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# Cultural Itineraries in the Region of Xanthi Using Web-based GIS Technologies

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**Abstract**

*Alternative forms of tourism, like cultural tourism, are constantly gaining appreciation as more and more people disengage from the standard forms of mass tourism. Cultural tourism focuses, mainly, in the promotion of local and regional cultural heritage and can contribute to its protection and preservation while providing new means for regional development and for dealing with typical problems of tourism, such as the shrinking seasons. Modern technologies based on Geographical Information Systems (GIS) can be efficiently applied in the promotion of cultural tourism due to its strong geographic nature. The combination of cultural heritage, tourism and GIS is the main idea in this work. The implemented system offers cultural itineraries in a user-friendly way, aiming to attract people to areas not so popular so far. Region of interest is the region of Xanthi, located in Thrace (Northeast Greece).*

H.2.8 [Database Management]: Database Applications: Spatial databases and GIS

## 1. Introduction

Culture and Cultural Heritage are of great significance and interest worldwide. Tourism on the other hand, is a universal phenomenon based to the human need for pleasure, escape from the daily routine and often curiosity to meet new places, people and cultures. The merging of the two – Culture and tourism – has produced the alternative type of tourism known as "cultural tourism" that accepts great appreciation since the '90s.

Greece, rich in culture and based, on a great extent, financially in tourism, can be one of the most attractive cultural destinations. Furthermore, the possibilities offered by the new technologies can contribute significantly to the dissemination of the Cultural Heritage attracting consequently a larger number of visitors.

Cultural Heritage, Tourism and GIS are the focus points of this paper. Cultural itineraries are offered in a friendly and easily accessible way aiming to familiarize and attract people to areas not so popular to tourists so far. Specifically, the region of Xanthi, located in Thrace (Northeast Greece) is the region of interest in this work. Rich in culture and art, Xanthi has to offer a number of different cultural itineraries to a visitor that wishes to acquaint himself with the area. Archaeological sites, monuments, local architecture, museums, folk traditions and festivals are some of the focal points that indicate the continuity of the region from antiquity until nowadays. Moreover, an on-growing stream of visitors appears to come to the region and gradually tourism becomes an issue of a financial importance. Taking under consideration the above, the technologies of Geographic Information Systems (GIS) along with the technologies of dynamic and interactive publishing through the Internet have been employed in order to promote the cultural polymorphism of the region of Xanthi. The result is a system based on a geographical database, which includes topographic information along with data about the present status, architectural and historical evidence, folklore and bibliographic references. The Internet application that represents the front-end of this database presents an interface that guides the users in the cultural content through cultural itineraries. In order to cover the needs and demands of various types of visitors, the suggested itineraries are offered in three different forms: chronologically, thematically and in the form of daily excursions.

## 2. Tourism

Tourism is a global social and economic phenomenon that originates from our need to escape everyday life, have entertainment, contact with nature and meet new places, people and cultures. The industry of tourism is considered one of the most prominent, worldwide, due to its contribution to regional growth and development, by building a stable comparative economic advantage, enhancing the competitiveness of the region and by exploiting the possibilities and characteristics of the region.

*Mass tourism* is the main form of tourism, today, following the model of the sun-sea package. This form of tourism, though, comes with the significant disadvantages that it introduces spatial and temporal concentration and has a very low level of exploitation of the cultural wealth. It is important today to enrich the tourist product with new and special forms of tourism (alternative tourism), that will be friendly to the environment, concentrated in providing new experiences and adapted to the regional and local communities.

*Alternative tourism*, apart from its symbolic significance, refers to any special form of tourism, which attracts tourists with special interests, contributes in the protection of environment, promotes the cultural heritage and, finally, offers solutions to the tourist seasons problem. Main characteristics of alternative tourism are the search for authenticity, the contact with nature, the denial for impersonal tourist offers or even the rejection of packages for secular beaches [Tan02].

*Cultural tourism*, a form of alternative tourism, is based on a mosaic of places, traditions, art forms, celebrations and experiences that portray the diversity and character of a nation and its people [Une82]. It refers to visits to archaeological sites, monuments and museums and to a need for discovering the way of life of people of the past and the present [PK04]. One of its main purposes is to promote the value of monuments and cultural sites, contributing to their protection and preservation. Travellers who engage in cultural tourism activities visit art galleries, theatres and museums, historic sites, communities or landmarks, participate in cultural events, festivals and fairs, meet ethnic communities and neighbourhoods, architectural and archaeological treasures.

