Key issues for the design and development of mobile commerce services and applications

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Abstract: This paper suggests a new approach for developing m-commerce services and applications based on a scheme that divides m-applications into directory- and transaction-oriented classes, identifies mobile user requirements, and takes into consideration the constraints of current technologies for mobile and wireless computing. The efficacy of the proposed approach in a real scenario is discussed.

Keywords: m-commerce; quality; mobile user requirements; mobile services; mobile applications.


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1 Introduction

Mobile commerce (m-commerce) is creating entirely new opportunities both for mobile devices and services. M-commerce enables the performing of transactions using a wireless device and data connection, which results in the transfer of value in exchange of information, services, or goods. An m-commerce transaction is defined as any type of transaction of an economic value that is conducted through a mobile device which uses a wireless telecommunications network for communication with the electronic commerce (e-commerce) infrastructure [1]. While m-commerce has evolved from e-commerce, it differs partially from e-commerce due to the special characteristics and constraints the mobile devices and wireless networks have, as well as to the specialised mobile users’ needs and requirements.

The number of users of mobile devices is continuously increasing. A projected number of handheld (mobile) devices will exceed the number of stationary terminals in the world in the next few years [2]. People on the move want services, information, and entertainment that move with them. With access to mobile devices, such applications and services can happen here and now. Mobile services benefit from three major factors that boost information value to end users: personalisation, time-sensitivity, and location awareness [3]. Combining these elements adds even more value.

M-commerce services and applications can be adopted through different wireless and mobile networks, with the aid of a variety of mobile devices. Although there are many systems supporting mobility and many solutions for wireless access, there are issues influencing the performance of the various mobile systems that need to be considered in the design of m-commerce services and applications. This applies especially to mobile devices that exhibit some major drawbacks compared to desktop systems.

A critical factor in designing quality m-commerce services and applications is the need for identification of the mobile user requirements to ensure that the service or the application is developed according to these needs. The classification of services with their unique properties is another important factor for detecting key activities of the design process based on the identified mobile user requirements and the constraints of mobile devices and technologies.

In this paper, we suggest a new approach for designing and developing m-commerce services and applications aiming at enhancing existing design methodologies. This approach focuses on improving the quality of mobile commerce applications by taking into consideration the unique mobile user needs and requirements, as well as the current technologies for mobile and wireless computing with their constraints. To facilitate the
applicability of our approach, a specific type of classification of m-commerce services and applications is proposed, which allows for the identification of specific design constraints posed by the mobile user requirements on one hand, and the available mobile communication infrastructure on the other.

The paper is organised as follows: Section 2 briefly reviews the various wireless and mobile networks and devices, together with their constraints, and discusses technical issues affecting the quality of mobile applications and services. Section 3 addresses the identification of mobile user requirements and Section 4 classifies the m-commerce services and applications in two major classes, directory-oriented and transaction-oriented. Section 5 suggests a new approach for designing and developing m-commerce services and applications called MobE that takes into consideration the mobile user requirements and integrates them with the proposed classification of m-commerce services and the constraints associated with the various mobile devices and technologies. Section 6 demonstrates the proposed approach through a mobile travel agency application. Finally, Section 7 presents the conclusions and suggests future work.

2 Mobile devices and technologies

Mobile commerce is an evolving area of e-commerce due to the continually increasing demand by the users of an ever-increasing number of mobile (handheld) devices to interact with advanced services offered by mobile e-service providers. These services enable mobile users to exploit the advantages of internet, mobile computing, and mobile communications. The interaction between mobile users and service providers is accomplished through different mobile and wireless networks. M-commerce is an interdisciplinary study covering mobile communications, computer science, business, and other studies. Therefore, a brief introduction of the current mobile devices and technologies, as well as the technical issues affecting the quality of m-commerce applications and services, is necessary for the reader to understand the concept of this paper.

M-commerce services can be adopted through different systems supporting mobility and many solutions for wireless access, like wireless telecommunications networks, namely cellular networks (GSM, GPRS, UMTS) and other wireless networks, as for example IP Wireless Local Area Networks (WLANs) using the IEEE standard 802.11× technologies [2]. The current situation, therefore, can be considered as facilitating mobile handheld devices by IP-based technologies to connect directly within the IP network or by wireless access technologies through WLANs or GPRS/UMTS cellular networks preferably interoperable, offering seamless provision of services at all network layers (i.e., physical to application) [4]. Thus, the exponential growth of wireless and mobile networks is bringing vast changes in mobile devices, such as multifunction interfaces and multiple network connections (such as GSM/GPRS/Bluetooth, WLAN, etc.).
2.1 Mobile devices

Services that are offered through the internet for stand-alone PCs, are now also available for users that use mobile handheld devices [4]. The design of mobile commerce applications and services though, should consider the constraints of the mobile devices, as well as the network resources and capabilities available. Table 1 presents the most significant technological constraints and classifies the impact on the design process of each constraint as high, medium, or low for each type of mobile device. For example, when a mobile service provider wishes to offer its mobile users the ability to purchase airline tickets, several constraints affect the design and development of the m-commerce application according to the mobile device used. If the mobile customer uses a mobile phone, constraints such as, small screen, small multifunction keypads, and graphical limitations, have a high impact, while if he uses a palm computer the constraints impact is lower.

