

Context-Centred Mobile Applications Development For Effective Adoption Of Mobile Technology

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Abstract: *Recent approaches in mobile computing consider context to be central to the design and implementation of mobile applications. Context considerations enables the mobile application to respond to the needs and purpose it is intended for. Qualitative and quantitative research techniques have been applied to investigate and come up with components that are critical in the development of context-centred mobile applications. It is however critical to understand how to separate core application logic from adaptive functionality in order to achieve a context-centred mobile applications.*

This paper presents the factors and technologies to consider in the development of the context-centred mobile applications. Further, a framework that emphasizes on the separation of core application logic and adaptive functionality for building a context-centred mobile application is presented.

Keywords: *Context, Context-centred, Mobile Applications, Core Application Logic, Adaptive Functionality.*

I. Introduction

Mobile technologies and applications have become ubiquitous in many aspects of our personal and professional lives. For instance, a number of mobile applications have been developed for business enterprises and individual users. Most enterprises have realized the need to use mobile applications to gain competitive advantages amongst their peers through improved productivity as a consequence of enhanced efficiency and responsiveness to the needs of the ever changing client needs (Unhelkar & Murugesan, 2010). Other application areas where mobile technology has greatly manifested itself and affected personal and professional lives of individuals include mobile commerce (m-commerce), Mobile Health (m-health), Mobile Agriculture (m-Agriculture), Mobile Insurance (m-Insurance), e-governance among others.

Whereas the development of the mobile applications tend to follow a number of strategies and approaches, recent developments in mobile applications have considered context to be key. The missing link is the relationship between the core application logic and adaptive functionality from the context perspective. Benou & Bitos (2008) indicates that the separation of these two application variables is important in understanding the effects of context in mobile application development and will enhance the ability of the application to perform transactions easily, timely and ubiquitously (Hu, Yang, Yeh & Hu 2008).

Underlying the debate on the role of context in mobile application development is the need to have applications that are independent of location and are easily adoptable by the user. The key in achieving this is the development of context-centred mobile application.

II. Context-Centred Applications

Mobile applications are intended to operate in a dynamic environment of everyday life. For instance, users keep changing their location and roles over time and hence the context of application should reflect these changes-adaptability of the application. Additionally the computing environment varies and users need the ability to choose the settings in their mobile devices. All this information surrounding the human-computer interaction, which can be exploited by applications, constitutes the context (Benou & Bitos, 2008). Critical in this is understanding the human behaviour and disposition. The human needs, characteristics, desires and even decisions are constantly variant and they thus define the human context or environment. Therefore, successful development of mobile applications must take into consideration the context since there is a strong coupling between its exact specification and efficient exploitation of the environment. This study demonstrates how context can be exploited in mobile application development by separating and analysing core application logic and adaptive functionality.

The area of use (i.e. environment) of the mobile application is also critical in determining the right context of the application. To put this into perspective, consider the classification of the application based on the application type. Different applications are modelled to perform a specific type of function. For instance, applications in the health sector are modelled to focus on the issues around the health sector and therefore the developed of such application will be done while focusing on the specific issues around the health sector. The classification of these applications would thus make it easy to understand the application and will lead to the development of a highly focused applications for a specific application type (Unhelkar & Murugesan 2010).

Unhelkar&Murugesan (2010) classify the mobile applications into five categories: m-transaction, m-operation, m-collaboration, m-information and m-broadcast. From their categorization, emphasis is on the underlying functions the application is expected to accomplish. For example, applications under the category of Mobile Broadcast largely broadcast a diverse set of information content to many mobile users. Mobile Information applications present user's requested information in a one way (unidirectional manner), that is, from the application to the user. Mobile Transaction applications broadcast and provide information in addition to facilitating and executing transactions. Applications under Mobile Operation category support the operational activities of an enterprise that do not encompass direct contact with clients. Finally, Mobile Collaboration category contains applications that promote organization-wide teamwork, that is, interaction of various organizational functional units.

