

Challenges and Best Practices for Mobile Application Development: Review Paper

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ABSTRACT

Over the last ten years or so, mobile devices technology has changed significantly, with these devices and operating systems becoming more sophisticated. These developments have led to a huge variety of mobile applications designed for mobile operating systems. These mobile applications are typically harder to design and build because of several factors such as screen size and limited processing power and so forth. Therefore, it is important to clearly identify the characteristics of mobile application development and the issues and challenges related to it, as well as, the key features that characterize a great mobile application which make them valuable and useful. This paper has reviewed existing literature of the challenge and best practices of mobile application development. This study contributes towards a great understanding of the characteristics of mobile application development process, examines real challenges faced and explores the best practices that can be effectively applied to improve the development of mobile application.

CCS Concepts

• Human-centered computing~Mobile computing • Human-centered computing~Empirical studies in ubiquitous and mobile computing

Keywords

Mobile application; mobile software engineering; mobile development; best practices; challenges.

1. INTRODUCTION

It has been observed, over the last decade, that mobile telecommunication industry is one of the fastest growing digital sectors which proved to be highly competitive, uncertain and dynamic environment [3]. This field has become very attractive for software organizations since it turned out to generate significant revenues [3].

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Besides its expansion, it has also brought up a number of issues and gained concern in the software industry and research community. For instance, the development process of mobile application is quite different from traditional software since the end-users expect same features similar to their desktop computer applications with additional mobile exclusive functionalities [11]. Moreover, in order to build a good mobile application, it is essential to comprehend the key features that characterize a good mobile application which, if practically applied, make them valuable and useful. Therefore, the objective of our study was to gain a better understanding of the mobile application development characteristics and the different challenges and issues connected to it. For this reason, the current review study aims at answering the following two questions: (1) What are the challenges and issues that are confronted through the development process of mobile application? And (2) What are the best practices which generally embraced to soften the challenges of mobile application development process?

This paper is an endeavor to review the published literature on the challenge and best practices which can be realized during the development of mobile application. The review study contributes towards a better understanding of the characteristics of mobile application development process, examines real challenges faced and explores the best practices that can be effectively applied to improve the development of mobile application.

The paper is organized as follows. Section 2 provides an overview of software engineering for mobile application development. Section 3 describes the general development process of mobile application. Section 4 identifies the characteristics of mobile applications. Section 5 classifies and identifies the issues and challenges of the mobile application development process followed by mobile developers. Then, Section 6 specifies mobile application development best practices. Finally, Section 7 concludes the paper and outlines future work.

2. SOFTWARE ENGINEERING FOR MOBILE APPLICATION DEVELOPMENT

In the last years, the mobile industry has witnessed rapid growth, and the potential number of various mobile applications is almost unlimited. With this increasing of fame and demand for mobile applications, the number of development projects for mobile application has been significantly increased [8]. As a consequence of this, the quality and quantity of mobile applications have introduced new concerns in software engineering industry. Mobile application development is the process of developing applications for small, low-power handheld devices such as cell phones [8][9].

This application can be either factory pre-installed applications or downloadable from application stores (App-stores) or mobile software distribution platforms [8]. Currently, numerous applications are accessible in the app stores to aid for a life based on mobile, or mLife which includes; mHealth, mEnvironment, mEducation, mTourism, mGovernment, mEntertainment, etc. Mobile applications can be categorized into [17] [23]:

- **Native Applications:** These applications are implemented for a certain platform using Software Development Kits (SDKs) and tools provided by platform owner, and this may limit the number of mobile devices running the app but it can benefit from all platform features offered for developers.
- **Web Applications:** These applications are implemented using the standard web technologies (i.e. HTML, CSS, and JavaScript) and can be accessed through the mobile web browser. This guarantees app availability on the Internet for different mobile platforms but these apps cannot utilize all mobile capabilities nor can it be used offline.
- **Hybrid Applications:** These applications combine the advantages of both native and web applications.

3. MOBILE APPLICATION DEVELOPMENT PROCESS

Mobile application development is a special case of the software development as the developers need to consider different aspects such as: short development lifecycle, the capabilities of mobile device, mobility, visibility, the specifications of mobile device such as screen sizes, user interface (UI) design and navigation of the application, security and user privacy, and necessity for application marketing to gain more popularity [7].

