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A Context-Aware Museum-Guide System Based on Cloud Computing

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Abstract

This paper proposes a context-aware museum guide system, which is able to present information on exhibits in accordance with visitor needs. Other features of this system include planning and directing a visit as well as providing locations, facilities and additional services. This architecture is designed based on the qualitative attributes of usability and modifiability by using the ADD (Attribute-Driven Design) method. The architecture of the proposed CAM-Guide system consists of two components including mobile and server components. The mobile component is divided into data and decision tiers. The server component is located in the cloud and is regarded as the backup for the mobile component. The SAAM method (Software Architecture Analysis Method) is employed to evaluate the CAM-Guide architecture. To this end, some scenarios have been codified for system capabilities by consulting museum experts. The proposed architecture satisfies the scenarios by resolving the issues arisen in each scenario. The mobile component is implemented as a mobile phone application, and the CIF-based questionnaire method is used to evaluate its usability. Investigating the received questionnaires indicate a high usability score for the proposed system. Finally, comparison of the capabilities of the proposed system with related research reveals that CAM-Guide benefits from a comprehensive design.

Keywords: Museum guide systems, Software architecture, Recommender system, Context-awareness.

1- Introduction

Nowadays, tourism is one of the greatest and most productive economic activities in the world. This industry has been rapidly progressing in many countries [**1**]. Tourism can be highly influential in economic, social and cultural developments in developing countries [**2**,**3**]. With improvements in the financial status and social welfare of the middle class citizens, tourism has been booming, significantly. One of the main concerns of tourists is the need for an appropriate guide. Many of them forbear to travel and visit places due to the absence of a guide; Others traveling without a guide, get confused without enjoying enough [**4**].

In the light of modern technologies, human life has undergone tremendous developments. These technologies have made significant changes to human lifestyle. With the advent and spread of new generations of smartphones equipped with different sensors such as positioning systems and the development of wireless sensor networks in public places [**5**], a smartphone has turned into an interesting and popular Personal Digital Assistant (PDA) to help tourists. Besides, with advances in pervasive computing, the things around us have now processing and storing capability, and everyone can receive customized services on computers embedded in the surrounding environment [**6**,**7**]. Mark Weiser was the first theorist who introduced his viewpoint on pervasive computing as the third wave of computing technology [***8***,***9***]. Pervasive computing tries to be aware of user's situation as well as the surrounding environment to adapt the actions to the current situation [**10**]. Pervasive computing applications are mostly context-aware. In other words, they receive context information characterizing the surrounding environment in an implicit way and perform appropriate operations, accordingly [**11**]. Context is "any information that is used to characterize the situation of an entity" pertaining to the scenario of the application [**12**,**13**]. The application uses this information to provide adaptive services regarding the current situation of the user.

Previously, some mobile museum guide systems have been introduced to help visitors [**14**,**15**,**16**,**17**]. One of the main functionalities of such systems is to determine visitor's current location to present information on nearby exhibits. GPS, Wi-Fi, QR Code, RIFD and NFC are among the technologies used for positioning. In this regard, NFC is a modern and developing technology. According to the statistics, it is predicted that in the near future most of mobile phones will be equipped to the NFC features [**18**]. Related museum guide papers do not benefit enough from the context-awareness potential. In fact, they at most use location for providing services and information. This study is meant to extensively use the context-aware potential and provide users with customized services based on age, language, education, specialty and interests. It proposes a mobile Context-Aware Museum Guide (CAM-Guide) system based on the NFC tag. The proposed system is designed to have four functionalities including presenting information on exhibits in accordance with visitor needs, planning and directing a visit, and providing location as well as facilities services. It is also designed to satisfy usability and modifiability. The opinions stated by the experts at Cultural Heritage Organization [**19**] in South Khorasan Province and the experts at Akbarieh Garden and Museum [**20**] in Birjand have been used for requirement gathering and analysis. The SAAM method is used to evaluate the CAM-Guide architecture. In this method, a scenario is provided for each functionality of the system and the proposed architecture is investigated accordingly. To evaluate usability of the proposed application, a questionnaire with three aspects is used including graphical design, application usability, and the usability of a specific functionality (providing information on exhibits). Investigating questionnaires indicates that the application usability indicator is high, something which shows the system is easy for users to use.

The rest of this paper is organized as follows: the second section reviews previous studies on mobile museum guide systems and investigates the technologies used in them. The third and fourth sections deal with the design and evaluation of the proposed system. Finally, the fifth section presents conclusion remarks as well as open research directions.

2- Related Work

Preliminary museum guide systems, proposed before the advent of smartphones, included mobile cassette players by which visitors could listen to the introductions on exhibits while going through the museum. The visitors could rewind any part that they did not understand. In this evolution, keypadbased audio guide systems were created to let visitors select their favorite exhibits and enter the exhibit number to listen to the corresponding audio track [**21**].

Since the advent and expansion of smartphones equipped with different sensors such as GPS [**5**], this device has turned into an interesting platform for the developers of museum guide systems. Various technologies are used in such systems to determine user location. The aim of knowing user location is to automatically provide information on nearby services and introduce adjacent exhibits to visitors. Many mobile museum guide systems have been introduced so far. The evolution of these systems is discussed here with respect to the utilized positioning method.

CARS [**22**] and VISIT [**23**] applications can determine current location of user by utilizing GPS of the smartphone to provide user with necessary information. MTGS [**24**] is a personal tour guide system that displays multimedia information based on user location. This system is implemented in Ram Bagh in Agra, India. When tourists approach an attraction, they are notified, and the relevant multimedia file is played on their mobile phones.

In the TAPIR [**25**] project, a sound tag is allocated to each artistic exhibit in Lee Ungno Museum in South Korea. These tags disseminate the unique ID information of each artistic exhibit in the environment through in audible audio signals, periodically. The microphone on each visitor's mobile phone automatically detects the signal from the closest sound tag and plays the relevant audio file for the visitor. The ARTIZT [**26**] project is implemented in an art museum by using ZigBee technology. This system can determine visitor location with less than one meter error. The Egheman [**17**] system uses the Bluetooth technology to determine locations and provide visitors with information. Cyberguide [**14**] and HIPPIE [**15**] systems detect visitor location with an infrared sensor.

Ubi Cicero [**16**] uses the RFID active tag to determine visitor location. All objects are tagged with RFID in the museum, and a unique ID is allocated to each tag. A visitor can acquire the necessary information with the RFID reader.

In the IMG [**27**] project, NFC is used to determine visitor location at the Wolfsoniana Museum in Italy. All objects are marked with NFC tags. After installing the application on their smartphones, visitors could receive relevant customized information.

Given the fact that GPS is usable in open areas, it has not been widely used in museum guide systems because it is not appropriate for such indoor environments. Therefore, the developers of applications are looking for an alternative method to detect visitor location in indoor areas such as museums. On the other hand, there may be some errors and interferences in systems with audio tags and active RFID, hence, they may not be able to acquire positions accurately. It is also difficult for users to utilize the barcodes of two or more dimensions. They also elongate the processing time. Therefore, NFC is used in this research to estimate location. The main difference between this paper and previous research is the comprehensive design with respect to tourist needs. This paper also presents adapted services with user situation and context information. To this end, different pieces of context information such as location, age, education, interests and specialty are used to design the system so that intelligent services can be provided to tourists.

