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# Designing an Interactive Museum Guide: A Case Study for Mobile Software Development

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## 1. Introduction

Portable devices disseminate the information sharing without encountering the location barriers. By the great enhancements of mobile phones, it has been changed the direction of computing to the people centric computing (Lane et al. (2006), Shi et al. (2010)). Mobile phones have advantages to support mobile learning (m-learning) through the use of wireless mobile technology to allow learners to access information from anywhere and at any time (Ally, 2009). M-learning can be defined as “using mobile and interactive technologies to transfer information and knowledge with different contexts” (Sharples et al., 2007).

Mobile phone has become a part of the personalized computing. Nowadays everyone has a strong loyalty to use these devices. Personalization helps users to identifying his intentions, and trends about a specific area. In the life-long learning activities, museums have interested to provide information from ancient history to modern ages. This viewpoint emphasizes the importance and role of the museums and their accessibility. By using mobile learning platform and its features, we can share information about the museums not only with audio guides about art objects but also the location of the museums and places located in near environment. Also, interactive tools can provide interfaces for users to access some art objects which located in a specific museum by help of the mobile solutions.

Lifelong learning process (LLP) covers learning knowledge and gaining new skills throughout his life and focuses on the post-educational period. In LLP, individuals have to be self-motivated and voluntary to learn themselves. Lifelong learning materials have to be designed for different age groups and different levels. Visiting a museum and obtaining knowledge from its exhibition is one of the suitable areas for lifelong learning. To provide the efficiency for the museum visiting, mobile museum guide will be a good way to directed learners (Aspin and Chapman, 2000).

The goal of this study is to develop an application that will provide information about museum guide, using smart mobile devices. This chapter presents the architecture and implementation of such a location-based application, called Mobile Museum Guide, with the mobile phone as a platform. Implemented on Android, the system is designed to provide museum guide information services; therefore, people can get museum guidance information that they need anytime and anywhere.

In the beginning of the 2000's, tourist guides or museum guides need to develop specific devices to provide information about art objects, finding a location about an art gallery, and providing detailed information about a particular art object. But now, rapidly increasing mobile phone market provides smarter phones that have abilities to access any portal by using Internet or executing specific software tools to push or pull some important information.

In this study, mobile devices are used for creating a mobile museum guide for exhibition contexts to improve the visiting experience, increase learning, and satisfying interests. In this book chapter, it will be described the design, implementation and deployment of a location-based application, named mobile museum guide for the mobile platform. This application will permit users to get museum guidance information when they need anytime and anywhere. In particular, the users could be browsed or queried through an Internet map service such as Google Maps.

This study includes following functional items:

- Find your current location within the Museum and explore the map.
- Get real-time directions to your next exhibit, a café, or anywhere else in the Museum by using the smallest route.
- Learn more about items from the Museum's collection, during your visit or browse exhibits from anywhere in the world.
- Choose from Museum highlights or in-depth guided tours.
- Plan your own tour before you arrive or on the spot.
- Share an interesting exhibit through email, Facebook, or Twitter.
- Want to learn more? Bookmark an item and receive a link to more information when you get home.

From the functional viewpoint, following manifesto items are the aim of this project for visitors (Chou et al., 2004):

- Mobile application should provide deep information about art objects,
- Mobile application should present information about any art objects or collection without requesting or searching information about it. Information should be provided as location based services.
- Museum exhibition should be enjoyable with accessing different activities and places by mobile application.

Forthcoming sections are considering consecutively about mobile technologies for museums, a mobile museum guide analysis, design, and development stages. Also at last, conclusions and future directions are given.

## 2. Mobile technologies for museums

Smart phones and tablets take place everywhere as mobile partners. These mobile devices have accessibility to Internet and wireless nets. When we look at the pros and cons of these devices, mobility and accessibility as portability seems to be advantages, but, small screen sizes, prices, heterogeneity in mobile applications, and constraints in presenting multimedia information gives a negative impression. For implementing these devices in museums,

smart devices' connectivity features have to be taking into account to providing exhibition, and guide information to visitors. When the mobile devices are concern point, location based services may be taking into account. New generation smart phones have support the GPS functionality. Thus, location based services can be a trigger the visitor to getting any information near to him.

