KIEL UNIVERSITY OF APPLIED SCIENCES

MASTER THESIS

Developing Cross-Platform Mobile Application Solution Using Xamarin and Microsoft Azure

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Supervisor:
Dr. Jens LÜSSEM

A thesis submitted in fulfillment of the requirements
for the degree of Master of Science in Information Technology

in

Department of Computer Science and Electrical Engineering
Kiel University of Applied Sciences

April 3, 2017

Declaration of Authorship

I, Ranjith MURTHY, declare that this thesis titled, "Developing Cross-Platform Mobile Application Solution Using Xamarin and Microsoft Azure" and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

Signed:

Date:

"Thanks to my solid academic training, today I can write hundreds of words on virtually any topic without possessing a shred of information, which is how I got a good job in journalism."

Dave Barry

Abstract

The global mobile market has experienced a tremendous increase in the number of smart computing device users per household. The mobile device base is strongly divided between different mobile platforms, most importantly Android, iOS and Windows Phone. Applications developed for one platform with traditional development methods only work on that platform, and supporting multiple platforms requires developing the application separately for each of the platforms.

This trend affects small business industry whose user spread across different mobile operating systems. Such companies strive to decrease the development time and with a satisfying solution that is delivered on time. To decrease the time-to-market and thus the cost of the final product, companies seek to develop applications independent of the target mobile operating system by using a cross-platform approach. This approach can eliminate the increased effort that normally comes with developing a separate application for each mobile operating system, providing a more efficient solution.

The aim of this thesis describes How to develop a cost effective multi-target mobile solution strategy for "Customer Feedback Management System for Restaurants". The application targets the leading mobile operating systems iOS Android and Windows. While sharing the business logic through a portable class library. The Xamarin and Microsoft Azure toolchain provides the mechanics for compiling the C# codebase to run on across different Operating platform.

During the research phase focus on finding the suitable data analysis method to analyses the user feedback data. In addition, finding suitable visualization techniques to visualize analyzed feedback data.

Acknowledgements

I would first like to thank my thesis supervisor Dr. Jens LÜSSEM of the Department of Computer Science and Electrical Engineeringat Kiel University of Applied Sciences. The door to Prof.LUSSEM office was always open whenever I ran into a trouble spot or had a question about my research or writing. He consistently allowed this paper to be my own work, but steered me in the right the direction whenever he thought I needed it.

I would also like to acknowledge Dr. Stephan Schneider of the Department of Computer Science and Electrical Engineeringat Kiel University of Applied Sciences as the second supervisor of this thesis, and I am gratefully indebted to his for his very valuable comments on this thesis.

Finally, I must express my very profound gratitude to my parents and to my brother for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis. This accomplishment would not have been possible without them.

Thank you.
Author
Ranjith MURTHY

Contents

List of Figures

List of Tables

List of Abbreviations

LAH	**L**ist **A**bbreviations **H**ere
WSF	**W**hat (it) **S**tands **F**or

Physical Constants

Speed of Light $c_0 = 2.997\,924\,58 \times 10^8\,\mathrm{m\,s^{-1}}$ (exact)

List of Symbols

a	distance	m
P	power	W ($\mathrm{J\,s^{-1}}$)
ω	angular frequency	rad

For/Dedicated to/To my…

Chapter 1

Introduction

1.1 Background

Welcome to this LaTeX Thesis Template, a beautiful and easy to use template for writing a thesis using the LaTeX typesetting system.

If you are writing a thesis (or will be in the future) and its subject is technical or mathematical (though it doesn't have to be), then creating it in LaTeX is highly recommended as a way to make sure you can just get down to the essential writing without having to worry over formatting or wasting time arguing with your word processor.

LaTeX is easily able to professionally typeset documents that run to hundreds or thousands of pages long. With simple mark-up commands, it automatically sets out the table of contents, margins, page headers and footers and keeps the formatting consistent and beautiful. One of its main strengths is the way it can easily typeset mathematics, even *heavy* mathematics. Even if those equations are the most horribly twisted and most difficult mathematical problems that can only be solved on a super-computer, you can at least count on LaTeX to make them look stunning.

