses two ways to display cultural information: cultural map and thematic lists. Cultural map is an interactive geographical map (Google Maps) that hosts pins of various colors and icons. Each pin represents a cultural item. Pins of the same cultural discipline, bear the same marker color and icon. In this way, users can easily
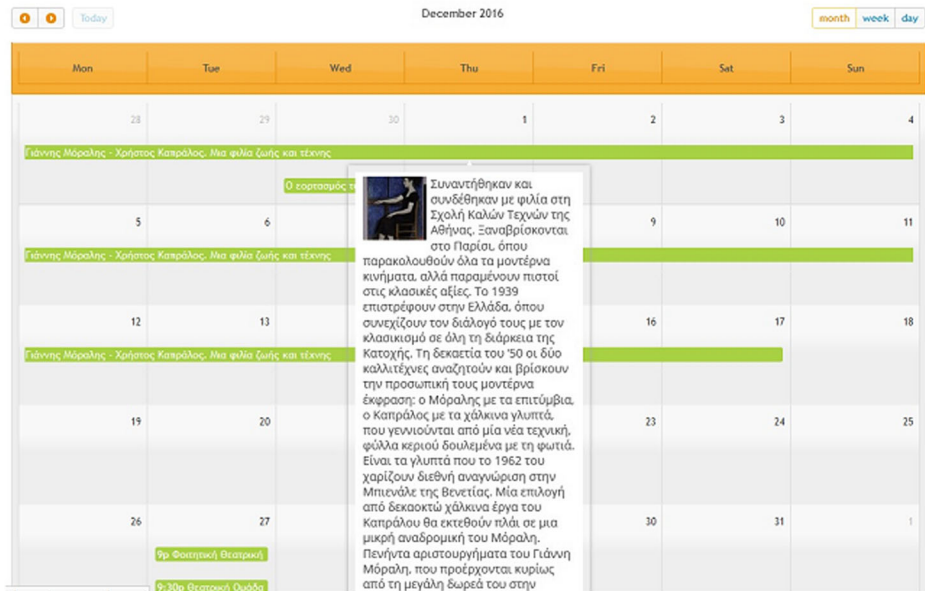
Cultural Events Calendar

Fig. 6 "Cultural events calendar" screen

distinguish information that belong to different disciplines. If a user wishes to explore a cultural item, she/he can click on a pin and a modal window appears with cultural item's title, distinctive image and some brief information. If users want to find out more about a cultural item, they can click on the title of the modal window and they will be redirected to the item's dedicated web page. That page displays a more detailed presentation of the cultural item with information concerning description, multimedia content, associated YouTube videos, the name of the user who listed the item and whether this item has been authored by an expert. Thematic lists are a more traditional way to display information. Cultural items are being displayed in lists per cultural discipline. When a user wants to find information about a cultural discipline, she/he navigates to the corresponding page, by using the appropriate menu item. Every page presents a blog style list of items that belong to the requested thematic category. The user can be redirected to cultural item's dedicated web page by clicking on the list item.

c) *Data searching*: Users are allowed to search for content per discipline, keywords, title, location and their location. The web interface provides several input fields, buttons, lists or graphical components to help users start their searching action. Every contribution is tagged from its owner by certain keywords and has a distinct title. If a user searches a word that belongs to the title or a set of keywords, then the system will retrieve and present information. Moreover, a user can find cultural content that concerns a certain cultural discipline. Additionally, if a user wishes to learn which cultural items are near a certain location, she/he has to enter the name of the charted location and all cultural information around this area will appear instantly. Culture Gate offers location-based search both through OWP and CGG. When a user wants to be informed about cultural points of interest that are located near her/him (the user is able to choose the distance of search area), she/he can use OWP or CGG. OWP implements a "Near" button that

searches for cultural points near the user, while CGG displays a google map with pins near the location of the user exploiting the integrated GPS sensor that operates in every smartphone. CGG provides another critical advantage. If Culture Gate database does not store information about nearby places, then the application communicates with Wikipedia, through the Wikipedia API and derives data from the largest online encyclopedia.

d) *Audio guide*: CGG offers audio guiding to users that want to visit a cultural place.

5.3 Dissemination and user attraction functionalities

Dissemination and user attraction functionalities draw the attention of platform visitors and intrigue them to spend more time to the platform. For that reason they should always be modern, interactive and engaging. Moreover, such functionalities could be commercially exploited in the future to provide revenue for the platform.

a) *Discussion forum:* The platform operates a conversation area, where community members can exchange opinions about several issues in the field of cultural heritage. Only registered users of the platform can access the online forum. Furthermore, users can give feedback to moderators about platform services, problems, graphic design and issues. Forum moderators inspect all uploaded replies and delete posts that are offensive or irrelevant with forum scope. Moderators can ban users that present a bad behavior towards other users. Discussion forum is the leading service that supports the sense of an online community. Users create small communities that focus on certain areas of cultural heritage and exchange ideas.

b) *Calendar of cultural events*: A calendar where the user-visitor can view all cultural events that take place all over the world. Culture Gate receives the appropriate feedback from the users or organizers of such events. Users can view all cultural events in a calendar view. If a user clicks on an event a new page opens with information about the event. Calendar offers three different views – monthly, weekly and daily, to be more readable by the users.