For example, portable devices such as personal digital assistants were used to provide interactive museum guidance. Chou et al. (2004) constructed a platform to support PDAs to give information about special art objects by using text, voice or video clip. Context-awareness is the popular human computer interaction discipline. A context-aware system defined as a system that "uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task" (Dey and Abowd, 2000). The presentation of these services or information brings with it the issue of proactiveness – should the system initiate the presentation of information or should it wait for the user to request information (Lanir, 2011). Context-aware systems might support three categories of features: (1) presentation of information and services to the user; (2) automatic execution of a service; and (3) tagging of context to information for later retrieval (Dey and Abowd, 2000). In a related project, Ghiani et al (2009) propose a multi device, location aware museum guide which able to read RFID tags. Context-dependent information presented to the visitor via his location and historical behaviors. Proactiveness of mobile visitors' guides brings with it a possibility for better service to the user at the cost of taking control out of the user's hand (Lanir et al., 2011)

As emphasized here that, smart phones and tablets can be used to support interactive museum guidance. By using Wi-Fi, 3G or another network connection method, visitors can access to bring exhibition related information and special event notifications. Also, GPS (Global Positioning System) provides mobile user location via satellite. By using the location data, location awareness can be obtained. For instance, "special exhibitions near to you alerts" can be produced for museum visitors. Floor plans of the museum and location information of the visitor may be matched and, some adaptive guidance can be generated. As illustrated in Fig. 1, museum collections and art objects categorization data is located in DB server and business logic related issues located in application server, web server handle the requests which are coming from the web and mobile clients (Xiehao et al., 2009). By using this network topology, geospatial data can be integrated with multimedia data. This architecture can present the location based services to the museum visitors. Location based service creates location and multimedia data relations to provide information.

### **3. A Mobile application for achieving museums: Mobile museum guide (MMG)**

Mobile museum guide development is the main idea of this study. In this section, mobile software development stages are detailed. MMG development project is organized base on the smart phone abilities. Functional and process based analysis is performed consecutively.

Software engineering encapsulates different techniques and models to support successful project management. Models and methodologies describe any system by using different notation, association semantics, and relationship between activities. Software methodology like UML covers all requirements engineering activities by using different diagramming techniques to enforce the software quality assurance. UML diagrams generate different

documents and models: requirements specification documents, analysis models, designs, code, testing specifications and reports and so on. These documents and models are the inputs for the related forthcoming and planned activities that reside in software development life cycle (Jacobsen et al., 1998).

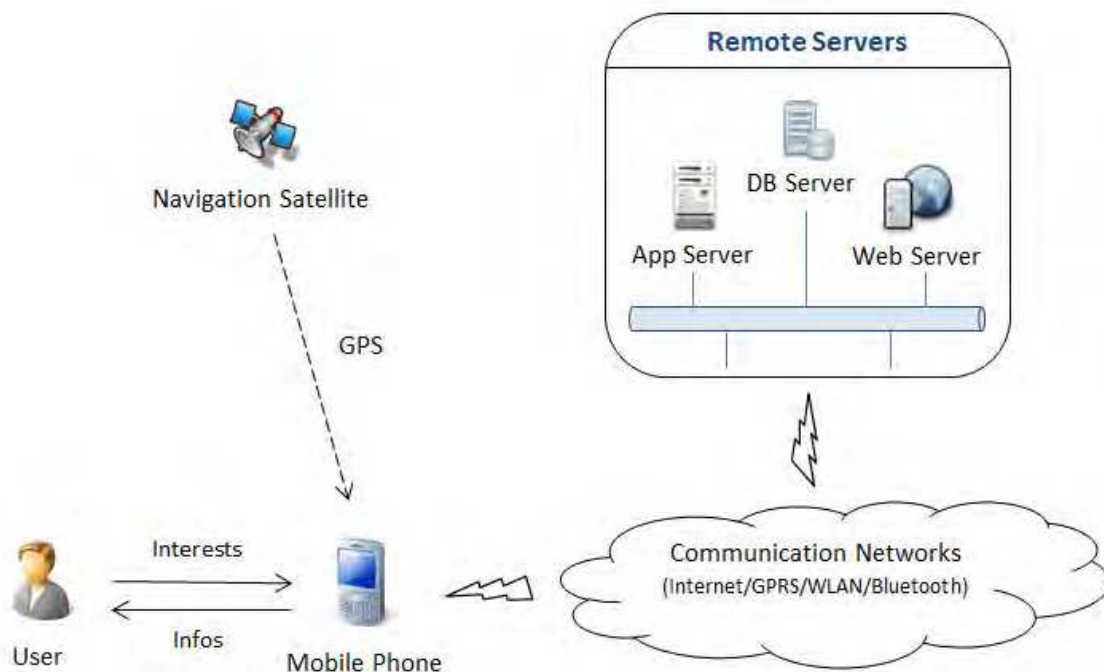


Fig. 1. Mobile users and accessible networks (Xiehao et al., 2009)

Following sub sections have details about mobile software development life cycle and its stages.