3- The proposed context-aware museum guide system

The architecture of a computer system is a structure including components, their externally visible properties and the relationships between them [**28**]. The architecture of each system should be designed after acquiring the requirements. In other words, functional requirements and non-functional requirements (quality attributes) should be taken into account in designing an architecture. In IEEE dictionary of scientific terminologies, "quality refers to the degree or extent to which a system meets user needs or expectations" [**28**]. Quality attributes are the factors which influence quality. Usability and modifiability are among the most important quality attributes required by a system. Modifiability evaluates the architecture with respect to the costs of changes [**29**]. Considering the fact that new technologies are introduced every day, systems should be modifiable and extendable because users will have new needs over time. Usability shows the ease of use. Given the fact that a visitor wants to use an application immediately after installation, this system should not need any specific tutorial. It should be totally usable and user-friendly. To acquire functional requirements of the proposed system, the experts were asked for their opinions, and the following functional requirements are obtained:

- **Providing information on exhibits according to the visitor's needs:** Considering the context data collected on visitors, the information on each exhibit should fit visitor status and knowledge. Moreover, different methods such as text and audio are supported by the system to present information. Users are divided into three classes including ordinary, enthusiastic and expert. The information presentation is understandable and normal, detailed and fluent, and detailed with specialized information for these three groups, respectively.
- **Planning and directing visits:** Many museums are comprised of different parts; therefore, it takes a long time to visit them thoroughly. The system should provide visitors with some suggestions on the map to prioritize different parts by considering visitor interests, available time, approximate visit time of each part and the museum's time schedule.
- **Providing location:** The system should display the last visited location on a map of the museum. This helps the user to continue visiting after a break.
- **Providing facilities and services:** Given the fact that many museums are located in traditional places, it should be possible to provide services such as nearby traditional restaurants and information on their menus as well as handicrafts and their sales points. In fact, tourists tend to use relevant services after visiting a museum.

Attribute Driven Design (ADD) [**30**] receives the system requirements (functional and quality attributes) as the inputs and provides the logical architecture design as the output. In this section, the proposed architecture is described with respect to the ADD method.

First, modifiability is taken into account to use the tactic that localizes changes. It divides the system into two components: mobile and server. In this tactic, the tasks, which are conceptually similar, are put into one component.

Moreover, the tactics preventing ripple effect are used [**28**]. Each component usually generates data for other components. If we decrease the number of components receiving data from the first component, a fewer number of components are practically influenced by changes in that component. Therefore, the ripple effect is prevented. Then the mobile component is divided into data and decision by using the abovementioned tactic and runtime tactics (pertaining to usability) along with the two-tier model. Figure 1 shows the proposed architecture of the system with its components.

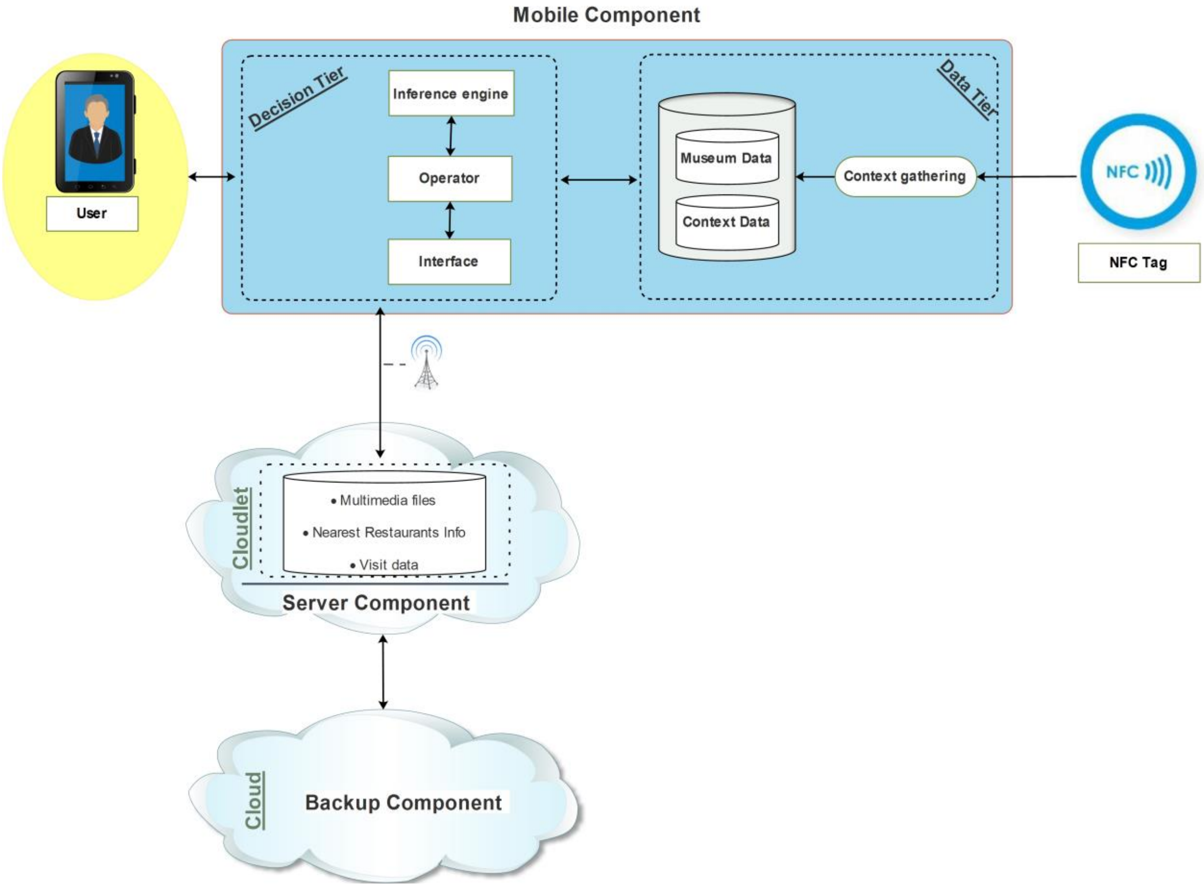

Figure 1: The proposed architecture of CAM-Guide

An NFC tag is allocated to each exhibit in the museum. This tag has a unique ID for the identification of that exhibit. According to NFC forum standard, there are four types of NFC tags [**31**]. In this project, NFC tag type II (Mifare) is used because it is more cost-effective and widely-used. The museum also has the cloudlet server to store the audio files including introductions on exhibits and the information on nearby classic restaurants. The internal environment is equipped with a wireless network. The cloudlet is used to decrease communication time. Hence, the system will be able to play audio files without much delay. Cloud is also used to support the cloudlet by maintaining a backup of its data.