c) *Cultural news*: Culture Gate hosts a section with worldwide cultural news from all cultural heritage disciplines. At the moment the platform uses RSS feeds of various news portals, to collect cultural news. More specifically we use the open RSS feeds for cultural news from New Yorker, Independent UK, RollingStone.com and EU Education, Audiovisual and Culture Executive Agency Service.

d) *Serious games integration*: Essential background is offered to specialists of serious games to demonstrate their applications through Culture Gate. Gaming is attractive and fun, especially to young users. Users receive cultural knowledge, while playing carefully designed and interactive educational games. For example a serious game where a user scans a medieval castle to find objects that were utilized by individuals of that age, could give users an overview of people's lives in the medieval era. Serious Games are expected to attract many visitors to the platform and engage them for long periods of time.

e) *Visual experiences*: Culture Gate gives the opportunity to creators of 3D representations, virtual tours and timelapse videos to promote their artwork through the platform. 3D representations and virtual tours are highly appreciated by the audience as they offer visual experiences, a means that is more attractive than written documents. For example, a 3D representation of Ancient Constantinople and a virtual tour around its streets, can be more

engaging and attractive to users than a manuscript that attempts to describe the same location. Timelapse videos are a great way to help users visualize changes that happened to a cultural place, event or artifact over time. For example, a timelapse video of changes that happened to the Acropolis of Athens from fifth century BC, when it was constructed, until now could attract a large audience of users to the platform.

f) *Cultural applications for smartphones and tablets overview*: Specialists can present their own smartphone applications for cultural heritage. A short bio of the creators is presented with some external links to their work and a thorough presentation of their specific application through a series of videos and tutorials. Users can make comments about any application and engage in a discussion with application creators. Thus, the creator can gather valuable feedback to make enhancements to her/his work. This service could be further exploited by the platform for commercial purposes.

g) *Point system*: Culture Gate operates a point system that awards points to its most loyal users based on system engagement. Members of the platform that engage the longer with the system or contribute cultural content, gain more points. Users that reach a certain threshold of points are awarded with community gifts and other rewards like highlighting of their contributions. This personalization service tends to engage users the longer with the system as they try to pursue a point goal or simply to surpass other users and reach thresholds faster than all the others.

6 Stakeholders and usage scenarios

Culture Gate is a multipurpose platform that can be used in a wide range of activities. The platform targets a wide spectrum of stakeholders both for achieving the goal of storing sound cultural information, but also for disseminating cultural heritage to the society thus making it exploitable for commercial or non-commercial purposes. A more detailed explanation of each target group of stakeholders follows.

- *Public authorities*: During the last few years public authorities and organizations all over the world have had a growing interest in transforming traditional cities into smart cities. This has become even more feasible with the tremendous technological advancements in mobile technology. The wide majority of citizens, nowadays, possess a smart mobile device that they constantly use throughout the day. Why not download and install applications that give them a constant row of information about their city's cultural background, events and activities? Also tourists could be benefited from such applications when they visit a new place and seek to reach locations of cultural interest. Moreover, public authorities, local or national, could use this tool to promote cultural sites, monuments and locations in their area, thus having a multiple impact to local society and market.
- *Scientists and specialists of cultural disciplines*: Such professionals can contribute high quality cultural information and also be a part of the auditors group to evaluate platform's cultural content. Scientists that work in the field like archaeologists could be extremely benefited by the functionality of CGC in order to store cultural data from their outdoor activities (excavations) easily and immediately. This content could be available in real time to a remote colleague for evaluation. Supported cultural disciplines are archaeology, architecture, music, museology, art history, serious games, history, folklore, libraries, literature, 3d representation and religion.

- *Museum curators*: Curators are in some way project managers of cultural heritage projects. Culture Gate could be very useful in promoting museum's content to a targeted audience that is interested in cultural heritage. Moreover, Culture Gate can highlight occasional museum events thus attracting visitors. Curators could provide information about their museum or their area of expertise.
- *Tour operators*: Tourism market professionals can use Culture Gate to promote cultural tours all over the world. This advertising tool can be very effective since the members of the platform are primarily interested in cultural heritage.
- *Academic personnel and students:* Such user groups can contribute high quality data to Culture Gate's content. Professors, researchers and post graduate students can help in auditing platform's content. In addition, professors could create private user groups with the students as members and present a more specialized material to them.
- *School teachers and students*: Such user groups can provide non-expert data like notes and annotations, enriching the platform's content. Teachers can create virtual tours to cultural sites from the classroom, students can make annotations to the things they notice and this content can become available for enrichment by another virtual class. Culture Gate's geographical cultural map is an easy and fun way for children to derive cultural information. Serious games applications or 3D representations can be really appreciated by students and help in educational procedure.
- *Special school teachers and students*: Culture Gate supports equal opportunities in education and information, by implementing accessible web design. Students with special needs require special attention and should not be opted out by poor design.
- *Parents and children*: Parents can urge their children to search for cultural information. Culture Gate provides a user-friendly manner to display cultural data and that can be fun for children. Parents can create virtual tours of cultural sites, monuments, buildings or museums and display them to their children. Serious games applications or 3D representations can be really appreciated by children and promote cultural heritage awareness to the youngsters.
- *Simple users*: Users that are interested in cultural heritage. Culture Gate provides rich cultural content of multiple cultural disciplines, promotes cultural events and highlights cultural news around the world.

