Smart Phones Application development using HTML5 and related technologies: A tradeoff between cost and quality

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Abstract

Smart Phone Revolution has forced companies to develop the smart phone versions of their applications. Smart Phone market is very fragmented and volatile and there is no single dominant platform. Building native applications for all the platforms is too costly and time consuming. As HTML5 is emerging as a viable option for building cross platform applications, experts are debating their quality and cost effectiveness. In this research paper we have evaluated the quality as per ISO 9126 and look closely where HTML5 based applications are standing against the major quality factors of ISO 9126. In this paper HTML5 based applications were evaluated against the quality factors like Functionality, Usability, Efficiency, Maintainability, Reliability and Portability. We have also discussed the possible cost effectiveness of HTML5 based applications in comparison with native application development.

Keywords: *HTML5, Smart Phones development, Quality Attributes.*

1. Introduction

Since the emergence of IPhone in 2007, smart phones (SP) have revolutionized the domain of cellular technology. Smart phones have already made a huge impact in our society. The ability of smart phones to give us the features that could be accessed only through personal computers in past are the major reason behind the popularity of Smart phones. Due to this dramatic growth of smart phone market, mobile application development has also seen a huge surge. Every business wants to target smart phone market because they want to stay relevant with their customer base. The biggest issue in capturing their customer base is that the smart phone market is very fragmented and there is no single popular platform that customers prefer. The market is divided among different

players and that is why businesses are confused i.e. which platform they should choose so that they could capture most of their customer base. In fact due to the fragmentation of market they can't just chose one platform. For capturing the whole customer base businesses have to develop multiple applications due to different platforms.

2. An Overview of Smart Phone market

As opposed to PC market where there is one single platform which is clearly a dominant force i.e. Microsoft Windows; the smart phone market is very much fragmented and distributed amongst various OS vendors. According to the latest data released by Gartner, a leading research company, market is divided amongst Google's Android, Nokia's Symbian, Apple's IOS, and RIM's Blackberry Operating Systems. According to the data released from third quarter of 2011 in table 1. Android has the majority of the market share with 52.5%. Symbian currently holds 16.9% of the market share while Apple's IOS has a 15% share[1]

Table 1: Worldwide smartphone sales by Operating System

Operating System	Market Share (%) (3rd Quarter of 2011)
Android	52.5
Symbian	16.9
IOS	15.0
BlackBerry	11.0
Bada	2.2
Microsoft	1.5
Others	0.9

3. Development platforms for Smart Phones

Smart Phone market is divided amongst multiple major players. In this section we have discussed in detail about the differences in the development platforms of these smart phone platforms.

3.1 Android

Android is Linux based operating system. Android OS consist of various components which include a Linux kernel, Android runtime, Set of various libraries, Application framework and Applications. Android uses Linux kernel version 2.6 for providing its essential services, such as process management, memory management, security etc. Android runtime includes Dalvik virtual machine. Dalvik Virtual Machine is conceptually quite similar to Java Virtual machine but instead it uses a different file format. Android applications are written in java language and compiles into dex files. These dex files are packaged into a single file called Android Package (apk).The dex files are optimized for consuming minimal memory[2].

3.2 IOS

Apple IOS is derived for MAC OS and specially designed for IPhone. The basic foundation of IOS stands on original MAC OS X including OS kernel, BSD sockets and C/C++ compilers for getting native performance[3].The stability and performance of IOS is excellent. IOS supports Objective-C language for developing applications. Apple provides IPhone SDK to developers for developing applications for IPhone. The programming framework used for user interaction in IOS is Cocoa Touch[4].

3.3 Symbian

Symbian operating system was designed by Symbian foundation and quite recently Nokia has announced to open source the Symbian OS. Symbian OS is a micro kernel based Operating System which is the basic reason behind its robustness and responsiveness[5]. Nokia recommends QT for development and publishing applications. QT SDK has an excellent support of easily creating applications along with tools that comes with QT SDK. Development of User Interfaces is simplified by QT which provides a new QML language which is quite similar to popular JavaScript language.