According to studies ([NEA06], [TCA06]), more and more travellers include cultural, arts, heritage or historic activities while on their trips, which, in some cases, leads to the extension of their trip time. The impact of tourism is such that many international organizations have already shown interest in the formation of progressive strategies in order to promote cultural tourism and protect cultural heritage. Travel trends that will probably dominate the tourism market in the near future reveal, on one hand, a need for an adaptation to the interests of the individual consumer (personalization) and on the other, that arts, heritage and other cultural activities are becoming one of the top five reasons for travelling and tourism. These trends empowered by solutions provided by the technology in the form of the proliferation of online services and tools, make it easier for travellers to choose destinations and customize their itineraries based on their interests.

## 3. New technologies in tourism

Modern technologies may offer, today, access to a significant amount of information through user-friendly and intuitive virtual environments and interfaces, offering interactivity, multilayered navigation and representation and new experiences through the reconstruction of old civilizations by exploiting the capabilities of networking.

This way, modern technologies can attract visitors with different scientific, social and educational background, rendering tourist programs and cultural collections significantly more accessible, with the result of making cultural heritage more comprehensive and the experience of discovering it more entertaining.

Specifically, GIS technologies can be used very effectively in cultural tourism, in order to provide dynamic and Internet-based user interfaces to a multimedia-rich digital content, for a better way of tourist product promotion. Since now, only a few attempts to exploit the capabilities of this technology for cultural tourism can be traced on the Internet. Among them, three are presented here as case studies:

- *PASTMAP – Bringing history to life:* PASTMAP brings together datasets owned by Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS) and Historic Scotland and allows users to locate and obtain information on archaeological sites and historical buildings of Scotland. It also provides detailed information on those sites and buildings that are protected by law, which were not available in the internet. Main objective to this project was to disseminate this information effectively and to improve the public's knowledge of historic sites in Scotland [Pas06].
- *Military architecture – Cultural Itineraries*: "Cultural Itineraries on the Internet" is a pilot application which uses new technologies in order to map the traces of military architecture networks formed by the Venetians and of the Knights of the Order of St. John, during their migrations in the Mediterranean area. More specifically, the main objective of the project is to promote cultural heritage as a determining factor of territorial development as well as to attract alternative tourism in those areas [HMC02].
- *Atlas of Hellenism*: It is an attempt to map the Hellenic world during a period of 2500 years, from the archaic period to the pre-liberation period from the Turkish occupation. It includes the vital space of Hellenism through the ages and from Gibraltar to River Indus (Alexander the Great), including part of Africa (Byzantium) and the Black Sea (Byzantium). This project aimed at the popularization of the historical information ([SAK02], [SAK04]).

## 4. Cultural itineraries in the region of Xanthi

The project aims at the development of a GIS application to emphasize and popularize the cultural wealth of the region and to promote the historical continuity since the archaic period. The scenario of this application is based on the construction and presentation of cultural itineraries that connect sites and places of significant cultural value. These sites are connected in various ways leading to different itineraries both thematic and in terms of duration. All the itineraries are grouped into three major categories:

- Chronological: in this category, sites are connected to form itineraries that follow a strict chronological similarity, i.e. sites of cultural value that date back to the archaic period are grouped together.

- Thematic: in this category, itineraries are formed through the connection of sites that share a common thematic ground, i.e. sites of importance due to the existence of Byzantine ruins are grouped together
- Daily excursions: various single-day excursions are proposed that cover both thematic and chronological categories, providing a representative sample of the cultural wealth of the region.

The user can, of course, choose and combine any of the proposed itineraries according to his/her interests and the available time.

The choice of the cultural content was a significant task during the designing of the web application and depended mainly upon the specific application's objectives. Considering that the site was designed in order to provide information to both general and scientific public, it was decided that the application would include the most popular tourist destinations. An important factor taken under consideration during the selection of the sites was their archaeological and historical significance and plenitude of documentation. Moreover, practical issues, like easy access to the sites, were also important selection criteria. The selected sites of cultural interest were those that represent, in the best way, the historical continuity of the region. On the total, 52 sites were inserted in the database including spatial and descriptive data.

The GIS system that was chosen to become the development and deployment platform for the application was a combination of ESRI's ArcGIS products [ESR06]. For the creation and editing of the Geodatabase the ArcInfo product [ESR04] was used, while for the web deployment the ArcIMS server [ESR05a]. ArcInfo is one of the most successful platforms for GIS development that provides a high level of functionalities and easy to use interface. ArcIMS is a light-weight choice of server software to publish dynamic GIS content over the Internet. Main advantage of this package is that it can guarantee high productivity as a result of its user-friendliness and the inclusion of site templates and plenty of informative source code for further development.