1.2 Problem Statement and Research Questions

LaTeX is not a WYSIWYG (What You See is What You Get) program, unlike word processors such as Microsoft Word or Apple's Pages. Instead, a document written for LaTeX is actually a simple, plain text file that contains *no formatting*. You tell LaTeX how you want the formatting in the finished document by writing in simple commands amongst the text, for example, if I want to use *italic text for emphasis*, I write the `\emph{text}` command and put the text I want in italics in between the curly braces. This means that LaTeX is a "mark-up" language, very much like HTML.

1.2.1 A (not so short) Introduction to LaTeX

If you are new to LaTeX, there is a very good eBook – freely available online as a PDF file – called, "The Not So Short Introduction to LaTeX". The book's title is typically shortened to just *lshort*. You can download the latest version (as it is occasionally updated) from here: http://www.ctan.org/tex-archive/info/lshort/english/lshort.pdf

It is also available in several other languages. Find yours from the list on this page: http://www.ctan.org/tex-archive/info/lshort/

It is recommended to take a little time out to learn how to use LaTeX by creating several, small 'test' documents, or having a close look at several templates on: http://www.LaTeXTemplates.com

Making the effort now means you're not stuck learning the system when what you *really* need to be doing is writing your thesis.

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1.2.3 Common LaTeX Math Symbols

There are a multitude of mathematical symbols available for LaTeX and it would take a great effort to learn the commands for them all. The most common ones you are likely to use are shown on this page: `http://www.sunilpatel.co.uk/latex-type/latex-math-symbols/`

You can use this page as a reference or crib sheet, the symbols are rendered as large, high quality images so you can quickly find the LaTeX command for the symbol you need.

1.2.4 LaTeX on a Mac

The LaTeX distribution is available for many systems including Windows, Linux and Mac OS X. The package for OS X is called MacTeX and it contains all the applications you need – bundled together and pre-customized – for a fully working LaTeX environment and work flow.

MacTeX includes a custom dedicated LaTeX editor called TeXShop for writing your '**`.tex`**' files and BibDesk: a program to manage your references and create your bibliography section just as easily as managing songs and creating playlists in iTunes.

1.3 Structure of the Thesis

If you are familiar with LaTeX, then you should explore the directory structure of the template and then proceed to place your own information into the *THESIS INFORMATION* block of the **`main.tex`** file. You can then modify the rest of this file to your unique specifications based on your degree/university. Section 1.5 on page 4 will help you do this. Make sure you also read section 1.7 about thesis conventions to get the most out of this template.

If you are new to LaTeX it is recommended that you carry on reading through the rest of the information in this document.

Before you begin using this template you should ensure that its style complies with the thesis style guidelines imposed by your institution. In most cases this template style and layout will be suitable. If it is not, it may only require a small change to bring the template in line with your institution's recommendations. These modifications will need to be done on the **`MastersDoctoralThesis.cls`** file.

1.3.1 About this Template

This LaTeX Thesis Template is originally based and created around a LaTeX style file created by Steve R. Gunn from the University of Southampton (UK), department of Electronics and Computer Science. You can find his original thesis style file at his site, here: http://www.ecs.soton.ac.uk/~srg/softwaretools/document/templates/

Steve's **ecsthesis.cls** was then taken by Sunil Patel who modified it by creating a skeleton framework and folder structure to place the thesis files in. The resulting template can be found on Sunil's site here: http://www.sunilpatel.co.uk/thesis-template

Sunil's template was made available through http://www.LaTeXTemplates.com where it was modified many times based on user requests and questions. Version 2.0 and onwards of this template represents a major modification to Sunil's template and is, in fact, hardly recognisable. The work to make version 2.0 possible was carried out by Vel and Johannes Böttcher.

1.4 What this Template Includes

1.4.1 Folders

This template comes as a single zip file that expands out to several files and folders. The folder names are mostly self-explanatory:

Appendices – this is the folder where you put the appendices. Each appendix should go into its own separate **.tex** file. An example and template are included in the directory.

Chapters – this is the folder where you put the thesis chapters. A thesis usually has about six chapters, though there is no hard rule on this. Each chapter should go in its own separate **.tex** file and they can be split as:

- Chapter 1: Introduction to the thesis topic
- Chapter 2: Background information and theory
- Chapter 3: (Laboratory) experimental setup
- Chapter 4: Details of experiment 1
- Chapter 5: Details of experiment 2
- Chapter 6: Discussion of the experimental results
- Chapter 7: Conclusion and future directions

This chapter layout is specialised for the experimental sciences, your discipline may be different.