### 3.1 Mobile software development life cycle

Mobile software development life cycle is same as traditional software development and its life cycle. But it has some different aspects such as in duration of the software development time. Rapidly increasing mobile devices and mobile software tools enforce the minimization of the development time of the mobile software. But, common development platforms, such as iOS, Android, Black Berry, Symbian, Windows Mobile, et al., support same capabilities with different efforts.

In this study, activities of the software development life cycle are taking into account as: "Analysis", "Development", "Testing/Training", "Documentation" and "Project go live".

At the analysis phase, system requirements analysis is performed and detailed the technical requirements of the software. This allows real time update of content, such as exhibition information of the museums, guided tours, special event notification and great flexibility of information. Also, it was decided to using Android platform which is the number one mobile platform for more easily learning and developing mobile applications.

Second work package of the analysis phase covers identifying processes for museum learning system modules. In this stage, design prototypes were prepared by Balsamiq software tool and UML diagrams drawn. At the development phase, we developed all modules for Android devices. At the testing phase, all modules were tested with Android supported device. At the last stage, review and acceptance of the study realized.

In this study, we might summarize following work packages in developing and implementing mobile museum guidance:

- Analyzing and designing context-awareness museum guide principals,
- Developing mobile application,
- Usability Testing to the mockups, resolving problems,
- Acceptance testing,
- Deploying the application.

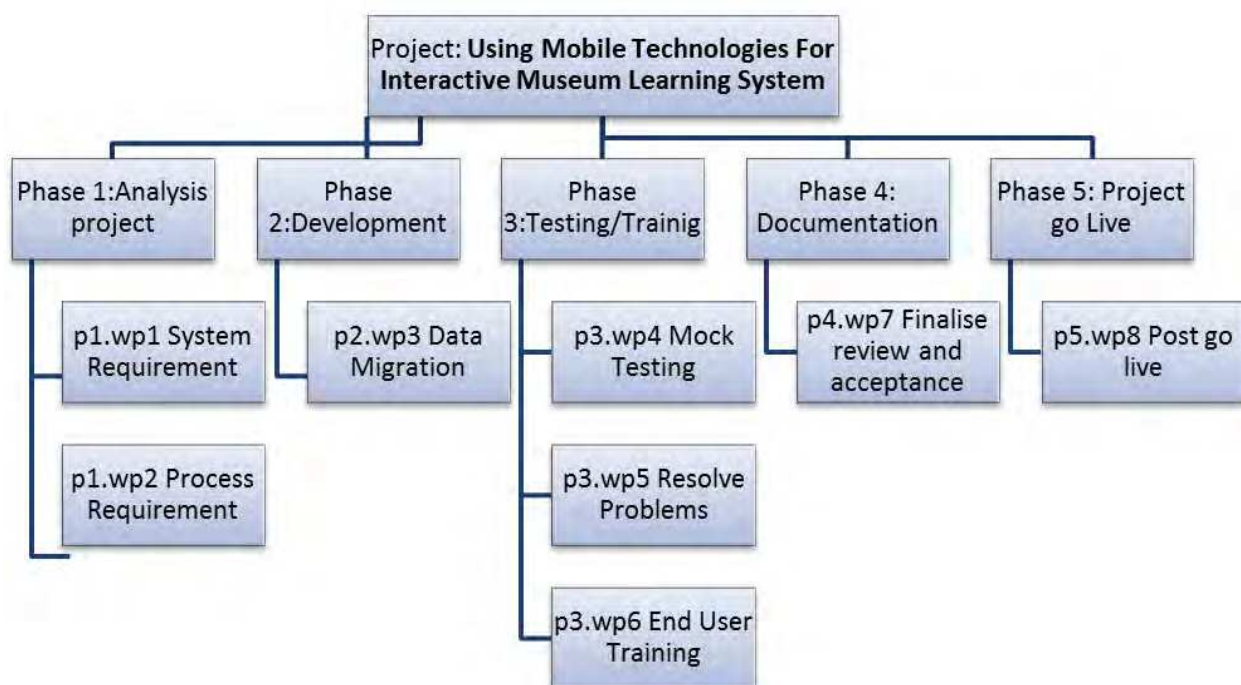


Fig. 2. Example Work Breakdown Structure (WBS)

### 3.2 Model driven analysis activities for developing MMG

Analysis activities start with investigating end users' (visitors) expectations from the MMG. As described by Richardson et al. (1998), interface development stage can be supported with task analysis and designers need to work detailed specification of requirements for the interface. For satisfying, functional and non-functional behavior of the proposed system, software specification has to be organized based on the hierarchical task analysis (HTA). Stanton (2006) proposes that HTA provides an opportunity to the analyst to plan tasks not only the designer but also end user viewpoint. Annett (2006) emphasize that "HTA encourages the analyst to consider not only what should happen, but also what does actually happen and how this can go wrong. He suggests that these questions will arise naturally as the analyst seeks

to discover the indicators for success and failure of each of the sub-goals" (Stanton, 2006). In investigating user requirements, task analysis, specially HTA might be a useful tool for system analysts and system designers (Stanton, 2004).

