



NATIVE VS HYBRID

*An Evaluation of Approaches for Developing Mobile
Shopping App*

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of the requirements for the Master Degree
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DECLARATION OF ORIGINALITY

I declare that this is an original study based on my own work and that I have not submitted it for any other course or degree.

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ABSTRACT

Explosion of Smartphone and Tablet led to the emergence of m-commerce. The term m-commerce is a generic term and often used to identify various business services available on mobile devices, i.e. Mobile Banking, Online Shopping etc. This project focuses on Online Shopping.

When choosing technology to use to reach consumers on mobile devices, there are numerous technologies available. These technologies can be grouped in three categories. These are:

Web – Developing app using web technologies (HTML5, CSS & JavaScript) that runs in web browser.

Hybrid – A cross platform app development technology using a combination of web technologies and native container. It removes some of the limitation of web technology to some extent and provides access to local resources.

Cross platform native – Uses a platform to develop app that is compiled to native app on relevant platform.

Native - A development approach that is native to a particular development, i.e. using Android SDK to develop Android App.

Deciding on which technology to use to provide online shopping service to consumers can be difficult. This project aims to reduce this difficulty by providing an objective analysis of technologies available including a detail evaluation of both Cross platform native and Native mobile app development technology.

1 INTRODUCTION

In recent years, technology such as mobile communication, cloud computing, big data and social media changed our society enormously and business within various industry was restructured (Lin et al., 2015). Advancement in mobile technologies, particularly Smartphone and Tablets, has changed the way we carry out our day to day activity. In 2015, 2.5 billion computing devices (desktop, laptop, tablet, smartphone) are expected to be sold worldwide and 87% of these devices are Smartphone and Tablet (Gartner, 2015). Although, these figures can be argued, it does indicate the influence of mobile computing in everyday life.

Popularity of mobile devices helped improvement of the wireless communication technology such as 3G, 4G and Wi-Fi(Chang et al., 2014). There has also been a significant improvement mobile internet. In the UK, 98% of home and business has access to 3G internet with average download speed of 5.9Mbit/s and 81% users has access to mobile 4G internet with average download speed of 14.7Mbit/s (Ofcom, 2015). Although, UK's average broadband speed is slower than fixed broadband speed which is currently 22.8Mbit/s (Ofcome, 2015), it does provide sufficient speed for a user on mobile devices for most tasks including watching HD (720p) video on YouTube which requires a speed of 2.5Mbit/s (Google, 2015).

Continuous improvement of mobile operating system and task specific mobile app made the mobile devices much convenient to use and accelerated the widespread adaptation of mobile devices. Dramatic increase in use of Mobile App transferred our e-life to mobile computing environment from a conventional desktop environment (Eom and Lee, 2013).

In many perspectives, Smartphone overcome laptop and desktop because of its size, portability and availability of internet (Cherian and Varghese, 2013).

There are millions of app on app stores for various tasks. There are apps for all sorts of tasks i.e. email, internet browsing, reading, banking, socialising etc. (Ravindranath et al., 2012). The differentiating characteristic mobile app, compared to desktop app, is the way user installs the app. One of the problem with desktop app is that user need make sure the app is downloaded from reliable source otherwise user may break the computer by installing virus. Primarily, mobile apps are delivered through app store like google play store for Android app. App stores provides a safe and convenient way to install and remove the app from mobile devices. Even before purchasing the app, user can read review and statistics on the app to verify the usefulness. User can make informed decision on selection and installing and app. Many tasks, that are done using web browser on PC, are done using Apps on mobile devices. For example, many banks have mobile app for banking.

Easy to use application, on board sensors and increased computing power of mobile devices created a new platform for business (Dehlinger and Dixon, 2011). Consumer's demands for various business services to be available on mobile devices led to the emergence of m-commerce or mobile commerce. Smartphone are widely used for m-commerce because of 'ubiquitous and instant connectivity' and 'ease of use' (Choi et al., 2014). Services like online shopping, banking, mobile ticketing, content purchase and delivery became very popular. US and European shoppers are expected to spend \$67 billion on shopping using mobile devices in 2015 (Chang, et al., 2014).

There are number of options for an internet retailer to reach to the customers on mobile device. For example, Mobile Web App, Hybrid Mobile App, Native Mobile App etc. It can be difficult to choose the right technology when forming mobile strategy. This project tries to ease the problem when choosing mobile app technology. This report is divided in following sections:

- **Section 2, Literature Review** - Researches state of mobile technology & options available to an online retailer to reach to customers on mobile devices.
- **Section 3, Design** - Analyses requirement for designing app for mobile shopping and design app using UML.
- **Section 4, Implementation** - Implement app using Android & Xamarin.
- **Section 5, Evaluation & Recommendation** - Evaluate the two approaches to mobile application development in details, Cross Platform Native App using Xamarin From and Native Android App.
- **Section 6, Critical Self-reflection** - Reflects on issues encountered during the projects & experience gained.

2 LITERATURE REVIEW

2.1 IMPORTANCE OF MOBILE COMMERCE AND ONLINE SHOPPING

This section of the report focusses on current state of m-commerce and m-shopping, what challenges and opportunity it brings for business and its impact on strategic decision making.

2.1.1 What is m-commerce an m-shopping?

M-commerce is a way of carrying out business transaction using mobile devices (Cherian and Varghese, 2013).

Examples of m-commerce includes Mobile Banking, Ticketing, and Shopping. M-shopping can be defined as purchase of good and services using mobile devices (Searleman, 2013).

Zhang and Hilton (2012) describes m-commerce as “capability to buy or sell a product or service on the Internet via a mobile device, such as a smart phone or a tablet”.

Chong (2013) defines m-commerce as “the buying and selling of goods and services through wireless handheld devices.”

As can be seen the term ‘m-commerce or mobile commerce’ is used to identify all business transaction as well as only purchase activity. To avoid any ambiguity, in this report m-commerce is used to identify purchase activity on mobile devices. Similarly, the term ‘e-commerce’ will be used to indicate all purchase activity on all electronic devices including desktop, laptop, smartphone and tablet.

2.1.2 Size and Growth of m-commerce

Decrease in Smartphone price and increase in the availability of mobile internet led to the growth of m-commerce (Zhang and Hilton, 2012). Global e-commerce is estimated to be \$1.3 trillion by end of 2014 and expected to be doubled (\$2.5 trillion) by 2018. In UK, e-commerce is estimated to be 18% of all retail sales by 2018 (eMarketer, 2014). As of Q1 2015, m-commerce represents 34% of global e-commerce, it is expected that, by end of 2015, m-commerce will represent 40% of global ecommerce transaction. (Criteo, 2015).

2.1.3 Influence of Smartphone on Instore Purchase

Increasingly, Smartphones are having a significant influence on instore purchase. Customers uses their Smartphone to check product information online before making final decision. Customer can look for information like product specification, review and compare prices using Smartphone. 58% Smartphone owner uses their Smartphone to find information about the product. 28% customers look up reviews and 27% look up prices. These numbers are growing year on year (Smith, 2013).

In-store mobile shopping experiences

% of adult cell owners who used their phone during the past 30 days inside a store to...

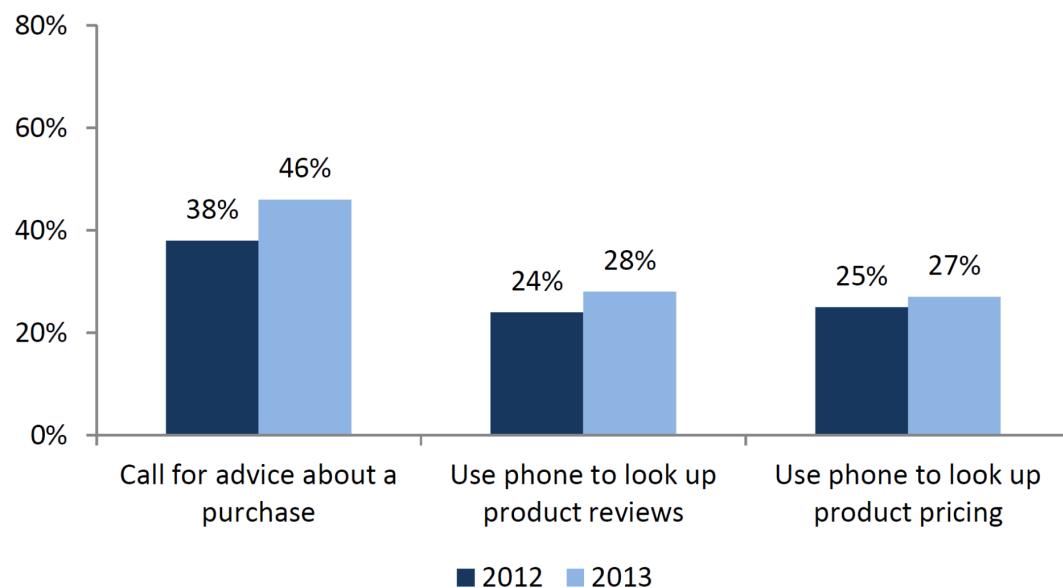


Figure 1: In-store Mobile Shopping Experiences (Smith, 2013)

2.1.4 Impact on Business Environment

(Porter, 2008) Argues that there are five forces that shape industry competition.

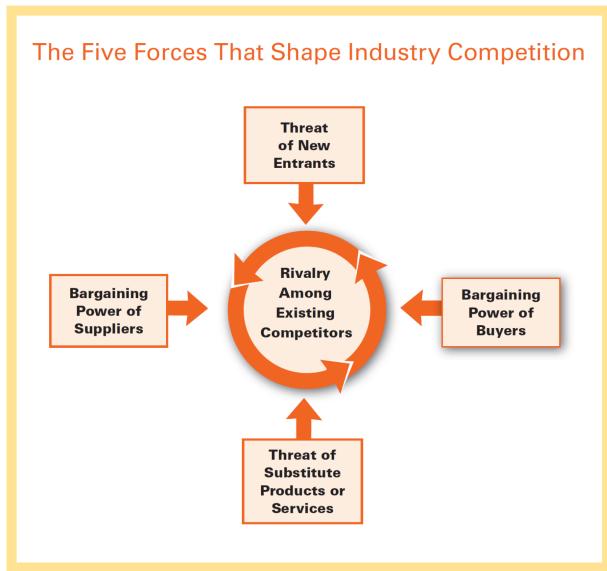


Figure 2: Porter's Five Forces (Porter, 2008)

Increasingly, adaption of mobile computing mediates consumer's social experience of markets and retail environments (McGuigan and Manzerolle, 2014).

If e-commerce is considered as industry, increasing use of Smartphone and Tablet directly influences three of these forces. First, customer gets more bargaining power using Smartphone to look up prices from different stores. Customers look for more competitive price online (Georgiadis and Chau, 2013). It increases competition among the retailers. Second, search keywords entered by the buyers are recorded by the search engine providers Google. New business, wish to enter into the industry, can use the data collected by search engine to analyse the demand for products and services that helps more business to enter into the market. Third, search engine data is also used by manufacturers to identify demand for products that helps manufacturers to makes substitute product. As a result, it increases the threat of substitute products and services. Overall, growing use of Smartphone makes it challenging for both online and high street retailer to stay competitive and maintain market share.

2.1.5 Impact on IT strategy

Increased volatility in business environment changed the way strategic decisions are made. Traditionally, strategic decisions were formed in steps similar to waterfall model of software development. Most strategic decisions were long term decision. Traditional approach to strategic decision making is no longer suitable for modern business environment where changes are more frequent especially in case of Information Technology. Businesses need to be agile to response quickly to change. To be sustainable business needs to implement game changing emerging technology like Big Data, Business Intelligence (BI) and Artificial Intelligence (AI). Not implementing this technology in time could lead to loss of market hence loss of income and long-term sustainability. These technologies also play an important role for the success of e-shopping and m-shopping. For example, use Artificial Intelligence and Big Data can improve marketing efficiency by displaying more relevant to a customer.

More and more consumers are using Smartphone to purchase products and services online or to look up product information online before purchasing the product in store. Therefore, it is absolutely vital for retailers to have mobile presence.

2.2 BARRIERS TO THE ADAPTION OF M-COMMERCE AND M-SHOPPING

Before researching the technologies used to provide m-commerce services, it is important to investigate what influences a user to accept or reject m-commerce. This will be helpful in evaluating m-commerce technologies.

There are frameworks that can be used to analyse the factors that influence the acceptance of a particular technology. Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT) are prominent among these frameworks (Alkhunaizan & Love, 2012). Other theories include The Theory of Planned Behaviour (TPB), Innovation Diffusion Theory (IDT) and Theory of Reasoned Action (TRA). Since their origin, UTAUT and TAM have gone through number of extension and revision to make framework more relevant to particular environment, i.e. health care (Ami-Narh and Williams, 2012). Original UTAUT was developed to be used in an *organisational context* to analyse the technology acceptance among employee. It was latter extended to be used in *consumer context* and called UTAUT2 (Venkatesh, et al., 2012). (Alkhunaizan & Love, 2012) proposes a revised UTAUT model to use in m-commerce context. The expanded TAM which is called TAM2 is also used in m-commerce context (Choi et al., 2014). I have chosen ‘Revised UTAUT Model’ for the project as constructs in UTAUT are more relevant for m-commerce than that of TAM2.