Figures – this folder contains all figures for the thesis. These are the final images that will go into the thesis document.

1.4.2 Files

Included are also several files, most of them are plain text and you can see their contents in a text editor. After initial compilation, you will see that more auxiliary

files are created by LaTeX or BibTeX and which you don't need to delete or worry about:

example.bib – this is an important file that contains all the bibliographic information and references that you will be citing in the thesis for use with BibTeX. You can write it manually, but there are reference manager programs available that will create and manage it for you. Bibliographies in LaTeX are a large subject and you may need to read about BibTeX before starting with this. Many modern reference managers will allow you to export your references in BibTeX format which greatly eases the amount of work you have to do.

MastersDoctoralThesis.cls – this is an important file. It is the class file that tells LaTeX how to format the thesis.

main.pdf – this is your beautifully typeset thesis (in the PDF file format) created by LaTeX. It is supplied in the PDF with the template and after you compile the template you should get an identical version.

main.tex – this is an important file. This is the file that you tell LaTeX to compile to produce your thesis as a PDF file. It contains the framework and constructs that tell LaTeX how to layout the thesis. It is heavily commented so you can read exactly what each line of code does and why it is there. After you put your own information into the *THESIS INFORMATION* block – you have now started your thesis!

Files that are *not* included, but are created by LaTeX as auxiliary files include:

main.aux – this is an auxiliary file generated by LaTeX, if it is deleted LaTeX simply regenerates it when you run the main `.tex` file.

main.bbl – this is an auxiliary file generated by BibTeX, if it is deleted, BibTeX simply regenerates it when you run the `main.aux` file. Whereas the `.bib` file contains all the references you have, this `.bbl` file contains the references you have actually cited in the thesis and is used to build the bibliography section of the thesis.

main.blg – this is an auxiliary file generated by BibTeX, if it is deleted BibTeX simply regenerates it when you run the main `.aux` file.

main.lof – this is an auxiliary file generated by LaTeX, if it is deleted LaTeX simply regenerates it when you run the main `.tex` file. It tells LaTeX how to build the *List of Figures* section.

main.log – this is an auxiliary file generated by LaTeX, if it is deleted LaTeX simply regenerates it when you run the main `.tex` file. It contains messages from LaTeX, if you receive errors and warnings from LaTeX, they will be in this `.log` file.

main.lot – this is an auxiliary file generated by LaTeX, if it is deleted LaTeX simply regenerates it when you run the main `.tex` file. It tells LaTeX how to build the *List of Tables* section.

main.out – this is an auxiliary file generated by LaTeX, if it is deleted LaTeX simply regenerates it when you run the main `.tex` file.

So from this long list, only the files with the `.bib`, `.cls` and `.tex` extensions are the most important ones. The other auxiliary files can be ignored or deleted as LaTeX and BibTeX will regenerate them.

1.5 Filling in Your Information in the `main.tex` File

You will need to personalise the thesis template and make it your own by filling in your own information. This is done by editing the `main.tex` file in a text editor or your favourite LaTeX environment.

Open the file and scroll down to the third large block titled *THESIS INFORMATION* where you can see the entries for *University Name*, *Department Name*, etc ...

Fill out the information about yourself, your group and institution. You can also insert web links, if you do, make sure you use the full URL, including the `http://` for this. If you don't want these to be linked, simply remove the `\href{url}{name}` and only leave the name.

When you have done this, save the file and recompile `main.tex`. All the information you filled in should now be in the PDF, complete with web links. You can now begin your thesis proper!

1.6 The `main.tex` File Explained

The **`main.tex`** file contains the structure of the thesis. There are plenty of written comments that explain what pages, sections and formatting the LaTeX code is creating. Each major document element is divided into commented blocks with titles in all capitals to make it obvious what the following bit of code is doing. Initially there seems to be a lot of LaTeX code, but this is all formatting, and it has all been taken care of so you don't have to do it.

Begin by checking that your information on the title page is correct. For the thesis declaration, your institution may insist on something different than the text given. If this is the case, just replace what you see with what is required in the *DECLARATION PAGE* block.