In interactive system design, task analysis has to take into account the end user profile and system usage. Ormerod and Shepherd (2004) proposes sub goal template to obtain requirements specifications by a task analysis.

Here, HTA analysis is performed to obtain the main skeleton of the application. As illustrated in Fig. 3, language selection, museum searching, creating favorites list, and items info are the main tasks for the MMG application. "Search Museum" function is the main task of the application and it has criteria for filtering museums by map, city, type, culture, term, era, or a year.

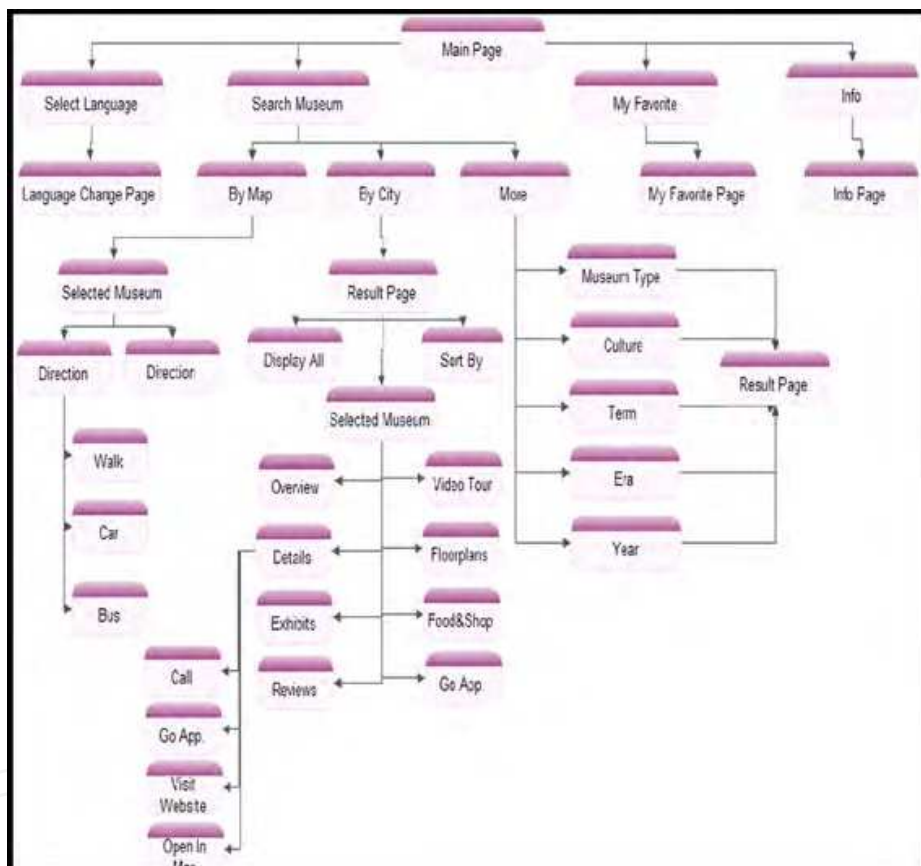


Fig. 3. Hierarchical task analysis and menu items

Use case driven approach is well known and used in the requirements elicitation phase of software development life cycle (Jacobson, 1992).

Hsu et al. (2012) propose a touristic trip forecasting and intelligent recommendation system. Also, they use Google Maps API to allow the user to adjust the geographic data according to personal needs. Google Maps API well accepted for connecting geospatial data with business data. Also in this study, transportation to the museum and directions are provided by using Google Maps API. After the selection process of the museum, extra information and features are presented to the visitors.

In Table 1, fourteen different use cases are listed to show all details of the MMG. In use case model 1, following steps are followed;

- User runs the application,
- User accesses main page,
- User selects “language change” button,
- User browses language change page,
- User selects another language from the list,
- Finally, system sets application language as selected.

Second use case includes museum searching steps:

- User runs the application,
- User goes main page,
- User selects “search museum” button,
- User browses search museum page,
- User selects search by map button,
- User explores via Google map and sets location,
- User selects a museum in this map,
- If user selects direction icon, system draws direction line (user current location with museum),
- If the user clicks car icon, system calculates taxi price,
- If the user clicks bus icon, system gives options bus name for current location,
- If the user clicks walk icon, system calculates the distance (user current location with museum).

Main concept of the designed system listed in the second use case model and illustrated in Fig.4.