### 4.1. Creation of the Geodatabase

The creation of the Geodatabase (the GIS database) was a process of three (3) phases. These phases are described in this section. Figure 1 depicts an overall workflow diagram of the Geodatabase development phases.

- *Phase 1 – sites selection and data collection*: a literature review was carried out in order to select the necessary information to describe the sites of cultural interest. The cultural content consists mostly of information based on text and photographic material. A GPS device was using for the acquisition of the exact coordinates of the sites. Finally, the required digital cartography data (georeferenced maps) were acquired from the Cartography and Geo-Informatics Laboratory of the Dept. of Geography of the University of the Aegean.

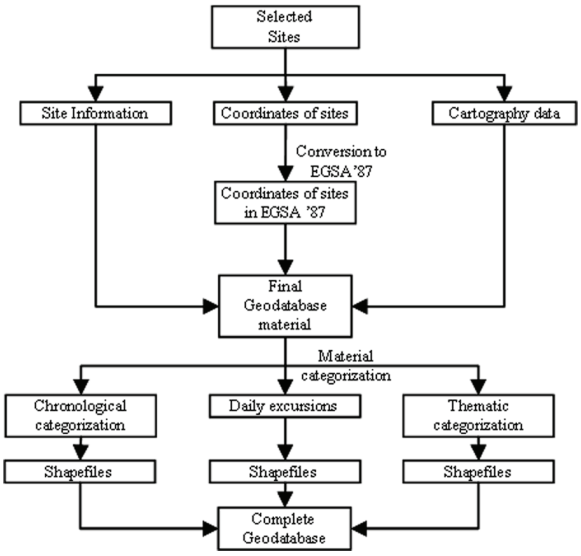


**Figure 1:** *Tasks during the Geodatabase construction*

- *Phase 2 – data processing and grouping*: the collected data of cultural interest were processed, evaluated and grouped into the following categories:
  - Chronological periods (antiquity, Byzantine period, modern times)
  - Thematic categories (archaeological sites, Byzantine monuments, castles, monasteries, bridges, watermills, traditional architecture, museums, folklore)
  - Daily excursions (four different daily excursions)
- *Phase 3 – data transformation*: the collected coordinates were transformed into the Greek projection system. The digital data were transformed into forms recognizable by GIS, resulting in the production of many different shapefiles, one for each itinerary.

### 4.2. Web publishing

A very important step in most web publishing applications is the analysis of needs and requirements. These requirements include:

- User friendliness in navigation and functionality
- Fast access to the pages of the web site
- Capability for further examination through the provision of links to specific electronic and paper material

The main requirements were dealt with by adopting the following rules:

- Comprehensive and easily readable content
- Linear and transparent access to the functionalities

- Large range of information given in a concise form
- Compliance with international standards (Cultural Website Quality Principles – Minerva)
- Consistent interface

The final web-site format was adopted from the Hyperlink template of the HTML viewer provided by the ArcIMS [ESR05b]. Figure 2 depicts a screenshot of the web application with some brief explanations.

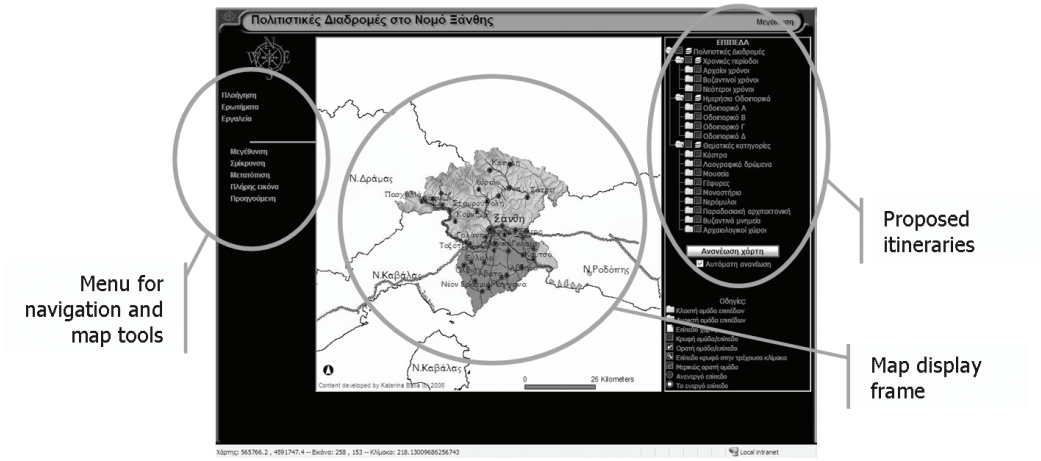


**Figure 2:** *Screenshot of the web application (in Greek)*

## 5. Conclusions

This work is an attempt to combine cutting edge technologies of web-enabled GIS with cultural heritage in order to propose a new way of promoting culture in the region of Xanthi in the North-East part of Greece.