3-1- Mobile Component

The mobile component includes two tiers: data and decision. The data tier includes the components of context gathering and database. This tier is responsible for collecting and storing data. The decision tier consists of inference engine, operator and interface, which are responsible for dealing with user requests and decisions on information display. The mobile component is placed on the smartphone. Its subcomponents are described in the following.

Context gathering: This subcomponent is responsible for collecting raw data obtained from the NFC sensors and input data entered by users. It transfers data to the database. In fact, it stores the data inserted into forms by users in the respective database by using SQL commands. It also gathers the data users receive with NFC-readers on their smartphones. Then it uses such data as an ID to extract the desired information from the museum database.

Database: There are two databases meant for context information as well as museum information. In the context information database, the user contextual information as well as interests are stored. The fields of this database include first name, last name, age, education, specialty (whether the visitor has any specialty regarding the exhibits), considered visit time, and visitor enthusiasm level for each part of museum. A questionnaire interface is used to obtain these pieces of information from users upon their arrival.

The museum database stores information regarding exhibits and sectors of museum including exhibit ID, exhibit name, sector ID, exhibit class, exhibit description and the exhibit media file address in the database. The sector ID is used to determine what sector an exhibit belongs to, and the exhibit class is used to determine what table or closet contains the exhibit inside the museum. Exhibit description is divided into three parts, which show appropriate information with respect to the visitor group. Besides, the museum information table contains information on different sectors in the museum. This information includes sector ID, sector name, and the number of exhibits in each sector. These data are copied into a user's smartphone after the installing the application. Users can receive the up-to-date version of these data by connecting to the museum wireless network in later re-executions.

Inference Engine: This engine is used to investigate data in accordance with a specific series of rules and algorithms to ascertain how exhibits should be introduced to the user. Given the result of data deduction, a recommendation is then presented for user's visit of the different museum sectors. The aim is to recommend a path to user for a visit to different sectors so that time can be saved and visits can be purposeful. Visitor enthusiasm for museum sectors, after which they are introduced, is obtained through the questionnaire interface. Afterward, a list including the museum sector numbers and visitor score for each sector is created. According to this list and visitor contextual information, the visitor is categorized as ordinary, enthusiastic and expert in each sector. A visitor maybe categorized into different groups in different sectors because each individual has different interests to different sectors. To this end, if a visitor is younger than 20 years old, he will be put into the ordinary group in some sectors with lower scores and in the enthusiastic group in some other sectors with higher scores. If the visitor is older than

20, academic educations are investigated. If the visitor does not have any academic educations, specialty (empirical experience) is investigated. If the visitor lacks experiential specialty in the desired area, he will be put into the ordinary group. If he has some experiential specialties regarding the exhibits, he will be put into the ordinary group in sectors with lower scores and into the enthusiastic group in sectors with higher scores. If the visitor has academic educations, the academic specialty is investigated. If the visitor has academic specialty, he is categorized into the ordinary group in some sectors with lower scores and into the expert group in other sectors with higher scores. Figure 2 indicates the decision tree, which is corresponded to this inference.

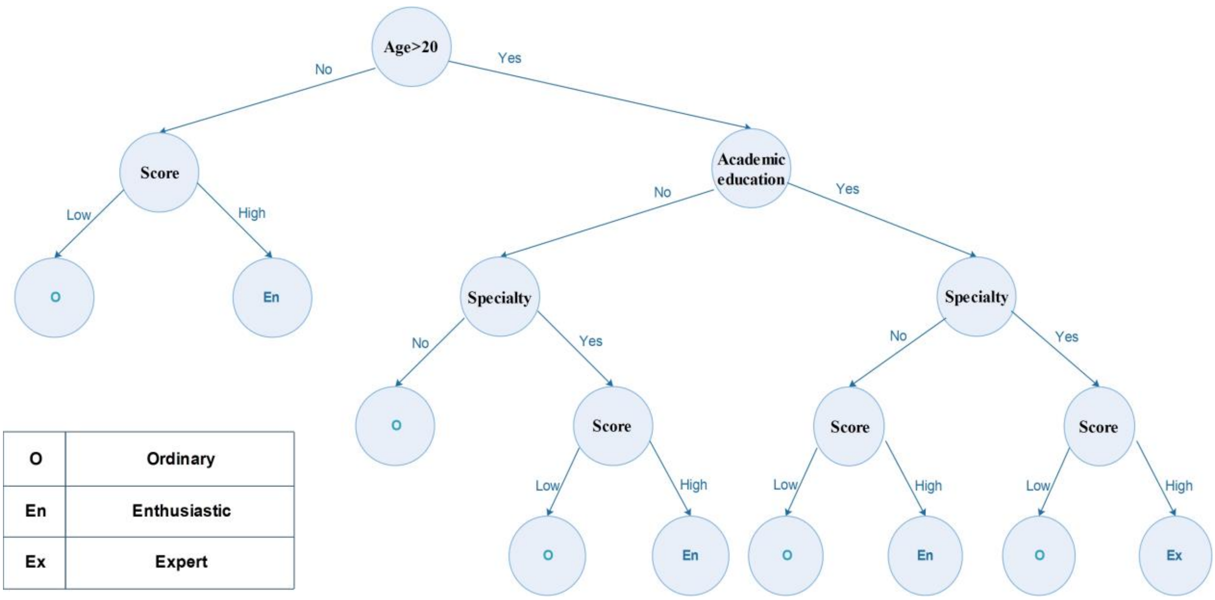

Figure 2: The decision tree corresponding to the inference

The time determined by the visitor to visit the museum, visitor scores to museum sectors, the number of exhibits in each sector, and the museum schedule are used to make a suggestion for visiting museum sectors. First, the visit time (T_{user}) is calculated by using the time that visitor intends to spend and the museum schedule (possible available time) in a way that the visit time should not exceed the museum working hours. The estimated visit time (T_{real}) is obtained from the number of exhibits in each sector and previous visit experiences as well as the time required to visit each sector with respect to the group in which the visitor is categorized into. In each sector, the corresponding information is selected from the museum database. Then a sorted list of museum sectors is made in accordance with visitor enthusiasm for visiting them. There are four possible states for the visit recommendation.

Case 1: If the visit time is longer than the estimated visit time, the regular visit recommendation is displayed to the user in a list on the map due to having enough time.

If the visit time is shorter than the estimated visit time, the absolute value of the difference between the estimated visit time and the visit time is calculated.

Case 2: If this value is smaller than 10 percent of the estimated visit time, it is highly probable for visitor to be able to visit all sectors on the list because of this slight difference between the estimated visit time and visit time.

Case 3: If this value is between 10 and 30 percent of the estimated visit time, some sectors of this list that have equal or close scores with different visit times will be sorted according to the visit time. Therefore, among the sectors with equal scores, a sector with a shorter visit time will have higher priority so that it will be possible for user to visit more sectors of the museum.