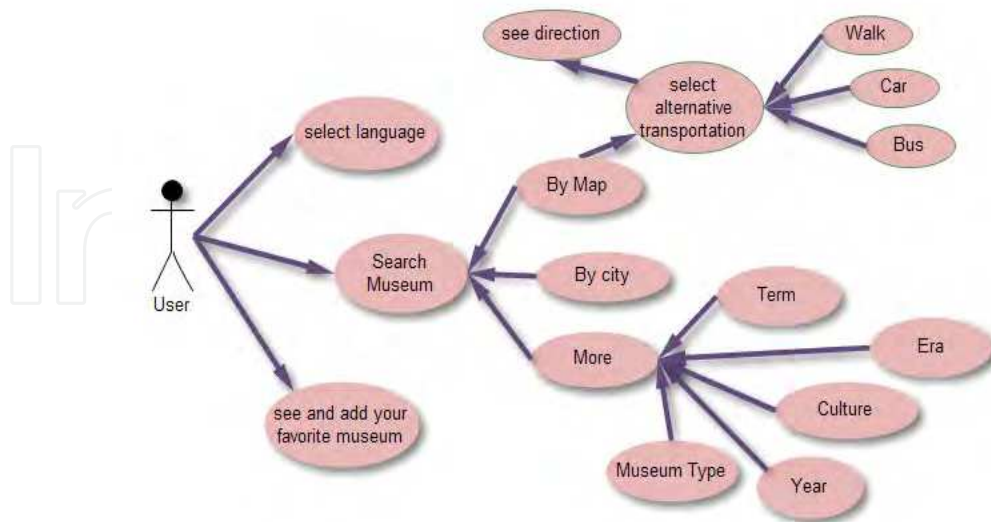


Fig. 4. Use Case Modeling diagram for searching museums

Functional requirements can be best obtained by using use case models (Jacobsen et al., 1992; Jacobsen et al., 1998). Business analysts and system analysts prefer to prepare the use



case models which include more practical business rules and descriptive statements of natural language. As mentioned before, use case modeling helps analysts to develop functional requirements and task models such as HTA or sub goal templates (SGT) are feeding user interface design stage. In the specification of use cases, the described activities are performed by entity when interacting with an actor (here end user or visitor).

Use cases, introduced by Jacobsen et al. (1992), versus task descriptions to identify sequences of actions, considering variants to generate a response from system to an actor (Booch, 1999). The definition emphasized that actions performed by system not user. The UML diagram reflects this, showing use cases as bubbles inside the system. Task descriptions don't cover

Quality requirements such as response time and usability, but they point out where quality is crucial (Lauesen, 2003). As Lauesen (2003) declared that, a UML use case diagram, which deals only with the computer system's actions and separate human and computer actions; but the task descriptions, which do not separate human and computer actions. This feature supports the requirements engineering activities based on the object oriented analysis and design side.

Use Cases	Description
Use Case 1	User changes language
Use Case 2	Find your current location and Museum location, explore the map. User get real time direction to museum User get distance to museum User get transportation option (taxi, bus, on foot)
Use Case 3	User search museums with some criteria (this criteria: by map, by city, museum type, culture, term, era, year)
Use Case 4	User adds favorite museums to favorite page.
Use Case 5	User display museum search result with some criteria (display all, A to-Z, area, distance, popularity)
Use Case 6	User display overview about selected museum and rate it.
Use Case 7	User display selected museum's exhibitions.
Use Case 8	User display selected museum's floor plan.
Use Case 9	User downloads selected museum's application.
Use Case 10	User display selected museum's multimedia tours.
Use Case 11	User display museum calendar (what's happening today, tomorrow and this weekend)
Use Case 12	User gets detailed information about selected museum (address, phone, web site address etc.)
Use Case 13	User searches alternative restaurant, café, shops near the selected museum.
Use Case 14	User share museum opinion with social network (Facebook, Twitter etc.)

Table 1. Use cases for MMG

One of the most important components of UML is the class diagram, that model the information on the domain of interest in terms of objects organized in classes and relationships between them. UML class diagrams allow for modeling, in a declarative way,

the static structure of an application domain, in terms of concepts and relations between them (Fowler and Scott, 1997).

A UML class diagram represents a set of objects with common features. A class has a rectangle and top the shape consist the name of the class. The attributes of the class diagram are denoted in the second cell of the rectangle. Third cell consists of the operations that associated to the object of the class (Berardi et al., 2005). N-ary association shows more than three connections between classes. Figure 5 illustrates the class diagram for MMG study.