The web application aims at making a visit to the region even more constructive and pleasant by proposing cultural itineraries that cover thematic, or chronological, or trip duration needs of the visitors, It also aims at attracting even more visitors and at contributing to the development and expansion of tourism of the region, while at the same time it aims at providing a solution to the problem of tourist spatial and temporal concentration.

Some of the topics for future investigation involve the enrichment of the Geodatabase, the inclusion of on-line reservations and the 3D representations of monuments.

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Technical paper

# Passive markers as a low-cost method of enriching cultural visits on user's demand

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**Abstract**

The idea of enriching a cultural heritage visitor's experience by employing mobile devices such as smartphones and tablets is an active research domain. This is mainly due to the worldwide user penetration of such devices along with their continuous hardware performance enhancement. This work presents the experience and feedback gained by one year of operation of an experimental information system that aims in enhancing the experience of a visitor on his/her demand. The evaluated system is based on the use case-scenario where the a mobile device is used to capture and decode passive markers (such as QR-codes) that are located on facades of selected important buildings in the old town of Xanthi, Greece, in order to enrich the visitor's experience through a broad context of historical and architectural information delivered over the Web.

***Keywords***: *On-demand information, Passive marker, QR-code, Smartphone, Visit enrichment.*

## 1. Introduction

The enrichment of a cultural heritage visit experience through the exploitation of information technologies is an active R&D field. Portable devices such as smartphones and tablets had a vast impact towards this direction. This is not only due to their extreme popularity (over one billion users according to a recent report from Strategy Analytics [1]) but also due to their continuous hardware and software advancements. Nowadays, it is common for such devices to be equipped not only with high-speed communication technologies but also with multi-core processors, graphics processing units, high resolution digital cameras, global-positioning circuitry, digital compasses and a variety of other sensors.

During the last decade, a number of research and development projects presented solutions that set a smartphone or tablet as a user-friendly terminal device that can enhance the cultural heritage visit experience. Today, it is obvious that such devices compose a versatile platform with an adaptable graphical user interface that can efficiently deliver multimedia content. This content can be generic or personalised. It can be presented either automatically by monitoring the user's actual position or on-demand based on the user's explicit request to interact with the system at a given time. Some of the most popular applications in the cultural heritage domain are focused on offering services such as information enrichment, interactive guides, augmented and virtual reality. Generally, the development of such systems is a vastly multilateral procedure due to the involvement of numerous challenges related to the characteristics of the environment being installed (indoors, outdoors or both), the distraction time of visitor's attention from the actual site or artefact, the visitor's effort and the non-uniformity of the system's user base (e.g. visitors of different skills, needs or interests).

In this paper, we discuss on the feedback gained by the one year operation and monitoring of an experimental low-cost cultural visit enrichment system that provides historical and architectural information about architectural entities (e.g. listed buildings, churches, squares, etc.) that are located in the centre of the old town of Xanthi. The current simplistic implementation delivers textual information to a mobile device on user's demand. A number of passive markers (QR-

code plates) are used as triggers for initiating the delivery of information about a point of interest through a Web browser.

More specifically, in Section *2* we provide an overview of related cultural visit enhancement systems while in Sections *3* and *4*, we describe and objectively evaluate our experimental system based on its annual operation and we discuss the experience gained. We conclude in Section *5*, which highlights the main properties and applicability of such systems in other cultural heritage domains.

# 2. Related work

Over the last years numerous cultural visit enrichment frameworks and systems have been proposed. They attempt to meet different requirements specifications that are dictated by the actual installation environment (e.g. museums, archaeological sites, urban areas, etc.). They also vary in the data types being used for content (e.g. textual information, images, video sequences, interactive/non-interactive multimedia content, etc.). On the other hand, they share engagement motives such as the efficient delivery of interesting information, the visitor's amusement, engagement and interaction with the environment that will lead to a significant visibility increase and understanding of our cultural heritage thesaurus [1]. In this section we present such systems that can be used for outdoor applications such as urban areas and archaeological sites and for indoor applications such as museum exhibitions, building interiors, etc.