In general, mobile application development lifecycle comprises of the following: (1) Analysis of the application idea, (2) User interface design, (3) Application development by utilizing the tools and programming languages for the target platform, (4) Testing the application on various devices, (5) Publishing the application on the target platform store, and finally (6) Application maintenance in which any new updates for the application are released in successive versions of this app for the target platform store [7].

The development of mobile application is considered a challenging task due to (1) The technical constraints related to mobile Operating System (OS), and (2) The nature of fast changing business requirements [8]. There are also the challenges confronted by development teams for working in a dynamic environment with frequent changes of client needs and expectations [8]. The challenges in mobile application development are discussed in details in section 5. Despite the fact that mobile application development process is similar to software engineering, it likewise introduces additional requirements which impose some adjustment of the traditional software development process [[9, 29, 31]. These special requirements and characteristics are discussed in details in the next section.

4. CHARACTERISTICS OF MOBILE APPLICATIONS

In order to develop high-quality mobile applications, it is essential to recognize the key characteristics that define quality mobile applications [10]. The quality characteristics which are considered for developing all software applications called “productivity

factors” (i.e. functionality requirements, usability requirements, reliability requirements, portability requirements, maintainability requirements, and efficiency requirements) are common between software and mobile application [17]. However, there are specific characteristics specified for mobile application development in further to other productivity factors [17]. This section aims to identify these characteristics which show how exactly mobile applications are different from traditional software.

Ashishdeep et al. (2016) [2] identified the main characteristics of mobile application regarding some aspects: user requirements are frequently changing with time, a change request is required, emphasizing on UI components, and the development/deployment time must be short. From literature survey, they further draw the attention to Agile approaches to be considered as the best suitable approach for mobile application development.

Kaleel and Harishankar (2013) [15] highlighted that mobile application requirements directly depend on end user requests demands, and they also pointed that mobile app industry is more concentrated on the product launch than on the process adherence of the product Software Development Life Cycle (SDLC), because mobile industry can only tolerate if it reflect end users view and has the app rapidly launch on demand. They further point the importance of market awareness in mobile app industry in which to attain the minimum time for app launch, it is essential to have regular and early releases of the application.

De Souza and De Aquino (2014) [25, 26] identified mobile application characteristics by conducting a systematic review. These characteristics are described below:

- **Limited Energy:** Each mobile device has a battery with a specific lifetime period, so the application implementation must not require a huge amount of hardware resources.
- **Graphical Interface:** The interface design is limited because of the small screen size.
- **Input Interface:** It is identified by the interaction means between users and the application such as a keypad, touch or voice screen, and image recognition.
- **Bandwidth:** A mobile application must consider and realize its massive variation bandwidth since it might have the maximum bandwidth at times and the minimum in other circumstances.
- **Connectivity Type:** Mobile applications can support various types of connectivity i.e. Bluetooth, 3G, 4G, Wi-Fi, Wireless, etc.
- **Change in Context:** The user can provide the data entries explicitly while the app implicitly provides the entries regarding the physical and computational context of user environments.
- **Constant Interruption of Activities:** Some applications are created to work offline and it synchronized when the apps become online. Thus, mobile applications must be designed for different scenarios because of the interruption of activities frequently such as low battery or lack of connection, etc.
- **Limited Performance:** All mobile devices have limitations of certain resources such as processing, memory, and connectivity.
- **Reduced Memory:** Because of limited hardware size, less memory is accessible.

- **Response Time:** The application development should be focused in the time variable. It requires the applications to be developed with a possible resource optimization for a better efficiency and response time.
- **Processing:** Response time is directly associated with processing power.
- **Portability:** Hardware Portability, a mobile application should have the support of a broad range of devices. Software Portability, a mobile application should have the capacity to perform the same things on a wide range mobile operating systems.
- **Native, Web or hybrid Application:** Based on the type of application, the issues and the complexity that must be taken into consideration, will be distinctive, demanding a different level of development efforts.

Flora and Chande (2013) [11] discussed the aspects which are not usually associated with traditional software applications, including: integrating app interface with different applications, dealing with device movement such as GPS app, compatibility of cross-platform app and different hardware factors, handling power consumption, security and privacy risks, UI design, the complexity of testing, 24/7 availability “always on”, and planning the development process, including app size such as app screen size. They further focus on the challenges faced by mobile app development teams which include: working on dynamic environment of various improvement and technical requirements, with constant adjustments in clients needs and expectations. They also consider Agile processes as the most suitable for this constant changing environment; where customer satisfaction is managed by early and frequent delivery, always welcome the new changes, short release cycle, a continuous collaboration between customer or stakeholder and engineers, and having a working program is considered the essential measure of progress.