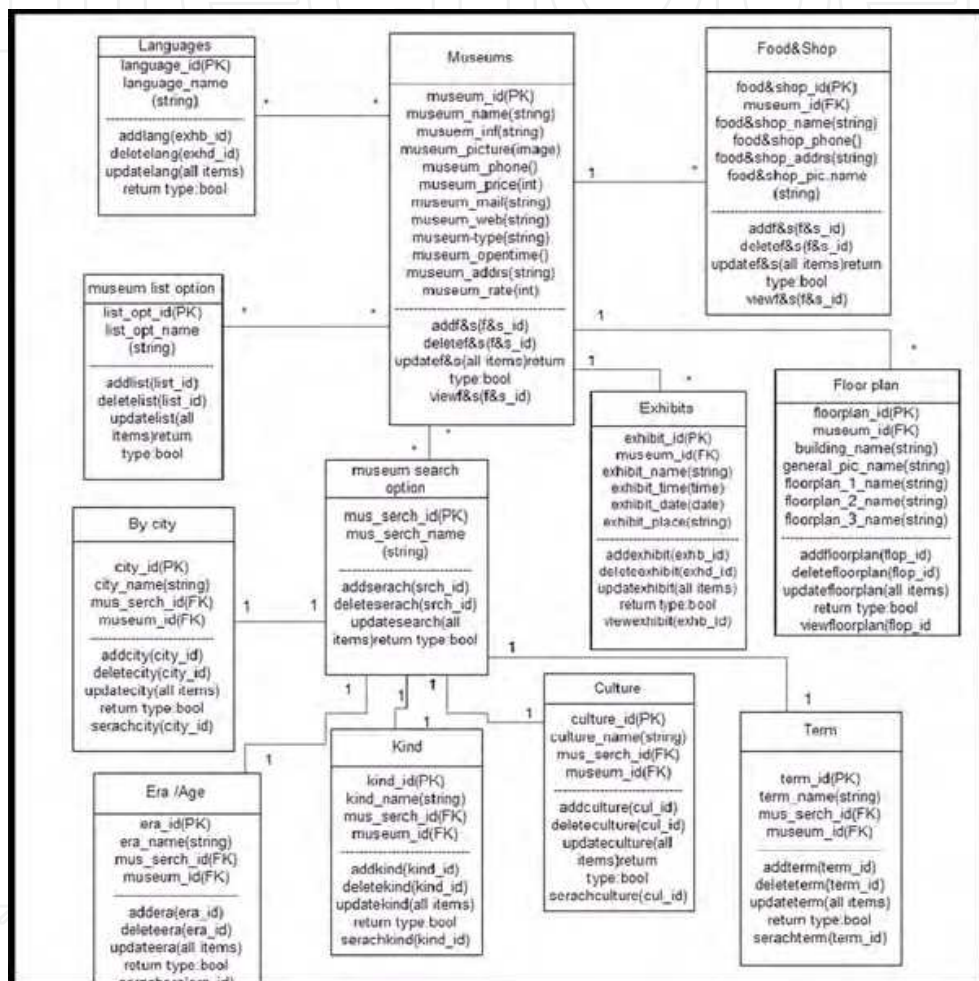


Fig. 5. Class diagram for MMG

Dynamic behavior of a system can be modeled in UML based sequence diagrams and proposed that at least a sequence diagram have to be drawn for per Use Case to describe the behavior of the sub system more efficiently (Jacobsen et al., 1992). By using the Use Case’s description, first version of the sequence diagram can be prepared. In the design process, the Use Case diagram or the Sequence diagram might be updated till fine and tuning satisfied (Larman, 1998). A sequence diagram has two parts, the vertical side represents time, and the horizontal side represents the different classes. Time proceeds down the page and, there is no significance to the horizontal ordering of the object types (Jacobsen et al., 1992). In figure 6, sequence diagram of museum search is depicted.