Sintoris et al. [3] discussed on the idea of enabled spaces. As enabled, they define a space, which has the ability to use novel technologies and offer information services. Raptis et al. [4] performed a survey on the design of enabled space applications. In their work, they describe the importance of a theoretical framework that defines context through four dimensions (system, infrastructure, domain and physical) that complement and interact with each other. The Agamemnon project introduced the idea of automated monument recognition based on images captured by visitors using their mobile device. The system composes a dynamic multimedia guide system that takes under consideration the time scheduled for a visit [5]. Angelaccio et al. [6] proposed a system architecture that combines geographic information systems (GIS) and business intelligence in order to compose a platform useful for developing Websites that provide tourist information such as hotel reservations, price comparisons, reviews, etc. Brondi et al. [7] worked on the development of a markerless augmented reality framework oriented to the cultural heritage domain. The system exploits the inertial sensors and the GPS sensors of the device in order to transform it into an augmented reality device. Uk Im et al. [8] presented an audio guide system that exploits the GPS sensor in order to offer dramatized local stories or simple narratives that describe the history of a place. Stefanov et al. [9] have recently reviewed a number of free applications that provide information about historical and urban areas of cultural importance located in Bulgaria.

One the other hand, Mathew Nickerson discussed on using smartphones for audio-based guides in museums using the Voice-XML technology [10]. Kuusik et al. [11] presented a museum-oriented solution for personalised content access that addresses aspects such as unifying user preferences, context information and content annotation. Za et al. [12] presented the MID-blue framework, a multimedia information distribution system architecture that operates over Bluetooth communication technology. Their framework is able to provide specific content related to the user's position within the premises of a museum. Furthermore, Rung et al. [13] created an iOS-based application focused on the work of Henri de Toulouse-Lautrec that could be used before, during or after the visit to the exhibition. A museum guide system was also presented by Ruf et al. [14]. Their system was based on the calculation of the scale-invariant feature transform (SIFT) on photos captured by a smartphone. Using SIFT coefficients as a content descriptor the system could recognise paintings in an art gallery and retrieve relevant information. Choudary et al. [15] presented an augmented reality system that is focused on prehistoric cave engravings. The system augments the captured images with expert's drawings, highlighting in real time the animal engraving that are almost impossible to observe with the naked eye. In order to track the drawings the systems detects a custom type of passive markers located around the engravings. Furthermore, the idea of using passive markers such as QR-codes has already been exploited for both indoors and outdoors applications [16]-[21]. It is a cost-effective and powerful technology to detect the user's context and to infer user interests [20]. The outdoor experimental system evaluated in this work also exploits QR-codes. One of the leading motives behind its implementation was to acquire an objective feedback of such a system's installation and operation while based on a real-world use-case scenario. Such feedback can be considered as a sufficient basis for future investments in installing such information systems or extending their functionality.

# 3. System architecture and implementation

The main idea behind the system described in this work is that a mobile device delivers historical and architectural information about architectural entities through a Web-browser according to the visitor's demand. The system does not offer a strict *follow-specific-path* interactive guide. It is a more open solution where the visitor chooses his/her own path to follow and when a point-of-interest (POI) captures his/her attention then through a minimised number of user

interactions, he/she can have access the digital content over the Web. QR-codes and generally passive markers based systems offer accurate localisation of the visitor through inexpensive infrastructure.

In addition, the cost of the presented system remains low as the required capabilities are already built in the visitor's device. More specifically, the visitor can use any mobile device that is: *i)* equipped with a digital camera, *ii)* can access the Web over WiFi or over a mobile carrier, *iii)* has any Web browser and QR-code decoding software installed. In fact, all major operating systems provide such functionality in terms of pre-installed software or as free applications that can be downloaded through a secured application download service (e.g. Google play, App store, etc.). Thus, the development was related solely on the implementation of the system's backend.

Fig. 1 illustrates the simplistic system's architecture along with the steps of user interaction involved. The backend operates on PHP, MySQL and CSS3 technologies and is able to deliver information using URI-based queries that include parameters that uniquely identify POIs and preferred textual content language. The system replies to each query with a Web page, which content is adapted to the screen resolution of the target device. Each Web page contains a generic text of historical and architectural aspects of the POI, followed by a number of related references.