Clearly, each of the mobile application categories by (Unhelkar&Murugesan 2010) has unique requirements and challenges. For example, Mobile Information applications require fairly less strict security requirements which results into concerns around privacy and usability. Mobile transaction applications require better security, quick feedback, highly developed and reliable transactions, high level of productivity and more trusted services. Mobile Operation transactions pose a challenge on the delivery of immediate information, inventory management challenges, adoptable planning of work, changing organizational structures and the integration of diverse backend systems and databases. Lastly the mobile collaboration applications present coding and data management challenges.

Varshney& Vetter (2001) identifies a number of categories of commercial applications of mobile technology. Among them include: Financial applications, Product location and shopping, and Mobile entertainment services among others. These classification is however limited to mobile commerce which is not exhaustive of all mobile applications.

Oinas-Kukkonen&Kurkela (2003) classifies mobile applications broadly into two groups; goal-driven and entertainment-focused. The goal-driven applications are modelled to offer fast feedback to requests. The entertainment-focused applications offers recreational opportunities to users. They then propose approaches which can be used for the development of highly goal-driven mobile applications which focuses on: relevance, usefulness, ease of use, mobility, effortless navigation, user-centred, and customization. The classification however is quite broad to limit focus on developmental issues specific to the two categories.

Some other aspect of environment that will also affect the mobile application development and deployment are the computing and communications paradigms. Some applications need to establish the user's location before they can offer some services and the continuously monitor the location to adapt services and information accordingly. This presents challenges of security, reliability and quality of service.

Missing in all these categorization is problem based approach (problem system development paradigm) to mobile technology development and deployment. The understanding here is that problem is context specific and the conceptualization of the solution based on the dynamics around the problem will be central in achieving a context-centred mobile application.

A lot of research has been done in mobile application development with a number of models and frameworks proposed by various researchers. Most of these models and frameworks mainly focus on categorization and providing a layered approach in mobile applications development. Researchers acknowledge the need to consider context in mobile application development and the need to develop context-centred mobile applications but they don't specify explicitly specific development guidelines in relation to core application logic and adaptive functionality, more-so in a highly dynamic environment. Buthpitiya, et. al (2011) also agree that many models and toolkits for developing context-centred mobile applications have been adopted for relatively fixed environments and they don't respond to the unique concerns, prospects and limitations presented by a dynamic mobile environment and the changing context.

2.1 Factors Influencing Mobile Application Development considering context

Unhelkar&Murugesan (2010) and Dehlinger& Dixon (2011) have identified these factors to be:

- a) Computing platforms and devices: As indicated in section 2.0, mobile applications operate on different frameworks and hence different platforms with different hardware have different computing capabilities. These different features are manifested on the existence of different mobile devices with different configurationally and adaptable features. It is thus critical to pay attention to these facts during mobile application design and development stage.
- b) User Context: This can be considered to be the user physical attributes such as user location and usage. It is therefore critical to provide a fairly well customizable application to allow for personalization since user context is variant. Moreover, the mobile devices themselves should track constantly the environment thereby making mobile applications intrinsically context-centred.
- c) Security: Security threats are dynamically changing with every new emerging technology. It is therefore important to consider the threats, vulnerabilities and potential risks surrounding the emerging technologies.

The security mitigation strategies implementable on the mobile application should be informed by the critical reviews of the existing security issues for a particular environment.

- d) The constantly changing computing requirements: The agility of the mobile application will be critical in an ever changing environment. The developers should focus on a highly tolerant mobile applications to accommodate any new requirements.
- e) Dynamism of supporting communication infrastructure: The support infrastructure are sometimes unstable due to inherent potential interruptions. Developers should focus on development of application which have some degree of fault tolerance.

2.2 Mobile Technologies supporting Mobile Application Development

Mobile technologies used in mobile application development can be broadly classified as communication, development platforms, middleware, presentation and security technologies.

Communication technologies like WIFI and Bluetooth which have enabled communication through a wireless network have significantly led to the growth of mobile computing and are an important consideration in mobile applications development. It will be critical for the mobile developer to be aware of the available communication technology in the particular environment where the application shall be used.