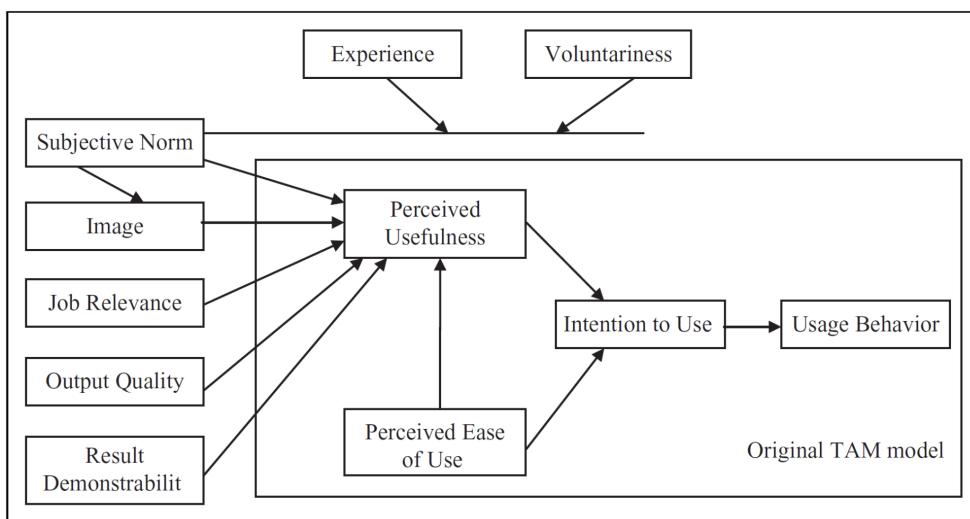


Figure 3: Extended TAM Model (TAM2)(Bhatiasevi and Krairit, 2013)

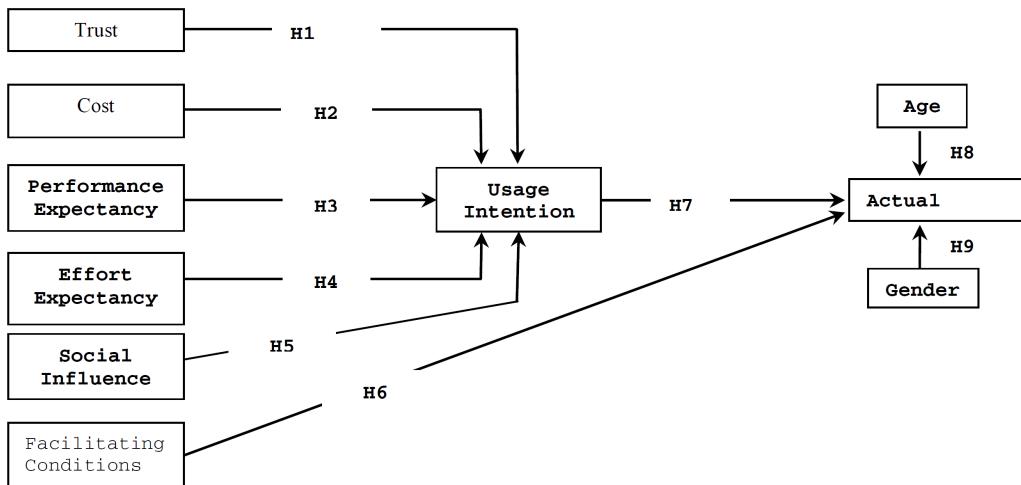


Figure 4: Revised UTAUT Model (Alkhunaizan & Love, 2012)

2.2.1 Revised UTAUT Model

There are seven constructs (H1-H7) and two moderators (H8-H9) are used in the model. Given that moderator remained unchanged, Positive construct indicates the behavioural intention to use the technology. However, if moderator changes, it can influence the actual usage behaviour. For example, even though m-commerce became more trustable because standardised practices and payment system, however people of different age and gender may think about trust differently. As a result, it may influence the actual uses behaviour of the technology.

This project doesn't carry out any user base survey or user-based testing. Therefore, UTAUT is simplified to use in the project and based on six constructs and assumes that moderators (age and gender) remains unchanged.

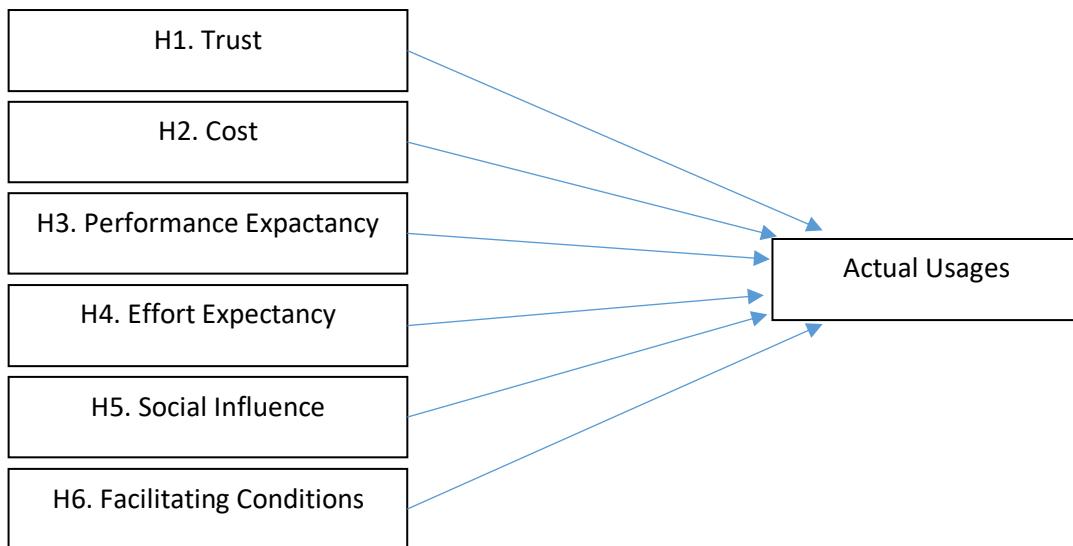


Figure 5: Revised UTAUT use in this project

2.2.1.1 Trust

Trust is a very important factor in adaption of m-commerce. Some research suggest that, if consumer cannot trust m-commerce, they are likely to discontinue to use m-commerce irrespective of satisfaction level (Chong, 2013). Most big retailer like Tesco now has mobile app. Overall trust in m-commerce is improving due to improved internet

connectivity and emphasise on security by technology providers. For example, popular Google Chrome browser will alert user when accessing website served using HTTP protocol (Brandom, 2018). 2/3 of the website may be affected by this change (Sharma, 2018).



Figure 6: Google Chrome security warning (Sharma, 2018)

2.2.1.2 Cost

Related cost includes cost of phone and cost of internet. Both of these costs have been reduced significantly in recent years. Android smartphone can be bought under £50.

2.2.1.3 Performance Efficiency

Latest Smartphones are quite powerful. Even a Smartphone costing under £50 comes with quad core CPU and 1GB RAM

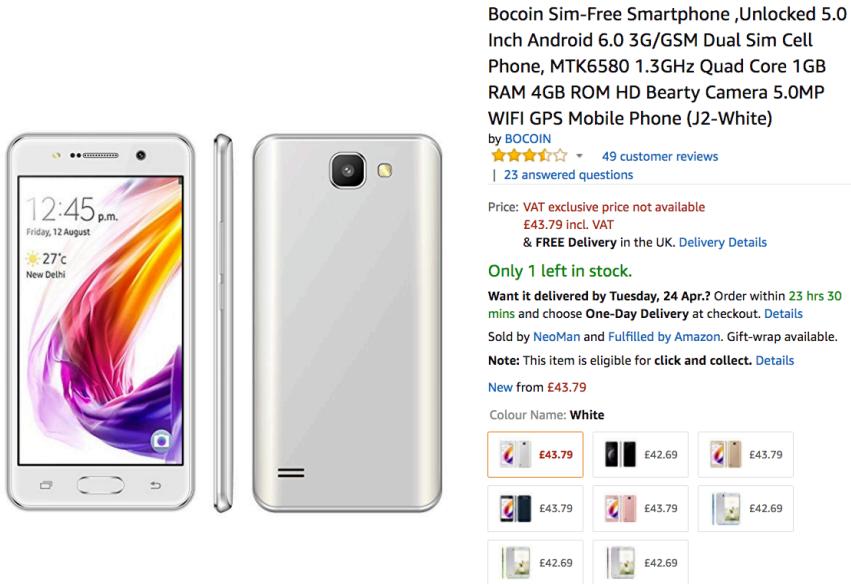


Figure 7: Smartphone under £50 on Amazon.co.uk

However, users of older Smartphone may suffer performance related issue.

2.2.1.4 Effort Expectancy

How easy it is to shop using mobile devices. Ease of use is one of the key factor for adapting m-commerce (Fong and Wong, 2015). However, poor mobile internet connection, small screen size and limited input capability can affect the usability of mobile application (Harrison et al., 2013). As a result, it may affect the adaption of m-commerce in countries with poor mobile internet connectivity.

2.2.1.5 Social Influence

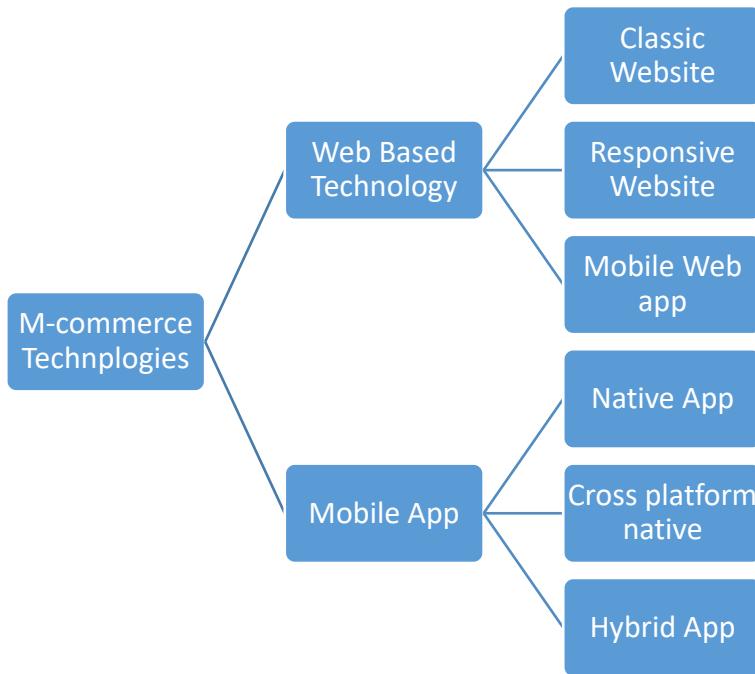
How surrounding people using the technology influence the user to accept the technology. Does friends and family are using m-commerce service. Social influence and peer pressure is one of the key factor for adapting m-commerce (Fong and Wong, 2015; Choi et al., 2014).

2.2.1.6 Facilitating Condition

cheap phone, fast internet available everywhere. Mobile device goes with the user.

Research finds that trust, ease of use, usefulness and cost are key determinants of users' intention to continue to use the m-commerce (Chong, 2013). As these conditions are improving, more users are likely make carryout business transactions using Smartphone. Next section of this report explains technologies that could be used to provide shopping service to Smartphone users.

2.3 USE OF TECHNOLOGIES TO IMPROVE MOBILE COMMERCE



This section discusses Technologies that can be used for m-commerce. Technologies used in m-commerce can be divided in two groups, Web Technology and Mobile App.

1. Web based technologies – this uses HTML5, CSS, JavaScript to develop application that is delivered through web browser on mobile devices.
2. Mobile App – this is an application that a user needs to install in order to use m-commerce. Mobile Apps are delivered through App Stores like Google Play Store for Android.

2.3.1 Web based technologies for m-commerce

Web based technologies can be subdivided in three groups based on their behaviour and application architecture.

These are:

1. Classic website/desktop style website
2. Responsive Website
3. Web App/Mobile Web App/ One-page app

Each of these has their advantages and disadvantages. Let's look at each of these technologies in detail.

2.3.1.1 Classic Website/Desktop Style Website

This is the tradition website primarily designed for users on desktop and laptop computers. Many companies let mobile users to choose between classic website and mobile site. Classic website need to be optimized for touch screen to improve the usability on mobile browser. There are number of factors that may influence user to use classic website instead of mobile version. First, particular user has been using classic website for long time and very familiar with the lay out and functionality. Second, mobile version may not provide all the feature and functionality of classic website. For some company, it could be that they have not implemented a mobile website yet. For example, eBay.co.uk has two websites, classic and mobile. User can switch between two and use the one user likes.

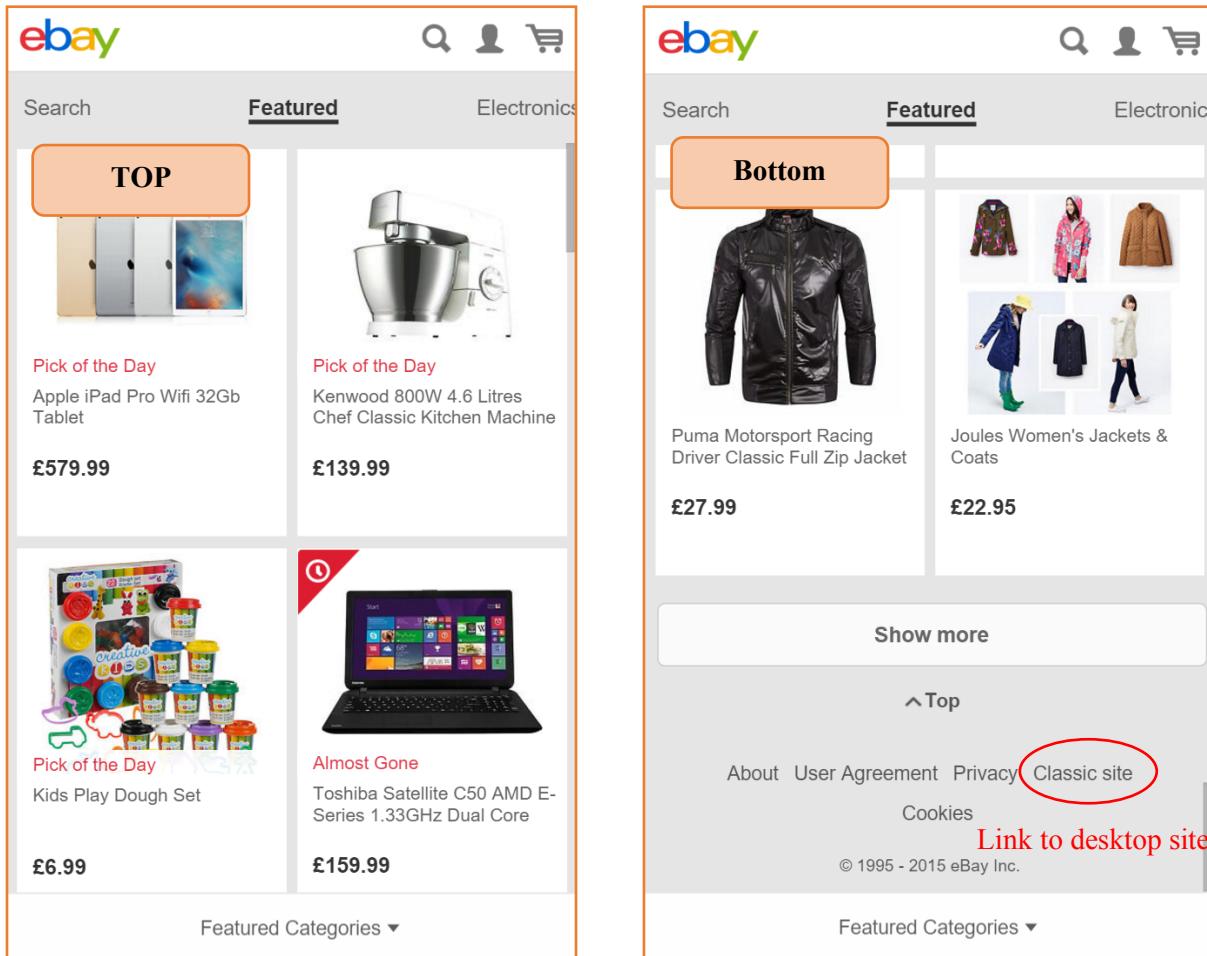


Figure 8: eBay.co.uk Mobile Web App (eBay.co.uk, 2015)

BLACK FRIDAY **GREAT DEALS ALL WEEK** **SHOP IT ALL** OPEN

Hello. Sign in or register | Daily Deals | Sell | Help & Contact | SHOP BLACK FRIDAY >

ebay Shop by category Search **TOP** All Categories Search Advanced

Following Today Fashion Home & Garden Electronics Leisure Collectables Jewellery & Beauty Motors Deals & Special Offers Pre-Owned Picks

TAKE A LOOK AT YOUR RECENTLY VIEWED ITEMS

Brand New SB054 NEW Kenwood SB056 Philips GC8651/10

NOT JUST THE ONE I COULD AFFORD.