<table>
<thead>
<tr>
<th>m-commerce constraints</th>
<th>Mobile phone</th>
<th>PDA</th>
<th>Palm</th>
<th>Laptop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small screen</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Small multifunction keypads</td>
<td>High</td>
<td>Medium/high</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Limited computational power</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Limited memory</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Limited battery life</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Non-volatile capacity</td>
<td>High</td>
<td>High</td>
<td>Medium/high</td>
<td>Low</td>
</tr>
<tr>
<td>Low display resolution</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Unfriendly user interface</td>
<td>High</td>
<td>Medium/high</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Graphical limitations</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Complicated text input mechanisms</td>
<td>High</td>
<td>Medium/high</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Limited security</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Limited bandwidth</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Low connection stability</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

Service providers can offer services and applications supporting localisation and personalisation through the emerging wireless technologies with better Quality of Service (QoS). Mobile users demand flexibility to carry out tasks (e.g., sending and receiving emails, browsing the internet, performing financial transactions, etc.) based on their personal preferences and regardless of their geographical location. Mobile users require location-based services and information; thus, modern mobile devices must have high computing and communication capabilities, low power consumption, standardised operating system to run many applications and advanced roaming capabilities. All the above, except advanced communication and roaming capabilities, are covered by the mobile devices vendors who produce advanced mobile devices. The continuous advancement of mobile technologies allows the mobile devices to achieve higher communication rates and more roaming capabilities.
Currently, most types of mobile networks can be equally compared in terms of services, capacity, communication rates and coverage with fixed networks. Table 2 provides a comparison of practical m-commerce factors for various mobile and wireless networks.

**Table 2** A comparison of practical m-commerce factors for various mobile and wireless networks

<table>
<thead>
<tr>
<th>Factors</th>
<th>Wireless LANs</th>
<th>Cellular networks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IEEE 802.11x</strong></td>
<td>Local</td>
<td>Wide</td>
</tr>
<tr>
<td><strong>Available capacity</strong></td>
<td>Up to 54 Mbit/sec</td>
<td>114 (effectively 30) Kbit/sec</td>
</tr>
<tr>
<td><strong>Application</strong></td>
<td>Data</td>
<td>Data and voice</td>
</tr>
<tr>
<td><strong>Limitations</strong></td>
<td>Security</td>
<td>Low capacity</td>
</tr>
<tr>
<td></td>
<td>Limited area</td>
<td>Billing schemes</td>
</tr>
<tr>
<td></td>
<td>(100’s of</td>
<td>Lack of services</td>
</tr>
<tr>
<td></td>
<td>metres)</td>
<td>Security</td>
</tr>
<tr>
<td></td>
<td>Security</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Authentication methods</td>
<td></td>
</tr>
<tr>
<td><strong>Status</strong></td>
<td>In use</td>
<td>In use</td>
</tr>
</tbody>
</table>

The main representatives of these protocol families are IEEE 802.11a, IEEE 802.11b, and IEEE 802.11g. Bluetooth was originally designed for Personal Area Networks (PANs). PANs are networks of devices such as mobile phones, digital cameras, camcorders, PCs, and other autonomous devices that are formed *ad hoc*. Within these networks these devices can exchange various forms of data. There are other forms of Wireless LANs such as HiperLan, HiperLan2, HomeRF, but our purpose is not to examine these networks but rather to show that other standards and protocols exist as alternative mobile and wireless communication technologies, each one with its own properties and capabilities that enable different methods of conducting m-commerce.

2.2 Technical issues affecting the quality of mobile applications and services

Mobile commerce applications and services depend heavily on the underlying network support. As discussed, two of the most significant factors that influence the development and the quality of certain applications and services are the available bandwidth offered by the wireless networks, and the coverage (Table 2 summarises these factors for various wireless networks). Undoubtedly the factors that need to be considered when designing a mobile service or application include the coverage area characteristics, the available capacity of the network, the type of service or application to be developed, and the various limitations of the networks, such as security, authentication, billing schemes, etc.
Furthermore, connectivity (and the associated topic of seamless handovers) is another issue that influences the quality of the mobile commerce applications and services; obviously, disconnections seriously affect the quality offered [5].