Some of the commonly used mobile application platforms include android, iOS, Adobe Flash lite, Java ME, and .NET CF. Gavalas&Economou(2011) conducted an assessments on four of the platforms and presented the appropriateness of each platform with respect to four critical application development requirements which are portability, functionality, development speed and performance. Their findings were that they operate differently under different context and operating systems. Their findings therefore underscores the need to have context in mind when selecting type of platform to be used. Furthermore, operating systems like Android, Windows CE, Palm OS, EPOC, Linux and proprietary systems as well, such as RTOS and GEOS, enable the various mobile devices to operate in different platforms. For example, J2ME, which is a light version of Java meets limitations and peculiarities of mobile devices (Benou&Bitos, 2008).

Mobile middleware manages different services in a mobile environment and also provides the connectivity means for different devices. WAP (Wireless application protocol) and iMode are examples of mobile middleware protocols. WAP is a secure specification that allows users to receive information instantly through their handheld devices and is supported by all mobile operating systems (Hu et al, 2008). I-mode uses packet transmissions to offer continuous access and uses a segment of HTML to make the creation of content faster and easy.

A multitude of diverse mobile devices available include both cellular phones, smartphones, PDAs and hybrid handheld devices that combine voice, data processing and communication capabilities. Standards like XML, WML and various kinds of HTML are used for content delivery. Voice XML technologies offer convenient user interfaces (Hansmann et al, 2003). The change in mobile environment calls for application designers to become more innovative and exploit the distinct benefits from the newer technologies (Benou&Bitos, 2008).

The position of a portable object is beneficial in context-centred mobile applications. This is classified as spatio-temporal context by Schilit, Adams, & Want (1994). The various positioning techniques include; satellite based, cellular network based, WLAN based and RFID-based systems. In Wireless local area networks the position determined from the access point and in Radio Frequency Identification the location of an object or user carrying an RFID card is determined from the location of the stationary reader that captures the signals emitted from the RFID card.

2.3 Context and Context Centeredness in Mobile Application Development

Pascoe (1998) defines context as the subset of physical and conceptual state of interest to a particular entity. Brown, Bovey&Chen (1997) consider context as location, identities of the people around the user, the time of day, season, temperature, and so forth. Schilit&Theimer (1994) refer to context as location, identities of nearby people and objects, and changes to those objects while Schmidt & Laerhoven (2001) identify context as the knowledge about the user's and the device's state, including surroundings, situation and location. Dey&Abowd (1999) states that context is any information that can be used to characterize the situation of an entity. In this paper, Dey&Abowd (1999) definition is adopted.

Borrowing from Dey&Abowd (1999) definition of context, the contextual information which is descriptive of what the entity is, focuses on which entity it concerns (Schilit, Adams, & Want, 1994). According to Schilit, Adams, & Want (1994) the classification includes User context (e.g. user identity, collection of nearby people, user's profile, and so forth); Computing context (e.g. hardware characteristics, software characteristics, network connectivity, communication bandwidth, nearby resources such as printers and displays); Physical Context (e.g. lighting, noise level, temperature and humidity); Spatio-temporal context (e.g. location, place,

time of the day, week, month, season of year and time zone); Task context (e.g. goals, tasks and actions of the user).

It is argued that for a system to be context-centred it must use context to offer relevant information and services to the users Dey&Abowd (1999). Context-centred mobile applications therefore uses information relating to a context to give feedback and respond to a highly dynamic computing environment. A context-centred mobile application is therefore one that is able to use contextual entities of the mobile environment and to adjust its behaviour to present appropriate content and services to the user. According to Schilit, Adams, & Want (1994) the net effect of the context-centred application should include:

- a) Proximate selection: This is a technique that emphasizes on the user interface. The rationale behind the technique is that objects or entities that are located closely to each other should be made in a manner that allows for easy selection.
- b) Automatic contextual reconfiguration: It is a process that focuses on the changing, adding or removing of new entities or components based on the changing context.
- c) Contextual information and command: Context should be able to parameterize “Contextual commands” so that queries on contextual information are able to respond based on the context.
- d) Context-triggered actions: The emphasis is on the decision rule that specify a specific reaction based on the context. It is based largely on the “if-then” rules.