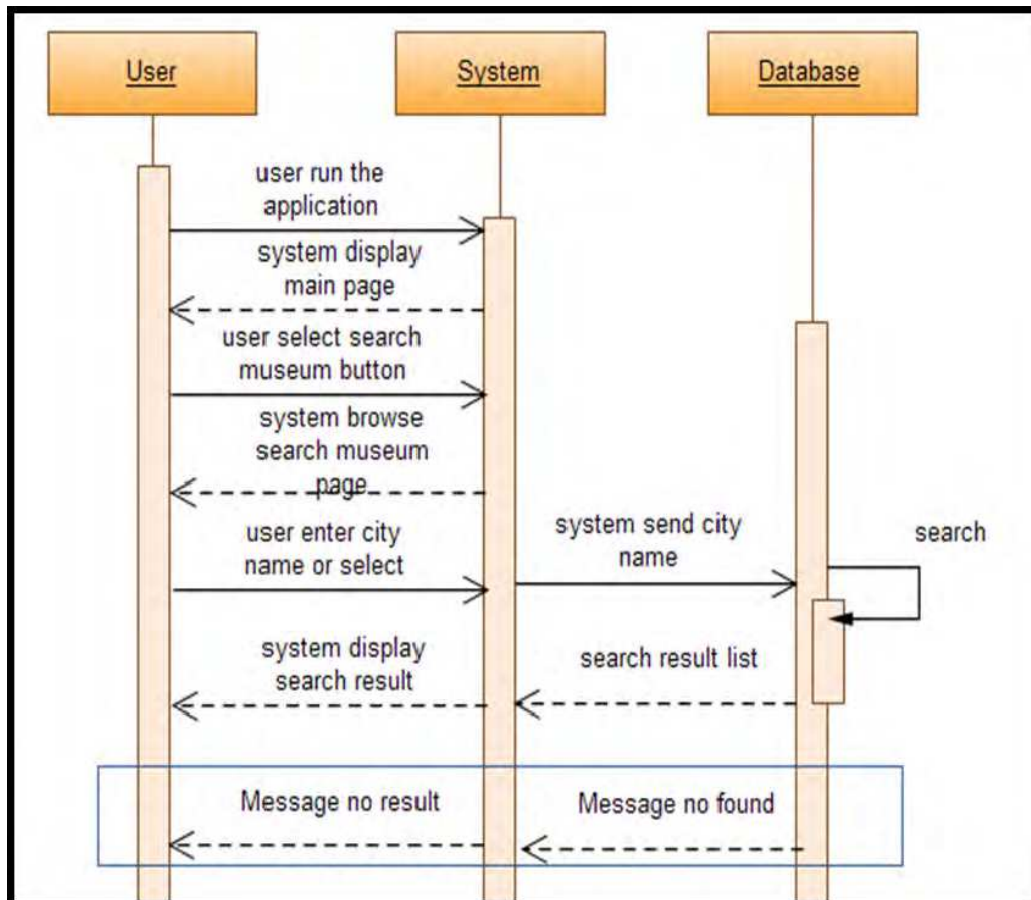


Fig. 6. Sequence Diagram - User searching museum by city name

### 3.3 User interface designing activities for MMG










Usability of mobile device depends on the size. Shneiderman's "Golden Rules for interface design" covers eight interface design guidelines (Shneiderman, 1998). But four of them can directly be applied to the mobile devices;












- Enable frequent users to use shortcuts,
- Offer informative feedback,
- Design dialogs to yield closure,
- Support internal locus of control.

Gong and Tarasewich (2004) propose modifications on other four design guidelines.

- Consistency (create input/output methodologies which are device independent),
- Reversal of actions (mobile applications should rely network connectivity as little as possible),
- Error prevention and simple error handling,
- Reduce short-term memory load (recognition of function choices instead of memorization of commands),

Following mock-up designs are constructed by considering the modified Golden Rules for interface design.

 <p>In the main mockup screen, user can select language information for the mobile application or select the search museum button. User can use action bar.</p>	 <p>The user can change mobile application language with this page.</p>	 <p>This mockup screen helps for searching museums. The user can enter city name and all museums can be listed which located in that city. Also user can search museums by map.</p>
 <p>In this mockup screen, selected city's museums are listed. The visitor displays all museum and sort by selected category.</p>	 <p>This mockup screen shows Google map to select museum via map. The user can reach the selected museum in map. MMG offers selections to reach there (car/bus/walk).</p>	 <p>In this mockup screen Google map helps visitor to reach museum. Application gets visitors location by GPS and calculates the distance to reach the museum. The user can see selected museum in map. He can see the distance to museum.</p>
 <p>This mockup screen has Google map. The user can see selected museum in map. Application offers an option to visitors for go there (car/bus/walk).</p>	 <p>This mockup screen helps visitor for searching museum by using criteria. These criteria are museum kind, culture, term, year, era.</p>	 <p>This mockup screen shows selected museum by the kind criteria. The user can see some kind of museums if visitor finds a specific museum he finds it very fast with This searching criterion.</p>

 <p>This mockup screen displays selected criteria result. Visitor can find museum's rate and distance.</p>	 <p>This mockup screen displays overview about selected museum. User can rate this museum.</p>	 <p>This mockup screen displays museum's floor plan.</p>
 <p>This mockup screen shows social network page. User can give some comment for visited museum.</p>	 <p>This mockup screen shows different alternative places such as restaurant, café, and shop for near the selected museum.</p>	 <p>This mockup screen shows selected museum and details information about this museum. User can access the selected museum's overview, details, exhibits, reviews, floor plans.</p>
 <p>This mockup screen displays information page of selected museum. User can reach museum address, phone, city, open time and close time, and entry price.</p>	 <p>This mockup screen shows multimedia page of museum. Visitor can watch museum's introduction video.</p>	 <p>This mockup screen displays culture criteria for searching museum. User can select a culture and list the selected culture's related museum(s).</p>
 <p>This mockup screen displays term criteria for searching museum. User can select a term and list selected term's museum.</p>	 <p>This mockup screen shows selected era or age criteria for searching museum.</p>	