A detailed demonstration of several usage scenarios follows. Those scenarios cover both the use of OWP but also the use of CGC and CGG. We classify scenarios in two categories based on the used service carrier: mobile user based scenarios offered by the dedicated smartphone applications of Culture Gate and static user based scenarios offered through OWP.

6.1 Mobile user-based scenarios

6.1.1 Culture gate collector - CGC

CGC is a dedicated smartphone application that is distributable to Culture Gate community members. Users can install the application directly to their android mobile devices. With the use of CGC a mobile user can store data in real time with the only requirement being an active internet connection. The basic usage scenario for CGC follows: After the application is installed on an android smartphone or tablet, the system prompts users to create an account, using a registration screen (Fig. 7). The user submits username, email, password and
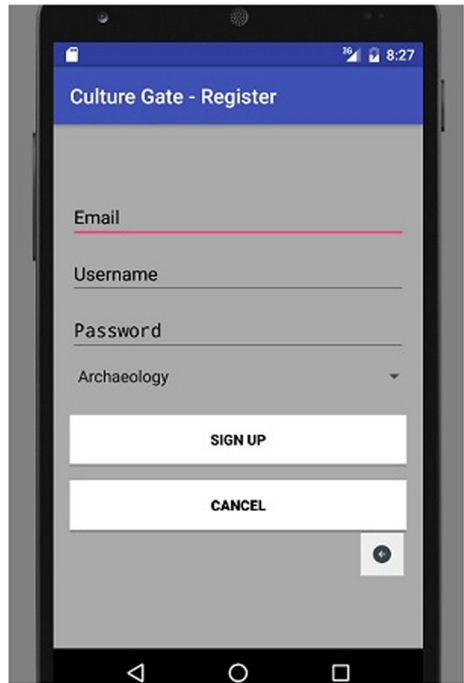
discipline. For security reasons, the user's password is encrypted. This is the first level of security implemented by the platform. When the registration procedure is completed, the user accesses a navigation screen that prompts her/him to choose the desirable service: (a) Field service: Captures audiovisual content from an outdoor uncharted location (like an excavation point) and sends it with its coordinates and notes to the web server. Users complete fields like: Title, Description, Discipline, Audio/Video/Image Files. CGC sends geographical data automatically during the uploading procedure. (b) Street service: Captures audiovisual content from an outdoor charted location (like a city street) and sends it with its coordinates and notes to the web server. (c) Indoor service: Sends text content related to a tangible cultural item (like an artifact in a museum), along with notes or audiovisual files to the web server. Each of the above services can be used by several user groups to store real-time data.

Usage scenario 1 - Field use on an archaeological excavation site: A team of archaeologists is divided in two groups, with one group working on the field (excavation site) at a remote uncharted location and the other group working at a university laboratory. CGC is being used by team members of the group that are on the excavation site. The user clicks and opens the application. If user has already used the application or has an account, she/he can sign in immediately. Otherwise she/he should register using the "Register" screen submitting a username, password, email and discipline (Fig. 7). After signing in the system, the user is welcomed and redirected to "Functionality Board" screen. From "Functionality Board" the user chooses to use field functionality by pressing the appropriate button. Then the user navigates to the "Field Functionality" screen where she/he can submit contribution title, description and the concerning discipline (in this case "Archaeology") (Fig. 8). The user can take a photo, record video or audio. When the user clicks the "Send Cultural Data" button, the

Fig. 8 CGC field functionality
screen usage
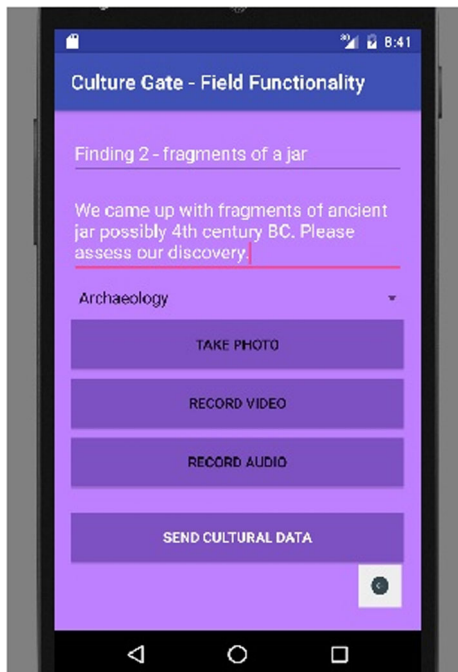
system sends collected data along with the excavation point's geographical coordinates to the web server. At the same time, other team members who are not on the field, receive the newly discovered findings, analyze them and send their response to their remote colleagues, immediately.