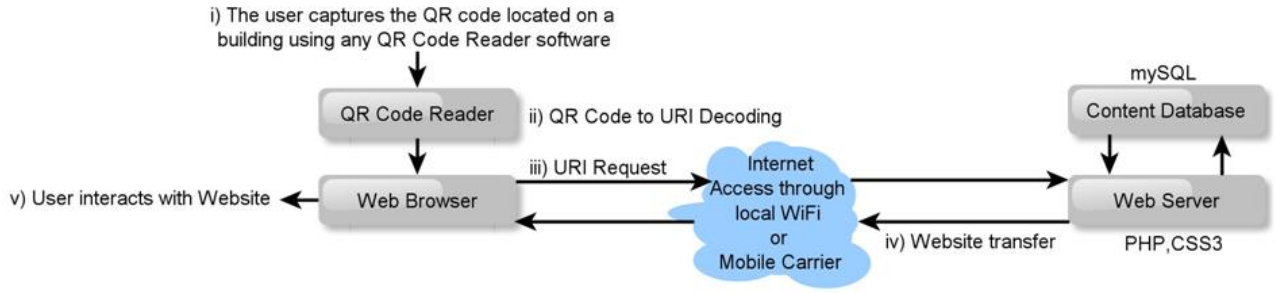



**Fig. 1:** System architecture and steps of user interaction

Furthermore, the centre of the old town of Xanthi, Greece was selected for installing and testing the system not only for its cultural importance but also because it has visiting activity throughout the year and because it is covered by the municipality's free Wi-Fi network. A total of thirteen POIs were identified and documented. Each of the POIs is referred to an architectural entity such as a listed building, a church or even a square of historic importance. In addition, all POIs are located in the centre of the old town as it is considered the most common region to be reached by visitors.

Additionally, all URI-based queries, that trigger the system to reply with a Web page, where encoded into QR-code images and were printed on custom metal plates covered with an antiglare film to improve camera capturing robustness. They were placed either on the facades of the buildings or on other high-visibility spots. Special permissions had to be acquired by the owners of the buildings and the municipality of Xanthi. Each plate has the equivalent size of an *A4* page and carries a short bilingual explanatory text about using the system. Fig. *2* depicts the POIs dense spatial distribution over an aerial view of the old town's centre along with a picture of an installed plate.

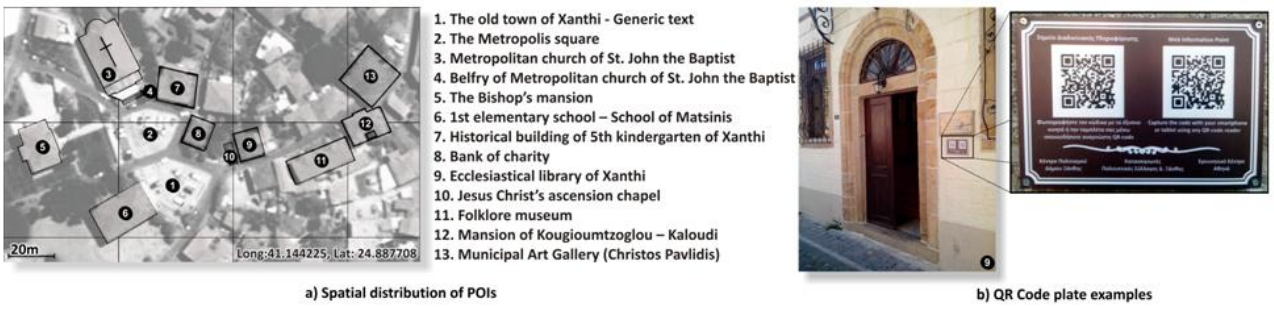
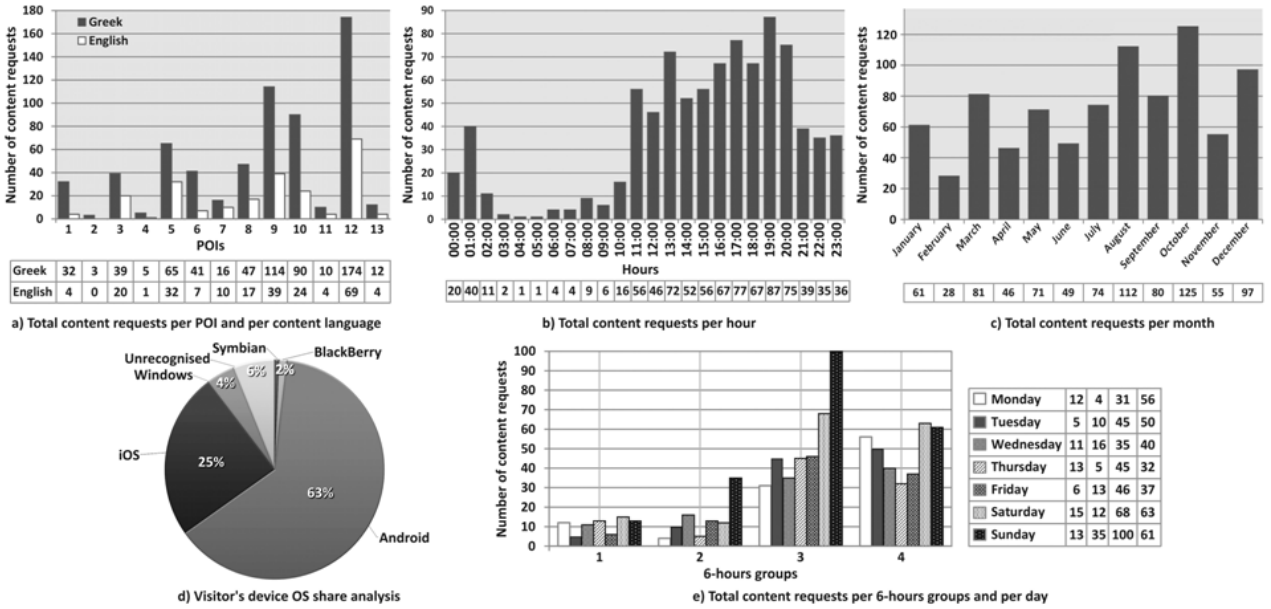