In addition, some key issues influencing the performance of the various mobile systems are the following [6–7]:

- **Interference**: High loss rates due to the fact that radio transmission cannot be protected against interference.

- **Low bandwidth**: Although they are continuously increasing, transmission rates are still very low for wireless devices compared to fixed-wired networks. Local wireless systems reach some Mbit/sec, while wide area systems only offer some 10s Kbit/sec.

- **High delays, large delay variation**: High delays of hundred milliseconds to seconds may occur.

- **Lower security, simpler to attack**: The radio interface is prone to the danger of being attacked. Thus, wireless access always has to include encryption, authentication, and other security mechanisms (thus increasing complexity and delay).

- **Frequent disconnections**: Cell interference, limited cell capacity or lack of network coverage may lead to frequent disconnections.

By developing an application or offering a service suitable for mobile commerce, one should have in mind the constraints of the underlying network infrastructure and how a specific wireless network will satisfy important quality parameters in order to prevent the degradation of the performance of mobile commerce applications and services in terms of e.g. blocking and disconnection of service, or delay and loss of data. Therefore, what is required is the use of reliable and survivable mobile and wireless technologies, so that mobile users can access mobile commerce applications and services with the minimum performance degradation. Furthermore, roaming across multiple heterogeneous networks can provide the availability of the mobile commerce applications and services from anywhere [8]. Much research work is done nowadays in the interoperability of different wireless technologies, like Wireless LAN and 3rd Generation Mobile Networks (UMTS) (see e.g. [6]) and of seamless roaming and handovers.

The understanding of existing mobile networks and devices technologies, together with mobile user requirements, described in the next section, is necessary for the m-commerce engineer to guide the successful design and development of quality m-commerce services and applications.

3 **Mobile user requirements**

M-commerce includes features and characteristics that are different from e-commerce, and these should be taken into consideration during the design and development of m-commerce services and applications. Table 3 provides examples of m-commerce applications linked to their more salient features [9–10]:

- **Ubiquity**: Mobile users must have the ability to receive information and perform transactions in real time, regardless of location. M-commerce can be present in any location or several places simultaneously.
• **Personalisation:** The huge amount of information, services, and applications presented on the internet is of great importance, but users of mobile devices require different services and applications that should be personalised according to their preferences.

• **Flexibility:** Users of mobile devices should be able to engage in activities such as receiving information and conducting transactions with ease.

• **Localisation:** Mobile users should have access to local information and services. This can be accomplished by having service providers know the location of mobile users in order to promote their products and services directly to their customers in a local environment.

<table>
<thead>
<tr>
<th><strong>Table 3</strong></th>
<th>Examples of m-commerce applications with their more salient features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>M-commerce features</strong></td>
<td><strong>Examples of m-commerce applications</strong></td>
</tr>
</tbody>
</table>
| Ubiquity | Stock prices  
| | Weather |
| Personalisation | Advertising  
| | Auctions |
| Flexibility | Purchase of goods  
| | Banking |
| Localisation | Customer service  
| | Local directory |

While there are similarities between e-commerce and m-commerce, the latter should be recognised as a unique business opportunity with its own unique characteristics and functions, and not just an extension of an organisation’s internet-based e-commerce channel. As such, these characteristics should first be fully understood and then drive the development activities of a mobile application.

M-commerce customers may be more demanding and less patient than e-commerce users [11]. Mobile users require value-added services that can be feasible or non-feasible according to existing technologies and m-commerce constraints, such as performance, reliability, security, ease of use, bandwidth, etc. Some of the most important basic user requirements may be summarised as follows:

• Easy and timely access to information (*e.g.*, the latest availability of flights).

• Immediate purchase opportunity (*e.g.*, the immediate purchase of tickets).

• Provision of wireless coupons based on user profiles (*e.g.*, the delivery of messages about a current sale in a local store).

• Financial or banking transaction ability through mobile terminals (*e.g.*, the withdrawal of money from an account that can be used later for an electronic payment).

• Location management (*e.g.*, locating a person/ATM/restaurant that is nearby).

• Personalisation capabilities (*e.g.*, adjusting the size of the fonts on the screen or the colours of the user interface based on user preferences).
To afford Quality of Service (QoS) in mobile applications and services demands provision of quality in three areas: the device and its respective protocols, the application, and the communication infrastructure. Customer satisfaction is directly or indirectly related with certain quality factors. Looking at the software quality factors as defined by the ISO 9126 [12] together with certain web quality factors [13] we can state that functionality, reliability, usability, efficiency, maintainability, and portability are key quality criteria for the mobile consumer’s satisfaction. More specifically:

- **Functionality**: Functionality refers to issues, such as suitability, accuracy, interoperability, compliance and security, that need to be investigated in designing a mobile application, or providing a wireless service to ensure that the mobile device and its application performs as it is expected to.