It is thus imperative to have a framework mobile application development that largely addresses the context from the four net effect as identified by Schilit, Adams, & Want (1994).

2.4 Core Application Logic and Adaptive Functionality in Relation to Context

Various components in a mobile application work together to complete a transaction in a mobile application Hu et al (2008). Understanding how the interaction among these component is vital in achieving the desired transactional level. There is therefore need to understand the application logic which is the mode of reasoning when developing a mobile application. The components in the mobile application transactions include the mobile application interface at the client side and server side, the mobile handheld device, mobile middleware, wireless and mobile networks and the host computers.

A mobile application implemented by the content provider must have the following programs; programs on the client side and programs on the server side. It is then expected that a handheld mobile device will offer the user with an interacting interface to the mobile applications through these set of programs. By using the middleware, the internet contents are mapped to mobile points which are supported by the various operating systems, micro-browsers and protocols. To ensure security and integrity of the content, the middleware provides a mechanism to encrypt communications. The transactions/requests from the users involving various entities of a mobile device are expected to be transferred to the nearest base station using the wireless and mobile networks.

Each of the entities in a mobile application transaction processing constitutes some form of context. For instance, the mobile application interface on the client side constitutes user context, physical context, spatio-temporal context and task context. A context-centred mobile application should therefore be able to change with context through aspects like interface reconfiguration. The developers should provide the means for adapting the mobile application to the context through configurable features. The mobile devices on the other hand should provide a computing context since the mobile devices differ in terms of processing power, storage capacity, interface features and so forth. The mobile middleware also provides a middleware context depending on the capability and technologies used at the middleware level. The mobile networks constitute a computing context in terms of network connectivity, communication bandwidth and content delivery. Finally the host computers host the application, the databases and the web servers and should be aware of the computing context and job context of mobile applications. In mobile application core logic, a mobile developer must take into consideration the participating entities' reasoning and thought process as far as the anticipated response on the usage of the mobile application is concerned.

The mobile application should also have elements of adaptive functionality. This describes how the mobile application is adapted by users and includes the client devices and the client programs. For example, the mobile device should be able to manage the clientside needs of a mobile application and the server side programming should endeavour to provide the development of software running on the mobile devices. This can be achieved by applying web interface construction with the use of popular languages like CSS, DOM, HTML, JavaScript, WML, XML and so forth. The adaptive functionality should thus considers mobile application properties like content and service delivery, device performance, information dissemination, consistent functionality across different mobile devices and platforms, a dynamic mobile environment and security considerations in mobile application use.

III. Proposed Context-centred Mobile Application Development Framework

The proposed context-centred mobile application development framework will have the following components and features:

3.1.1 Mobile device characteristics

The following characteristics were imperative in developing this framework: Screen size, processing power, operating platform and mobile device type or make are some of the features that must critically be considered in mobile application development. Benou & Bitos (2008) established that in general the mobile devices have small screens, limited interaction, low processing power and limited memory. They also pointed out that during the mobile application development phase aspects around design and performance of the computing devices be considered. As discussed in section 2.0, the mobile device characteristics are inherently dependent on the context. This means that the characteristics should be interpreted by the developer based on the context of the mobile application.

3.1.2 Mobile application development platforms and operating platform

Mobile application development platform is a critical factor in successful development of a mobile application. The mobile device development platform include: android, iOS, Adobe Flash Lite and Java ME among others. Different development platforms affect portability, functionality, development speed and performance in different ways (Gavalas & Economou, 2011). In section 2.2, we provided the basic understanding on the effect of development platforms on the mobile application.

Unhelkar & Murugesan (2010) and Dehlinger & Dixon (2011) indicates that mobile device operating platforms do also affects mobile application development. This study reaffirms that mobile device operating platform is a core application logic component in mobile application development. Consideration of these factors will influence the outcome of the application.