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Buy	Sell	Bottom	companies	About eBay	Help & Contact
Buying Basics	Selling		Shopping.com	Media Centre	Resolution Centre
Deals	eBay Top-rated sellers		StubHub	Advertising on eBay	Delivery & Returns
eBay Mobile	Seller Centre		eBay Motors	Affiliates	Contact Us
eBay Money Back Guarantee	Postage Centre			VeRO: Protecting Intellectual Property	Community
Shop by Brand	Seller Protection			eBay Responsible Practices	Answer Centre
eBay Guides	Sell for Charity				Discussion Boards
eBay for Charity					Groups
eBay Shops					News
eBay Wish list					eBay Sites
					 United Kingdom ▾

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Figure 9: ebay.co.uk Classic Website (ebay.co.uk, 2015)

Some companies have their own development team and developed their bespoke e-commerce system. However, there are many ready to use e-commerce platform developed by various vendors such as Magento, WooCommerce by WordPress, Shopify, BigCommerce and Oracle. According to biltwith.com (2015) 20% of top 10,000 e-commerce websites are built with Magento (Magento 13% + Magento Enterprise 7%) that makes Magento the market leader.

Ecommerce Usage Statistics

Statistics for websites using Ecommerce technologies

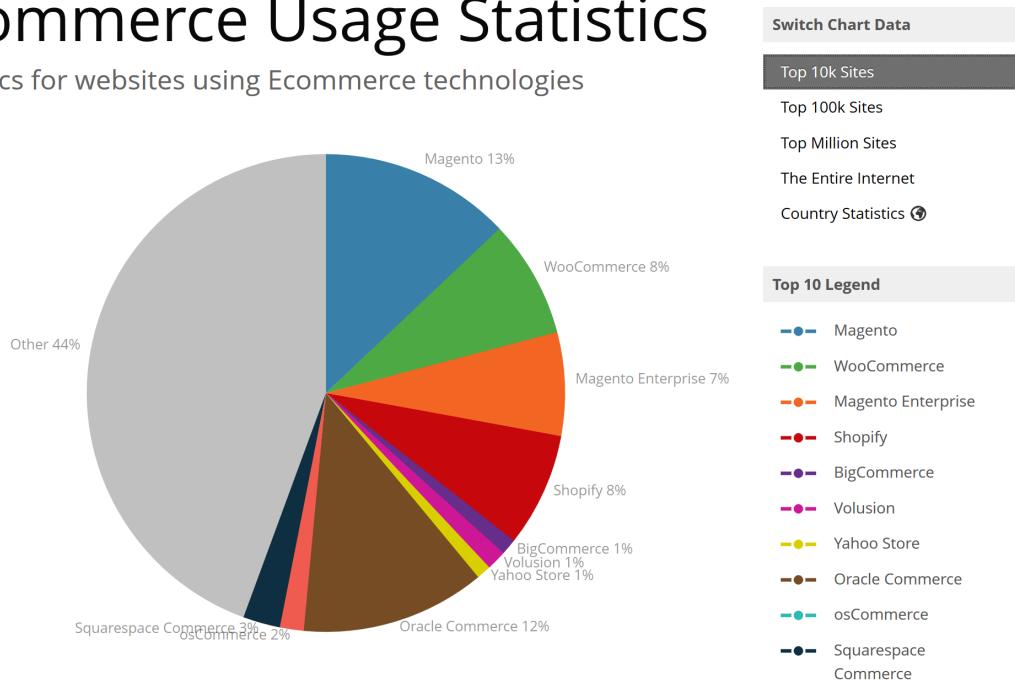
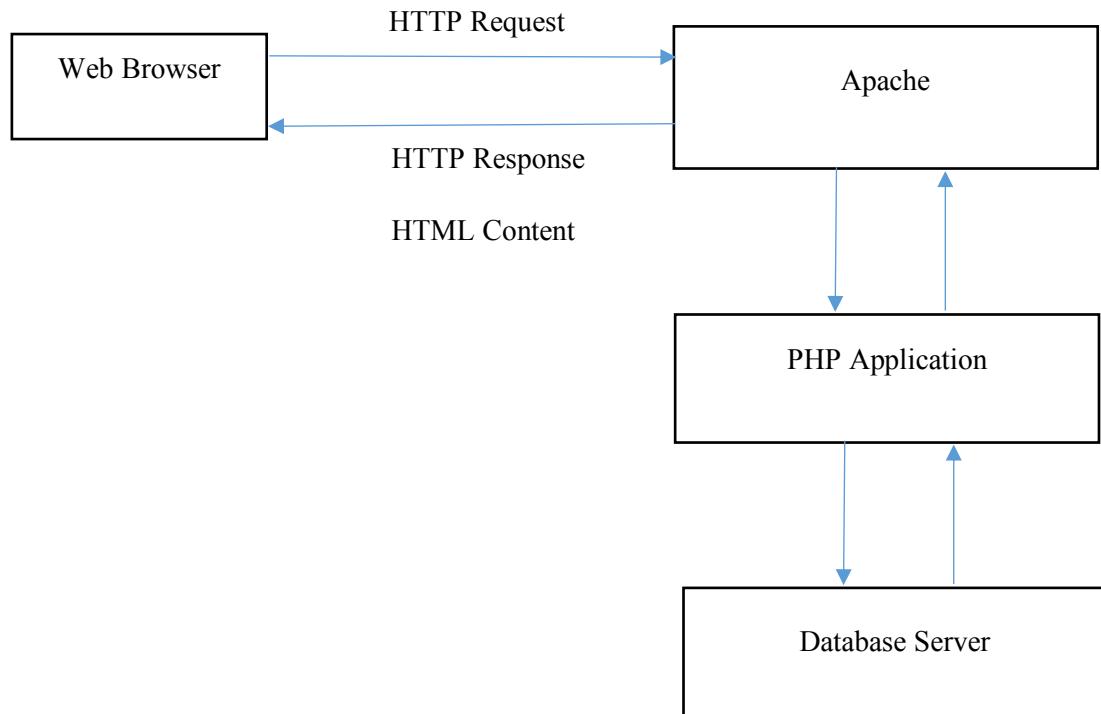


Figure 10: E-commerce Application Market Share (builtwith.com, 2015)

Developer	December 2014	Percent	January 2015	Percent	Change
Apache	90,846,940	50.57%	89,831,550	50.72%	0.15
nginx	26,466,559	14.73%	26,255,870	14.82%	0.09
Microsoft	21,057,292	11.72%	18,684,665	10.55%	-1.17
Google	14,184,320	7.90%	14,378,260	8.12%	0.22

Figure 11: Webserver Market Share (Netcraft, 2015)

Most ecommerce system has a multi-tier architecture. Key components of an e-commerce include database server (MySQL, MSSQL, Oracle) and web/application server (Apache, Microsoft IIS). More than 50% of the website runs on Apache server (Netcraft, 2015). Web application are developed using server side programing language such as PHP, Java, C#. A combination of PHP, MySQL and Apache is most popular choice for e-commerce application and used by top e-commerce engine Magento and WooCommerce.



As shown in above diagram, in case of Apache, PHP and MySQL based e-commerce system, web browser sends an http request to web server for a webpage, web server pass the request to PHP application that verifies the request, communicates with database if necessary and generates the HTML contents and pass it to Apache. Finally, Apache sends the HTTP response with HTML content back to the web browser. This is a simplified description using just main component. E-commerce application such as Magento has a very complex architecture as can be seen in the diagram bellow. Some of the features of the Magento will be discuss latter in this report. For the discussion in this section, it would be sufficient to know that, in case of a classic website, all the content (HTML, CSS, JavaScript and Binary files) required to display a web page are generated by the server for each request and sent to the browser.

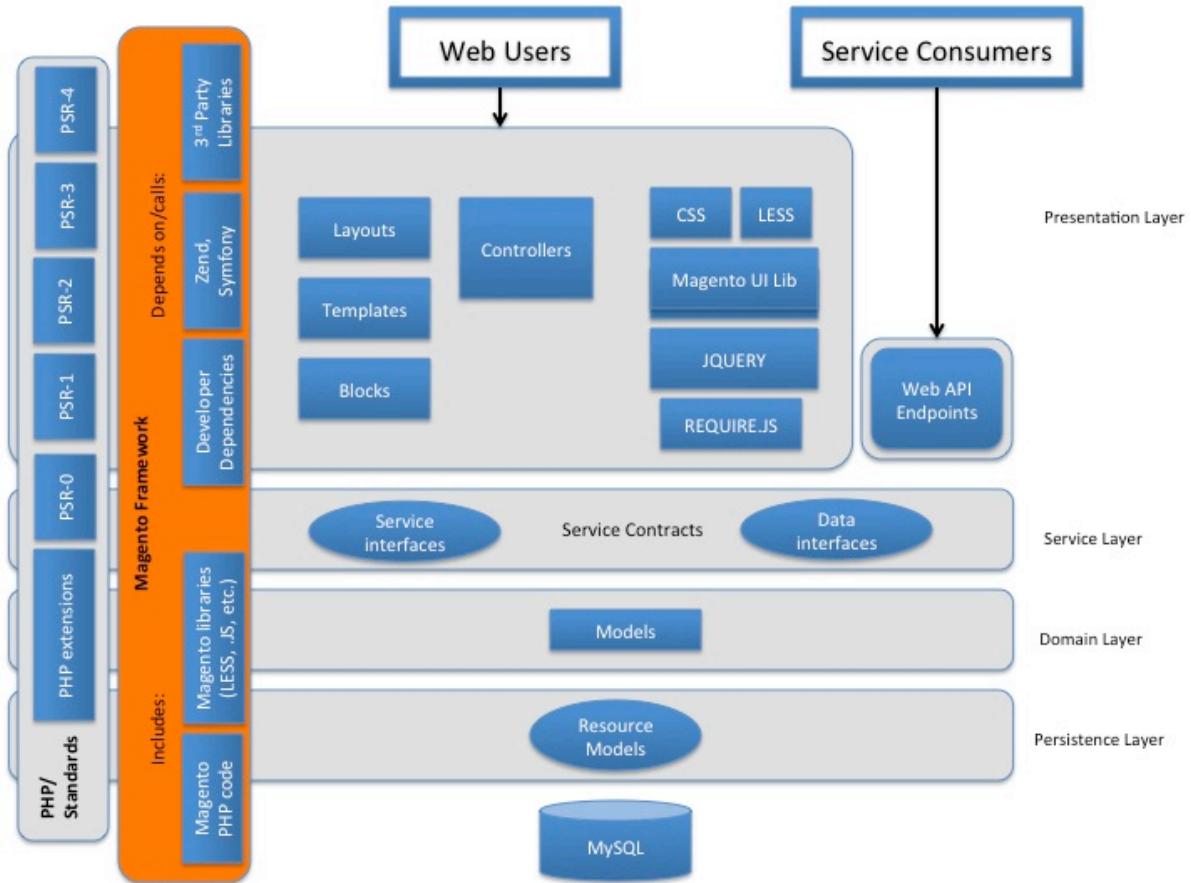


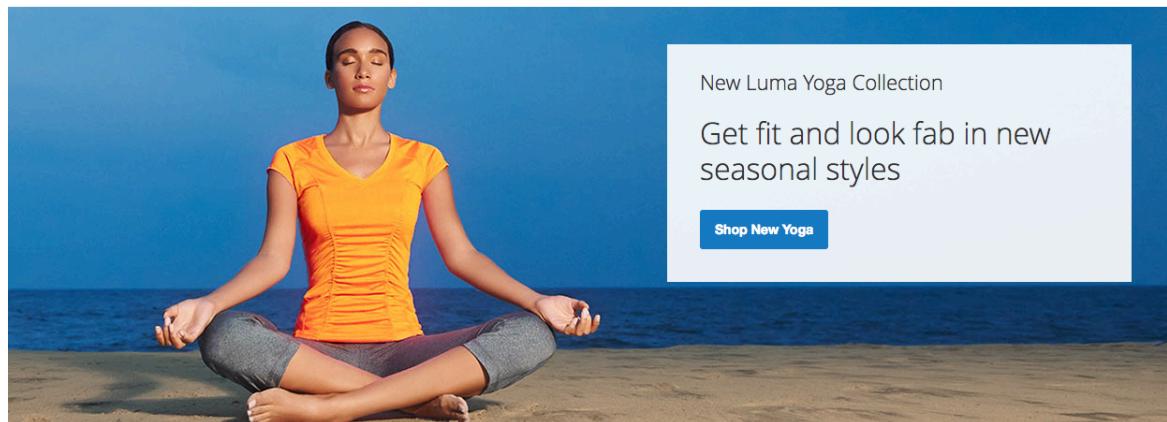
Figure 12: Magento 2.0 Architectural Diagrams (Magento, 2015)

2.3.1.2 Responsive Website

Recently, responsive web design has grown in popularity. Responsive and classic website have similar architecture. However, responsive website can adjust the layout based on screen device's screen size and capabilities (LePage, Pete, 2015). As a result, responsive website looks good on most devices including Smartphone, Tablet, Laptop and Desktop. Moreover, responsive website is easier to use on mobile devices than classic website. As a result, responsive removes the need for separate desktop and mobile version of website and reduces the cost. Most e-commerce solution including Magento comes with both classic and responsive theme. An example responsive website provided below.