Kakkar et al. (2013) [14] discussed the difference between mobile applications and traditional software applications, in which the major issues that must be handled in mobile application development are security, reliability, performance and memory storage. And the other issues that are associated with mobile applications are: (1) Interaction with different applications, (2) Native or Hybrid applications and (3) Sensor handling, (4) Software and Hardware compatibility, (5) Security, (6) User interfaces must follow the UI guidelines offered by SDKs, (7) Complexity of testing, and (8) Power Consumption.

Vithani and Kumar (2014) [28] identified the differences between a personal computer (PC) and mobile application development which are summarized in Table 1.

Table 1 The difference between PC and Mobile Applications

Criteria	Mobile App	PC App
Life Span	Shorter than PC app	Longer than Mobile app
Functionalities	Complex, one or few (limited) functionalities	Often simple, numerous functionalities
Physical interfaces	Few physical interface such as a touch panel or mobile keyboard	Many physical interfaces such as a keyboard, mouse, touch panel and other external devices.
No. of screens	Many screens for	Less number of screens

for Interaction	interaction, small screen	for interaction, large screen
Platform Development	Having limitation of application reachability in mobile app development in one platform (native) or cross-platform app development	No limitation regarding platform.
Battery & Memory usage	Should be designed to use the available memory optimally.	It is not a major design decision as the idle processes running on PC would not consume a major percentage of the available battery or memory in the PC compared to Mobile application.
Updates	Mandatory	Optional

As discussed previously, there are many studies that consider the Agile approach to be the best fit for mobile application SDLC [2, 4, 17]. On the contrary, Popa (2013) [23] stated that it is not required for mobile application SDLC phases to be clearly defined since each phase can start before the preceding phase can be ended, which may emphasize the short development lifecycle and decrease the development costs. Also, the SDLC like Waterfall, Agile, Spiral, etc. can be used for mobile application development. The key aspects of the mobile application SDLC are:

- User Experience (UX) should be enhanced by developing UI prototypes on several platforms.
- Testing must be conducted using numerous devices having an extensive variety of hardware and software features. Also, testing the application only on the emulators is insufficient.
- Maintenance must be conducted by updating the application to the latest versions of the mobile platforms.

Moreover, many researches stated regarding using a specific methodology, that there are many aspects that influence the selection of practices or methodology for mobile applications development, and it is extremely difficult, if not impossible to simply identified only one methodology or set of practices that universally works best on all mobile app development projects [8]. Besides, Agile approaches is about people, not technologies and the organization should use and utilize what suits their team and culture, as a platform hardly dictates the methodology [8]. Inukollu et al. (2014) [12] discussed the factors that cause low-quality application and explained that the reasons for this quality from SDLC point of view, which are:

- Developers are not conforming to the SDLC phases, since the majority of developers start the implementation phase without collecting the requirements or having the design.
- Lack of training and experience on the development SDKs.
- The testing coverage is not enough.
- Poor maintenance and support.

Anwar (2015) [1] reported that the most significant quality characteristics among the top rated and low rated mobile application developer, for which they tested the application are functional and usability testing.

To summarize, it is clear now that development of mobile applications is quite different from traditional software development because of their specific environment, restricted resources, changing requirement, market, etc. [4]. Moreover, to build a good application, it is important for developers to comprehend the key characteristics that define a good mobile application [10].

5. MOBILE APPLICATION DEVELOPMENT CHALLENGES

To date, several studies have identified and published the fundamental challenges in mobile computing. A few studies of them are briefly summarized below.

Wasserman [29] identified issues associated with mobile application development, based on its development tools, processes, application portability, user interface design, quality, and security, which are; (1) Potential interaction with other applications, (2) Sensor handling, (3) Type of applications (native and hybrid i.e. mobile web), (4) Families of hardware and software platforms supporting the OS, (5) Security, (6) User interfaces and the restriction to follow externally developed user interface guidelines such as SDKs, (7) Complexity of testing for mobile web applications, and (8) Power consumption by mobile applications.

Dehlinger and Dixon [5] identified four main challenges for mobile application development which are: (1) Creating a universal user interfaces poses some challenges since each mobile platform has a unique guide for user interface requirements, (2) Enabling software reuse across mobile platforms (e.g., iOS, Android, Windows 7, etc.) with different hardware makers (Apple, HTC, Samsung, Google, etc.) having different delivery methods (i.e., native application, mobile web application) and different computing platforms (i.e., smartphone, tablet), (3) Designing context-Aware mobile applications (time-aware, location-aware, device-aware, etc.), and (4) Balancing agility and uncertainty in specifying and analyzing mobile application requirements.