3.1.3 Nature of content and service delivery

Content and service delivery is an adaptive functionality component that encompasses aspects usability and user experience like font size, aesthetic values, formatting of data, the mobile application graphical user interface and identifying with core user stories or feedback (Hu et al, 2008). These features influence the acceptability and adoptability of the mobile application in terms of usage from the user perspective. It is however critical to note that formatting of data or content and the user interface are the most critical features of service delivery in mobile applications development.

3.1.4 Changes in the mobile environment

In section 2.2, we have highlighted on how user locale can influence the context and hence affect mobile application development. The content and content requirements by the user vary from time to time and nature of content and service delivery are rated as the most significant mobile environmental features. The framework therefore should include changes to the mobile computing environment as a significant core application logic and adaptive functionality component in mobile application development.

3.1.5 Cellular network capabilities

A cellular network capability is both an adaptive functionality factor and a core application logic factor in mobile application development. Benou & Bitos (2008) have identified that cellular networks have some abilities like broadcasting abilities. Cellular network broadcasting abilities or host application broadcasting abilities determine the method of mass information dissemination while the performance of the cellular network affects also the mobile application performance.

3.1.6 Mobile Security considerations

Mobile application development guidelines by Benou & Bitos (2008) don't address mobile security but instead recommend further research since they believe security is critical. Unhelkar & Murugesan (2010) emphasize that mobile application developers need to consider the threats, vulnerabilities and risks arising from the use of current technologies and use secure tools to implement security and privacy in mobile applications. Security has also to be applied at the various stages of mobile application use and this include; at the user level, over the cellular communication network and at the host computers that run mobile applications. Authentication, cryptography, secure communication, and secure mobile payment methods can be used to provide the much needed security in mobile applications. The significant core application logic and adaptive functionality features of mobile application security considerations include; current host and end-user mobile security threats and vulnerabilities, development platform threats and vulnerabilities, data transmission threats and vulnerabilities and authentication, confidentiality, integrity and availability.

3.1.7 Human and mobile device interaction

Human aspects like preference, knowledge, and attitude among other are determinant factors of the user expectations on the kind of mobile application to adopt. The human and mobile device interaction is derived from the adaptive functionality feature that takes into consideration the aspects that affect usability of the application thus influencing the user experience.

3.1.8 Mobile application performance

Performance of mobile devices, the dynamic communication and networks affect the mobile application performance. Speed of the cellular network and the computational power of the host computers also affect the mobile application performance significantly.

3.1.9 Application consistency across mobile devices and operating platforms

Benou&Bitos (2008) indicate that the same mobile application should operate on different devices and should offer some consistency in usage in terms of meeting the functional needs and interfaces on different devices in which they run. Mobile applications should therefore provide consistent functionality across different mobile operating platforms and mobile devices and this is affected by the mobile application development platform and the mobile device development technologies.

3.2 The framework

The figure 1 presents the framework which highlights on how the interaction of the various components and features discussed in section 3.1 can be achieved so as to develop a context-centred mobile application.