Then comes a page which contains a funny quote. You can put your own, or quote your favourite scientist, author, person, and so on. Make sure to put the name of the person who you took the quote from.

Following this is the abstract page which summarises your work in a condensed way and can almost be used as a standalone document to describe what you have done. The text you write will cause the heading to move up so don't worry about running out of space.

Next come the acknowledgements. On this page, write about all the people who you wish to thank (not forgetting parents, partners and your advisor/supervisor).

The contents pages, list of figures and tables are all taken care of for you and do not need to be manually created or edited. The next set of pages are more likely to be optional and can be deleted since they are for a more technical thesis: insert a list of abbreviations you have used in the thesis, then a list of the physical constants and numbers you refer to and finally, a list of mathematical symbols used in any formulae. Making the effort to fill these tables means the reader has a one-stop place to refer to instead of searching the internet and references to try and find out what you meant by certain abbreviations or symbols.

The list of symbols is split into the Roman and Greek alphabets. Whereas the abbreviations and symbols ought to be listed in alphabetical order (and this is *not* done automatically for you) the list of physical constants should be grouped into similar themes.

The next page contains a one line dedication. Who will you dedicate your thesis to?

Finally, there is the block where the chapters are included. Uncomment the lines (delete the `%` character) as you write the chapters. Each chapter should be written in its own file and put into the *Chapters* folder and named **`Chapter1`**, **`Chapter2`**, etc...Similarly for the appendices, uncomment the lines as you need them. Each appendix should go into its own file and placed in the *Appendices* folder.

After the preamble, chapters and appendices finally comes the bibliography. The bibliography style (called *`authoryear`*) is used for the bibliography and is a fully

featured style that will even include links to where the referenced paper can be found online. Do not underestimate how grateful your reader will be to find that a reference to a paper is just a click away. Of course, this relies on you putting the URL information into the BibTeX file in the first place.

1.7 Thesis Features and Conventions

To get the best out of this template, there are a few conventions that you may want to follow.

One of the most important (and most difficult) things to keep track of in such a long document as a thesis is consistency. Using certain conventions and ways of doing things (such as using a Todo list) makes the job easier. Of course, all of these are optional and you can adopt your own method.

1.7.1 Printing Format

This thesis template is designed for double sided printing (i.e. content on the front and back of pages) as most theses are printed and bound this way. Switching to one sided printing is as simple as uncommenting the *oneside* option of the `documentclass` command at the top of the **`main.tex`** file. You may then wish to adjust the margins to suit specifications from your institution.

The headers for the pages contain the page number on the outer side (so it is easy to flick through to the page you want) and the chapter name on the inner side.

The text is set to 11 point by default with single line spacing, again, you can tune the text size and spacing should you want or need to using the options at the very start of **`main.tex`**. The spacing can be changed similarly by replacing the *singlespacing* with *onehalfspacing* or *doublespacing*.

1.7.2 Using US Letter Paper

The paper size used in the template is A4, which is the standard size in Europe. If you are using this thesis template elsewhere and particularly in the United States, then you may have to change the A4 paper size to the US Letter size. This can be done in the margins settings section in **`main.tex`**.

Due to the differences in the paper size, the resulting margins may be different to what you like or require (as it is common for institutions to dictate certain margin sizes). If this is the case, then the margin sizes can be tweaked by modifying the values in the same block as where you set the paper size. Now your document should be set up for US Letter paper size with suitable margins.

1.7.3 References

The `biblatex` package is used to format the bibliography and inserts references such as this one (Chau, Govindaraj, and Reith, 2017). The options used in the **`main.tex`** file mean that the in-text citations of references are formatted with the author(s) listed with the date of the publication. Multiple references are separated by semicolons (e.g. (Wieman and Hollberg, 1991; Chau, Govindaraj, and Reith, 2017)) and references with more than three authors only show the first author with *et al.* indicating there are more authors (e.g. (Arnold et al., 1998)). This is done automatically for you. To see how you use references, have a look at the **`Chapter1.tex`**

source file. Many reference managers allow you to simply drag the reference into the document as you type.