Williamson [31] listed three distinctive challenges for mobile application development, which are: (1) Form factors and user input technology which is significantly different compared to previous software form, (2) Usability and user interaction design for mobile applications drive the need for more investment in it, especially for user-centered design, and (3) The choice of implementation approach for mobile application (native, web and hybrid).

El-Kassas et al. [7] identified the challenges and restrictions of mobile applications development which are;

- Limited Resources of the mobile devices i.e. limited computing power, limited storage space, connectivity for mobile devices will be affected by the movement [16].
- Heterogeneity of Mobile OS, in which developing an app by iOS SDK can only run on iOS devices, and the same for Android Apps which can only run on Android devices [24].
- Heterogeneity of Devices may require various versions of the same application [24], in which when developing mobile application different computing capabilities and hardware structures of devices must be considered such as (screen size, input methods i.e. touch screen, keyboard, and TV remote control).
- User Experience, by defining a simple and a user friendly interface for mobile applications [22].

- Application Maintenance and Support, since frequent updates of the mobile platform may affect some application in which these applications may become unusable in the new version; thus, application maintenance is required [22]. Additionally, the version management is challenging because the users may not update the app to the latest version when it is released [24]. The application maintenance for different platforms means repeating the same updates in all versions of different platforms by the development team [21].
- Cross-platform Development which implies the development of the same application for different platforms because of the difference in platform vendor, programming languages, and development tools.

Dye and Scarfone [6] discussed different security challenges as a consequence of the richness of mobile software applications recently and talked about the probable risks exposed to these devices due to the absence of development standards and best practices.

Kaur and Kaur [17] discussed various challenges in mobile application development that have not yet faced in the traditional application development; (1) Fragmentation which means having multiple devices with various OS versions in the market. (2) Testing on different devices, in which it is not feasible to get a new device for every time a test simulation when there is a large variety of mobile devices. (3) Time to market should be reduced by having short and rapid release cycles. (4) Newer Versions Adaptation. (5) Multitasking in which it is difficult to show many applications at the same time; because of the small screen, and with different applications running in the background, a considerable amount of battery will be wasted. (6) Form Factor by having a distinctive form of mobile devices such as phones and tablets, which make designing apps for them is very different. (7) Diversity, which means the different qualities of handsets in terms of screen size, OEM, operators, etc.

Flora et al. [9] present the unique issues and challenges faced during mobile application development emerging from their study results related to hardware and software issues. First, the challenges related to hardware include:

- Cross-platform Compatibility: Mobile companies need to design and develop their applications to be able to run on several devices and since most businesses only focus on a single platform which may reduce the applications reachability. Hence, offering a cross-platform app may help to spread the app to various platforms but maintaining application across these platforms with limited resources is quite challenging.
- Varying Hardware Complexities: Comparing to desktop computers, mobile-phone hardware is much limited regarding the memory, speed, graphics processing, power availability, real time data streams, etc. Moreover, through mobile app development, mobile developers have to disable few utilities that consume a large amount of memory and fast processing speed, because of that, it is a challenge to maintain app quality.

Second, the challenges related to software include:

- Inexperienced Resources: It is essential to follow the guideline for each mobile device when building mobile application. Studies showed that less than 10% of participants revealed their concern on the absence of

knowledgeable resources to code for different mobile devices.