TOP

Search entire store here... [Women](#) [Men](#) [What's New](#) [Gear](#) [Training](#) [Collections](#) [Sale](#)

Bottom

[About us](#)
[Customer Service](#)[Privacy and Cookie Policy](#)
[Search Terms](#)
[Orders and Returns](#)
[Advanced Search](#)
[Contact Us](#) Enter your email address

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Figure 13: Responsive website on desktop browser, using Magento 2 Luma theme

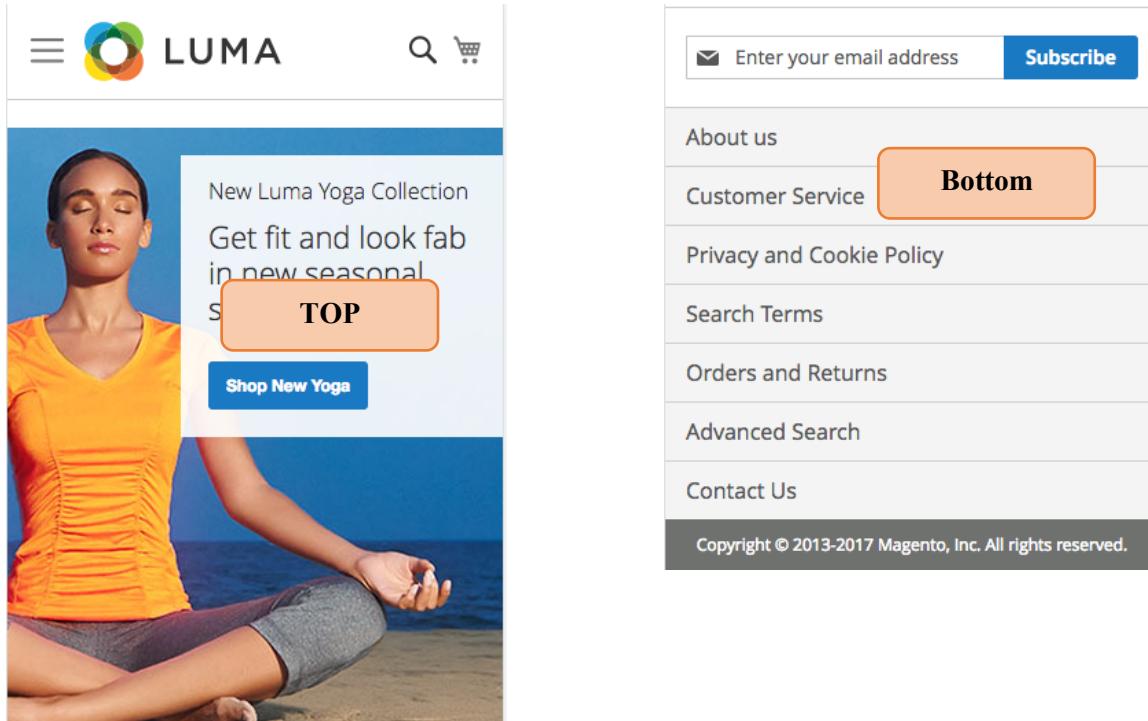


Figure 14: Responsive Website in Mobile Browser, using Magento 2 Luma theme

2.3.1.3 Mobile Web App/ One-page app

There are on the definition of Mobile Web App. Some defines Mobile Web App as “simply websites optimized specifically to be rendered on mobile devices.”(Vraa, 2015). Mobile version of ebay.co.uk mentioned earlier is an example this. However some argues modern web app are much sophisticated. Heitkötter et al., (2013) define Mobile Web App as “an application that runs within web browser as opposed to static content and build with HTML5, CSS3 & JavaScripts which is different from Mobile App that is distributed through App Store”. SpringDeveloper (2013) suggests that web app has much sophisticated architecture. When user request the URL first time, server sends the web app to browser including all necessary files and data (HTML, CSS, JavaScript). Once the Web App is loaded in the browser, subsequent request for data are sent to webserver using HTTP web service or WebSocket and response are often in XML or JSON format that requires less bandwidth. Additionally, WebSocket eliminates the limitation of HTTP protocol by providing bidirectional persistent connectivity between client and server that allow the server to push the notification to the client (Jasdeep, 2015). Web app provides near native look and feel as it presents data to user without refreshing the webpage by retrieving the data in background. However, because of extensive use of JavaScript in Web App, search engines cannot index web apps properly. Despite this backdrop, Mobile Web App gaining momentum as developers are able reach users on largest range of devices compared with native application development (Desruelle and Gielen, 2015). There are many HTML5 based frameworks that can be used to develop Mobile Web App. Ionic, Intel’s App Framework, OnsenUI and The-M-Project are among the most popular frameworks (Sohn et al., 2015).

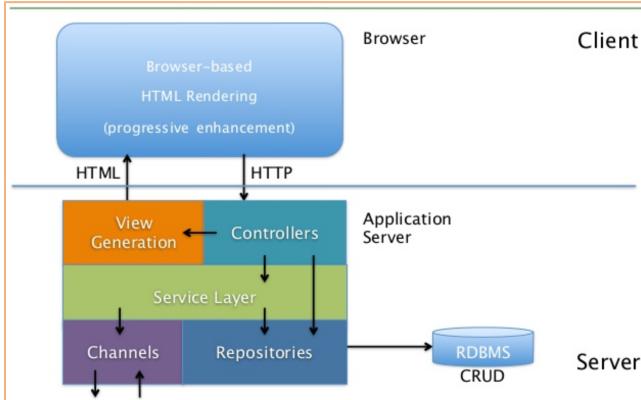


Figure 15: Java Based Website Architecture (Andrews, 2013)

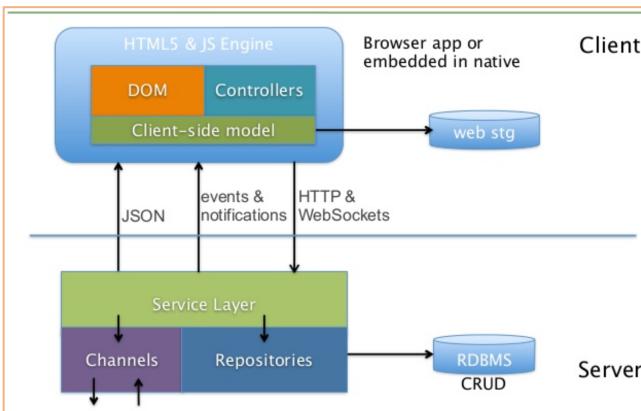


Figure 16: Java Based Web App Architecture (Andrews, 2013)

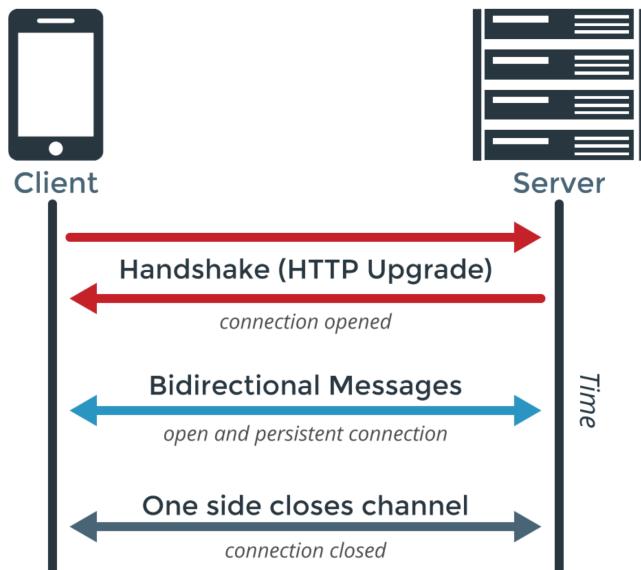
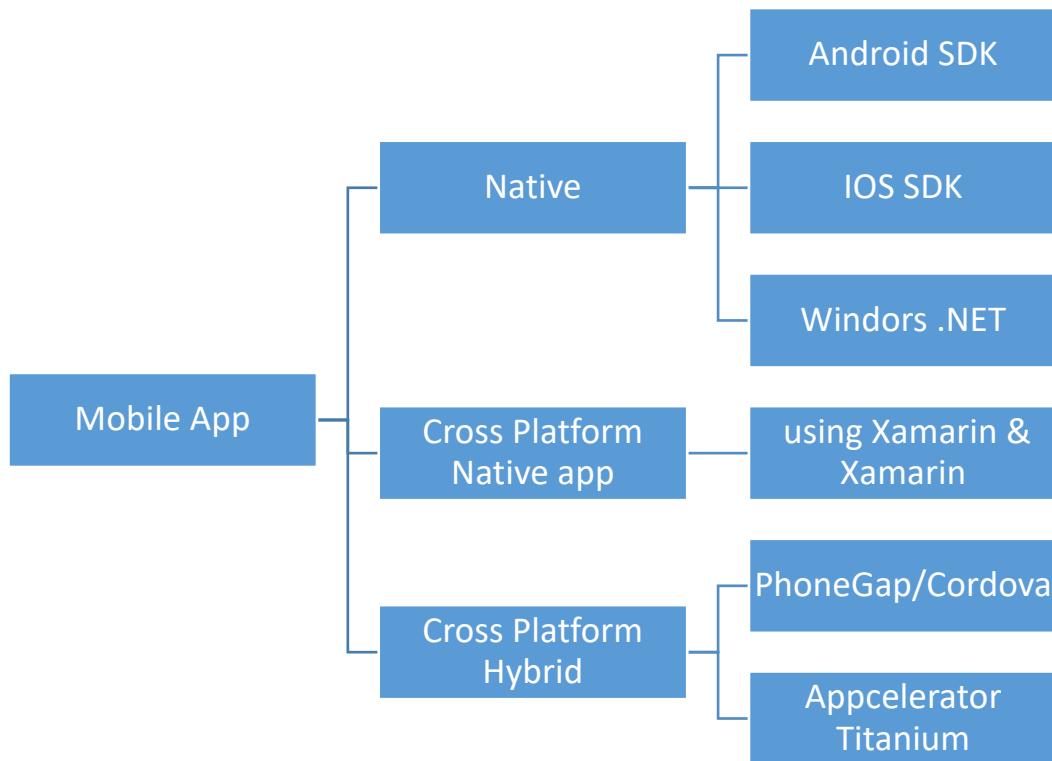


Figure 17: WebSocket Communication (Jasdeep, 2015)

2.3.2 Mobile App

Mobile App are different from Mobile Web App discussed earlier. Mobile App need to be installed before they can be used while Mobile Web App is delivered via web browser. There are three approaches to mobile app development, Hybrid App, Cross Platform Native and Native App.

2.4 APPROACHES TO MOBILE APPLICATION DEVELOPMENT



There are three primary approach to mobile app development, native, cross platform native and hybrid. Let's look at each of them in detail.

2.4.1 Native App

Native Apps are developed using native language (i.e. Java for Android and Objective-C for iOS) of the platform and provide best performance of all mobile app development method as native are compiled in machine code (in Apple iOS) or byte code (in Android) (Ziflaz, 2015).

However, native app is most costly strategy as it requires to develop app for every targeted platform. Currently, Smartphone and Tablet operating system Android &iOS covers more than 98% of the market share. (State Counter, 2018)



Figure 18: Mobile Operating System Market Share Europe (State Counter, 2018)

There for business wish to take native app development approach need to target at least two platforms (Android and iOS) to reach majority of the customer. Each of this platform has their own architecture. Let's look at architecture of Android and iOS.

2.4.1.1 Native Android App Architecture

Android App is developed using Java Development Kit (JDK) and compiled to byte code that runs Android Runtime(ART).

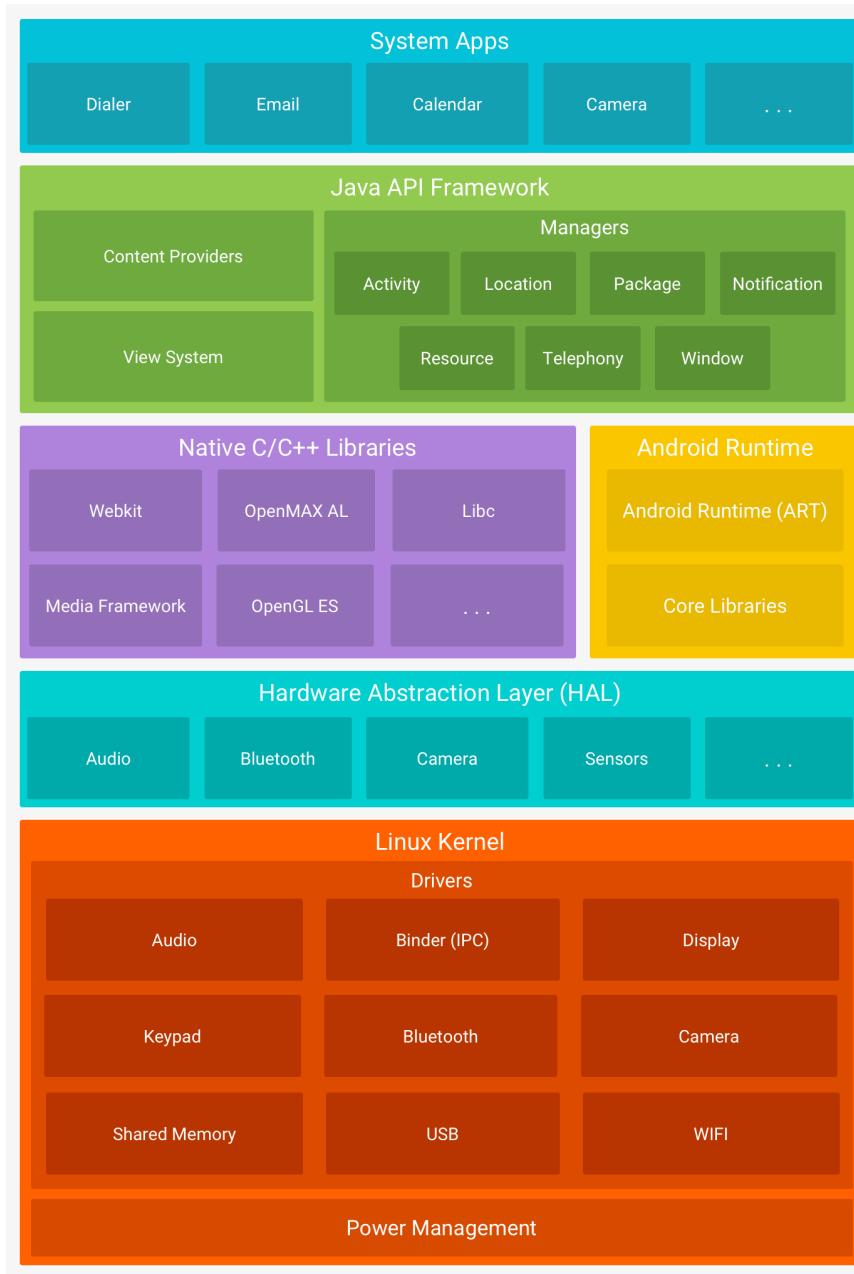


Figure 19: The Android software stack (Android, 2018)

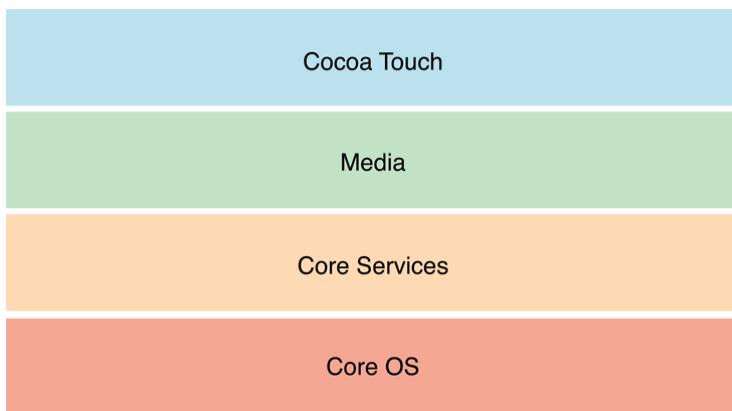
Java was the primary programming language for Android, however Kotlin programming language developed Jet Brains is now official language for Android (Android, 2018).

2.4.1.1.1 Development Environment

Android Studio is used for native android development. Android Studio has been developed based on one of the most popular IDE IntelliJ Idea Community edition. It has many features that helps developer to be more productive. Android Studio is available for both Windows & Mac. To publish App on Google Play Store, Google Play Console is required that costs \$25.