Scientific references should come *before* the punctuation mark if there is one (such as a comma or period). The same goes for footnotes[1]. You can change this but the most important thing is to keep the convention consistent throughout the thesis. Footnotes themselves should be full, descriptive sentences (beginning with a capital letter and ending with a full stop). The APA6 states: "Footnote numbers should be superscripted, [...], following any punctuation mark except a dash." The Chicago manual of style states: "A note number should be placed at the end of a sentence or clause. The number follows any punctuation mark except the dash, which it precedes. It follows a closing parenthesis."

The bibliography is typeset with references listed in alphabetical order by the first author's last name. This is similar to the APA referencing style. To see how LaTeX typesets the bibliography, have a look at the very end of this document (or just click on the reference number links in in-text citations).

A Note on bibtex

The bibtex backend used in the template by default does not correctly handle unicode character encoding (i.e. "international" characters). You may see a warning about this in the compilation log and, if your references contain unicode characters, they may not show up correctly or at all. The solution to this is to use the biber backend instead of the outdated bibtex backend. This is done by finding this in **`main.tex`**: *`backend=bibtex`* and changing it to *`backend=biber`*. You will then need to delete all auxiliary BibTeX files and navigate to the template directory in your terminal (command prompt). Once there, simply type `biber main` and biber will compile your bibliography. You can then compile **`main.tex`** as normal and your bibliography will be updated. An alternative is to set up your LaTeX editor to compile with biber instead of bibtex, see here for how to do this for various editors.

1.7.4 Tables

Tables are an important way of displaying your results, below is an example table which was generated with this code:

```
\begin{table}
\caption{The effects of treatments X and Y on the four groups studied.}
\label{tab:treatments}
\centering
\begin{tabular}{l l l}
\toprule
\tabhead{Groups} & \tabhead{Treatment X} & \tabhead{Treatment Y} \\
\midrule
1 & 0.2 & 0.8\\
2 & 0.17 & 0.7\\
3 & 0.24 & 0.75\\
4 & 0.68 & 0.3\\
\bottomrule\\
\end{tabular}
\end{table}
```

[1] Such as this footnote, here down at the bottom of the page.

TABLE 1.1: The effects of treatments X and Y on the four groups studied.

Groups	Treatment X	Treatment Y
1	0.2	0.8
2	0.17	0.7
3	0.24	0.75
4	0.68	0.3

You can reference tables with `\ref{<label>}` where the label is defined within the table environment. See **`Chapter1.tex`** for an example of the label and citation (e.g. Table 1.1).

1.7.5 Figures

There will hopefully be many figures in your thesis (that should be placed in the *Figures* folder). The way to insert figures into your thesis is to use a code template like this:

```
\begin{figure}
\centering
\includegraphics{Figures/Electron}
\decoRule
\caption[An Electron]{An electron (artist's impression).}
\label{fig:Electron}
\end{figure}
```

Also look in the source file. Putting this code into the source file produces the picture of the electron that you can see in the figure below.

Sometimes figures don't always appear where you write them in the source. The placement depends on how much space there is on the page for the figure. Sometimes there is not enough room to fit a figure directly where it should go (in relation to the text) and so LaTeX puts it at the top of the next page. Positioning figures is the job of LaTeX and so you should only worry about making them look good!

Figures usually should have captions just in case you need to refer to them (such as in Figure 1.1). The `\caption` command contains two parts, the first part, inside the square brackets is the title that will appear in the *List of Figures*, and so should be short. The second part in the curly brackets should contain the longer and more descriptive caption text.

The `\decoRule` command is optional and simply puts an aesthetic horizontal line below the image. If you do this for one image, do it for all of them.

LaTeX is capable of using images in pdf, jpg and png format.

1.7.6 Typesetting mathematics

If your thesis is going to contain heavy mathematical content, be sure that LaTeX will make it look beautiful, even though it won't be able to solve the equations for you.

The "Not So Short Introduction to LaTeX" (available on CTAN) should tell you everything you need to know for most cases of typesetting mathematics. If you need more information, a much more thorough mathematical guide is available from the

FIGURE 1.1: An electron (artist's impression).

AMS called, "A Short Math Guide to LaTeX" and can be downloaded from: `ftp://ftp.ams.org/pub/tex/doc/amsmath/short-math-guide.pdf`

There are many different LaTeX symbols to remember, luckily you can find the most common symbols in The Comprehensive LaTeX Symbol List.