Case 4: If the absolute value of the difference between the estimated visit time and the visit time is greater than 30 percent of the estimated time, it will not be possible to visit all parts of the museum due to the serious lack of time. Therefore, a number of sectors with lowest scores will be omitted from the recommendation list. To this end, the number of sectors recommended for visit is calculated through the following formula:

$$\mathbf{n_R} = \left[\left(\mathbf{0.3} - \frac{|T_{user} - T_{real}|}{T_{real}}\right) * \boldsymbol{N}\right] + \mathbf{N}$$

In this formula, n_R is the number of recommended sectors, and N refers to the number of museum sectors. Moreover, T_{user} is the visit time, and T_{real} shows the estimated visit time. The formula is obtained empirically by considering comments of the experts of this area. The assumption behind this formula is that the user could visit all sectors of the museum by only spending 70 percent of the expected time. Therefore, the system omits any other sectors to keep the visit time on this value. For example, consider a museum with 9 sectors (N). If a visitor's available time (T_{user}) is 60 minutes while estimated visiting time according to user's assigned group (T_{real}) is 120 minutes, 7 sectors (n_R) that have higher scores are recommended to them. Finally, the recommended visits are shown in accordance with the resultant list on the map. Figure 3 shows the decision tree corresponding to the visit recommendation.

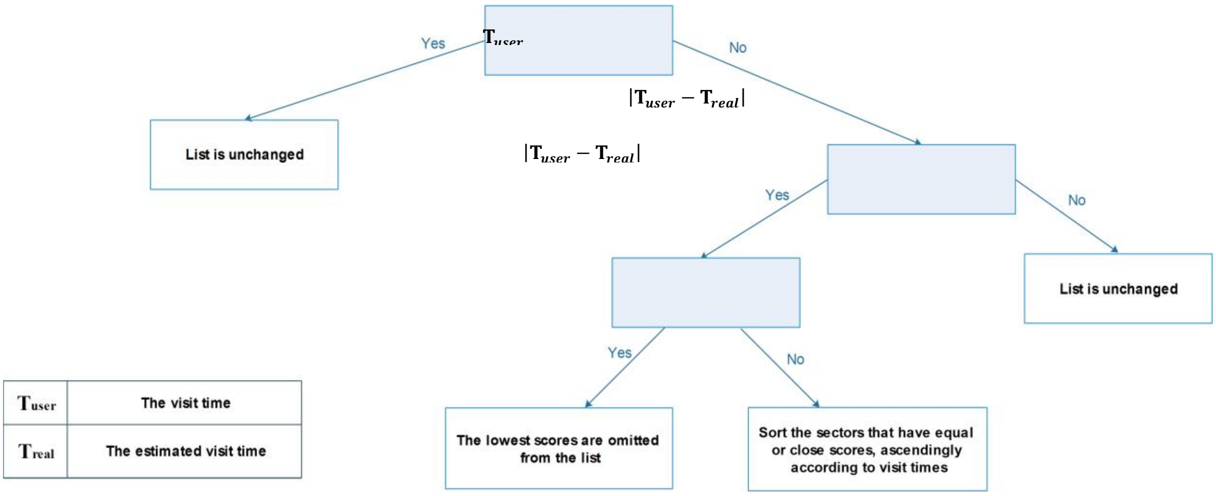

Figure 3: The decision tree corresponding to the visit recommendation

3-2- Server Component

Due to storage limitations on mobile devices, the cloudlet server is used in the museum environment. Multimedia files have big sizes in comparison with the entire application; therefore, it may not be possible to put them on smartphones, directly. Thus, a support server is used in the museum environment. Given the fact that there is a considerable delay in cloud communications, a local cloudlet is used in the museum environment. A general cloud is also used as the cloudlet support to provide a backup of data and increase the reliability of the proposed system.

The method of streaming media files is used for online delivery instead of downloading and opening the entire media files. The main idea of media streaming is that the media file is divided into some parts, which are sent subsequently [**32**]. The visitor smartphone can receive and decode one part of a media file and play it without waiting for the entire file. Multimedia file streaming makes it possible to deliver media files and display them at the same time. Streaming decreases the delay time in receiving multimedia files from the server in comparison with other data transfer methods. Due to dynamic nature of restaurants schedules and their menus, the cloudlet server periodically requests for the information on nearby traditional restaurants from cloud so that up-to-date and new information can be sent to the visitors' mobile devices.

4-Experiments

The CAM-Guide is implemented as pilot on Akbarieh Garden and Mansion Museum [**20**] in Iran. It has been implemented by the Eclipse [**33**] developer on Android. The minimum Android SDK (Software Development Kit) required to support the NFC feature is equal to ten, which is corresponding to Android 2.3.3 (Gingerbread). Figure 4 shows the main interface of the CAM-Guide.

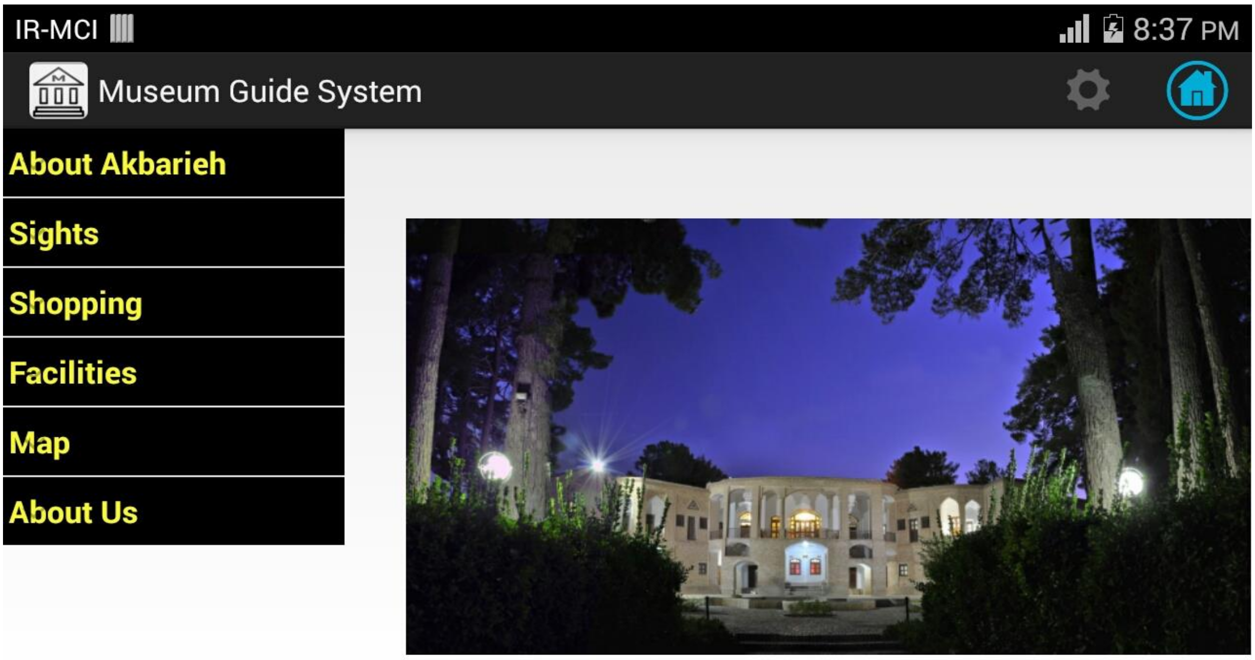

Figure 4: The CAM-Guide main interface

The scenario-based methods are known as the most important approaches to the evaluation of software architectures [**34**]. The simplicity and flexibility are the most important features of such methods, which has resulted in the widespread use of them [**35**,**36**]. In this approach, the functional requirements of the architecture are evaluated with respect to a set of scenarios. The scenario is a brief description of the interaction between a user and a system. Each scenario investigates a particular requirement [**28**]. In fact, the scenario-based approaches are systematic methods, which determine whether an architecture can execute a scenario.