2.4.1.2 Native iOS App Architecture

iOS application is primarily written in Objective-C and compiled into machine code which is run by iOS. Apple announced Swift programming language in 2014 that became one of the fastest growing languages in history (Apple Inc, 2018). Swift can also be used to develop iOS app (Apple Inc, 2018). iOS has four abstraction layers, Cocoa Touch, Media, Core Services and Core OS. Cocoa Touch layer provides an object-oriented abstraction layer for developing iOS App. Media layer includes C-based technologies like OpenGL ES, Quartz and Core Audio for handling media contents such as 2D and 3D drawing, video and audio. Core Services and Core OS layers provide fundamental interfaces such as low-level data type and sockets (Yaseen and Tariq, 2012).



iOS has significantly different and flat architecture than Android.

2.4.1.2.1 Development Environment

Xcode is used for development on Apple platform. Xcode is free download and use but to publish app on app store Apple Developer Program subscription is required that costs 99 USD per membership year (Apple Inc, 2018).

2.4.2 Cross Platform Native App using Xamarin & Xamarin.Forms

Xamarin & Xamarin.Forms are separate component.

2.4.2.1 Xamarin

Xamarin is owned by a subsidiary of Microsoft. After acquisition on 2016, Microsoft open sourced Xamarin. It is included all version of Microsoft Visual Studio including Visual Studio communication edition. Xamarin can be used for developing cross platform native mobile. Xamarin uses C# programming language and Mono .Net framework for development. Compiler compiles the code in native application on iOS, Android & Windows Phone.

- On Android, C# is compiled to IL and packaged with MonoVM and JIT'ing. Any unused class is removed.
- On iOS, C# is compiled to ARM assembly language, .Net framework is included and any unused classes are stripped out.
- On windows, C# is compiled to IL and run by built I run time environment and doesn't require Xamarin tool

(Dunn, 2018)

2.4.2.2 Xamarin.Forms

Xamarin.Forms is a natively-backed UI tool kit abstraction that facilitates development cross platform UI that renders into native UI during run time (Xamarin, 2018).

Syntax

```
[Xamarin.Forms.RenderWith(typeof(Xamarin.Forms.Platform._ListViewRenderer))]
public class ListView : ItemsView<Cell>, IElementConfiguration<ListView>, IListViewController
```

Remarks

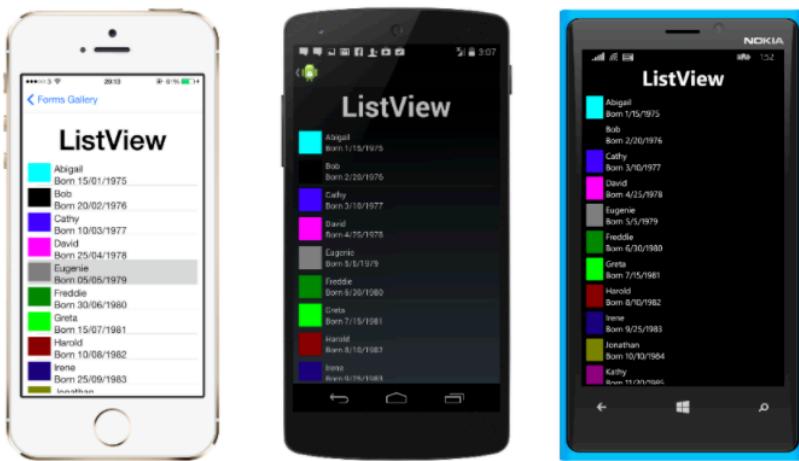


Figure 20: Example Xamarin.Forms ListView on iOS, Android & Windows (Xamarin, 2018)

Xamarin.Forms also provides a Device class that could be utilised to provide platform specific UI configuration. i.e. height, colour, padding etc.

2.4.2.3 Development Environment

Xamarin tool is included in all version of Microsoft Visual Studio including free Microsoft Visual Studio community edition. To develop iOS, Xcode is required. Therefore, to develop app for both iOS and Android, one of two following development setups is required.

1. Windows – if visual studio is used in Windows, a separate Mac running Xcode is required.
2. Mac – Visual Studio for Mac can be used. Windows PC is required.

2.4.2.4 Native UI designer

Xamarin has great support for native UI. Visual Studio has native UI designer for iOS and Android to design supplicated native UI easily that can be manipulated using C# code.

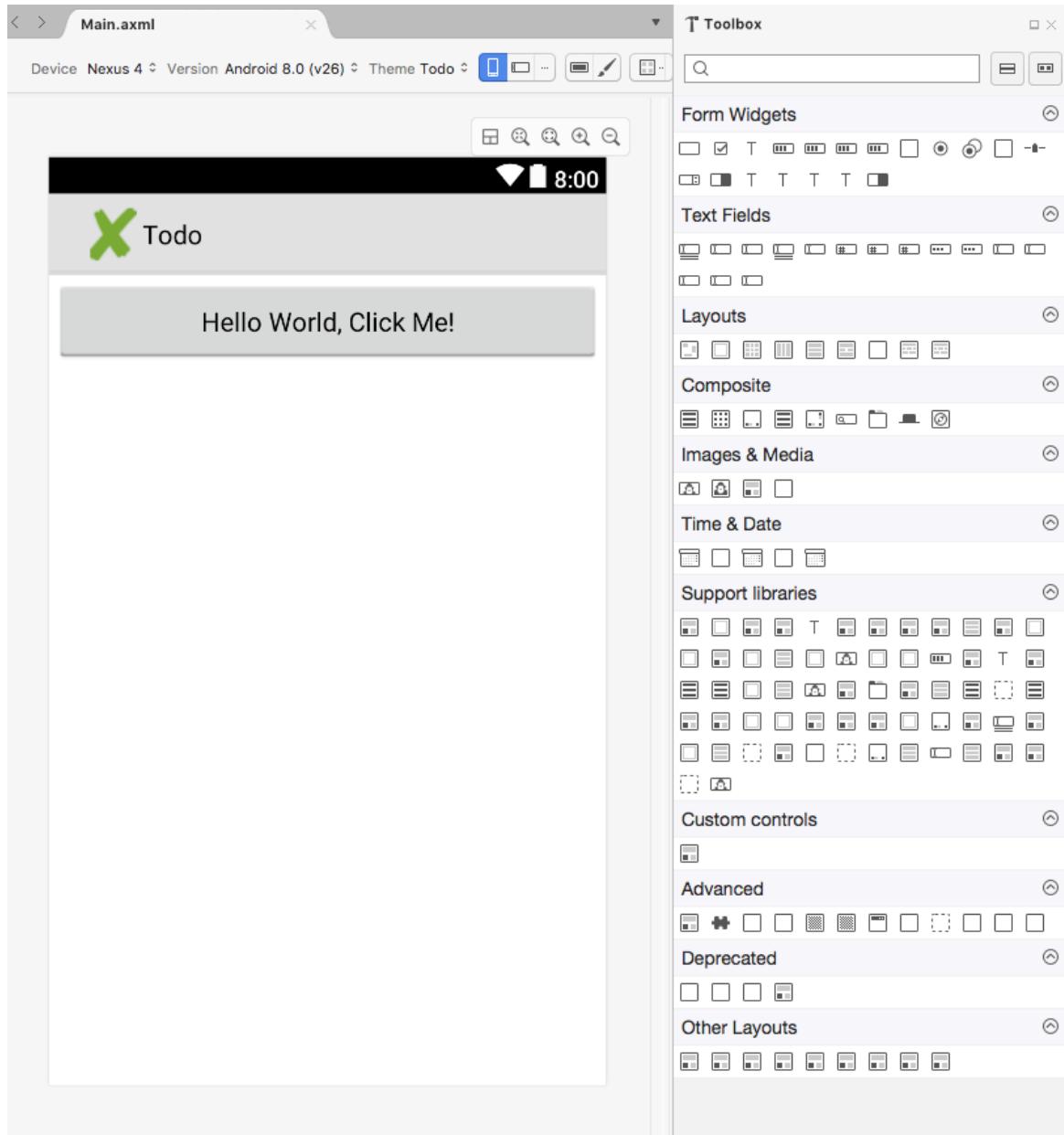


Figure 21: Visual Studio UI designer for Android UI

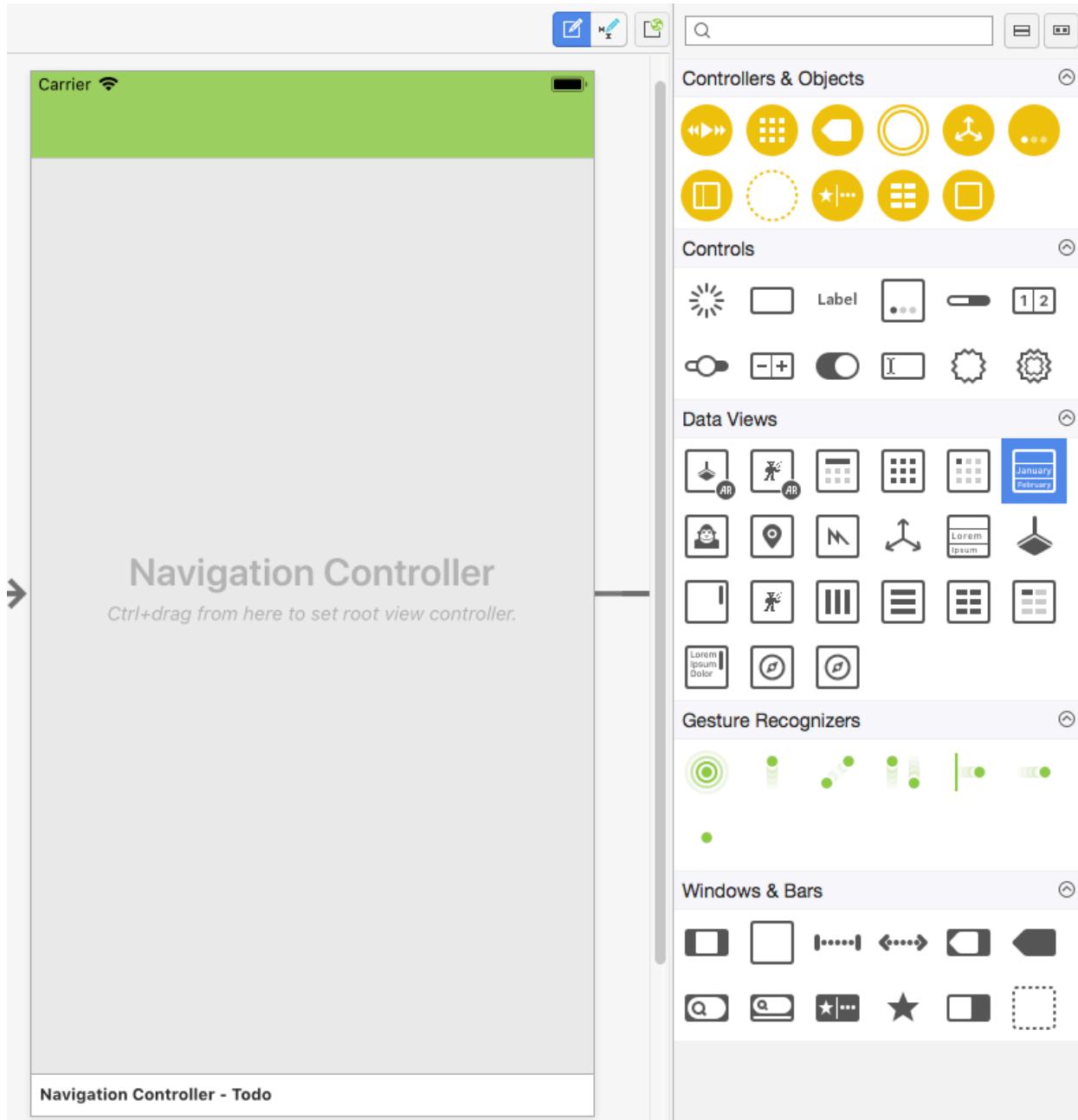


Figure 22: Visual Studio UI designer for iOS UI

Visual Studio with Xcode & Android SDK provides complete cross platform development environment.

2.4.3 Hybrid Mobile App

2.4.3.1 PhoneGap/Cordova

Hybrid mobile app development tool PhoneGap or Cordova is easier to learn than the one in native framework and anyone with web development can develop mobile app easily hence the popularity of HTML5 based mobile app development is growing (Sohn et al., 2015).

Hybrid app requires more computing resource to run all separation layers, native web container/web runtime and additional JavaScript libraries(Chmielewski, 2014) like AngularJS, jQuery UI, Google Material Design used for front end design. Now a day, most Smartphone comes with multicore processor and user many not experience performance issue. However, higher processor usages of Hybrid App could drain the battery quickly.

Cordova uses standard HTML, CSS & JavaScript to build cross platform app including Android & iOS.

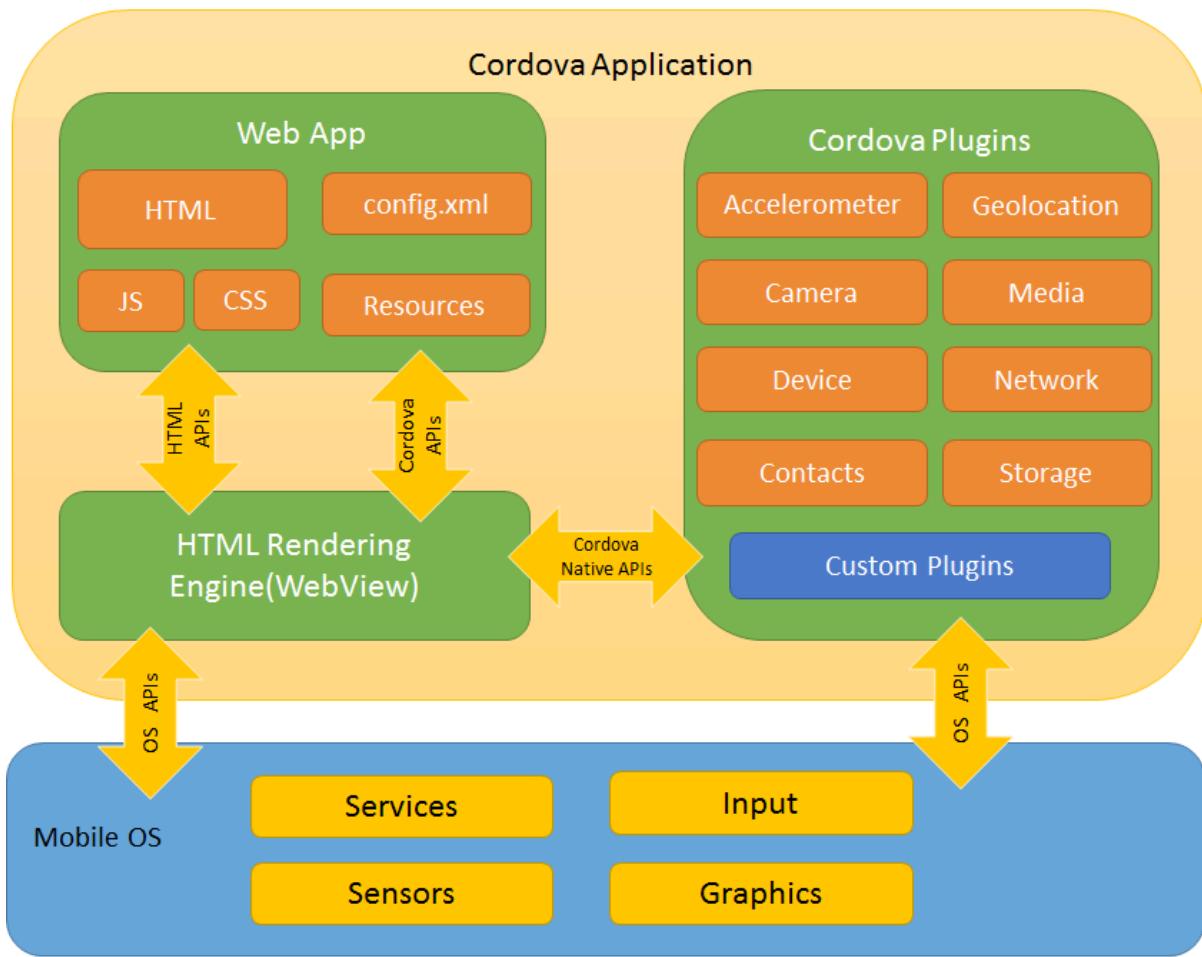


Figure 23: Cordova architecture (The Apache Software Foundation, 2018)

2.4.3.1.1 Development Environment

There is no official IDE for Cordova. Eclipse Hybrid Mobile Tools (THyM) (Ercan, 2018) & Intel XDK (Intel, 2018) could be used for developing Hybrid Mobile App with Cordova.