You can write an equation, which is automatically given an equation number by LaTeX like this:

```
\begin{equation}
E = mc^{2}
\label{eqn:Einstein}
\end{equation}
```

This will produce Einstein's famous energy-matter equivalence equation:

$$E = mc^2 \tag{1.1}$$

All equations you write (which are not in the middle of paragraph text) are automatically given equation numbers by LaTeX. If you don't want a particular equation numbered, use the unnumbered form:

```
\[ a^{2}=4 \]
```

1.8 Sectioning and Subsectioning

You should break your thesis up into nice, bite-sized sections and subsections. LaTeX automatically builds a table of Contents by looking at all the `\chapter{}`, `\section{}` and `\subsection{}` commands you write in the source.

The Table of Contents should only list the sections to three (3) levels. A `chapter{}` is level zero (0). A `\section{}` is level one (1) and so a `\subsection{}` is level two (2). In your thesis it is likely that you will even use a `subsubsection{}`, which is level three (3). The depth to which the Table of Contents is formatted is set within **`MastersDoctoralThesis.cls`**. If you need this changed, you can do it in **`main.tex`**.

1.9 In Closing

You have reached the end of this mini-guide. You can now rename or overwrite this pdf file and begin writing your own **`Chapter1.tex`** and the rest of your thesis. The easy work of setting up the structure and framework has been taken care of for you. It's now your job to fill it out!

Good luck and have lots of fun!

Guide written by —
Sunil Patel: www.sunilpatel.co.uk
Vel: LaTeXTemplates.com

Chapter 2

Methodology

2.1 Literature Review

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It is also available in several other languages. Find yours from the list on this page: http://www.ctan.org/tex-archive/info/lshort/

It is recommended to take a little time out to learn how to use LaTeX by creating several, small 'test' documents, or having a close look at several templates on: http://www.LaTeXTemplates.com

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You can use this page as a reference or crib sheet, the symbols are rendered as large, high quality images so you can quickly find the LaTeX command for the symbol you need.

2.2.4 LaTeX on a Mac

The LaTeX distribution is available for many systems including Windows, Linux and Mac OS X. The package for OS X is called MacTeX and it contains all the applications you need – bundled together and pre-customized – for a fully working LaTeX environment and work flow.

MacTeX includes a custom dedicated LaTeX editor called TeXShop for writing your '**`.tex`**' files and BibDesk: a program to manage your references and create your bibliography section just as easily as managing songs and creating playlists in iTunes.

2.3 Getting Started with this Template

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Chapter 3

Mobile Application Development

3.1 Mobile Platforms

According to a market share study by IDC (Chau, Govindaraj, and Reith, 2017), the smartphone market is currently clearly dominated by Android, which held over 86.8 percent of the market during the second quarter of 2016. Meanwhile, iOS saw its market share for 2016Q3 grow by 12.7 percent QoQ with 45.5 million shipments. The iPhone 6S followed by its newest model, the iPhone 7 were the best-selling models this quarter. Windows Phone experienced a QoQ decline of 35.2 percent with a total of 974.4 thousand units shipped this quarter. With Microsoft's focus on business users, the decline in the consumer market is expected to continue.

The market shares of the top three mobile platforms and the remaining market during the second quarter of each year between 2015 and 2016 are shown in (e.g. Table 3.1).

3.1.1 Android

Initially developed by Android Inc., which Google bought in 2005, Android was unveiled in 2007, along with the founding of the Open Handset Alliance – a consortium of hardware, software, and telecommunication companies devoted to advancing open standards for mobile devices. Beginning with the first commercial Android device in September 2008, the operating system has gone through multiple major releases, with the current version being 7.0 "Nougat", released in August 2016. Android applications ("apps") can be downloaded from the Google Play store, which features over 2.7 million apps as of February 2017. Android's source code is released by Google under an open source license, although most Android devices ultimately ship with a combination of free and open source and proprietary software, including proprietary software required for accessing Google services. Android is popular with technology companies that require a ready-made, low-cost and customizable operating system for high-tech devices.

TABLE 3.1: Smartphone Operating System market shares from years 2015 to 2016.