3.4 BlackBerry

BlackBerry OS was developed and designed by Canadian Company, Research in Motion (RIM). RIM does not share the information about the internal design and architecture of BlackBerry OS[5]. Black Berry applications can be developed using Java language. BlackBerry provides a blackberry Plugin for eclipse and also provides an integrated development environment through JDE (Java development Environment). BlackBerry Java SDK includes Java Me API's as well as BlackBerry specific API's.

3.5 Windows Phone

Windows Phone is Microsoft based Compact edition of windows i.e. Window CE. Windows Phone supports Silverlight and powerful XNA framework for building applications. Windows Phone SDK comes up with Visual Studio 2010 IDE for building applications, Windows Phone Emulator, XNA Game Studio and Expression Blend software[6]. The Silverlight framework is used for event driven applications and provides a XAML based syntax for creating Rich User Interfaces. The XNA framework is used for games and provides a great gaming experience. With the latest version of windows phone these two frameworks could also be combined into one single application.

4. HTML5, Related Technologies and Hybrid Approach

In this section we have discussed various features of HTML5 that could help in building high quality applications. We have also discussed the CSS and hybrid approach of development.

4.1 HTML5

HTML (Hyper Text Markup Language) is the basic markup language which is used to display web pages. HTML was initially developed to display only simple static web pages. These simple static pages were comprised of some static text and simple images without any animation. As with the growth and popularity of World Wide Web businesses found the need of some complex

applications that could cater the need of their users. There was the requirement of more user interactive websites with dynamic content. Due to the limitations of HTML developers were heavily dependent on third party plugins like Flash or Silverlight. The biggest disadvantage of these third party tools is that the users are required to install the plugins for these third party tools to view the page. Also as they were propriety technologies they were not supported on different mobile platforms.

4.1.1 Canvas

The canvas element facilitates developers to draw diagrams, graphics and complex animations[7]. The canvas is very simple yet very powerful as almost all kind of 2d graphics could be drawn very easily with the help of Canvas. Canvas is a low level bit map based element. JavaScript is used to communicate with the canvas element and all kind of images and graphics are drawn using JavaScript on canvas. All graphics are rendered within the defined width and height. With the use of JavaScript we can get the reference of canvas element and then can draw required graphics easily[7].

4.1.2 Local Storage

One of the biggest limitations of HTML was the absence of any data storage capability. Client Side storage is the basic requirement for any interactive modern day application. This was the area where native applications had a huge advantage over web applications. HTML5 solved that issue by introducing many data storage capabilities. One of those is local storage which is also referred as Web Storage as per HTML5 specification[8]. Local Storage provides a way for web pages to store data as key/value pair within the browser. This key/value pair data persist even after we close the browser.

4.1.3 Web SQL Database

Web SQL Database is another specification that is used for storing and persistence purposes. HTML5 brings the capabilities of Relational SQL to the client side with the help of Web SQL Database[9]. The SQLite database is pre-embedded in the browsers which provide all the capabilities of defined and structured data storage. As the database is embedded in the browser it does not require any installation. The default size of each database is 5Mega byte which can be extended with the permission of the user[10].

4.1.4 Video and Audio

HTML5 provides the video and audio elements through which web pages can play the video and audio without requiring any third party plugins. The biggest issue with HTML5 audio or video is the dispute of codecs among the browsers. For example Mozilla and opera supports Theora which safari does not support instead it supports H.264 which is also supported by IE9. Both IPhone and Android also supports H.264 on their mobile browsers. W3C recommends OggVorbis and Ogg Theora for audio and video respectively[11].

4.1.5 Geolocation API

HTML5 provides Geolocation API to developers which facilitates in adding location based features to their applications. Location Based Services are quite popular these days in native applications. HTML5 Geolocation API provides the geographical position of a user by finding its latitude and longitude. The HTML5 geolocation API finds the location of a user through GPS or using Network signals like tower or using other sources like IP Addresses etc.[12].