- **Reliability**: Producing a reliable application involves understanding issues such as maturity, fault tolerance, crash frequency, and recoverability in both the underlying hardware and the software application that runs on this hardware. The mobile device must maintain a specified level of performance in case of software or hardware faults with the minimum crashes possible. Both the device and the software application should also have the ability to reestablish their level of performance and must consistently produce the same results, and meet or even exceed users’ expectations.

- **Usability**: Issues like understandability, learnability, operability, friendliness, and playfulness are vital factors indicating the quality of the mobile service, highly contributing to further promotion and overall acceptance. The application should allow easy understanding of its functioning and behaviour even by novice m-commerce users. Aesthetics of user-interface, consistency and ease-of-use are attributes of easy-to-learn systems with rapid learning curve. Taking into consideration human emotions, an application may provide friendly messages to the user adapted to his/her personal profile. Playfulness is a significant feature that should be examined to see whether it is required by the application and if so, to what extent. It is important to note that playfulness is a critical success factor for certain mobile applications.

- **Efficiency**: The response-time performance of a mobile system (device and software application) should be high enough to satisfy user demands. Fast access to information must be examined to ensure that users’ requirements are met on one hand, and that the system is competitive and useful on another.

- **Maintainability**: Some crucial features related to maintaining a mobile application is its analysability, changeability, stability, and testability. With the rapid technological changes especially in the area of wireless technologies, as well as the rigorous user requirements for continuous, new and updated services, easy system modifications and enhancements, both in content and in the way this content is presented, are also success factors for a mobile application; therefore, the design process should include an examination whether the application is up-to-date.

- **Portability**: The ability of the mobile application to be installed and run by any mobile device as well as to be adaptive to different specified environments are also critical success factors for the design and development of mobile commerce applications and services.
Providing QoS in m-commerce requires in-depth understanding of the factors that are considered critical for the design and development of an m-commerce system (i.e. the mobile user requirements and the technology constraints). Therefore, a classification of m-commerce services is necessary to identify precisely the requirements and constraints for a given application and tackle specific problems and concerns that may be encountered during the design process. A certain type of classification is proposed and described in the next section.

4 M-commerce services and applications classification

A classification of m-commerce services and applications is necessary to better understand the m-commerce features and characteristics, as well as the mobile user requirements for the design and development of these services and applications. The classification can assist analysts to reveal critical factors and requirements for the design of m-commerce services and applications that methodologies tend to miss, and guide designers to develop systems of high quality. One way to classify m-commerce services and applications is by examining the functionality they provide to the mobile users. This kind of classification results in two major classes, the directory- and the transaction-oriented services and applications. The major difference between these two classes of services is that in the former a mobile user performs only read requests to a directory, whereas in the latter a user performs read and write requests to a transaction server. One may argue that there is also a third class of applications, the nomadic or peer-to-peer class, but after a detailed analysis of the properties of this class we end up to the conclusion that it is essentially included in the directory or the transaction-oriented classes: If we assign the roles of the client or the server to the peers and we constantly interchange these roles, then the peer-to-peer model of computation may be viewed either as a directory- or transaction-oriented model.

The directory-oriented class of m-commerce services comprises applications that provide information to mobile users. This information must be highly available to the mobile user, independent of location and technology constraints. Quick access and response time are very important requirements for providing fast information to the mobile user wishing to efficiently use an m-commerce service. Searching for an m-commerce service should be easy and simple, utilising rule filtering for each request. Directory-oriented services should include security mechanisms for safeguarding the information presented to the mobile user. The m-service should also be location, content, and user dependent, being localised and personalised in ways appropriate to the specific mobile user. For example, a mobile user, being away from home, needs up-to-date information regarding his/her current location as well as local facilities that he/she can use. Note that directory-oriented m-commerce services can also be offered via broadcast.

The transaction-oriented class comprises various services and applications with which the mobile user conducts transactions with the service provider. The transactions contain read and write operations on behalf of the mobile user. Security is a critical factor in performing an m-commerce transaction for protecting the user’s personal data as well as the service’s information. Therefore, requirements and constraints in developing a secure service for m-commerce transactions include bounded execution time for each transaction request, data consistency, data integrity and redundancy.
Table 4 provides a sample list of constraints and requirements for the directory- and transaction-oriented m-commerce services. While there are services that belong only to the directory-oriented class, others can attribute from both the directory-oriented and the transaction-oriented categories, for example, the last minute purchase of a flight ticket, which requires quick access and response time from a directory-oriented service and bounded transaction execution time, data integrity and security for the actual transaction to be performed.