2.4.3.2 Appcelerator Titanium

This another popular technology for developing cross platform native, hybrid & mobile web app using JavaScript, HTML & CSS. Titanium is more capable than Cordova and has API for accessing native UI. Appcelerator (2018) claims that “Supported by a development community of over 660,000 mobile developers with 75,000 mobile apps deployed on over 280,000,000 devices”.

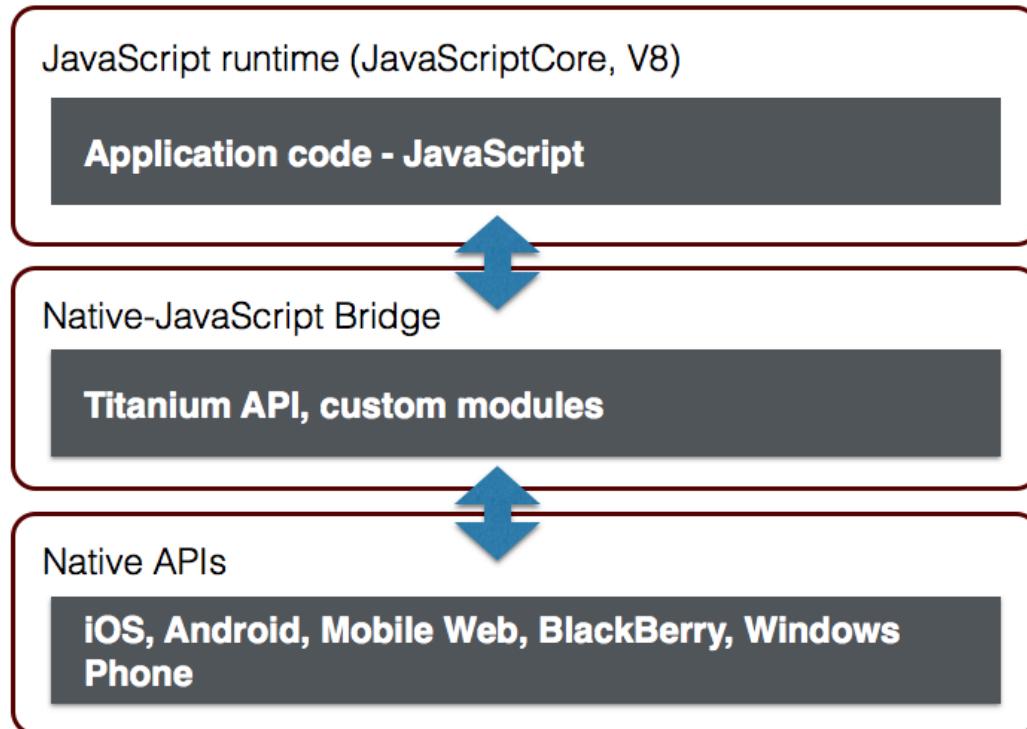


Figure 24: Titanium at 10,000 feet (Appcelerator, 2018)

2.4.3.2.1 Development Environment

Aptana Studio is used for developing app with Titanium SDK. Appcelerator developed Aptana Studio based on popular open source IDE Eclipse.

2.5 IMPORTANCE OF AND APPROACHES TO MOBILE USER INTERFACE DESIGN

Mobile Web App requires different user interface (UI) design to fit on smaller screen and improve usability on touch screen devices as mobile device does not have pointer based navigation (Heitkötter et al., 2013). “Mobile applications should provide users with an optimal experience based on the specific contextual capabilities of their device and environment.”(Desruelle and Gielen, 2015). It can be challenging to decide what content to show on mobile app and how best to present the component in mobile user interface.

2.5.1 Importance of Mobile UI Design

User experience influences customer’s perception of value and product quality consequently it affects customer loyalty and retention (Georgiadis and Chau, 2013). Mobile devices come in various screen size and regulation that makes it difficult to design UI for mobile application developer (Dehlinger and Dixon, 2011). Users can easily provide a bad review if the app is not to their satisfaction. Reviews are seen by all user when installing app from app store. Bad reviews may discourage other users to install the app. Therefore, it important that mobile app is designed carefully before first as cost for recovering from bad review could be.

2.6 ETHICAL ISSUE IN M-COMMERCE

“Your mobile number is your identity and your mobile phone is always connected and can be tracked.”(Zhang and Hilton, 2012). Recently, privacy became huge concern due miss handle of user’s private data by big corporation like Facebook (Graham-Harrison, 2018). Government in many countries including USA is considering regulating how user’s private data is collected and use. General Data Protection Regulation (GDPR) is coming into force on 25/05/2018. A key part of ecommerce & m-commerce is collection of user’s data to provide personalised product recommendation, ads and content to user. Careful consideration is required how personal data is collected and used by mobile application.

2.7 M-COMMERCE SECURITY

“M-commerce also could face a less secure security environment. Mobile devices send and receive data through open air space where anyone with the right technology can intercept it. Although encryption technologies are available, they are not always properly configured by the wireless network providers or owners.”(Zhang and Hilton, 2012).

Technology provider like Google is pressing hard on online security. Google Chrome browser will flag any website using HTTP (Sharma, 2018). This indicates attitude on security in the overall technology industry. A mobile shopping typically communicates with webserver to retrieve data. App developer need to ensure that appropriate steps are taken to protect user’s data.

2.8 SUMMARY

An ecommerce business need to target Android & iOS platform to cover 98% of the mobile users. Developing app in each native platform is more expensive and time consuming. On each update, two code base has to be maintained.

Hybrid platform Cordova & Titanium provide a convenient way to develop cross platform app, but they suffer from performance inefficiency of underlying technology such as JavaScript.

Acquisition of Xamarin by Microsoft in 2016 opened a new chapter in the history of cross platform. Microsoft made it easy for new developer to get started in cross platform app development by making Xamarin open source and providing a free community edition of Visual Studio. Xamarin tools are built into all version of visual studio. As a result, nearly two decades worth of .Net & Mono .Net development can be ported to cross platform high performance mobile app development.

Next section looks in requirements for developing mobile shopping app & design a shopping app using UML.

3 DESIGN

3.1 USE CASE

3.1.1 Diagram

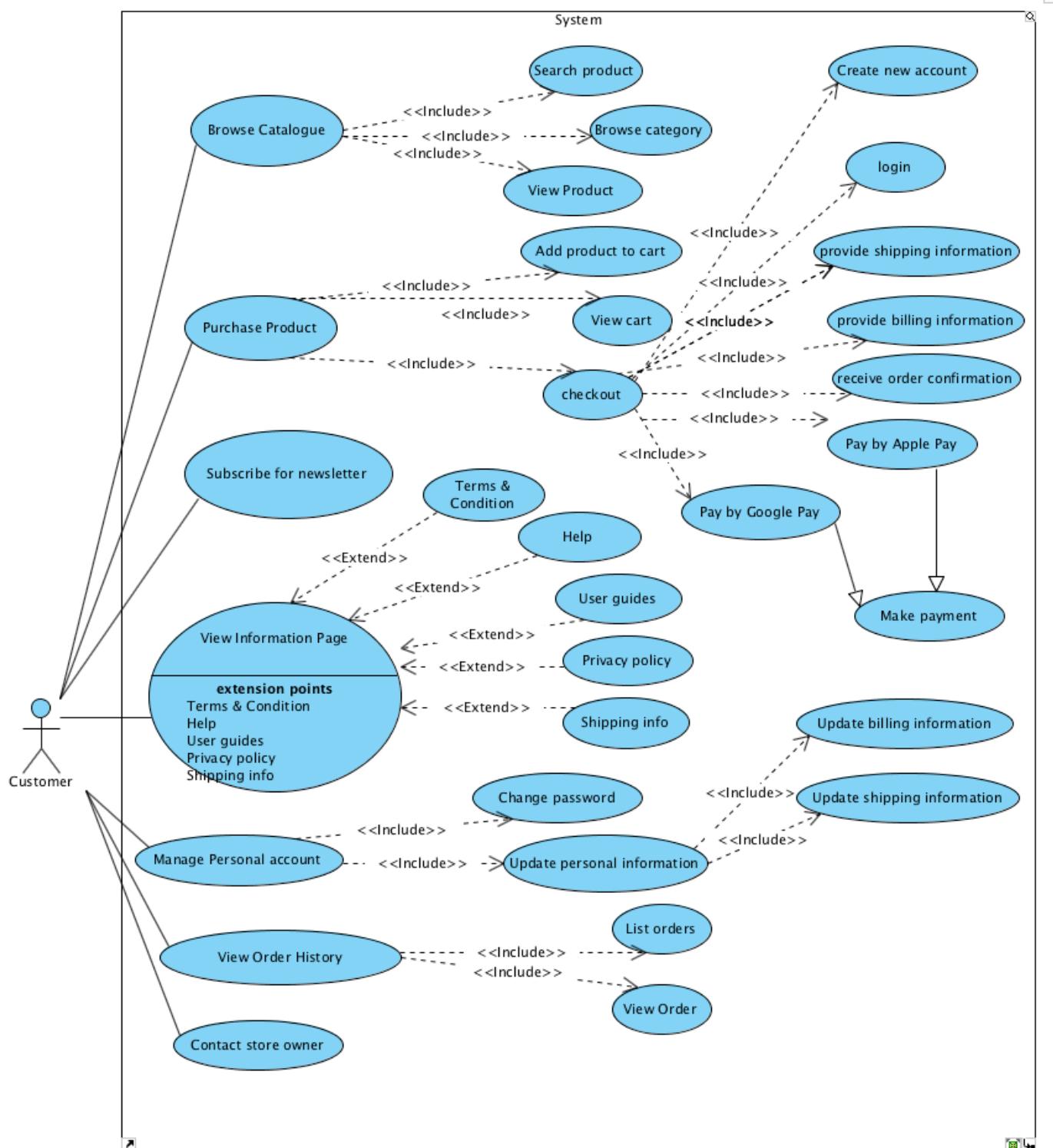


Figure 25: Use Case Diagram for Shopping App

3.1.2 Use case description

3.1.2.1 Browse Catalogue

This is key part of mobile shopping experience. This includes:

- Browsing product categories
- Searching for products
- Viewing product details

3.1.2.2 Purchase Product

Purchasing a product requires number of steps. This can be better illustrated in sudo code

```

customer adds product to cart
customer view cart
customer proceeds to checkout

if customer is not logged in
    customer is presented a with a login page
    if customer has an account
        customer logins
    else
        customer creates new account and logins

customer provides billing information
customer provides shipping information
customer makes payment using apple pay or google pay

if payment is successful
    system displays order confirmation to customer
    system sends order confirmation via email to customer
else
    system displays cart with error message

```

3.1.2.3 Subscribe for newsletter

This is a common way to collect customer email address. Many online stores provide discount for subscribing to email newsletter.

```

customer submits email address using newsletter subscription

if customer email doesn't exist in newsletter subscription list
    system adds customer email to newsletter subscription list

system sends email confirmation to customer

```

3.1.2.4 View information page

Generally, customer is less interested in information page. These pages are often called CMS page. Some information pages are required by law i.e. privacy policy.

3.1.2.5 Manage Personal Account

Customer uses app to change their password and update their personal information.

3.1.2.6 View order history

Customer uses app to view order history and order status update

3.1.2.7 Contact store owner

Customer uses app to contact store owner for various issues.

3.1.3 Use case selected for implementation & evaluation

Implemented all use cases provided in use case diagram is beyond the scope of this project and not required for evaluating framework. Customer uses greater amount of time of the shopping journey by browsing products.

Performance of this use case is absolutely crucial for good customer experience. There only **Browse Catalogue** has been selected for implementation.

3.2 REQUIREMENT SPECIFICATION USING FURPS FOR BROWSE CATALOGUE USE CASE

FURPS stands for:

1. Functional requirement
2. Usability requirement
3. Reliability requirement
4. Performance Requirement
5. Supportability Requirement

3.2.1 Functional requirement

3.2.1.1 Search Product

User can invoke search function from anywhere within the app. Search field must be present on all pages.

3.2.1.2 Browse category

- Main page must contain a list of main categories for user's selection.
- When users tap a main category on home page, system must display category list page with
 - A list of sub category
 - A list of products within the category
- If user tap a subcategory, system display result for the subcategory
- If user tap a product from product list product detail page is shown

3.2.1.3 View Product

When user selects product, product detail page is shown. Product detail must contain followings:

- Product name
- Product image
- Product sku
- Product stock status
- Field to enter quantity to add to cart
- A button to add the product to cart
- Product description

3.2.2 Usability Requirement

- User Interface must clutter free and position accurately
- Prioritise based on relevancy. Content that are more relevant to the user should be provided first

3.2.3 Reliability requirement

App must be able handle temporary internet connection outage. User must be able to browse catalogue during temporary network outage.

3.2.4 Performance Requirement

- Search result must be instant & result is updated on text change.
- Search result may return large number. App must be able to handle large number of item
- Product list on category list page may contain a large number of product. App must be able to handle that.
- To reduce RAM, CPU & network resources, image is only loaded when the UI using the image comes in to the focus. This is often called lazy load.

3.2.5 Supportability Requirement

- Source code must be separated in presentation layer and data layer for easier maintenance and upgrade and to increase code reuse.
- MVC or MVVM architecture is preferable.