Usage scenario 2 – Indoor use on a museum school visit: A class teacher decides to visit the city museum with a class of students and communicates with a moderator of Culture Gate in order to create a private user group for the class, with her/him as the group leader. Moreover, the class teacher asks students to install CGC to their smartphones and create accounts. The teacher informs moderators about the user accounts to be added to the user group. When the class visits the museum, the teacher informs students to sign in Culture Gate and navigate to "Indoor Functionality" screen (Fig. 9) to start using CGC's indoor service. Students consults the teacher about capturing artifacts, making notes stating their point of view and sending them to Culture Gate. The teacher can use CGC to record an audio file with museum's conducted guide. When the visit is over, the teacher accesses and checks the content contributed by students. Afterwards the teacher publishes the content with visibility only to group members. In the next lesson, she/he will be able to discuss this museum visit with the students and publish the corresponding virtual tour to the public.

Usage scenario 3 - Capturing a cultural event situated on a city street: A user walks on a city street and witnesses a folklore event happening right now. Several individuals are dancing traditional songs on a stage. The user activates CGC on her/his smartphone and navigates to "Street Functionality" from the "Functionality Board" screen. The user fills the appropriate fields (Title, Description, Discipline) and starts capturing the event by clicking on the "Record Video" button. When recording is over the user clicks on the "Send Cultural Data" button and

Fig. 9 CGC indoor functionality screen usage

sends the cultural document to Culture Gate web server. A cultural happening that would otherwise be lost in time has now been captured, digitized, preserved in digital form and available to all from the screen of their computers through Culture Gate OWP.

6.1.2 Culture gate guide - CGG

CGG aims at presenting points of cultural interest that are located nearby the user (Fig. 10). There is no need to create an account in order to use CGG. The basic usage scenario for CGG follows: A user downloads and installs CGG in her/his smartphone. In order for CGG to work properly, GPS must be enabled. When everything is ready, the user can view nearby points as pins on a geographical map. The user can filter the presented items per discipline. Such cultural data exist in Culture Gate database and have been previously uploaded by members of Culture Gate. If the user is unhappy from the presented results she/he can choose to scan surroundings in order to derive information from Wikipedia. CGG uses smartphone's location to extract GPS data and assigns the geographical data to a named location. Then the module connects to Wikipedia, using the Wikipedia API and tries to find related articles that refer to user's named location. The system retrieves corresponding articles and presents them in a listed form.

Usage scenario 4 – Guiding a tourist to cultural points of interest in a city: A tourist wonders around the streets of Athens and decides to find out which cultural places are located nearby her/his current location. The user opens the pre-installed CGG application and waits for a response. The application finds her/his current location and presents a geographical google

Fig. 10 User searches for nearby
cultural content using CGG
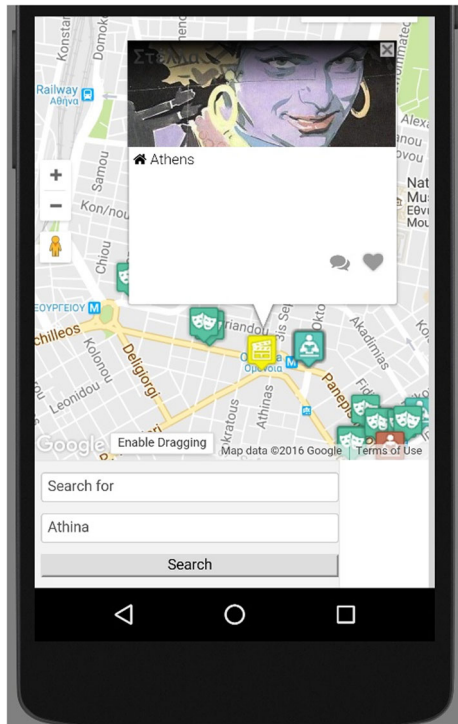
map, centered in her/his position, with nearby pins that indicate the existence of cultural points of interest (Fig. 10). The user clicks on the pin and a modal window with some brief information appears. The application starts to "talk" to the user about this cultural item. If the user wants, she/he can ask from the application to give her/him directions to access this location. The application provides several different ways to reach the desired location (walking, public transportation, car). The user can adjust mile range within which cultural places are demonstrated. If the platform does not have cultural information to present near user's current location, a connection with Wikipedia is initialized.

6.2 Static user-based scenarios

While CGC's main task is to collect and upload digitized cultural content, OWP extends this task to include management, presentation and dissemination functionalities.

Usage scenario 5 – A software expert creates a serious game and integrates it with Culture Gate: A software expert, creates a serious game that deals with the lives of citizens in Rome in the first century BC. The creator aims in informing young children and teenagers about the lives of ancient Romans, their everyday activities etc. Moreover, the creator organizes an in-game scavengers hunt as well in order to make the game more interactive and interesting for the children. The game could be played in real time, while the children walk the streets of current Rome. The expert communicates with Culture Gate stuff and informs them about her/his intentions. The expert is asked to provide a quick bio about her/his work, a thorough presentation of her/his artwork and a demo video of how the game is played. Moreover, through the technology of iframe Culture Gate users can access the serious game and start playing.

Usage scenario 6 – Museum curator promotes an event that will take place in its premises: A museum curator organizes an event to highlight and promote museum collection of artworks. The curator wants to notify the event to as many people as possible without spending a lot of money. The curator creates an account on Culture Gate and starts using its services. The curator is allowed to create a new cultural event and displays it in the dedicated section of "Calendar of Cultural Events" (Fig. 6). The curator can inform the audience about the time, place and scope of the event. Moreover, the curator can upload multimedia content about museum exhibits. Visitors of the platform that search for cultural events are informed about this new cultural event directly.