In this study, the SAAM method [**37**] is used as the most well-known scenario-based method for architecture evaluation. This method generally has six steps including the creation of scenarios, description of the architecture, classification and prioritization of scenarios, evaluation of scenarios, determination of communications between scenarios, and general evaluation [**38**]. The previous section presents the description of the architecture. Now the applicable steps are investigated. For this purpose, the scenarios are defined independently and with equal priorities. They are not related. Finally, the general evaluation is presented.

The CAM-Guide system has four functional requirements including providing information on exhibits according to visitor's needs, planning and directing visit, providing locations, and providing facilities and services. A scenario is presented for each of these functional requirements. After implementing the system, a standard questionnaire for evaluating the usability is distributed among users and the results are investigated. The first step of the SAAM method, which is the description of scenarios, is described here.

Scenario I: Providing information on exhibits according to visitor's needs

Justin is an English man who is very interested in traveling to other countries and getting to know their cultures and civilizations. He plans to visit natural and cultural attractions of Iran with a group. They have traveled to Birjand, center of a province in east of the country. The tour guide has decided to take them to the archeological museum in the afternoon. Justin remembered his trip to South Korea and his visit to the Lee Ungno Museum in which an audio guide system was used. Although the information was provided in Korean by the museum guide system and he could not understand it, he found this method of information presentation interesting.

Upon his arrival at the archeological museum, Justin was amazed because the English-speaker museum-guide expert had taken a few days off, and the tour guide was responsible for describing the exhibits. He was not up to the task because he had not good competence at historical and archeological terminologies in English and did not know history, professionally. Therefore, he could not understand Justin's curious and dynamic mind to answer his questions, properly.

Now the architecture of the proposed system is investigated regarding the abovementioned issue. Figure 5 shows the sequence diagram of executing this scenario by the proposed system. After installing the CAM-Guide system on Justin's smartphone, he at first chooses the language, inputs personal information, and sets preferences on the interface. This information is gathered and transferred by the context gathering to the database for storage. The system assigns the user to a group in each museum sector by utilizing the context information of user and museum. After detecting an exhibit by NFC, the context gathering module sends the ID of the exhibit to the database to retrieve associated data. Then the operator sends this data to the interface for display. If Justin makes a request to play the media file, this request will be transferred to the operator through the interface. The operator presents the associated media file to the interface after receiving it from the cloudlet server.

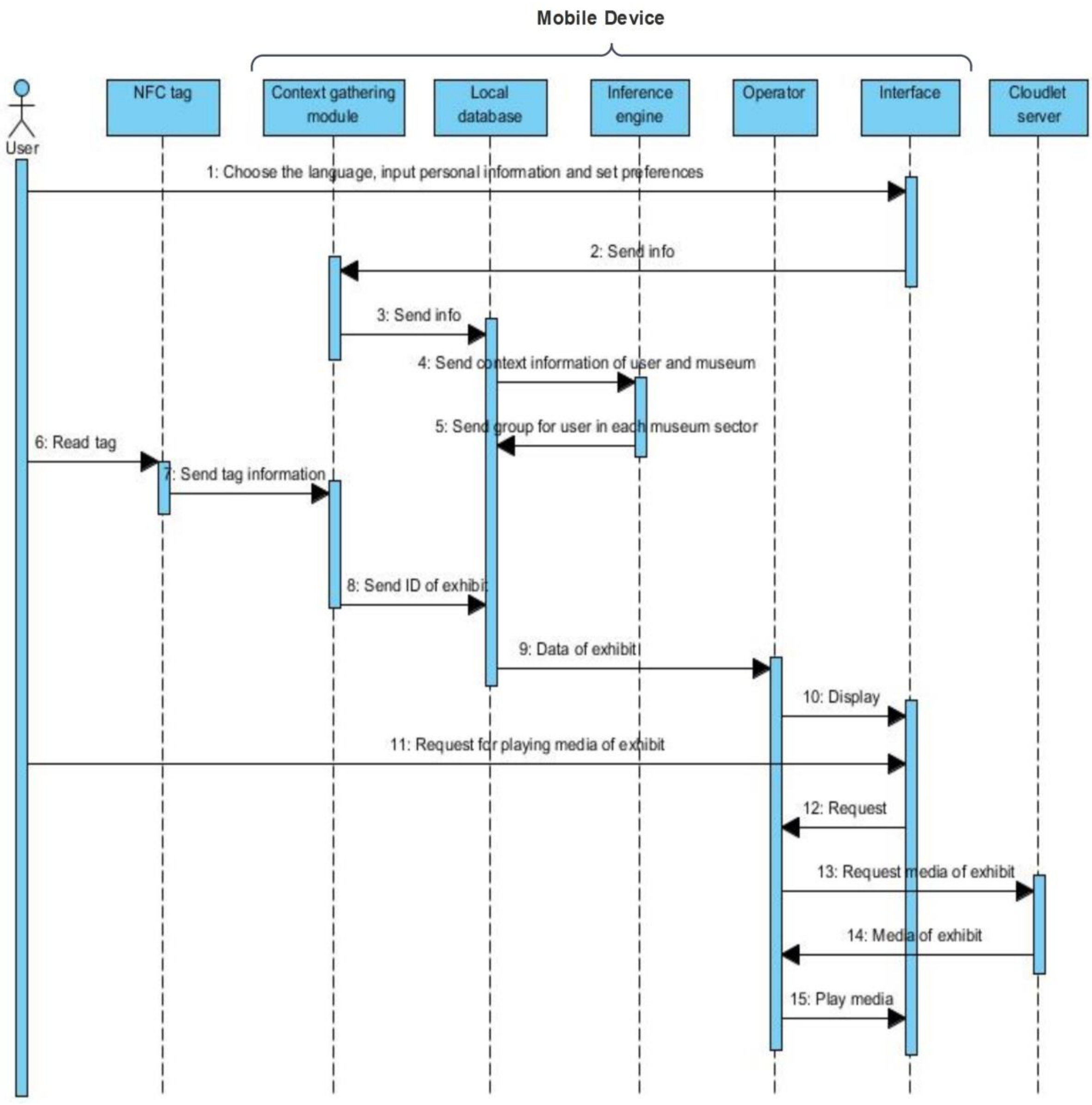

Figure 5: The sequence diagram of the "providing information on exhibits" scenario

Scenario II: Planning and directing a visit

John wants to visit the museums of Akbarieh Garden and Mansion in Birjand [**20**]. *Since he is not aware of different sectors and exhibits included in each museum, he buys tickets for several museums. He starts visiting the first museum and tries to spend more time in his favorite sectors to see almost everywhere. After hours of visit, he realizes that the visit time is over; however, he has not visited his favorite museums yet and he has some tickets available. He regrets why he did not visit his favorite museums at first and why he wasted his time and money.*

Now the proposed system is investigated for this scenario. CAM-Guide can resolve the issue of the scenario. Figure 6 shows the sequence diagram of satisfying this scenario. The visitor makes a request for planning a visit through the interface. This request is sent to the inference engine for evaluation. The inference engine requests personal information as well as museum information from the database. Afterward, it plans a visit with respect to the operations discussed for the inference engine. Therefore, a list of visit recommendations is codified and sent to the operator. After taking necessary actions, it is displayed to the visitor through the interface.