**Fig. 2:** POIs spatial distribution and QR-code plate examples

## 4. System evaluation

In order to perform an objective evaluation of the experimental system, we monitored its annual usage based on mechanisms offered by the system's Web server and gathered quantitative data. In this section, we present some of the

statistics related to its operation. Overall evaluation results covering a full year of operation are shown in Fig. 3, which depicts visits per POI and language, per month, day and hour of day, along with data regarding the operating system used by the visitors' devices. In the following paragraphs we provide comments and insight on these results.




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Greek | 32 | 3 | 39 | 5 | 65 | 41 | 16 | 47 | 114 | 90 | 10 | 174 | 12 |
| English | 4 | 0 | 20 | 1 | 32 | 7 | 10 | 17 | 39 | 24 | 4 | 69 | 4 |

| | 00:00 | 01:00 | 02:00 | 03:00 | 04:00 | 05:00 | 06:00 | 07:00 | 08:00 | 09:00 | 10:00 | 11:00 | 12:00 | 13:00 | 14:00 | 15:00 | 16:00 | 17:00 | 18:00 | 19:00 | 20:00 | 21:00 | 22:00 | 23:00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20 | 40 | 11 | 2 | 1 | 1 | 4 | 4 | 9 | 6 | 16 | 56 | 46 | 72 | 52 | 56 | 67 | 77 | 67 | 87 | 75 | 39 | 35 | 36 |

| January | February | March | April | May | June | July | August | September | October | November | December |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 61 | 28 | 81 | 46 | 71 | 49 | 74 | 112 | 80 | 125 | 55 | 97 |

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Monday | 12 | 4 | 31 | 56 |
| Tuesday | 5 | 10 | 45 | 50 |
| Wednesday | 11 | 16 | 35 | 40 |
| Thursday | 13 | 5 | 45 | 32 |
| Friday | 6 | 13 | 46 | 37 |
| Saturday | 15 | 12 | 68 | 63 |
| Sunday | 13 | 35 | 100 | 61 |

**Fig. 3:** Statistical analysis of system's annual usage

Fig. 3a depicts the totals of content requests (unique hits) served by the system ordered per POI and per content language. A total of *879* unique content requests were served by the system (*648* requests for Greek language content and *231* requests for English language content). The higher number of requests for the Greek language content may be considered as an indicator of the old town visitors' nationality. Fig. 3a clearly depicts that there are a few favoured POIs regardless of the content's language. This is highly related to specific POI's properties such as the notable architectural characteristics and the visitor's easiness of accessing the passive marker. Considering the case where most visitors walk on the middle of a pedestrianized street to have a good view of the buildings of both sides then it is probable that a marker that is located in narrow streets (POIs *9* and *10*) or on a crossroad (POI *12*) will be more popular. Again, POI *12* is located on a crossroad that it considered as one of the most photographed areas of the old town and this is also depicted by its high number of views. It should be noted that POIs *2* and *4* were damaged at some point within the first month of the system's operation. The plate at POI *2* was completely removed while POI *4* content was scratched to a degree that QR-codes were unreadable. Nevertheless, the damaged plates (≈15% of total number of plates) were not replaced before the completion of the experiment, as vandalism was also an important aspect that should be taken under consideration during the experimental operation of such an unattended system.