3.3 CLASS DIAGRAMS FOR BROWSE CATALOGUE USE CASE

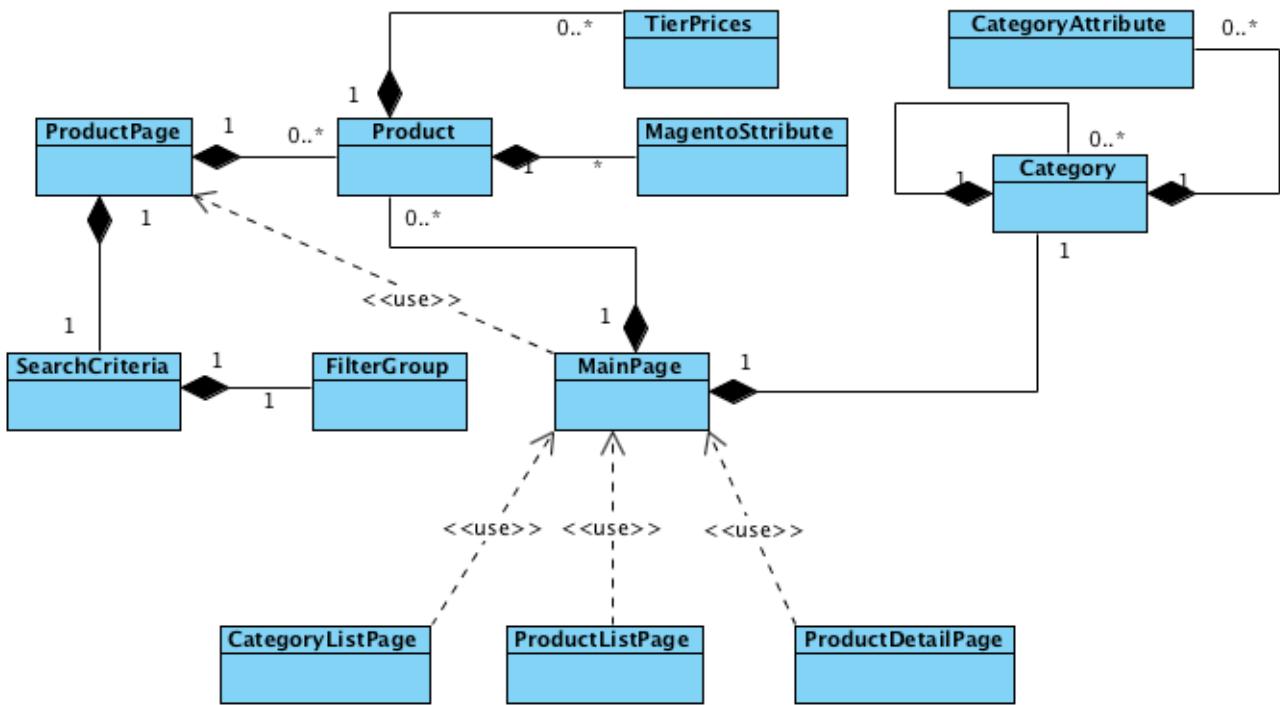


Figure 26: Class Diagram for Browse Catalogue Use Case

Classes can be grouped in

1. Data classes
 - ProductPage
 - Product
 - TierPrice
 - MagentoAttribute
 - SearchCriteria
 - FilterGroup
 - Category
 - CategoryAttribute
2. Presentation classes
 - a. MainPage
 - b. CategoryListPage
 - c. ProductListPage
 - d. ProductDetailPage

MainPage uses ProductPage to get a list of all products. MainPage holds a list of all Product and root Category in static variables. Other presentation classes use the data stored in MainPage class.

4 IMPLEMENTATION

4.1 IMPLEMENTING USING NATIVE ANDROID FRAMEWORK

4.1.1 Data Layer

For data layer on android-magento-client package from MVN repository has been used. More detail on this package can be found on following website:

<https://mvnrepository.com/artifact/com.github.chen0040/android-magento-client/1.0.5>

4.1.1.1 Request follow

When user launches application, system starts MainActivity.

```
System calls onCreate() method in MainActivity
onCreate() method calls loadCatalogData() method to load data using
background service class DataLoaderService
DataLoaderService uses static data from JSON file and updates the views
```

Once application is launched, user can click ... on main activity to refresh the data from web server. In production application this must be done in background without user noticing.

Using sample date

LOAD LIVE DATA

Top Categories

Figure 27: Load Live Data Button on Android App

4.1.2 Presentation Layer

Android uses term ‘Activity’ instead of ‘Page’. Therefore, class names are different. Following table maps Android Activity classes to Page classes in the class diagram.

Class name in diagram	Class name in android
MainPage	MainActivity
CategoryListPage	CategoryListActivity
ProductListPage	ProductListActivity
ProductDetailPage	ProductDetailActivity

Figure 28: Class map table for Android

4.1.2.1 Request follow

Main activity shows a list of main categories, List of new product collation & a list of best selling products.

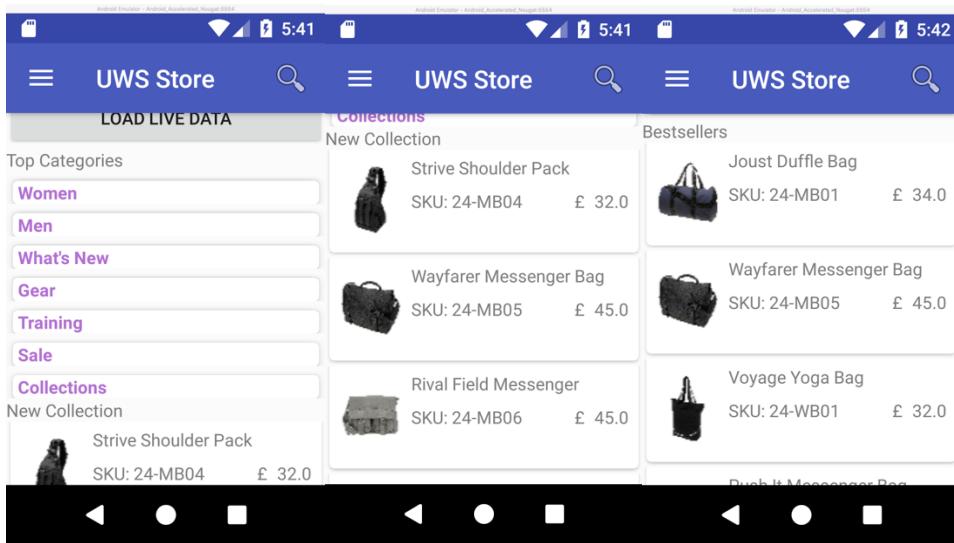


Figure 29: Main Activity on Android App

If user selects a category, CategoryListActivity is displayed.

- It contains a list sub category if any subcategory exists
- A list of products, if category has any products

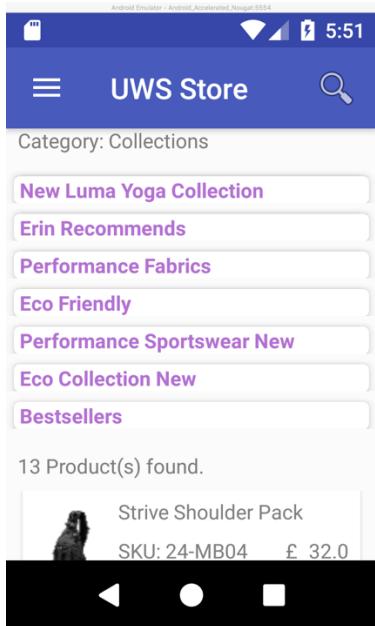


Figure 30: Android CategoryListActivity

User can start ProductListActivity by taping search button  from anywhere. Search result is displayed when user types first character and updated on every text change.

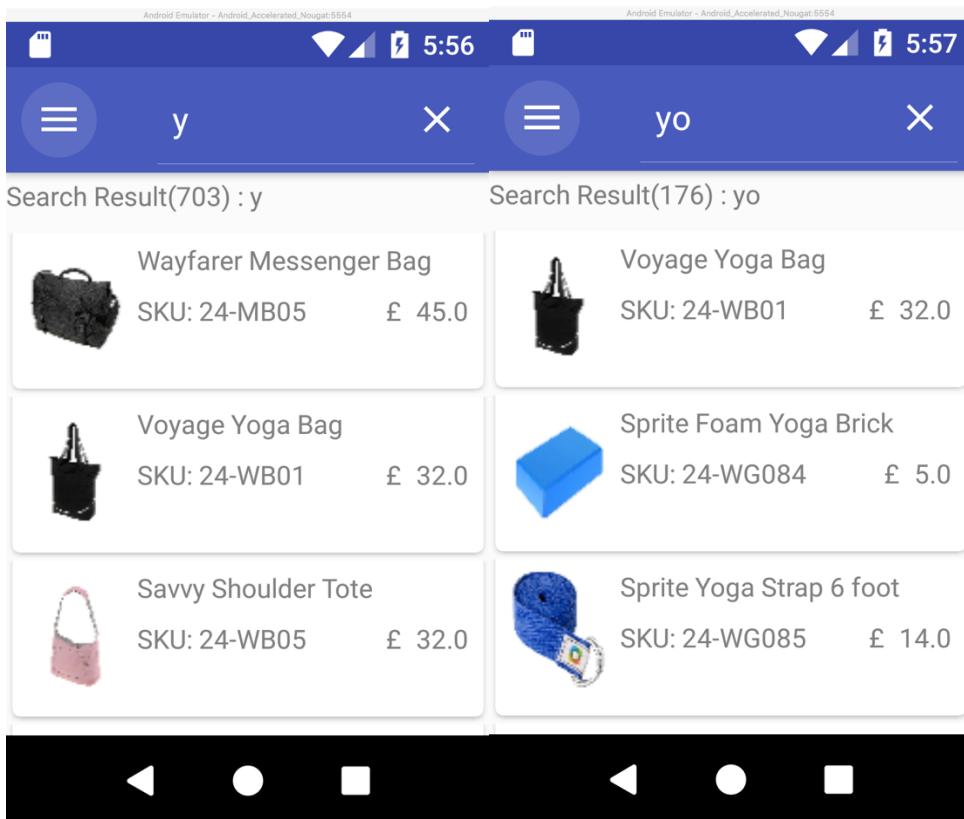


Figure 31: Android Search & ProductListActivity

A setting activity is also provided to update settings for connecting to Magento 2 server.

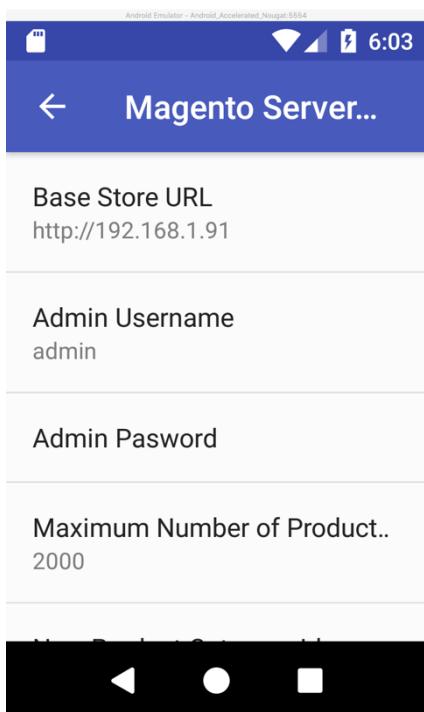


Figure 32: Android Setting Activity

4.2 IMPLEMENTING USING XAMARIN & XAMARIN.FORMS

4.2.1 Data layer

There is no compatible REST client library for connecting to Magento 2 on NuGet. Therefore, all the classes in diagram implemented. This can be found in Model folder in Visual Studio projects. A REST client was also implemented using MagentoClient that can be found in services folder.

4.2.1.1 Request follow

Request follow slightly defers from Android app. JSON file is read in Android's MainActivity class then passed on Xamarin's App class. App class them passes the JSON string to MainPage (ShopPortablePage).

4.2.2 Presentation Layer

Instead on native UI, Xamarin.Forms UI has been used. Each page is a combination of .xaml & .xaml.cs Here is the class map for pages.

Class name in diagram	Class name in Xamarin
MainPage	ShopPortablePage.xaml, ShopPortablePage.xaml.cs
CategoryListPage	CategoryListPage.xaml, CategoryListPage.xaml.cs
ProductListPage	SearchPage.xaml, SearchPage.xaml.cs
ProductDetailPage	ProductDetailPage.xaml, ProductDetailPage.xaml.cs

Figure 33: Class Map table for Xamarin

Request flow is similar to Android app described in last section, but the UI is little different.