Period	Android	iOS	Windows Phone	Others
2015Q4	79.6%	18.7%	1.2%	0.5%
2016Q1	83.5%	15.4%	0.8%	0.4%
2016Q2	87.6%	11.7%	0.4%	0.3%
2016Q3	86.8%	12.5%	0.3%	0.4%

Android is built on a modi
ed Linux 2.6 series kernel that provides core system services such as security, memory management, process management, network stack and driver model. The kernel and low level tools are contained in the bottom layer, colored red in the illustration. The basic libraries included in Android are programmed in C and C++, and are accessed through the Android application framework.

The Android runtime contains a set of Java core libraries and the Dalvik virtual machine (VM). The Dalvik VM executes
les in Dalvik Executable (.dex) format, usually transformed from Java byte code to Dalvik byte code.[16 TBD]

Every Android application runs in its own process with its own sandboxed instance of Dalvik VM. abstraction of the underlying hardware for the rest of the software stack.[23 TBD]

The application framework layer gives the developers access to the same framework Application Programming Interfaces (API) used by the core applications. [43] The frameworks are written in Java and provide abstractions the Android libraries and the features of the Dalvik VM.[16]

Applications for Android are developed through the Android Software Development Kit (SDK), usually with the Java programming language. The SDK provides the API libraries and developer tools for building, testing and debugging for Android. Development can be done in any of the current major operating systems and an integrated development environment (IDE) of choice, although Google recommends using Android Studio. Another common option is to use Eclipse IDE with Android Developer Tools (ADT) plugin, provided by Google, which integrates the Android SDK into Eclipse. The ADT allows the developer to test the application with an Android emulator or a connected device, and provides a graphical editor for building the user interface (UI) of the application.[5]

The main distribution channel for Android applications is the Google Play Store, formerly known as Android Market, where developers can publish their applications after registration.

3.1.2 iOS

iOSis a mobile operating system created and developed by Apple Inc. exclusively for its hardware. It is the operating system that presently powers many of the company's mobile devices, including the iPhone, iPad, and iPod Touch. It is the second most popular mobile operating system globally after Android. iPad tablets are also the second most popular, by sales, against Android since 2013.[9]

Originally unveiled in 2007 for the iPhone, iOS has been extended to support other Apple devices such as the iPod Touch (September 2007) and the iPad (January 2010). As of January 2017, Apple's App Store contains more than 2.2 million iOS applications, 1 million of which are native for iPads. These mobile apps have collectively been downloaded more than 130 billion times.

The iOS, there are four abstraction layers: the Core OS, Core Services, Media, and Cocoa Touch layers.

The various core frameworks are written in the Objective-C programming language. The Core OS layer contains the low-level features most of the other technologies are built upon. Applications rarely use these technologies directly, but rather use them through the other frameworks. However, the layer contains frameworks for features such as security, Bluetooth support and communicating with external hardware, that can be used by applications if needed. The layer also contains the kernel environment, drivers and low-level UNIX interfaces of the operating system. Access to the kernel and drivers is restricted to a limited set of system frameworks and applications.[9]

The various system services used by applications are contained in the Core Services layer. This includes technologies to support features like location, iCloud storage, peer-to-peer services and networking. The Media layer above it contains the graphics, audio and video technologies needed to implement multimedia features in applications. Finally in the top layer resides the Cocoa Touch framework, providing the key frameworks for building iOS applications. This includes high-level programming interfaces for making animations, networking and modifying the appearance of the application. Cocoa Touch also handles touch-based inputs and multitasking.[8]

Building iOS applications requires using Apple's Xcode IDE on a Mac computer running OS X 10.8 or later and iOS SDK. Xcode provides the standard tools to code, debug and design the interface for the applications. Generally iOS applications are written in Objective-C language.[8]

Applications for iOS are distributed to consumers exclusively through Apple's App Store. Developers enroll in Apple Developer Program and pay yearly fee to be able to publish applications in the App Store, and applications go through an approval process by Apple before appearing in the store.[8] The approval process causes longer development times, but lowers

the number of low-quality applications in the store.[17] The approval process can pose a challenge for applications developed with various cross-platform methods. For example, in 2010 Apple maintained that apps must be "originally written in Objective-C, C, C++ or JavaScript" to be accepted into the store. The restrictions have been eased since then, but applications still sometimes get rejected for being too slow or not feeling native enough. Apple App Store can also reject apps that download executable code or interpret code not contained within the application archive.[32]