Usage scenario 7 – Forum discussion about the theatrical activities organized by city authorities: Several members of Culture Gate engage in a conversation about theatrical activities that are being or will be held in their city of residence. Theatrical activities are organized by city's authorities in order to raise awareness about cultural events among their citizens. Registered users of Culture Gate, access platform's dedicated discussion area, the discussion forum (Fig. 11). Conversation starts when a user opens a forum topic under the category "Theatre". Other users join the conversation and present their opinion about the quality of these theatrical shows, their cost and other issues worth mentioning. City authorities' members could also join the conversation and state their opinion about their decisions. This direct feedback could be accessed and analyzed by city authorities to correct possible problems that arise from their planning and see if their action has indeed raised awareness about culture among citizens of their city.

Fig. 11 Culture Gate discussion forum

Usage scenario 8 – A school teacher urges his students to search for cultural heritage locations in their city: A school teacher asks the students to choose a cultural point located in their city, collect information about it and write a report of their search. This project can serve several educational purposes. Children learn about online search of information, they find out more about their living area and its history and discover if they are fond of the field of cultural heritage in general. Culture Gate is a great starting point for their inquiry since it collects and presents a plethora of cultural heritage information. The same point of cultural interest, could become the contributed object of many different contributors. Each one of them can give a different perspective of how she/he comprehends a cultural item, thus resulting in a more thorough presentation of each point of cultural interest. It is very easy for the children to check for information, using the interactive geographical cultural map (Fig. 12) and filtering cultural items based on their city's location. Students learn about every cultural item in their area, choose a specific cultural point and start learning information about it. There are cultural items that also provide links to other sources of information like Wikipedia, so that students can continue their search.

Usage scenario 9 – Tour guide uploads information about a visit point: A professional tourist guide wants to promote her/his services associated with the visit of a cultural site. Guide registers on Culture Gate and accesses the "Add Listing" screen to upload information about the cultural site (Fig. 4). The guide contributes a brief description and multimedia content of the place to attract possible clients, while providing contact information and operation hours for potential tourists to be notified. This could result in increasing the number of tourists that choose him as their guide in the historical locations and gain more income.

7 Implementation technologies

The Culture Gate platform uses several technologies to implement all its modules: Apache Web Server, PHP scripts, MySQL database, Google Maps API, Wikipedia API and Android
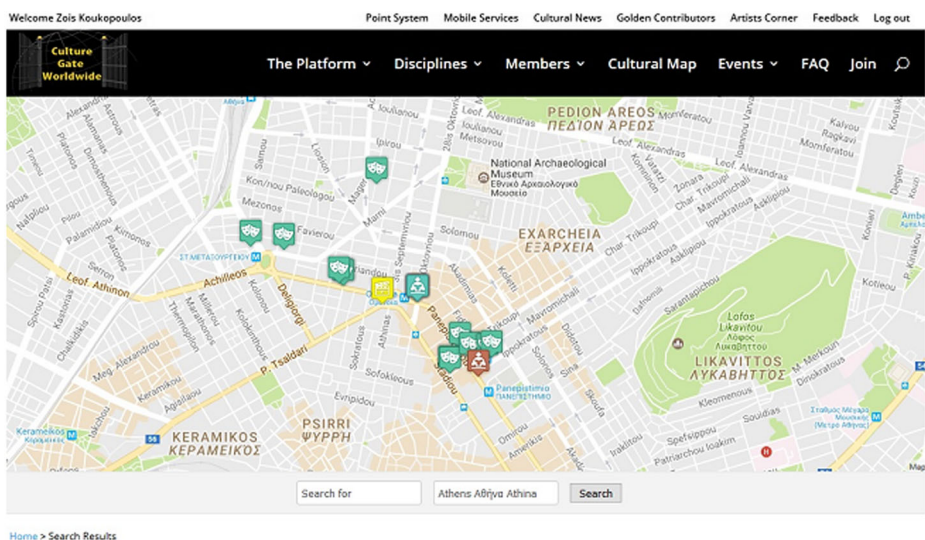

Fig. 12 Culture Gate geographical cultural map presenting pins in Athens

operating system (JAVA, JSON, XML). For the implementation of OWP we used a Windows 10, Intel core i7–2600, 8GB RAM at 1866 MHz system.

Apache Web Server is the world's most used web server software. Released under the Apache License, Apache is free and open-source software. Apache supports a variety of features, many implemented as compiled modules which extend the core functionality ranging from server-side programming language support to authentication schemes. PHP language interface and MySQL database implementation are the key features used by Culture Gate. Apache has the ability to get and post data from remote machines that have access to the internet, interact with the database and file system and send the requested material back to the user's screen. Apache's design reduces latency and increases throughput, relative to simply handling more requests, thus ensuring consistent and reliable processing of requests within reasonable time-frames. These key features, offer the desired agility, speed, security, concurrency and scalability to our platform.

MySQL is an open-source relational database management system. It performs extremely well in the average case and has proved to be fast, stable and true multi-user, multi-threaded sql database server. Those characteristics are desirable for our implementation.