- **Insufficient and Uncertain Requirements:** It considers one of the challenging factors when the project requirements are insufficient and uncertain. As also how to assess the effort required at the beginning of the project while analyzing and understanding the client's requirements may result in increasing the application development workload.
- **Budget and Schedule:** It is generally misguided that mobile app development effort are small and thus need a low budget, when in fact this process itself considers a complex process that embraces many constraints and stages, specifically when mobile developers working with limited budgets and tight schedules to meet deadline, they may have to choose between delivering an app with poor quality or miss the deadline.
- **User Experience:** It is a challenge to design for mobile app as gestures and sensors have a significant part in the design process.
- **User Interface:** It considers a challenging task for mobile developers to get the best possible use of limited screen space, and user interface design takes on greater importance than ever.
- **User Input Technology:** It is quite a challenge to identify different non-keyboard ways to gather and send information to the user of mobile devices.
- **Form Factors:** It is also quite challenging to deal with small screen size and low screen resolution while developing a mobile app, since this means only a few amount of data can be displayed once to the user which may require clarity and simplicity of information.
- **Delivering Quality Applications:** Formal reviews and intensive testing are required to guarantee that an application meets all user requirements and demonstrates a high-quality software before it releases to the customers, which may consider quite challenging to maintain this level of high-quality.
- **Complexity of Testing:** Testing also becomes challenging with different varieties of devices and operating system. The test scenarios must be executed on emulators, as well as on real devices to test the success or unexpected failure of mobile apps by recognizing any issues related to network connectivity or mobile hardware.
- **Analyzing the Target Users:** It is vital to really know and analyze potential clients needs before developing a new application, since the failure to identify and analyze them may lead to the development of an application that has nothing in value for the target market with tough competition.
- **Security and Privacy:** It is very challenging to manage such a variety of various devices and OS, particularly in industries that are intensively regulated such as finance, healthcare, etc. It is one of the obligations of mobile developer to protect and secure the data from end-to-end, including the software, and additionally information transmission and servers.

It can be obviously seen that these issues are imperative. Accordingly, these issues should be considered during the early development process in order to mitigate the effect of poor decisions. Also, for each of these mentioned issues, there are well-known solutions. And, even though each mobile platform has its exclusive best practices, many of these mobile application best practices are standard across all platforms [19].

6. MOBILE APPLICATION DEVELOPMENT BEST PRACTICES

It is necessary to have “best practices” in place since these practices are regularly recognized for the success of mobile application development method. These best practices include a comprehensive set of standards and guidelines that eliminate the speculation and guarantee quality and consistency in all mobile application SDLC aspects. However, these practices are not considered “cure-all” for everything, rather they can give a good preliminary stage that needs additional revising as the team members develop and mature [30].

Platform Guidelines: There are several distinctive design guidelines for every mobile platform, which consist of a set of recommendations and rules to reach the desired quality which can relate to User Experience, Graphical User Interface (GUI), and many other facilities, for platform SDK [29]. For example, The World Wide Web Consortium has issued a set of recommendations for mobile web applications [20]. Apple has issued Application Programming Guide for iOS [13]. The Developer’s Guide for Android addresses the best practices regarding application compatibility, performance, UI guidelines, etc. [27]. Consequently, developers must embrace the assistance guidance for developing a successful mobile application.

The next section aims to list the general best practice recommended for the successful development of mobile applications from literature with respect to SDLC.

6.1 Planning

Determining the design methodology is a key to mobile application development, particularly in a cross-platform environment where multiple efforts may be ongoing simultaneously [9,18]. Therefore, it is recommended to design a proper plan before starting programming the application, which may have considered an efficient strategy to attract the potential clients.

6.2 Requirements

It considers as the most important phase in which the discussion regarding the business plan will take place after collecting, analyzing and documenting the client’s requirement. The planning strategy must comprise the best method of user interaction, performance, and the utilization of the limited resource, after that, frequent and rapid iterations of requirements reviews are conducted [9].

6.3 Design and Architecture

Designing the most proper architecture for mobile applications must be taking into account by developers [9,18]. Some studies consider the best way is to develop a layered application, in which the consistency of mobile app functionality is guaranteed across all platforms [9]. It is also recommended to create re-usable platform components can help accelerate the development time [10,18].

6.4 User Experience

- Guidelines: Defining and specifying the font usage, colors, layout, pictures, etc., is fundamental to UX. These guidelines must also describe predictable behaviors under some conditions like (user walk-away, network changing, timeouts, etc.) [30].
- App Branding: Regular branding inside an application and all through an organization's portfolio forms a sense of familiarity and attachment with the client [30].
- Wireframe and Prototyping Tools: Using the wireframes and prototyping tools early in the SDLC phases will aid clients to visualize the overall application flow. Moreover, changing the application design in early phases is considerably easier and cheaper compared to other phases [30].

6.5 Development

Despite which mobile platform an organization selects for mobile application development, a universal set of development process best practices is identified from literature as follows:

- The appropriate level of code documentation will increase the code readability, and this becomes more important when the development team grows [30].
- The development team must have the proper knowledge and expertise in the exact mobile platforms being targeted [18].
- Iterative development of mobile application by having short iterative cycles with continuous delivery, in order to get user feedback earlier in the development process, which can simplify the process of prioritizing and developing these changes [30].
- Peer code review to ensure that developers are following the well-known coding standard and for identifying defects in code [30].