<table>
<thead>
<tr>
<th>Directory-oriented</th>
<th>Transaction-oriented</th>
</tr>
</thead>
<tbody>
<tr>
<td>High availability</td>
<td>Security</td>
</tr>
<tr>
<td>Quick access time</td>
<td>Data consistency</td>
</tr>
<tr>
<td>Quick response time</td>
<td>Data integrity</td>
</tr>
<tr>
<td>Localisation</td>
<td>Redundancy</td>
</tr>
<tr>
<td>Personalisation</td>
<td>Bounded transaction execution time</td>
</tr>
<tr>
<td>Filtering (rules filtering)</td>
<td></td>
</tr>
<tr>
<td>Security</td>
<td></td>
</tr>
</tbody>
</table>

The current mobile and wireless technologies suffer from constraints due to the wireless and mobile environment, as these were described in Section 2. These constraints influence the transaction-oriented m-commerce services in a much higher degree in terms of operation than the directory-oriented m-commerce services. Problems like frequent and sudden disconnections, weak connectivity, and high delays degrade the quality of service offered to mobile users and add complexity to the service provider. Consequently, the service provider must find ways and solutions to deal with these problems in order to maintain high quality levels of the service and reduce the computational overhead that derives from the disconnected users’ active sessions.

The significance of the above classification of services lays to the fact that it can help the service providers to deal with specific problems of each class independently. In the case of the directory-oriented m-commerce services and applications replication, copies of the local content and copies on the base stations of the mobile infrastructure can assist the availability and increase the quality of this kind of services. On the other hand, strategies like the use of intercept agents and proxies on the fixed-wired network can increase the availability and stability of the transaction-oriented m-commerce. The use of intercept agents can also hide the problems and constraints of the mobile environment from the service provider and move the responsibility on the specially designed intercept agents [11].

Having identified the constraints of the existing mobile devices and technologies and the mobile user requirements and proposed the classification of m-commerce services to directory- and transaction-oriented, the next section describes a design and development approach for m-commerce services and applications.
5 A design and development approach for m-commerce services and applications

Web engineering and mobile engineering are different from traditional software engineering in several significant ways due to the unique features of web and mobile applications. These include:

- Support for heterogeneous user platforms.
- The design of user interfaces is of paramount importance.
- The design of applications and services must often be flexible enough to support adaptive changes.

In addition, traditional software engineering is employed where the number of users is limited, the users’ experience, location, and technology are known, and the user requirements are easier to identify. On the contrary, in web and mobile environments the number of users is ‘unlimited’, the users’ experience, location and technology are practically unknown, and the user requirements are difficult to identify. Therefore, web engineering processes and models have been developed extending and/or adapting existing classical software engineering methodologies (e.g., Waterfall, Spiral, Prototyping, etc.) to support these issues in the web application design and development. One may argue that user-driven design methodologies [14–16] incorporate users’ needs and suggestions at the early stages of the analysis and design process; this, however, is not applicable in the mobile engineering context due to the differences mentioned above, on one hand, and to the immediacy constraint in developing mobile applications and services [17] on the other. In addition, the evolution of m-commerce from e-commerce and the fact that both areas share similar characteristics drive the need for adopting a disciplined approach for designing mobile commerce applications and services based on successful web engineering methodologies.

In this section, we explain how the key issues previously identified can be incorporated into an existing successful web engineering process namely the WebE process [17]. This approach relies on the special needs and requirements of the mobile users as defined in Section 3, the classification of m-commerce services and applications presented in Section 4, as well as the current technologies for mobile and wireless computing and their constraints, already described in Section 2.

The proposed design and development approach is based on the WebE process, which is modified to include the requirements and peculiarities of designing and developing quality mobile services and applications. More specifically, the primary difference between the WebE and the proposed MobE process lies with the identification of mobile user requirements and their incorporation within the MobE, together with the specific classification already described and the consideration of the mobile devices and technologies constraints, which determine the successful implementation of a quality m-commerce service or application [18].

The proposed MobE process includes six phases (see Figure 1):

1. **Formulation**: Defines the tasks and goals of the m-commerce service/application and specifies the length of the first increment.
Key issues for the design and development of mobile commerce

2 **Planning:** Estimates the total project cost and the risks associated with it, and sets a time frame for the implementation of the first increment as well as the process of the next increments.

3 **Analysis:** Identifies all mobile user requirements and identifies the content items that will be incorporated.

4 **Engineering:** Involves two parallel tasks: (i) content design and Production, and (ii) architectural, navigation, and interface design.

5 **Service/application implementation and testing:** Codes and tests the m-commerce service/application.

6 **User evaluation:** Evaluates the interaction and usability in the mobile context by utilising several methods, such as empirical testing, discount usability, and cognitive and task analysis methods.