Google Maps API allows the integration of Google Maps offering the capability to implement the cultural geographical map. Google Maps is a web mapping service developed by Google. It offers satellite imagery, street maps, 360° panoramic views of streets (Street View), real-time traffic conditions (Google Traffic), and route planning for traveling by foot, car, bicycle or public transportation.

For CGG and CGC implementation we used Android Studio as the IDE, target SDK version 23 and minimum SDK version 8 in order for Culture Gate application to be applicable in the vast majority of android smartphones and tablets [5] and Samsung Galaxy Grand Neo to test the resulted application. Android applications use JAVA and XML to implement functionality. A user downloads the application from www.culture-gate.com, free of charge, installs it on the machine, collects cultural material and sends it to the Web Server. Responses from the server use JSON. JSON is an open standard format that uses a human-readable text to transmit data objects consisting of attribute–value pairs. It is the most common data format used for asynchronous browser/server communication.

8 Evaluation

A vital issue when building a public online digital platform is its position in relation to other relevant online platforms. The online digital domain is filled with systems that offer complementary or competitive services. In our opinion the use of a platform does not exclude the use of other similar platforms, since internet users tend to seek information, about the same thing, from several different sources. For example, when a user wants to be informed about sports, she/he will not just visit one website but several ones until she/he is convinced that she/he is fully informed about sports. This reality is also valid when users seek cultural heritage information. A cultural heritage platform does not have to be "the best" platform, it is sufficient to stand out in the competition and be accepted by the crowd as a great alternative to find and manage cultural content. The broader the scope of the platform the better chances are for it to attract more and more visitors.

In this section we are trying to evaluate Culture Gate against other online digital platforms that host cultural heritage content. This kind of evaluation is unfeasible if we don't set some

limitations. We compare implemented cultural heritage management systems that store information corresponding to more than one cultural disciplines. We believe that the chosen comparison criteria, provide a useful outlook about platforms' scope, features and capabilities offered to users. A detailed description of comparison criteria follows:

- *Public view*: Refers to the involved user groups that are targeted by a platform. A platform can target an expert audience (professionals of cultural heritage, specialists, scholars, researchers, curators) or a broader audience (both experts and simple enthusiasts of cultural heritage).
- *Content type*: Cultural heritage content is classified in two categories: tangible and intangible. Tangible content like buildings, monuments, landscapes, books, works of art, and artifacts and intangible content like folklore events, traditions, narrations, language, and knowledge. There are platforms that host all types of cultural content, while others host only tangible or intangible content.
- *User content*: Refers to the capability given to users to upload cultural content. There are systems that allow users to participate in the procedure of collecting cultural content and others that gather information internally, by their own project team.
- *Scope*: There are systems that host cultural content originated primarily from a unique location, area or country and others that have a more international scope.
- *Interactive map*: This is a highly appreciated feature by the users. They interact with the geographical cultural map in order to view or search cultural information in a friendly manner. This feature is not supported by many systems, so a platform that offers this capability can stand out from the competition.
- *Direct digitization*: Refers to the tools that a system offers to users, to capture cultural content in real time when it happens. Most of the platforms store pre-existing cultural content. Capturing, digitizing, uploading, storing and publishing cultural content when it happens is a very important feature both for the public but also from researcher's aspect. Especially for intangible cultural content, by nature, the amount of information lost in time and space is significant. If a platform provides tools to capture and preserve this kind of information, like witnessing and capturing a folklore event, while walking the streets of city, it could be widely used by experts and the public.
- *Mobile application*: There are platforms that implement, support or communicate with dedicated mobile applications and others that don't. Nowadays more and more users access cultural information from their smart mobile devices. Platforms that follow this trend are more likely to gain more visibility and attract more visitors.

Comparison criteria appear as columns in Table 1, while cultural heritage platforms appear as rows. The platforms used for the comparison with Culture Gate are EUROPEANA [29], KORA [71], MQUADRO [78], Sierra Leone [12], Muse [35] and The Prow [72]. Those platforms were chosen because they preserve and disseminate content from multiple cultural heritage disciplines. Also all those platforms are online and there is sufficient supplementary content (scientific papers, tutorials, online websites) about their features. Every column hosts a unique criterion. Second column hosts the *Public View* criterion. Platforms that allow public viewing of information have a tick in the corresponding table cell or a dash if they aim at an expert audience. *Content Type* criterion appears in third column. Platforms that host both tangible and intangible content contain the word "Both" in the corresponding table cell, the ones that host only tangible content contain the acronym "Tan." and the ones that host only