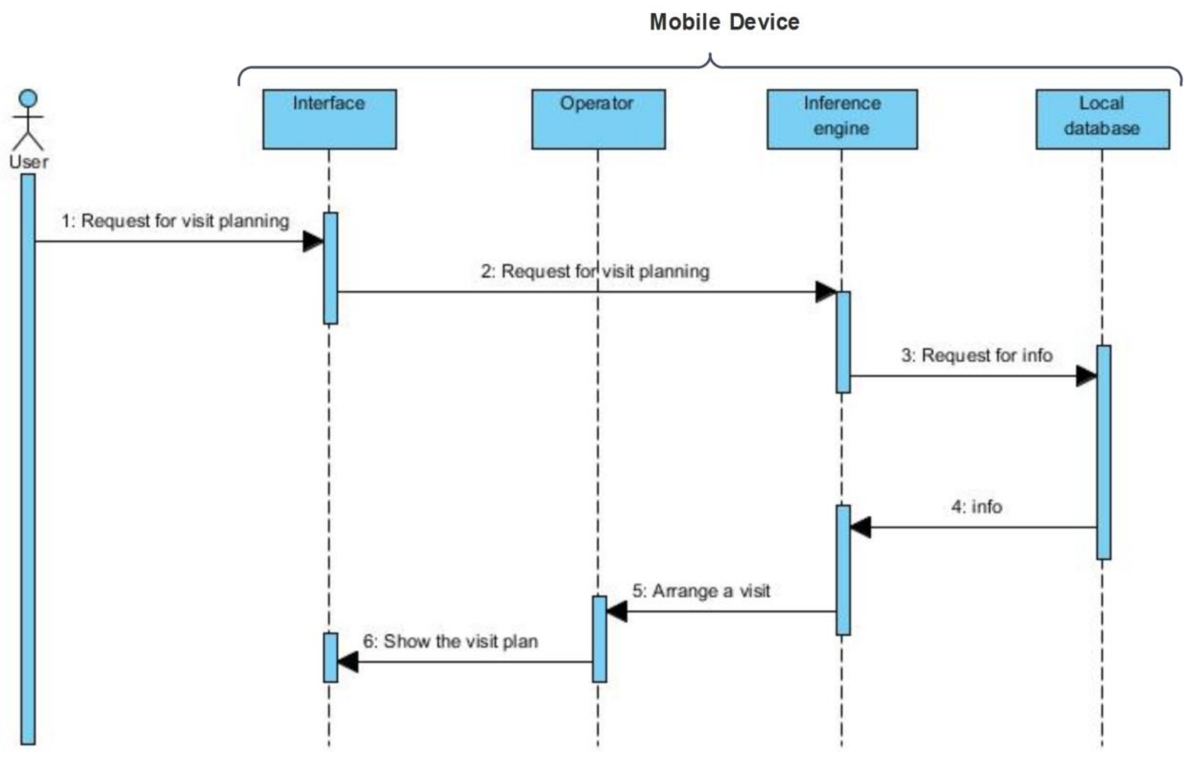

Figure 6: The sequence diagram of the "planning and directing a visit" scenario

Scenario III: Providing location

Justin is visiting the museum when he exits the hall for an emergency. He does not pay any attention to his surroundings and the exit which he took because he is in a hurry. He looks for restrooms outside the hall. Following the signs, he finally finds one. However, he forgets what path he took exactly. Therefore, *it takes him a long time to find the last exhibit he was visiting. After wasting such a long time, he continues his visit.*

Now the architecture of CAM-Guide is investigated regarding this scenario. To this end, figure 7 shows the sequence diagram of executing the scenario. After going out of the restrooms, Justin sends a request for the current location and the last visited location through the interface. The operator handles this request by retrieving the information on the current and the last visited location. Subsequently, this information is displayed on map.

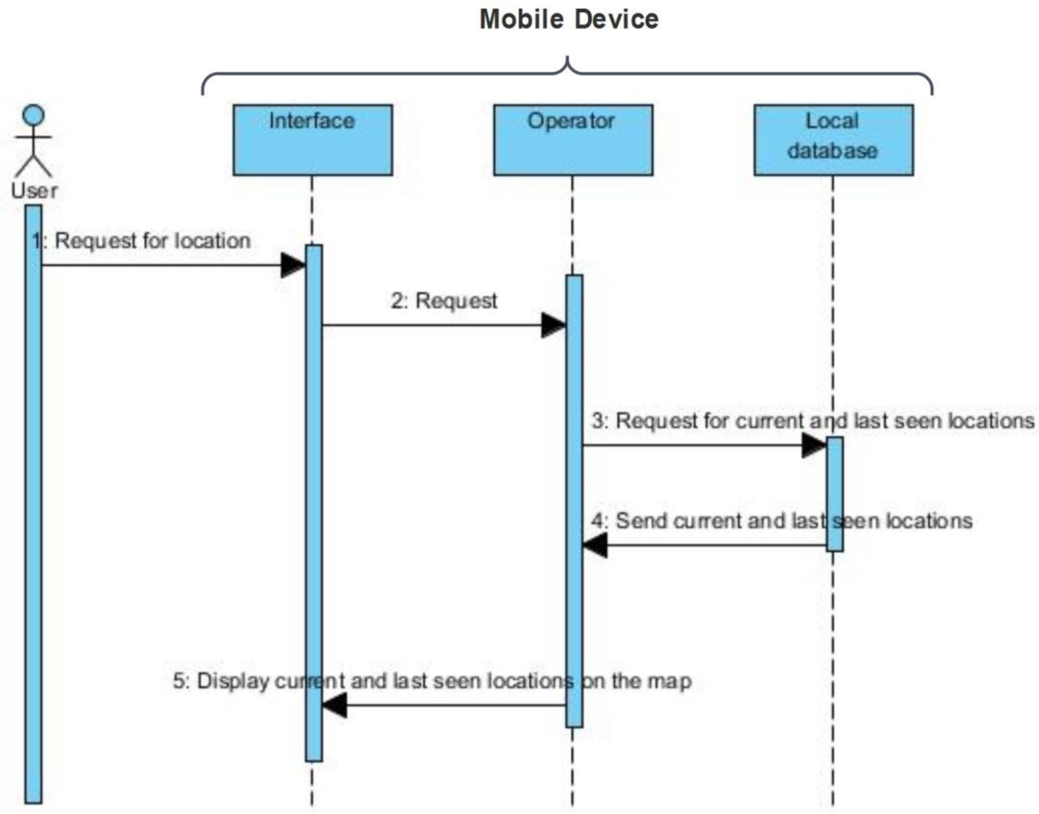

Figure 7: The sequence diagram of the "providing location" scenario

Scenario IV: Providing facilities and services

Alice has traveled to Birjand for the first time. Since she is interested in antiquities, she decides to visit the archeological museum in Birjand. After visiting the museum, she feels hungry at noon. As she knows that there are some traditional restaurants around the museum, she decides to go to one. Therefore, she takes a look around to find someone and asks the address to the closest traditional restaurant. Then she goes to a restaurant behind the museum. However, it only serves meals at nights. She goes back to look for a restaurant on the nearby streets and finds another traditional restaurant. However, this one is closed for maintenance and renovation. After wasting much time, she cannot find a traditional restaurant at last, so she disappointedly returns to her hotel to have a meal.