Figure 1 The MobE process for m-commerce services and applications

Our focus in explaining the MobE process is mainly concentrated on the Analysis and Engineering phases since our proposition involves the identification of mobile user requirements and the classification of m-commerce services in the Analysis phase, together with the identification of the constraints of mobile devices and technologies in the Engineering phase enhancing the quality of the m-commerce service or application. The rest of the phases are similar to the ones found in the WebE process; therefore we...
will avoid the repetition of describing them again. Following, we indicate the issues we propose to be considered during the Analysis and Engineering phases.

5.1 Analysis phase

This phase includes a complete analysis commonly found in a web engineering context comprising [17):

- **Content analysis**: The full spectrum of the content the mobile service/application contains (e.g., text, images, etc.)
- **Interaction analysis**: The detail description of the navigation mechanisms of the mobile service/application
- **Functional analysis**: The identification and explanation of all functions and operations of the mobile service/application
- **Configuration analysis**: The identification of the protocols, technologies, and infrastructure the mobile service/application will run on.

In addition, the introduction of mobile user requirements together with the classification of m-commerce services are utilised in the Analysis phase to reveal the full spectrum of the content to be provided by the m-commerce service or application as indicated by the arrow in the Analysis phase in Figure 1. More specifically, our proposition for the analysis of m-commerce services and applications is provided by a stepwise approach as follows:

**Step 1: Initial requirements elicitation**

As mentioned previously, the elicitation of requirements is a quite difficult task due to the absence of a clear group of users with which the analyst could meet and discuss their functional needs. Usually, though, an m-commerce service/application is developed on behalf of a client organisation, the latter wishing to address a specific target group of users in a certain market. Thus, the mobile engineer may gather a set of general requirements from the client organisation which will include all the necessary features for the m-commerce service or application to be functional and run according to the organisation’s objectives. This can be achieved by several methods, such as questionnaires and discussions with managers and executives of the client organisation, as well as by performing various forms of market research dedicated to the business/functional targets of the mobile service/application.

**Step 2: Identification of the class of service or application**

Once a basic set of requirements has been formed the next step is to classify the service/application under development in one of the two types proposed by the process, the directory- or transaction-oriented class. This is a key step in the m-commerce application and service development process. As mentioned in Section 4, the directory-oriented and the transaction-oriented class of services/applications share different constraints. By defining the class of service, the mobile engineer can examine the constraints posed by each of the two classes and further identify other distinct
requirements for that specific class or reform/define the collected general requirements according to the relevant constraints. Examples of m-commerce constraints related to the services and applications relate to navigation mechanisms, security, reliability, user interface, etc. For example, in the case of a mobile user who wishes to enter into a mobile transaction, the requirements of ease-of-navigation, high security, and reliability are just few of the factors that can be identified as having higher importance than in a directory-oriented service or application.

**Step 3: Detailed mobile user requirements elicitation**

This step builds upon the previous two steps and involves the gathering of the detailed mobile user requirements and the ranking of these requirements according to the user needs. While this may be considered a typical activity in the development of a software application, it is however, a complex task in the mobile engineering context. Apart from the fact that the potential users are unknown, there is also the difficulty introduced by the high number of possible mobile devices the users may operate and the characteristics of the underlying technological infrastructure (networking, communication). Having determined the class of services/application to be developed the analyst aims at refining to the best possible extent the set of general requirements collected in Step 1 and oriented by the constraints identified during Step 2. This refinement involves a more detailed description of the functional needs to be served by the service/application under development, a task that may be accomplished with the use of questionnaires and interviews of small groups of people that constitute the future users of the service/application. Paper or software prototypes may be used at this stage to verify the correctness and appropriateness of the functional part of the system. The important thing to note here is that the functional part of the user needs is driven and at the same time restricted by the characteristics and constraints of the class of service/application, as well as of the mobile devices to be supported and the available technological infrastructure. In addition, the general mobile user requirements of ubiquity, flexibility, personalisation, and localisation are examined under the same constraints’ prism. For example, under personalisation, the mobile user requirements for a wearable device (e.g., small, light and fashionable) are different from that of an executive’s mobile phone (e.g., videoconferencing, business ‘card’ exchange function and virtual secretary). These requirements need to be investigated thoroughly to assure the development of quality and successful mobile systems.

**Step 4: Quality requirements verification**

The mobile engineer must ensure that the analysis process and findings comply with the quality user requirements explained in Section 3. While all quality factors are important to be considered in this phase, great emphasis should be given primarily on functionality and usability. The examination of these two factors based on the collected requirements will enhance the possibility of producing a widely acceptable mobile service or application.
Step 5: Examination of human, social, cultural, and organisational issues

This step may be ignored initially because of its complexity and prolonged duration but it can be performed at a later stage to produce valuable complimentary information that would otherwise stay uncovered. Human, social, cultural, and organisational issues when explored can reveal hidden aspects of everyday working activities of end users that significantly affect the business targets and the functional requirements of the mobile service/application. Taking into account and incorporating such hidden factors in the set of requirements where appropriate may highly contribute to the quality of the overall design [19–20].