Table 1 Comparison of multidisciplinary cultural heritage platforms

Platform	Criteria						
	Public view	Content type	User content	Scope	Interactive map	Direct digitization	Mobile application
Culture Gate	✓	Both	✓	INT	View/ Search	✓	✓
EUROPEANA [29]	✓	Both	✓ (comp-leme-ntary)	INT	View	-	✓
KORA [71]	-	Both	-	INT	-	-	-
MQUADRO [78]	✓	Tan.	✓	LO	-	-	✓
Sierra Leone [12]	✓	Both	-	NAT	-	-	-
Muse [35]	✓	Tan.	✓	INT	-	-	✓
The Prow [72]	✓	Inta.	✓	LO	View/ Search	-	-

intangible content contain the acronym "Inta.". In column four, we meet the criterion *User Content*. Platforms allowing user contributions have a tick on the corresponding table cell or a dash if they don't. *Scope* criterion appears in column five. Platforms that host locally originated content contain the acronym "LO", the ones that host national content contain the acronym "NAT" and the ones that host content from several different countries contain the acronym "INT". Column six presents the *Interactive Map* criterion. Based on allowed user actions, platforms that host an interactive cultural map and allow viewing and searching of cultural content, contain the words "View/Search" in the corresponding table cell, the ones that allow only viewing contain the word "View" while platforms that don't offer this service have a dash on their table cell. Platforms that allow *direct digitization* (column seven) hold tick in their table cell while the others hold a dash. Last, column height hosts the *Mobile Application* criterion. Platforms holding a tick in the corresponding table cell support dedicated mobile applications while the ones that don't, contain a dash in their cell.

Six of the seven systems, Culture Gate included, offer a public view of cultural information. Only the KORA platform offers expert view since its target audience is project managers and data-entry personnel. Culture Gate, EUROPEANA, KORA and Sierra Leone platforms preserve both tangible and intangible cultural content. MQUADRO and Muse store solely tangible content, while The Prow stores only intangible content. The majority of the platforms allow users to contribute cultural content. Culture Gate, MQUADRO, Muse and The Prow, offer this capability as a main function, while EUROPEANA only complementary. On the other hand, KORA and Sierra Leone platforms rely on their project teams to digitize and store cultural content. Culture Gate, EUROPEANA, KORA and Muse host information originated from different countries. MQUADRO (Cortina d'Ampezzo, Italy) and The Prow (Nelson, Tasman and Marlborough) preserves location-specific content, while Sierra Leone's scope, as indicated by its name, is national. Only Culture Gate, EUROPEANA and The Prow host interactive cultural maps. Culture Gate and The Prow allow users not only to view cultural content on the map, but also to search and filter content based on a series of keywords. EUROPEANA lets users to only view and not search content thus limiting map's interactive power. Culture Gate is the only platform that provides tools for direct collection and digitization of cultural content, pre-existing or primitive through CGC at the time of the evaluation. Culture Gate implements a mobile services module that hosts two dedicated mobile applications, CGC and CGG. EUROPEANA, MQUADRO and the Muse also provide mobile applications.

9 Conclusion and future work

The success of social media has opened a new way of approaching the design and implementation of modern online digital platforms. It has indicated that we can create systems and guide users to contribute information thus resulting in the collection of vast amounts of information. Platforms that gather loads of information may be the only feasible solution to data-hungry environments like smart cities. In order to achieve the goal of building successful participatory platforms, a series of challenges and difficulties appears. We tried to address many of those issues with the implementation of a participatory digital platform for cultural heritage that can serve as a guide to similar efforts that expand beyond the borders of digital cultural heritage domain.

Culture Gate is a multipurpose, multidisciplinary online participatory digital platform that manages cultural heritage content. The platform serves various different goals from storing and organizing cultural heritage information in an online library accessible by broad public to disseminating and exploiting cultural heritage information for commercial reasons, promoting cultural sites, monuments, institutions and events, highlighting the work of artists, specialists and scientists and aiding at attracting young people to culture while becoming a useful tool to the educational procedure. Culture Gate finds application to all major cultural disciplines. This feature is unique, as no other online platform has this broad application spectrum and points out the significance of this effort.

Culture Gate tries to tackle several issues arising from its participatory nature, like security and privacy. Its modular architecture provides security, scalability and data integrity. Users retain ownership of the information they upload, thus the system cannot be held responsible about intellectual property rights violations. If the user chooses to share content with the public, the content is moderated by platform's moderators. System's user management scheme offers the capability to create user groups. A user can choose to join a user group with colleagues and share findings and data easily and directly. This feature can facilitate interaction between colleagues that work on a project, leading to a secure collaborative environment. In order to deal with the expected noise produced in such systems, Culture Gate implements an auditing procedure that ensures cultural data consistency. Users that upload information are able to ask system help to check their content soundness. The platform approaches specialists and scientists members of the platform, that are willing to participate in the auditing procedure.

Culture Gate uses a user-friendly way to present cultural heritage content to its members. Geographical cultural map with pins that represent cultural information which are organized in various cultural disciplines, provides a user-friendly experience for all visitors. Virtual tours of cultural sites, monuments or institutions enriched with annotations and hypertext also provide users a unique environment. The platform offers a realistic and educational experience to its audience by hosting visual experiences like time lapse cultural heritage videos, 3D representations of cultural heritage content and serious games implemented by artists, specialists and scientists. Furthermore, Culture Gate was designed using modern techniques that offer a large suite of capabilities. The platform has a responsive design, so users can access it from mobile devices in a user-friendly manner. It also maintains dedicated mobile applications like Culture Gate Collector and Culture Gate Guide. CGC offers an extremely useful functionality as it can be used to directly digitize and preserve primitive cultural content when it happens. Cultural heritage scientists that work in the field like archaeologists, architects, and social anthropologists could also be benefited from its use by capturing tangible and intangible information and storing it immediately and easily to a web server. This procedure gives them the opportunity to

secure their findings, digitize content and preserve them, share their content with colleagues in real-time and exchange information with them in a protected manner. Every new finding is enriched with additional information, automatically, like the coordinates of the location where the discovery has been made or relating annotations.