Now the architecture of CAM-Guide is investigated regarding this scenario. Figure 8 shows the sequence diagram that demonstrates how CAM-Guide satisfies this scenario. The visitor issues a request, through the interface, to see the information on traditional restaurants nearby the museum. After receiving this request, the operator sends it to the cloudlet server. The server sends the information about the near traditional restaurants that are open to the operator. The operator sends this information through a list to the interface to be displayed on the map. It should be noted that, the cloudlet server periodically requests cloud for the information regarding close traditional restaurants.

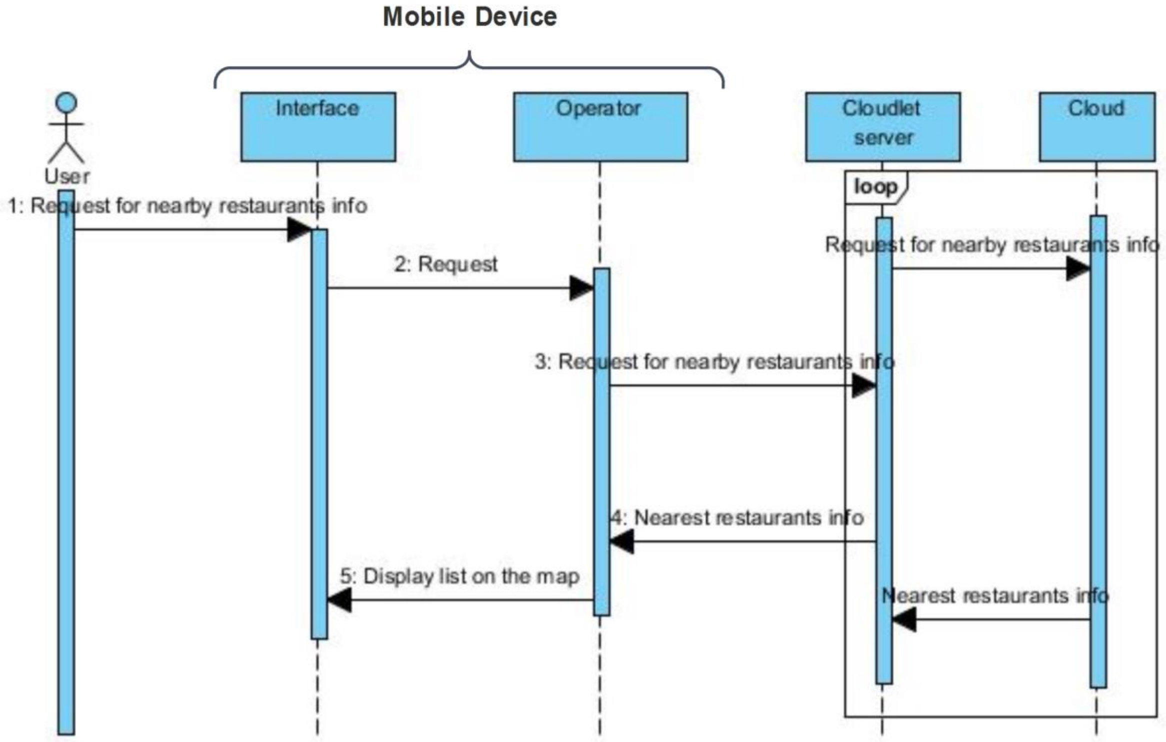

Figure 8: The sequence diagram of the "providing facilities and services" scenario

After implementing the prototype of the application for the National Museum of South Khorasan [**39**], a questionnaire based on CIF (Common Industry Format for Usability Reports) [**40**] has been designed to evaluate CAM-Guide with respect to usability. This questionnaire evaluates the application from three aspects including graphics design, application general usability, and the usability of a specific functionality. The key items of this questionnaire are as follows:

1. How satisfactory is the appearance of the application?
2. Do you find the quality of graphics appropriate?
3. Is the application easy to learn?
4. Is it easy to use?
5. Is it easy for you to choose a language?
6. How satisfactory is the presentation of information?
7. How satisfactory is the audio guide?

8. Is the information presented accurately according to your interests?

An integer score between 1 and 6 is given to the response to each question based on user satisfaction level. The scores of the first and second questions are calculated for the first aspect. The scores of the third and fourth questions are calculated for the second aspect, and the scores of the other questions are calculated for the third aspect. The following formula is used to calculate users' satisfaction from the question "q":

$$Sq = \sum_{l=1}^{L} \frac{l}{L} \cdot \frac{x_l}{N}$$

, Where Sq is the level of users' satisfaction with the question q, L is the number of possible responses (in this case 6), x_i is the number of people who gave the response l to the question q, and N refers to the number of people who filled out the questionnaire. The statistical population includes 25 participants. The average satisfaction indicator of this application is 91%. Figure 9 shows the results of satisfaction with questions.