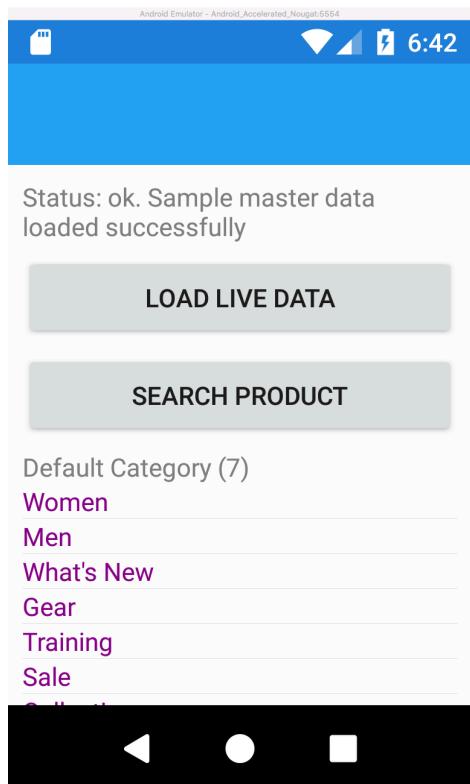


Figure 34: MainPage Xamarin Android

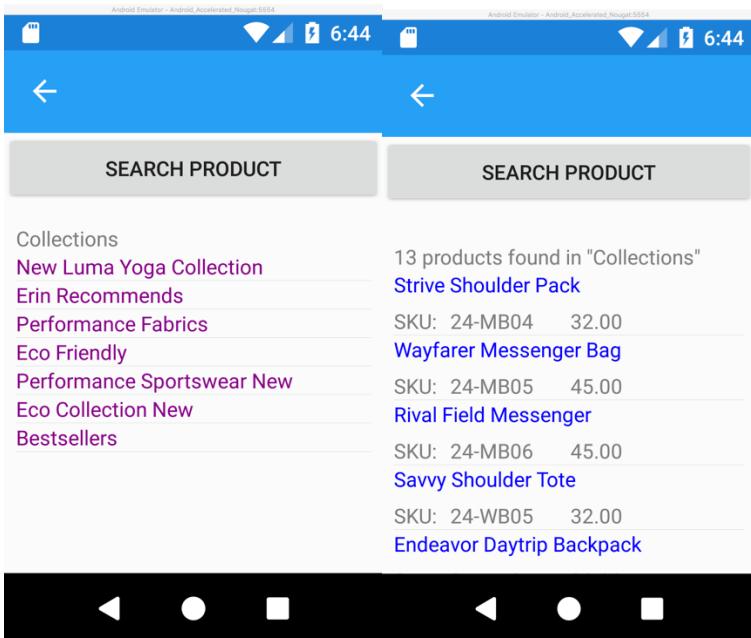


Figure 35: Category List Page, Xamarin Android

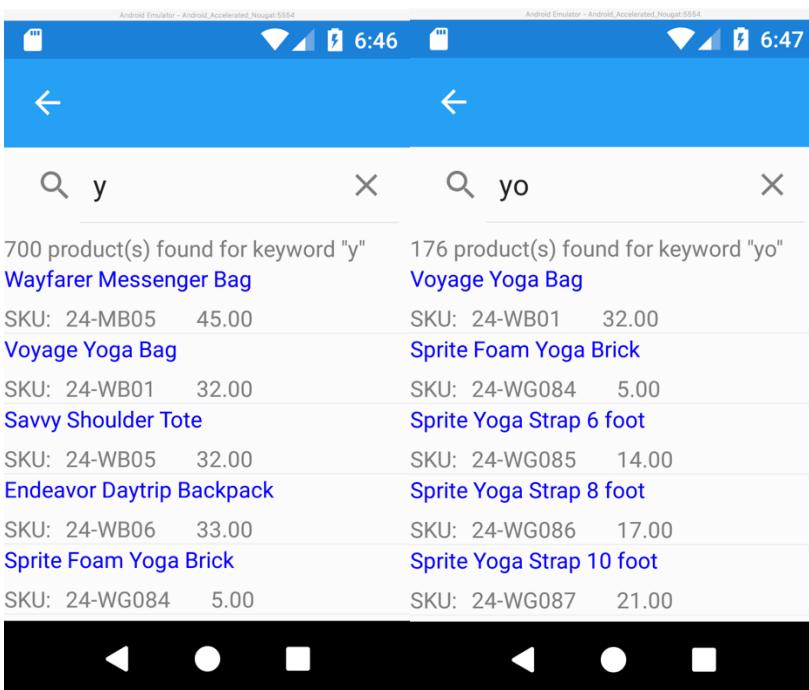


Figure 36: Search Page, Xamarin Android

4.3 REQUIREMENTS IMPLEMENTED FOR BROWSE CATEGORY USE CASE

6. Functional requirement – Fully implemented.
7. Usability requirement – Implemented enough UI design for testing
8. Reliability requirement – Partially implemented. App can function without connecting to server. Data can be refreshed from server by clicking the button page. This was done on purpose to control loading of data. In production application, data needs to be refreshed in background.
9. Performance Requirement – High performance instant search was implemented on both platform. On Android platform, images on search result page is loaded when image views come into focus. Popular Picasso library was used for this.
10. Supportability Requirement – Application code has been separated in data layer and presentation layer. MVC or MVVM architecture has not been used as suggested as this only implements one use case. For production app, MVC or MVVM is more appropriate architecture.

Note! Source codes for both app is provided separately as it many pages to include source code for both app.

5 EVALUATION & RECOMMENDATION (15)

5.1 EVALUATION

5.1.1 Vendor Credibility

5.1.1.1 Microsoft

Microsoft is one of the key player in technology industry. Acquisition of Xamarin 2016, making it open source and including Xamarin in all version of Microsoft visual studio should provide confidence in using Xamarin for cross platform app development in long term.

5.1.1.2 Cordova

Cordova is open source, and many used by many other frameworks like PhoneGap. Cordova is very popular among web developers and provides opportunity for web developers to build mobile app with very little learning curve.

5.1.1.3 Appcelerator Titanium

Titanium is growing fast and could become key player in cross platform mobile app development.

When it comes to vendor credibility, Microsoft certainly excels but Appcelerator becoming a strong competitor.

5.1.2 Programming Language Features and Performance

5.1.2.1 JavaScript

JavaScript was designed to be a light weight scripting language that can run web browser. In recent years, there has been a trend to use JavaScript in other areas such as server site application using Node.js. However, JavaScript still suffers from inefficiency of being a dynamic language.

5.1.2.2 C#

C# has been around for nearly two decades. It is recommended language for developing in windows platform. C# is an object-oriented language. LINQ and LAMBDA make C# very flexible and powerful.

C# has many advantages over JavaScript, learning curve is higher than JavaScript and is not as flexible as JavaScript.

5.1.3 Framework Feature

5.1.3.1 Xamarin

Xamarin is based on Mono .Net framework which has been under development nearly 2 decades. Xamarin.Forms provides a universal UI for cross platform App development. Xamarin also provides access to native UI classes that can be manipulated using C#. Many features like UI Data Binding and LINQ reduces the amount of code to be written to implement a data driven features.

5.1.3.2 Cordova & Titanium

Both Cordova & Titanium uses JavaScript as a main programming language. Core features of JavaScript is not as rich as C#. But there are numerous open sourced JavaScript framework that could be used for achieving feature like C#.

5.1.4 Development Tools and Integrated Development Environment (IDE)

IDE plays key role in any kind of development. Good IDE can significantly improve developer's productivity. Cordova doesn't have an official IDE. Appcelerator provides Aptana studio for developing app with Titanium SDK. Aptana studio is not as mature and stable as Microsoft Visual Studio.

5.1.5 Automated Testing

Automated testing is key part of reliable app development and maintenance. It reduces human error and saves time during. Xamarin has support for automated testing of data layer and UI.

Appcelerator partnered with SOASTA to provide automated testing.

5.1.6 Community Support

5.1.6.1 *Code library*

Nugget.org has over 110,000 packages for .Net. A search with Xamarin keyword resulted in excess 4,100 packages.

5.1.7 Availability of Skills

An online retailer may already have a development team to develop and maintain their website. If the .Net is not being used in the organization, it could be costly and time consuming to recruit and setup a development team for developing app using Xamarin and C#.

5.1.8 Importance of User Satisfaction

Xamarin provides greater control for fine tuning UI in both iOS and Android platform over other framework. If used properly, this can improve the user's satisfaction

5.2 RECOMMENDATION

As explained previously, codes in mobile shopping App can be grouped in two categories

- Data layer
- Presentation layer

If the app is developed using Java on android & Objective-C on iOS, code cannot be shared.

If Xamarin is used, majority of the code can be shared on both platform. But data layer must be implemented. More than half of the development time may be required for data layer.

Cordova & Titanium uses JavaScript. JavaScript supports JSON natively and can be used in presentation layer directly. It reduces time required for data layer. Developer can allocate more time in fine tuning presentation layer. However, Cordova & Titanium lacks support for native UI. Support for automated test is not as solid as Xamarin platform.

It looks both Apple & Google has identified this dilemma when choosing an app development framework. They came to rescue by introducing new programming language for their platform.

Google announced Kotlin as the official language for Android development recently. Kotlin has built in support for that is likely to reduce the code for data layer. Kotlin is designed to be easy to learn that should reduce the learning curve for new developer. More on JSON parsing on Swift can be in following link.

<https://kotlinlang.org/api/latest/jvm/stdlib/kotlin.js/-j-s-o-n/index.html>

Apple has introduced Swift programming language to make the programming on Apple platform easier. Similar to Kotlin, it has built in support for JSON. More on this can be found on following link.

<https://developer.apple.com/swift/blog/?id=37>

UI is the most important part of a mobile shopping app. An online retailer must get the App right first time. Not getting right first-time lead to bad review on App store and cost recovering from this could be very high. Only app developed in native platform provides absolute control on UI design. As Kotlin & Swift reduces the work required in data layer, it is now probably to use Kotlin & Swift and native iOS & Android platform for developing mobile shopping app.

6 CRITICAL SELF-REFLECTION (10)

I have originally started this project in September 2015 and stopped in early 2016. I have restarted the project after two years. A lot has happened in mobile app development technology.

Microsoft acquired Xamarin and made it open source. Microsoft included Xamarin in all version Studio Including free community edition. It was well accepted by developer community and Microsoft & Xamarin became a key player in cross platform mobile app development. Xamarin.Forms were released on 03/05/2015 and fairly new when I started project in September 2015. On that time, I have not even considered Xamarin.Forms as a method for developing cross platform UI. Xamarin.Forms has grown significantly. Xamarin, Xamarin.Forms & Visual Studio facilitates not only development of mobile app for all three mobile platforms (Android, iOS & Windows Phone) but also developing MacOS and Windows desktop apps. All these key factors promoted me to learn C# and explore Xamarin & Xamarin.Forms.

Back in 2015, titanium was key player in cross platform mobile app development. I have even started learning Titanium. It has much stricter and some feature of the framework was not free. Appcelerator has recently open sourced all component of Titanium. Documentation and community support have also grown significantly.

When I started this project, the main aim was to find a suitable framework for developing cross platform mobile shopping app I found developing in Java & Objective-C is time consuming. Both of these languages are old and not very easy to learn. It seems, I wasn't the only one thinking like this. Google and Apple also realised this problem. Google introduced Kotlin and Apple introduced Swift to make easier for new developer to get started with app development and improve overall speed of development.

This project may not as relevant now as it was in 2015. Microsoft's acquisition of Xamarin in 2016 shake the industry and became a key player.

Kotlin & Swift are two fasted growing language. It is well accepted by developer community. It is questionable Xamarin can remained a dominant framework for developing cross platform mobile app.

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8 APPENDICES

9 MSc PROJECT SPECIFICATION

University of the West of Scotland

School of Engineering and Computing

MSc Project Specification

Student name: Shakh Mehedi

Banner ID: B00279242

Email:shakhmehedi@yahoo.com

MSc Programme/stream: Information Technology

Project Title:

Native VS Hybrid: An Evaluation of Approaches for Developing Mobile Shopping App

Research Question to be answered:

Is hybrid mobile app framework better choice for developing mobile shopping app than developing native mobile shopping app?

Outline (overview) and overall aim of project:

In Europe, online shopping is growing at a rate of 18%. One half of the website browsing for online shopping happens on mobile devices but only small portion of the users uses mobile phone to make the final purchase. Shopping using mobile devices is expected to grow by 88.7% in 2015 **Invalid source specified..**

There are two primary reasons that could force the mobile user to make the final purchase using a PC. Firstly, many ecommerce website are not mobile optimised that makes it difficult to browse the website. Secondly, internet communication on mobile devices is not as reliable as broadband that often causes failures in processing online payment. It is absolutely crucial to have a mobile optimised website if the website receives significant number of mobile users. However, a mobile app provide better experience for the users **Invalid source specified..** A mobile app also handles the internet communication better than mobile web app. Therefore it is important to have mobile app for ecommerce website.

Developing mobile app often turns into developing for multiple mobile platform, i.e. Android, IOS, Windows Mobile etc. Developing native app for each platform is time consuming and costly. Currently, there are number mobile app development framework (Cordova, PhoneGap etc) that enables developer to rapidly develop hybrid mobile app for multiple platform. Hybrid app uses existing web content (HTML, CSS, JavaScript) and package it as mobile app. Although, hybrid app has access to some additional IO, it is likely to suffer similar user experience issue like mobile web app. This project aims to develop a hybrid mobile app and a native mobile app and critically evaluate their suitability for developing mobile shopping app.

Objectives (list of tasks to be undertaken to achieve overall aim of the project and to answer the research question posed):

1. To conduct literature review on:
 - a. Importance of mobile commerce
 - b. barriers to the adaption of mobile commerce
 - c. use of technologies to improve mobile commerce
 - d. importance of and approaches to mobile user interface design
 - e. approaches to mobile application development (Native, Hybrid, HTML5)
2. To design a prototype for mobile shopping app
3. To implement the design using:
 - a. Native framework
 - b. Hybrid framework
4. To evaluate both approaches to mobile app development to:
 - a. identify the advantages and disadvantages of each approach
 - b. justify why a business should choose one particular development approach over another

Relationship of proposed project to MSc programme/stream:

- Application Development with Java
- Dynamic Web Applications
- Object Oriented Analysis & Design
- Database Principle & Design
- Business Driven Computer Network

Indicative reading list and resources:

Alkhunaizan, A. & Love, S., 2012. What drives mobile commerce? An empirical evaluation of the revised UTAUT model. *International Journal of Management and Marketing Academy*, 2(1), pp. 82-99.

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Marking scheme:

Introduction	5		
Literature review	25	Objective - 1	

Design	15	Objective - 2	
Implementation	30	Objective - 3	
Evaluation & Recommendation	15	Objective - 4	
Critical self-reflection	10		
Total	100		

Supervisor:

Michael McCready

Moderator:

Date specification submitted:

Please complete the 'ethics' form below for all projects. **SCHOOL OF ENGINEERING AND COMPUTING
MSc PROJECT - ETHICAL CONSIDERATION DOCUMENT**

SECTION 1: TO BE COMPLETED BY THE STUDENT

Does your research involve: research with human subjects, access to company documents/records, questionnaires, surveys, focus groups and/or other interview techniques? (please enter Y in the appropriate box)

YES		complete the rest of the form
NO	Y	skip to the end of the form for supervisory sign off

Please answer ALL of the following questions concerning your proposed research:

	(please enter either Y or N in each box)	Y/N
1.	Are the participants and subjects from any vulnerable group or (e.g. NHS patients, children) or from a 'captive' audience (e.g. students)	
2.	Are the participants and subjects of the study in any way unable to give free and informed consent within the meaning of the Mental Capacity Act 2005 to the best of your knowledge?	
3.	Are you asking questions that are likely to be considered impertinent or to cause distress to any of the participants?	
4.	Are any of the subjects in a special relationship with the applicant (e.g. colleagues)?	
5.	Does your project pose any risk to either yourself or the participant?	

If you have answered **Y** to **any** of the above questions, or are **unsure**, please contact your supervisor (students) or any member of the School Ethics Committee (Staff).

Please answer ALL of the following questions concerning your proposed research:

		Y/N
1.	Participants will be/have been advised that they may withdraw at any stage if they so wish.	
2.	Issues of confidentiality and arrangements for the storage and security of material during and after the project and for the disposal of material have been considered.	
3.	Arrangements for providing subjects with research results if they wish to have them have been considered.	
4.	The arrangements for publishing the research results and, if confidentiality might be affected, for obtaining written consent for this have been considered.	
5.	Information Sheets and Consent Forms had been prepared in line with University guidelines for distribution to participants.	
6.	Arrangements for the completed consent forms to be retained upon completion of the project have been made.	

If you have answered **N** or you **cannot confirm** the answer to **any** of the above questions, contact your supervisor (students) or any member of the School Ethics Committee (Staff).

SECTION 2: APPLICATION CHECK LIST FOR SUPERVISORS

Please enter Y, N or TBD* in all of these boxes.

I confirm that an Information Sheet and a Consent Form have been prepared and will be made available to all participants. These contain details of the project, contact details of the researcher and advise subjects that their privacy will be protected, their participation is voluntary and that they may withdraw at any time without reason.	
I confirm that research instruments (questionnaires, interview guides, etc) have been reviewed against the policies and criteria noted in The University Research Ethics Committee Notes for Guidance.	
I confirm that all related documents, including any questionnaires, interview schedules and copies of the Information Sheet and Consent Form, are attached and submitted with this application.	

*TBD issues need to be resolved during project management

Supervisor (print name): Michael McCready

Signature:

Date: 13/10/2015