4.2 CSS3

CSS (Cascading Style Sheet) is the markup language through which we can give styles to different elements of our webpage. CSS3 is the next version of cascading style sheet. In CSS3 many new features have been added to enhance the user experience and look & feel of the elements.CSS3 allows developers to achieve important design features such as animations or transitions of an element and also through CSS3 it has become very easier to achieve the existing design features very easier for example presenting the content in multiple columns etc. Similarly we can select the specific element easily by using CSS3 which was only possible through JavaScript before. CSS3 is divided into various modules[11]. Each module is independent and there are around 50 such modules. Modern mobile browsers already started supporting many features of CSS3.

4.3 Hybrid Approach

Hybrid applications are the combination of native applications and web development. In Hybrid Application developers write their code in HTML5/CSS and JavaScript and could also access the device hardware features through native access. The hybrid application get access to device API's using a bridge between the browser and the device. This allows hybrid applications to get access to all the hardware features of the device. PhoneGap is an HTML5 application platform that allows developers to write smart

phone applications in HTML5/CSS and JavaScript and access the device API's through PhoneGap JavaScript API's [13]. The PhoneGap works by taking all the code that is written in HTML, CSS and JavaScript and wraps it in the native device web view control. The application runs inside a web view control but it behaves like a normal application i.e. it is impossible for user to differentiate it with the normal application. PhoneGap also provides a set of JavaScript functions that are mapped to native device functions. Through these JavaScript functions we could easily access device features like Camera, Accelerometer, GPS etc.

5. Quality Attributes of HTML5 bases Smart Phone Applications

According to ISO 9126 there are six major quality attributes. These factors are Functionality, Usability, Efficiency, Reliability, Maintainability and portability[14].

5.1 Functionality

Functionality is evaluated by determining the availability of different features in HTML5 technology, especially the device based features which are being used commonly in native application. According to the functionality test results most of the device features are available to modern versions of Smart Phones specially IPhone, Android and Windows Phone 7 through PhoneGap frame work. Some features are missing from both Symbian and BlackBerry. Although most of the device features are available in HTML5 but still there are many features which are not available to HTML5 based apps. Such as we can't change the wallpaper of our phone, or add the ringtones to our phone etc. Similarly, there are many cloud based service API's such as Apple's ICloud services or Google's cloud print services which are available to native apps but are not available to HTML5 applications. Other utility services such as Google's C2DM which is available to native Android developers for utilizing Push based services are also not available in HTML5. Different open source implementations of some of these services are available to HTML5 based developers but they are not as reliable yet.

5.2 Usability

The usability factor of HTML5 based Smart Phone apps are evaluated on the basis of the overall user satisfaction in using HTML5 based Smart Phone applications. For this purpose we have developed a simple sample application and distributed this sample application to customers who are also the frequent users of native Smart Phone applications. Most of the Smart Phones today have touch-based interfaces and easy touch interaction plays an important part in the overall usability of the application. Building applications with web based technologies is always different and challenging. Our sample application is a simple Employee Information system. This application was deployed on multiple platforms and handed over to seven experienced Smart Phone users. The usability factor was evaluated on their feedback. For their feedback a questionnaire was developed and distributed to these customers. Customers were asked about their opinion on Visual appeal of the application; Ease of navigation from one form to another, Touch based control responsiveness, Task completion time, Individual Screen's design, Organization and proper use of controls, scrolling behavior of the screens and overall usability satisfaction. According to the feedback of these customers the overall usability results were very satisfactory and on the basis of these results more complex usability survey could be done.

5.3 Efficiency

The efficiency factor is evaluated on the basis of response and processing times. The efficiency factor means how effectively an application does its required task i.e. how quickly and efficiently an application performs its job. According to a study, for a user the task is instant if it is taking around 0.1 seconds to perform. If the task is taking around 1 second then the delay would be noticeable to a user but user will not be disturbed with this delay. However if some task is taking around 10 seconds to perform then user starts getting annoyed and this is the time limit when some feedback should be given to user from the system[15]. For evaluating the efficiency of HTML5 based applications some normal performance tests were conducted which were, Application launch time and execution time of different tasks. These tests were conducted on almost the same hardware specifications. The first series of tests were conducted to measure the application launch time.