Culture Gate aims in attracting people all over the world that are interested in cultural heritage. The platform, aspires in creating a vivid online community with members that have a profound passion for cultural heritage. Scientists and specialists, artists and curators, academic professors and researchers, students of all grades, parents and children, people with special needs, cultural event organizers, tour operators, public authorities that promote tourism, practically everyone that is attracted by cultural heritage or wants to use it for commercial purposes, can participate in this effort. This diversity offers great power to the success of this effort. Users can interact and exchange views about cultural topics, through the discussion forum hosted by the platform and also provide direct feedback to platform moderators about problems in functionality or new additions that will make the platform more useful to its members. Moreover, Culture Gate can have a significant social impact in sectors like tourism, education or cultural heritage market. School teachers can use the platform to teach students cultural heritage in a fun and attracting manner, thus improving educational procedure. Museum curators can promote museum collections by uploading information about them to the platform. Tour operators or public authorities could use Culture Gate to highlight certain cultural heritage spots and attract new clients and tourists, thus helping local and national markets. Organizers of cultural events have the opportunity to easily advertise their events to an immense and targeted public for free. Moreover, the platform accessible design contributes in attracting people with special needs. However, many challenges concerning individuals with special needs remain to be addressed. The accessibility of the platform is a work in progress, as we constantly add new services and the technical procedure deals with new accessibility issues. The geographical cultural map, for instance could be a feature that those individuals may find easy to use and interact. We are organizing a case study with a class of students with special needs to check if they can indeed use some of the platform's features effectively.

This multi-community scheme is the key to establish Culture Gate as a thoroughgoing online community for cultural heritage. Culture Gate has an extremely broad scope, something that could be confusing for the public. A broad scope can be dangerous for the well-being of an online platform because it can drive away users that do not understand or bring the platform to their own needs and expectations. On the other hand, small communities could be more attractive and understandable by the users since they can relate more easily with them and envisage how they could be a part of them. Small communities combined together would lead to the formulation of a large community, just like cells combine together to create a living organism.

Trying to evaluate relevant platforms, we compared Culture Gate with other accepted cultural heritage multidisciplinary platforms. To the best of our knowledge, Culture Gate is one of a few systems that visualizes data content in an interactive map with searching capabilities. Also Culture Gate is the only platform that supports direct digitization of tangible or intangible cultural content through a dedicated mobile app easily downloadable from its portal which communicates transparently with the platform web server.

Currently, our team has completed design and implementation phases and the platform is open to the public [26]. Everyone can create an account and start uploading cultural information. Moreover, we are enriching the Mobile Services System with the second application, CGG. We aim at evolving MSS to host augmented reality mobile applications where the user

will be able to see information about a cultural place as a non-existent modal window embedded in the real world, via his smartphone. Alongside with technical tasks, we are evaluating the use of our platform in educational environments to indicate the strength of Culture Gate as an educational tool. Moreover, we are trying to formulate project teams to cope with the constantly growing maintenance workload of the platform. Lastly, we are trying to build a large network of experts in Information Technology and Cultural Heritage to help us attract more visitors to the platform and promote our online community.

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Zois Koukopoulos was born in Arta, Greece, in 1984. He received the bachelor diploma in computer and software engineering in 2007 and the MSc in computer science and technology from the University of Patras, Greece, in 2010. Currently Zois is a PHD candidate in the Department of Cultural Heritage Management and New Technologies University of Patras, Greece since 2015. His current research interests include smart cities, intelligent cultural environments, IoMT and crowdsourcing. He currently works as a freelance software developer and IT consultant.

Dimitrios Koukopoulos is an Assistant Professor at the Department of Cultural Heritage Management and New Technologies (University of Patras, Greece). He is an author of more than 45 papers in well-known international journals (TCS, TOCS, JPDC, JECR) and conferences (SPAA, HiPC, DISC). His major fields of study cover algorithms, trustworthy multimedia networks and cultural technology. He participated as a researcher in many EU funded projects. He has served as a member of program committee in various conferences and as a reviewer in many journals. He is an editor of a handbook for applications in cultural heritage environments published by IGI.

Jason J. Jung is an Associate Professor in Chung-Ang University, Korea, since September 2014. Before joining CAU, he was an Assistant Professor in Yeungnam University, Korea since 2007. Also, he was a postdoctoral researcher in INRIA Rhone-Alpes, France in 2006, and a visiting scientist in Fraunhofer Institute (FIRST) in Berlin, Germany in 2004. He received the B.Eng. in Computer Science and Mechanical Engineering from Inha University in 1999. He received M.S. and Ph.D. degrees in Computer and Information Engineering from Inha University in 2002 and 2005, respectively. His research topics are knowledge engineering on social networks by using many types of AI methodologies, e.g., data mining, machine learning, and logical reasoning. Recently, he have been working on intelligent schemes to understand various social dynamics in large scale social media.