All the requirements and product features of the m-commerce application or service under development that are identified and prioritised will be utilised during the Engineering Phase. This way it will help the mobile engineer to design and develop a high quality application or service based on the customer and mobile user needs.

5.2 Engineering phase

As with the previous phase, this phase also utilises design and engineering practices commonly found in a web engineering context, comprising [17]:

- **Architectural design**: The overall structure and detailed layout of the information content.
- **Navigation design**: The design of navigation pathways that will enable the user to access the m-commerce content and services.
- **Interface design**: The design of the user interface of the mobile application.
- **Content design**: The generation of m-commerce content to be used by the mobile application or service.
- **Production**: The production of the material (e.g., graphics) to be used by the mobile application or service.

In addition, in the Engineering phase, the peculiarities of the mobile environment and devices reported in Section 2 (e.g., tiny displays, drain of batteries, connectivity problems, and diverse device profiles), together with the mobile user requirements of the specific class of m-commerce services identified in the previous phase need to be considered. This consideration enables the orientation of both the type and volume of content, the form of the navigating facilities to access this content, and finally, the m-commerce device interface, as well as the architectural design of the whole system. Therefore, it is necessary to examine the constraints of mobile networks and devices and comply with restrictions they pose both at the architectural and the detailed design of the mobile service/application.

The Engineering phase also follows a stepwise approach for the development of an m-commerce application or service explained below:
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Step 1: Examination/incorporation of mobile devices constraints
While the mobile service may be ‘open’ to run in various mobile devices, there are certain cases that services or applications are designed for a specific mobile device. This step is dedicated to address and examine in detail the constraints of these mobile devices in order for the mobile engineer to design the application to fit in those limits of each targeted mobile device. For example, an application that requires extensive input (e.g., a game) must be designed differently when it is run on a mobile phone than on a laptop. One constraint in this case is the small keypad found on mobile phones. While on a laptop this may seem not to be a main problem, different ways must be found to input data.

Step 2: Examination/incorporation of wireless networks constraints
Same as before, this step is involved with the detailed examination of wireless networks constraints, which will assist the mobile engineer to design the application in the boundaries they pose. The mobile engineer should keep in mind the available network together with its limitations, available capacity, coverage area, and the type of data to be transferred.

Step 3: M-commerce service/application design
This final step performs the actual design of the m-commerce application or service based on the findings of the previous two steps, as well as those of the Analysis phase. The design includes all the activities as explained before: architectural design, navigation design, interface design, and content design.

Examining in-depth the constraints of mobile devices and technologies in the Engineering phase and utilising the findings during design are critical activities that drive the successful design and development of m-commerce services and applications.

6 Application of the proposed approach
In this section, we will briefly discuss the efficacy of our proposed approach in a real scenario. Particularly, in order to demonstrate our approach, we have investigated a travel agency’s attempt to design and implement a mobile application that aims to sell tickets.

The travel agency under investigation is one of the biggest companies in the travel industry in Cyprus. The creation of the company was the result of a merger between two large travel agencies in 1989, which have dominated the industry for years. Their merger aimed to create a stronger organisation, which could successfully compete with bigger firms in the European and international markets. The company’s activities include Ticketing, Outgoing tourism, Incoming tourism, Cruises, Representation of airline companies (Aviation), Organisation of conferences and athletic events, International shipping, Freight forwarding, Cargo logistics, Travel and marine insurance.

Recently, e-commerce and generally e-business became a new channel for the company not only for approaching its customers (Business to Customer channel) but also a channel to contact other partners and associates (Business to Business channel). Therefore, the company’s top management thinks of e-business as an opportunity for
further business development. The management’s vision was to create, within the company, the necessary structure and processes to enable the company to take advantage of the great opportunity presented by the adoption of e-business and become a leader in introducing e-commerce in the travel industry of Cyprus.

In order to gain a significant strategic advantage and stay ahead of the competition, the top management decided to enter the world of m-commerce. The company developed an m-business strategy that stays in-line with its e-business strategy. The idea was to be able to sell most of their products and services to end-customers and business associates, through any mobile device.

The design and development of the specific mobile commerce application were carried out using the proposed MobE process. During the Analysis phase, the constraints and requirements were first identified and the services were classified both as directory-oriented and transaction-oriented. Particularly, under the directory-oriented category the mobile service would have to provide the destinations and prices, as well as promotional offers. The mobile users’ demands identified were summarised as follows:

- quick access to and response from the system
- high availability
- easy navigation mechanisms
- profile with the user’s preferences about destinations and own personal information
- information about the travel agency’s offices based on location of the mobile user.