Table 2: Application Launch Time test results

	Test Run 1	**Test Run 2**	**Test Run 3**
Android	4700ms	3950ms	3923ms
IPhone	4221ms	3346ms	3499ms
BlackBerry	5339ms	5125ms	4356ms

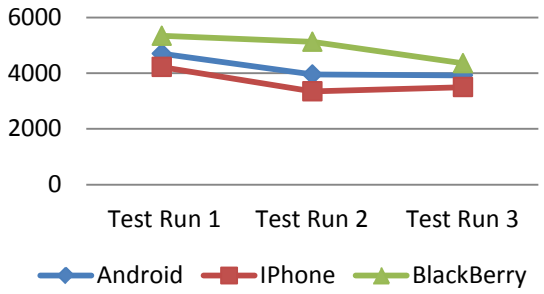

Fig.1 Application launch time test results

The time an application launch took on android was between 3-5 seconds (3000 to 5000ms) as presented in the table 2 which was under the acceptable limit as discussed in the response time study. In the second series of tasks we moved from one screen to another in our application and recorded the execution time of the whole process. In our application list of employees is retrieved from the database and presented in the form of a table with images when we move from one screen to another.

Table 3: Screen Navigation and data Retrieval Test Results

	Test Run 1	Test Run 2	Test Run 3
Android	2356ms	1958ms	1937ms
IPhone	1989ms	1945ms	1971ms
BlackBerry	2546ms	2347ms	2456ms

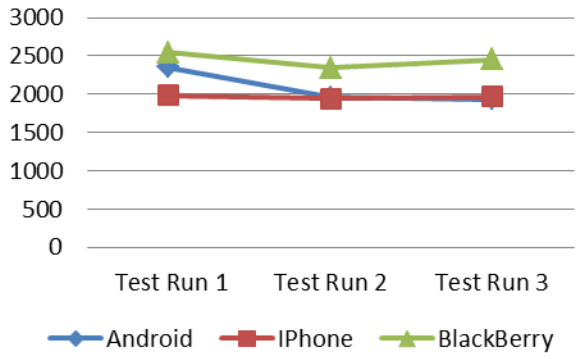

Fig 2 Screen navigation and data retrieval test results

We also recorded the process of inserting an employee record in the database and showing the success message i.e. the total execution time between the add button tap and success notification from the application.

Table 4: Data Insertion Test Results

	Test Run 1	Test Run 2	Test Run 3
Android	1387ms	1179ms	1487ms
IPhone	1234ms	1089ms	0987ms
BlackBerry	1578ms	1387ms	1433ms

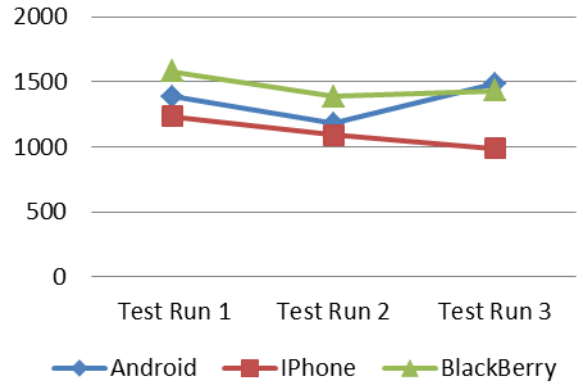

Fig 3 Data insertion test results

As per the results execution time moving from one screen to another and data insertion time on the local database were quite acceptable.

5.1.4 Maintainability

.Maintainability is the degree of flexibility an application provides in changes and extensibility. Developers always found it hard to maintain the programs written in JavaScript in comparison with high level languages such as Java and C#. Due to the unstructured nature of JavaScript language programs written in JavaScript are very difficult to understand. Although the quality of the person writing the code is also very important but because JavaScript is an unstructured language an average developer finds it hard to write good manageable code in comparison with Java or C#. Especially when the size and numbers of JavaScript files in the application increases the complexity of the code increases so much that it becomes much difficult too. Maintenance of JavaScript code is very much dependent on the expertise of person writing the code. Writing managed code in JavaScript is difficult in comparison with other languages such as Java or C# but by applying proper design patterns it is very much possible to write managed JavaScript code. As JavaScript is gaining importance very fast progress is being made from different companies on providing good debugging and code inspecting tools for JavaScript.