Fig. 3b illustrates the totals of content requests per hour. The system is found to be used even on late-night hours. Fig. 3c depicts the system's total usage activity per month. The highest numbers of content requests are found during the months August and October (*112* and *125* respectively). It should be noted that during the last week of August and first week of September an annual festival dedicated to the old town takes place and thus the number of visitors is significantly increased.

Fig. 3d depicts the percentage share of the visitor's mobile device operating system. The results gained do step with the current generic user penetration levels of these operating systems. The Android operating system was the most popular between the visitors' devices followed by iOS. The share ambiguity of the unrecognised operating systems devices was a result of the inability or denial of the mobile device's Web browser to provide the logger script with the request information. The wide range of operating systems portrays the system's high accessibility from different mobile devices. It should be noted that the version fragmentation of the Android operating system that is depicted in the system's log (Version *2.2.1* up to more recent such as version *4.1.2*) also confirms the previous conclusion.

Fig. 3e illustrates the total activity of the system on a daily basis. The totals are organised into four groups where each one represents a time period of six hours (*00:00-05:00*, *06:00-11:00*, *12:00-17:00* and *18:00-23:00*). The weekend days are found to be the most active ones as well as midday and evening hours.

Other performance aspects such as the system's responsiveness was unable to be accurately monitored as the primary bottleneck, that is the variable wireless data transfer bandwidth, relies on the current Wi-Fi network or on the bandwidth offered by the various mobile carriers. Nevertheless, the small data size (≈ *30KB*) of each POI content resulted a low-cost in terms of usage system (mobile carrier data transfer charges) and an average delay of eight seconds for the procedure of QR-code capturing, decoding and content transferring using a 3G network of a national mobile carrier. The previous measurements were performed using a single core (Cortex A8-*1Ghz*) Android (version 4.0.3) smartphone device equipped with the free QR Droid [22] application and Android's native Web browser. Last but not least, it is worth to mention that a positive side effect of such systems is that content retrieval accuracy and precise visitor localisation is always guaranteed by the use of unique passive markers.
The previous statistics indicate that visitors were familiar with passive marker based systems and were interested in either getting additional information or curious to use their mobile devices for purposes other than the ordinary. It should be noted though that although the old town of Xanthi is covered by a Wi-Fi network that can be used for free it requires a registration procedure that might be considered by some visitors as a time consuming or distracting procedure. Moreover, in cases where a visitor has to use a mobile carrier to access the Web, the significant issue of data transfer charges is raised especially for those that are using roaming services.

# 5. Conclusion

Nowadays, visiting experience enhancements can be achieved with the use of a familiar to the visitor personal device. In this work, we presented the feedback gained after the annual operation of an experimental low-cost passive markers based information system that can be accessed by a wide range of mobile devices. We based our case study in an urban area of historical importance and architectural multiformity, where the visitor could retrieve information on-demand over the Web. The obtained statistics indicate that the existence of such a system is meaningful and it will be used up to some extent to enhance the visiting experience while keeping the cost of infrastructures and operation to a minimum. Another important characteristic of the development costs had to do with use of the mobile device's build-in capabilities. Such an approach allows the minimisation of software development. Again, the low maintenance cost is highly associated with the passive markers. They have key properties such as their construction quality and durability that should be taken under consideration. The use of an antiglare film proved to be an efficient solution for outdoor applications that experience varying lighting conditions. Furthermore, the large passive marker size (equivalent to an *A4* page) used in this experiment had to do with the need to make the existence of the system obvious. In a real case scenario, small sized passive markers can be used, as those will be supported by other means of publicity. Conclusively, passive marker-based systems are cost-efficient solutions that should be taken under consideration in cases where there is a need to create inexpensive and discreet outdoor or indoor information systems. The usage statistics presented in this work play an objective indicative role for the development of similar systems. Yet, the coverage and the quality of the content provided by such systems do play a significant role in their overall success. We will be using the experience and feedback gained from this work as a basis for the future development of a similar system of extended functionality that will be also related to semi-automated guided tours and other topological-based services by exploiting previous works [23].

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