6.6 Testing

- Simulators and “On Device” testing: Applications should be tested early using simulators to measure the usability and performance, and final testing must be conducted on real mobile devices [9, 18, 30].
- Test coverage: Applications should be tested with multiple browsers, devices, and OS to identify any unusual performances [9, 18, 30].
- Continuous Testing: Testing should frequently be done in each iteration to assist in determining any faults earlier in the process which marks them less expensive to be fixed [9, 30].
- Automation Testing: Automation the testing using scripts in order to reduce the time, effort and cost of this process [30].
- Mobile Specific Scenarios: Testing the application for explicit mobile conditions such as memory leaks, power consumption, network connection, interruptions from different applications, etc. [30].
- Testing “in-the-wild”: Performing tests under real world conditions will picture the app performance on a user’s device, like different applications running at the same time, insufficient memory, etc. [30].

6.7 Deployment

There are a few aspects that organizations should consider towards the deployment of mobile applications including:

- The plan should involve a well-defined release cycle for deploying mobile applications and an explicit description of the hosting environment if needed such as (test, development, production, etc.) [30].
- Automating the process of configuring and installing will save time and eventually result in saving significant cost [30].
- Always ensure developer certificates are up to date to prevent and avoid any possible delays when deploying the application to commercial app stores [30].
- Delays may also be avoided by confirming that all App Properties have been updated (version, compatibility, signature, etc.) before the deployment [30].

6.8 Maintenance and Support

Maintenance phase deals with fixing various issues that were faced by the users due to compatibility or software and hardware constraints which were not identified during the testing phase, it also involves developing/releasing new features and functionalities [12]. A few recommendations from literature regarding this phase is listed below:

- Application analytics: The performance of mobile application in the market should be monitored by incorporating an analytics features, to help distinguish all current technical issues, as well as to reveal which features are not used anymore by users, so that they can either be eliminated or made easily accessible [9, 18].
- Explicit feedback mechanism: Developers should develop a feedback mechanism through e-mail, social network or inside the actual application, to assist users expressing their opinion regarding what they like and dislike about the application, and report the technical issues, consequently this will minimize the technical issues as well as it will provide some improvements and updates regarding application future plan [9, 18].

6.9 Other Aspects

- Security: Mobile devices are vulnerable, and these devices must incorporate the inherited security capabilities from the mobile platform as well as using appropriate and up-to-date security tools for protecting sensitive data [9, 18]. This can be handled by utilizing: Access control using enterprise authentication, Securing web services/APIs, Data encryption (at-rest and in-transit), etc. [30].
- Privacy Policy: Privacy policy should be clear, transparent and not ambiguous, covering the data collection, data sharing, and use practices. Mobile developers should present the privacy policy about the components use across different platforms, to facilitates its maintainability [9]. In order to create effective policy, it is recommended to communicate effectively and openly, use clear and simple language, offer users some controls and choices regarding their acceptances or not, protect user’s data and ensure accountability [9].

7. CONCLUSION

A key goal of the study was to gain a better understanding of the main challenges encountered during the development of a mobile application and to recognize and identify the best practices which are acknowledged for the success of mobile application development strategy. After investigation of best practices, it is suggested that these issues and challenges should be considered during the early development process in order to mitigate the effect of poor decisions. Also, for each of these mentioned issues, there are well-known solutions, and even though each mobile platform has its exclusive best practices, many of these mobile application best practices are standard across all platforms. These best practices include a comprehensive set of standards and guidelines that eliminate the speculation and guarantee quality and consistency in all mobile application SDLC aspects. The study lists and reviews the general best practice recommended for the successful development of mobile applications from literature with respect to SDLC. This review will assist individuals and enterprises for planning and improving their mobile strategies and applications.

The issues, challenges and best practices discussed in section five and six, respectively, can be considered as potential research topics in mobile application development and can likewise indicate the extent and breadth of research requirements and mobile industry. For future studies, a survey can be conducted among mobile application developers in Saudi Arabia to have more detailed analysis about the local challenges and best practices. Further work in this area is directed toward carrying out further validation of the underlying best practices and perform proper case studies to identify the standard practices which are applied by individuals and enterprises on a global basis. A comparison can be done with Native, Web and Hybrid application to realize if there are a unique set of best practice for each category of mobile app development method or not. Although there are a huge number of mobile applications, an extensive number of complex issues remains where further work is required.

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