5.1.5 Reliability

Reliability factor of HTML5 based applications were evaluated on the basis of the Jquery Mobile based Employee Information application that we developed for usability testing. For evaluating the reliability of hardware access we added an extra form in the application which accessed the different hardware API's. As done previously the application was handed over to seven existing customers. The questionnaire was also distributed to those customers for getting their feedback. This time the questions were related to reliability factor of the application. Questions included in the questionnaire were Successful application load, Successful screen navigation, Touch based event responsiveness, application response rate, Data persistence and retrieval, device API's accessibility and overall reliability of the application. The overall reliability factor results in case of this survey were quite satisfactory. Although some customers were unhappy because some features were not of that caliber due to the fact that the device API's were not working properly on their devices. There were some data persistence issues with one of the customers other than that the reliability of the application was quite satisfactory and more complex research in this area could be done on the basis of these results.

5.1.6 Portability

The biggest reason of smart phones application development using technologies like HTML, CSS and JavaScript is to achieve cross platform portability. Without any major changes in the code PhoneGap provides the portability for HTML5 based applications. For screen designing and UI development cross platform tools like Jquery Mobile and JQTouch helps developers to build consistent screens across multiple Platforms. For evaluating portability we deployed our Employee Management application for multiple platforms successfully without any major problem.

6. Cost Effectiveness of building HTML5 based Applications

For finding the cost effectiveness of building HTML5 based applications we have found the difference in estimated cost of a native application and HTML5 based application. We have done our estimations and evaluations on the basis of an already developed application. Smart Cash Flow application is a smart and easy-to-use personal budget organizer. This application provides full control on personal finances by managing income and expense categories and multiple accounts. According to the results the minimum total estimated time for developing the application is 206 hours and if we build it for five multiple platforms to gain the maximum market the estimated time to develop and ship the application is around 1046 hours. This show how much time consuming application development could be if we build it natively. On the other hand the total estimated development time of building HTML5 application for all the five platforms was 338 hours which shows the effectiveness of developing HTML5 based application. The total development time and cost of HTML5 based application is 67% lesser then native application development which shows the cost effectiveness of HTML5 based application. The real advantage of HTML5 based application is its cross platform support on multiple platforms which is the main reason behind cost effectiveness.

Table 5:Cost Estimations of Native Application and HTML5 based Application

	Native Applications	HTML5 based Application	Difference
Total Time	1046 hours	338 hours	67%
Total Cost	15690 $	5070 $	67%

7. Conclusion and Future Work

The first goal of this research paper was to evaluate the quality of HTML5 based application development on smart phones. The quality was gauged against the ISO 9126 standard. There are six major factors according to ISO 9126 standard, which are Functionality, Usability, Efficiency, Maintainability, Reliability and Portability. Functionality was evaluated by finding the availability of different features to HTML5 applications specially the device based features which are being used commonly in native applications. Usability was evaluated on the basis of the overall user satisfaction in using HTML5 based Smart Phone applications. As per the feedback the results were quite satisfactory. The efficiency was evaluated on the performance of task completed in our application and most of the results were quite satisfactory. Maintainability of HTML5 based application was evaluated on the degree of flexibility HTML5 based applications provide in future changes after the initial development. Reliability factor was also evaluated on the basis of customer feedback and as per our study the results were quite satisfactory. Portability is perhaps the biggest advantage of building HTML5 based applications during the study we

successfully ported our application to multiple platforms using PhoneGap.

The second goal of the study was to find out the cost effectiveness of building HTML5 based applications and for this purpose a real world project was estimated on the basis of per man hour and a comparison of its timelines and cost were made and as per our study we found out that HTML5 based application was around 67% cost effective. Although our study is still in its initial phases but we have found out that HTML5 has a great potential to be great cross platform language without compromising too much on quality. As per our study the initial level performance tests were also quite satisfactory and more advanced tests should be done on these basis. Future work could be carried out by extending the application used in this study to include more complex tasks and then all the quality factors should be evaluated on those complex scenarios. The cost estimations should also be extended by including the developer per hour cost differences according to different technologies.

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