Under the transaction-oriented category, the system would allow purchases of tickets using any mobile device. Emphasis for the provision of m-purchases was given on bounded transaction execution time, data consistency, data integrity, security and redundancy.

In the Engineering phase, we followed the mobile user requirements as identified in Section 3 to develop a quality m-application. Particularly, the m-application should offer all required functions provided by the company, which included the listing of destinations together with their prices, promotional offers, as well as the ability to purchase tickets. Accuracy, compliance, interoperability and security were considered as primary quality factors for the functionality of the system. The m-application was designed on one hand to be highly available and reliable with the least possible disconnections, and on the other hand to be able to quickly recover itself and continue offering the service to the mobile customers. Main emphasis during the design of the system was given on the usability and more specifically on the understandability, learnability, and navigability of the m-application, factors that were considered critical for the quality of the mobile application, highly contributing to further promotion and overall acceptance. The m-application was designed to efficiently provide fast access to information and quick purchase of tickets. The m-service developed provides daily updates in content with new offers and destinations and the system is modified and enhanced whenever is necessary to provide more services and improve its overall quality. The m-application can be run on any mobile device, as well as to be adaptive to different specified environments (e.g., GPRS, UMTS, etc).

The tasks of the Engineering Phase of the MobE process for m-commerce services and applications, involved the architectural, navigation, interface, and content design, as well as the final production of the m-commerce application, taking into consideration the
constraints of mobile devices and technologies, together with the specific mobile user requirements identified in the previous phase. The application under study keeps a user profile to avoid certain constraints, such as small screens, small multifunction keypads, and limited computational power encountered in offering quality mobile services. Keeping a user profile it also allows reduction of steps in accomplishing a specific task (e.g., when a mobile user wishes to be informed about promotions). Among the several mobile devices and technology constraints aforementioned, security was a main issue addressed in the design of the transaction-oriented operation. Security weaknesses were observed with un-encrypted data cached in the WAP gateway. In the mobile travel agency application data transmission from the WAP Gateway to the travel office takes place over a secure connection (using SSL 3.0) with 128-bit encryption. The WTLS (Wireless Transport Layer Security) protocol guarantees security for the agency’s customers. WTLS ensures that data are protected during transmission between the mobile device and the WAP Gateway [21–22].

Figure 2 presents some of the functions provided by the travel m-application. At present, the mobile user is able to search for destinations, make reservations, and purchase tickets. In the near future, the company aims at expanding its line of products and services with the use of m-commerce to shipping and freight.

Figure 2 Sample screenshots of the travel m-application

The short presentation of the process followed to develop the travel mobile application demonstrated the way to execute its specific steps and provided evidences that the proposed m-commerce services and applications design and development approach is able to capture and tackle the problems encountered by properly identifying and incorporating user requirements and constraints, thus offering high quality mobile applications.
7 Conclusion

M-commerce is an evolving area of e-commerce, where users can interact with the service providers through a mobile and wireless network, using mobile devices for information retrieval and transaction processing.

M-commerce services and applications can be adopted through different wireless and mobile networks, with the aid of several mobile devices. Although there are many systems supporting mobility and many solutions for wireless access, there are issues influencing the performance of the various mobile systems that need to be considered in the design of m-commerce services and applications. This applies also to mobile devices that exhibit some major drawbacks compared to desktop systems. An important factor in designing m-commerce services and applications is the need for identification of the mobile user requirements as well as mobile devices and technologies constraints. Services and applications must be designed and developed according to these requirements and constraints.

M-commerce services and applications can be classified based on the functionality they provide to mobile users for allowing easier identification of constraints based on the design and development process. This kind of classification results in two major classes: The directory- and the transaction-oriented services and applications, with their unique properties.

This paper suggested a new approach for designing and developing m-commerce services and application called MobE, which is based on the WebE process. The proposed approach relies on mobile user needs and requirements identified using a classification of m-commerce services and applications, as well as the current technologies for mobile and wireless computing and their associated constraints. The paper explains this process following a stepwise approach during Analysis and Engineering phases aiming at guiding the mobile engineer to successfully design the m-commerce service or application. This process allows analysts to identify critical factors and requirements for the design of m-commerce services and applications and designers to develop systems of high quality.

Furthermore, the efficacy of the proposed approach in a real scenario was discussed. The case of a travel agency’s attempt to move from e-commerce to m-commerce following our approach was demonstrated illustrating the key points of the MobE process. Future work will include a further verification of the design process described through the development of several other m-commerce services and applications, as well as possible further refinements of the process to tackle design issues related to emerging technological and telecommunication advances, e.g., in all-IP 4th generation wireless networks.

References


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