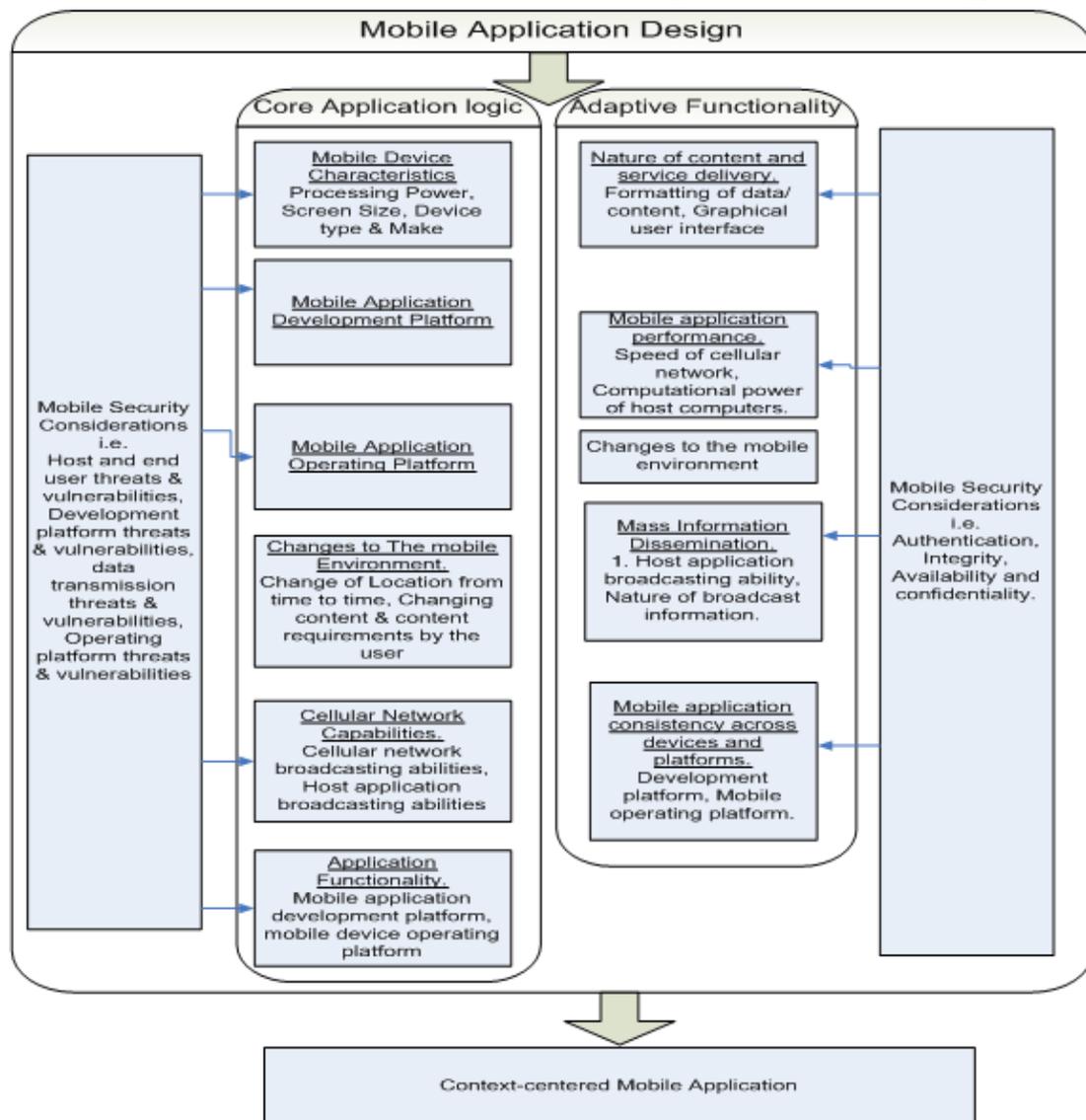


Figure1: Mobile applications development framework using context centeredness analogy

This framework is divided into two sections; core application logic and the adaptive functionality. Core application logic has six components that contain critical features a developer should consider and adaptive functionality comprises of five components. The framework is then encapsulated by the mobile application security considerations. Mobile application security affects many of the components in the framework and therefore must be considered at the component level.

The framework focuses principally on mobile application development where there is a separate host supporting the mobile application. Each individual or mobile application development company has its different approach in application development. Mobile application developer needs to have a clear understanding of the requirements, the rationale of development and the end product in order to gainfully use this framework. Mobile application developers are free to categorize and emphasize on particular aspects of mobile application development that will be more useful for each development.

IV. Conclusion

The study identified, analysed and separated mobile application development factors and components into core application logic features and adaptive functionality features. A framework that highlights components and critical features to be considered in the mobile application is presented. The exploitation of context both on the core application logic and adaptive functionality will lead to development of a context-centred mobile applications. In developing a mobile application, the core application logic and adaptive functionality features should be considered separately as depicted in the proposed framework. An extension of this study could consider contextual information and its classifications, that is, user context, computing context, physical context, spatial-temporal context and task context. Moreover, manner of context acquisition, that is, sensed context, derived context or where context is explicitly provided could also be considered.

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