### 3.4 Usability analysis based on the ISO9241-11

The development of mobile applications has some important limitations; such as, size of the screen, memory and processing capacities of the smart phones. For these reasons, different design decision for the tasks has to be taking into account (Rauch, 2011). Nielsen (2011) reports that the mobile user experience improving slightly 59% to 62% and these success rates obtained by computing correctly versus incorrectly done tasks. Also, shown that, acceptance of mobile applications are better than mobile site. Even web site is good; success rate of mobile application usage is 76% and 64% for web site success rate.

These feedbacks show that mobile applications may suffer from the usability and design issues. To handle design issues effectively, mobile interface analysis and design stages have to be supported with mock-up usability tests. As Nielsen (2009) reported that, since WAP phones (2000), there is not progress in task performance. He conducted two simple tasks to users and expected that current phones have improvement from usability perspective. But, results show that feature phones (regular cellular phone) have worst user experience when accessing web sites. Smart phones and touch phones have average success rates 55% and 75% respectively when accessing web sites. Bigger screen of the mobile phones provides better user experience (Nielsen, 2009).

Activity	Average Results
1. Time to complete to task	234 seconds
2. Percent of task completed	%86
3. Percent of task completed per unit time	%69
4. Ratio of success to failures	0
5. Time spent in errors	0
6. Percent or number of errors	0
7. Number of competitors better than it	2
8. The number of commands used	10
9. Frequency of help and documentation use	0
10. Percent of favorable/unfavorable user comments	%50
11. Number of repetitions of failed commands	0
12. Number of runs of success and failures	0
13. Number of times interface misleads the user	2
14. Number of good and bad feature recalled by users	2
15. Number of available commands nor invoked	16
16. Number of regressive behaviors	1
17. Number of users preferring your system	3/5
18. Number of time average number of users need to work around a problem	0
19. Number of times the user is disrupted from a work task	0
20. Number of times user loses control of the system	2
21. Number of times user expresses frustration of satisfaction	0

Table 2. ISO9241-11 Usability results

From these viewpoints, here, usability analysis conducted with five expert users with “search museums nearby here” scenario. In ISO9241 usability standard, twenty-one criteria can be used to measuring the usability and the possible ways to set the worst/best case and planned/now-level targets. These measurements are named as usability metrics. We now describe the development and evaluation of usability trails for MMG with five HCI experts to access on smart phones by performing ISO 9241-11 usability standard. Parameters and average trail results of the interfaces are listed in Table 2 for five experts.

#### 4. Conclusion

As a result, best way to provide information to people, seems to be mobile phones. But these devices have some miserable aspects such as screen size. To provide information efficiently and more rapid way, design aspects have to be consider for different sized mobile phones. Even mobile applications have usability advantages when compared with web sites; but also, they have also limitations, because of the design shortcomings. This chapter shows that mobile application development stages can be modeled by model driven software development in software development life cycle. Mobile applications development platforms and programming languages can be different. But, main design idea is same; keep it simple, accessible and minimal. Complex and confused design strategies might be hazardous for mobile applications and web sites.

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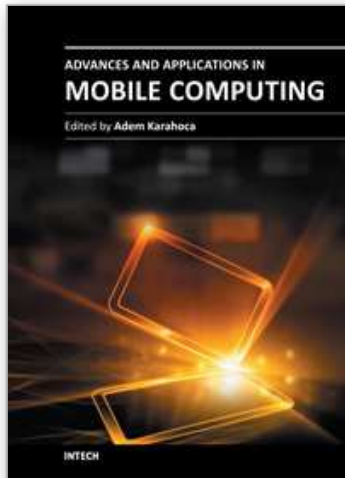
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## **Advances and Applications in Mobile Computing**

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Advances and Applications in Mobile Computing offers guidelines on how mobile software services can be used in order to simplify the mobile users' life. The main contribution of this book is enhancing mobile software application development stages as analysis, design, development and test. Also, recent mobile network technologies such as algorithms, decreasing energy consumption in mobile network, and fault tolerance in distributed mobile computing are the main concern of the first section. In the mobile software life cycle section, the chapter on human computer interaction discusses mobile device handset design strategies, following the chapters on mobile application testing strategies. The last section, mobile applications as service, covers different mobile solutions and different application sectors.

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