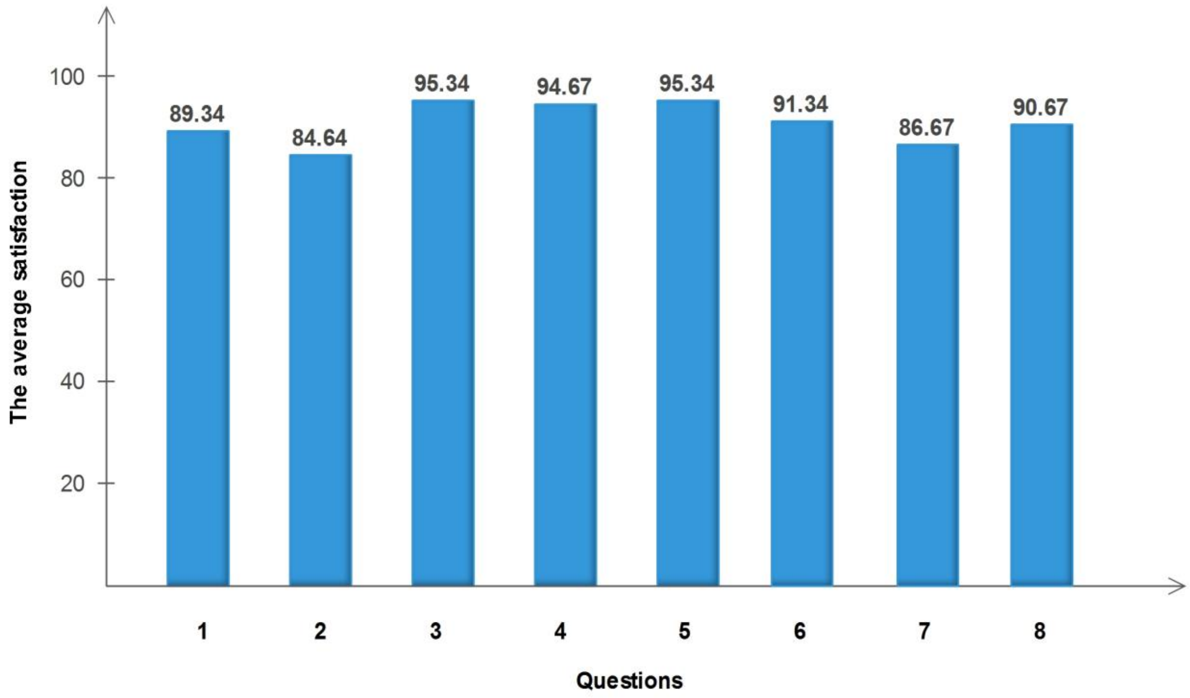

Figure 9: The results of usability satisfaction

The results of investigating the chart indicate that there is an excellent satisfaction level. Figure 10 indicates the satisfaction with each aspect. Application general usability has the highest satisfaction level, and graphic design has gained the lowest level. The low satisfaction level of graphics is due to the fact that the application is in the experimental stage. The satisfaction level of this indicator will increase in the next versions. The high level of application general usability shows the ease of use. Given the fact that a visitor wishes to use the application immediately after installation, these systems should not require specific trainings. The high indicator of satisfaction with usability of a specific function shows that the CAM-Guide is successful in matching the offered information to the user context.

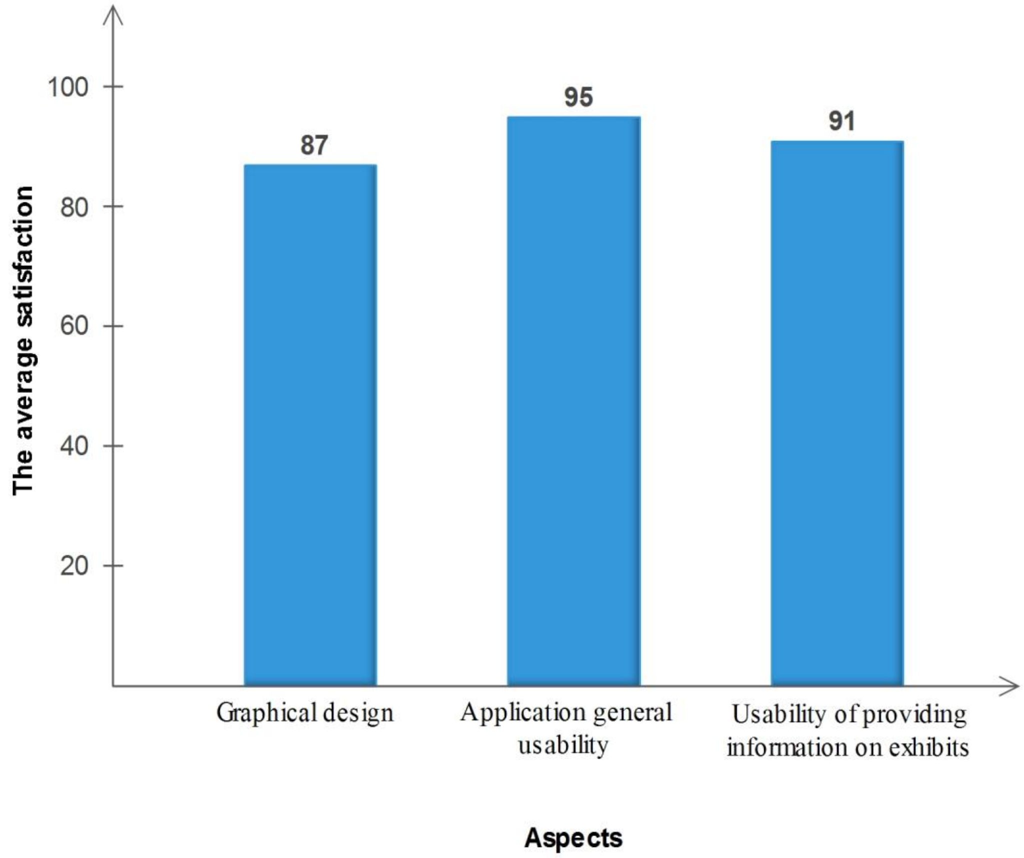

Figure 10: Satisfaction results by aspect

The aim of modifiability tactics is to control the cost and time of implementation, experimentation and establishment of changes. The modifiability tactics used in designing the system include the tactics which prevent the spread of changes as well as the tactics of localizing changes. The system architecture has been designed in two independent components: mobile and server. The changes of one component often do not impose much change to the other one. In addition, the mobile component has been designed by using a two-tier model including data and decision. The use of a two-tier model decreases the changes caused by the changes made to one tier. As a result, modifiability increases. The systems designed by using the abovementioned tactics and models are acceptably modifiable [**28**].

Finally, Table 1 shows a comparison between the functionalities and the usability attribute of the CAM-Guide system with other similar systems. As can be seen, two functionalities are exclusively provided by CAM-Guide.

Table 1: Comparison of the CAM-Guide with other similar systems

Usability	providing information		Providing location	Providing facilities and services	Planning and directing a visit	Requiremen / System
	Information personalization	Exhibits introduction				
+	-	+	-	-	-	**TAPIR** [25]
+	-	+	+	-	-	**ARTIZT** [26]
+	-	+	+	-	-	**EVE** [41]
+	+	+	+	-	-	**IMG** [27]
+	+	+	+	+	+	**CAM-Guide**

5- Conclusion

This research has been conducted to designed and implement the museum guide system with four functionalities including providing information on exhibits according to the visitor's needs, planning and directing a visit, providing location, and providing facilities and services as well as the quality attributes of usability and modifiability. Multimedia tools such as film, photo, clip and sound have been used to change the static atmosphere of the museum into a dynamic one. The proposed CAM-Guide system presents customized information to visitors in accordance with their needs by leveraging the context-aware capability. One advantage of the proposed system is that it prevents visitors from being mixed up. It is also cost-effective due to the use of available NFC technology, which is becoming widespread. It provides additional services and does not need a translator and saves the visitor's valuable time.

One of the open research directions of the current research includes making museum visits interactive and social in a way that it can be possible to get feedback from visitors on each exhibit. People can have different interpretations of paintings and exhibits; therefore, they can be studied to reach a deeper understanding. Moreover, a social network can be set up as a part of the application to help visitors interact and share their experiences.

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