3.1.3 Windows

Windows 10 is a personal computer operating system developed and released by Microsoft as part of the Windows NT family of operating systems. It was officially unveiled in September 2014 following a brief demo at Build 2014. The first version of the operating system entered a public beta testing process in October, leading up to its consumer release on July 29, 2015.[9]

Windows 10 introduces what Microsoft described as "universal apps" expanding on Metro-style apps, The first release of Windows 10 also introduces a virtual desktop system, a window and desktop management feature called Task View, the Microsoft Edge web browser, support for fingerprint and face recognition login, new security features for enterprise environments, and DirectX 12 and WDDM 2.0 to improve the operating system's graphics capabilities for games.

Universal Windows Platform (UWP) apps[1] (formerly Windows Store apps and Metro-style apps)[2] are apps that can be used across all compatible Microsoft Windows devices, including personal computers (PCs), tablets, smartphones, Xbox One, Microsoft HoloLens, and Internet of Things. UWP apps are primarily purchased and downloaded via the Windows Store.[3]

3.1.4 Tizen

Tizen is an open and flexible operating system built from the ground up to address the needs of all stakeholders of the mobile and connected device ecosystem, including device manufacturers, mobile operators, application developers and independent software vendors (ISVs). Tizen is developed by a community of developers, under open source governance, and is open to all members who wish to participate.

The Tizen operating system comes in multiple profiles to serve different industry requirements. The current Tizen profiles are Tizen IVI (in-vehicle infotainment), Tizen Mobile, Tizen TV, and Tizen Wearable. In addition to that, as of Tizen 3.0, all profiles are built on top of a common, shared infrastructure called Tizen Common.

With Tizen, a device manufacturer can begin with one of these profiles and modify it to serve their own needs, or use the Tizen Common base to develop a new profile to meet the memory, processing and power requirements of any device and quickly bring it to market.

Mobile operators can work with device partners to customize the operating system and user experience to meet the needs of specific customer segments or demographics.

For application developers and ISVs, Tizen offers the power of native application development with the flexibility of unparalleled HTML5 support. Tizen also offers the potential for application developers to extend their reach to new “smart devices” running Tizen, including wearables, consumer electronics (TVs, gaming consoles, DVRs, etc.), cars and appliances.

The Tizen project resides within the Linux Foundation and is governed by a Technical Steering Group. The Technical Steering Group is the primary decision-making body for the open source project, with a focus on platform development and delivery, along with the formation of working groups to support device verticals.

The Tizen Association has been formed to guide the industry role of Tizen, including gathering of requirements, identification and facilitation of service models, and overall industry marketing and education.

Tizen provides application development tools based on the JavaScript libraries jQuery and jQuery Mobile. Since version 2.0, a C++ native application framework is also available, based on an Open Services Platform from the Bada platform.

Samsung Releases New Preview of Visual Studio Tools for Tizen

3.2 Mobile Applications

Mobile applications are consist of software/set of program that runs on a mobile device and perform certain tasks for the user.Mobile application is a new and fast developing Segment of the global Information and Communication Technology.

Mobile Screens are small, But Mobile apps are big, and life as we know it is on its head again. In a world that's increasingly social and open, mobile apps play a vital role, and Today we have changed the focus from what's on the Web, to the apps on our mobile device. Mobile apps are very imperative. But where do we start? There are many factors that play a part in your mobile strategy, such as your team's development skills, required device functionality, the importance of security, offline capability, interoperability, etc., that must be taken into account. Finally it's not just a question of what mobile application will do, but how we will reach there. get it there.

Mobile applications come in two distinct formats: native apps and web apps. Due to differences in their underlying technology, each approach has inherent advantages and drawbacks.

3.2.1 Native Applications

A native mobile app is built specifically for a particular device and its operating system. Unlike a web app that is accessed over the internet, a native app is downloaded from a web app store and installed on the device. Native apps are written in Java, Objective C, or some other programming language. This is changing with HTML5, but functionality is inconsistent and incomplete.

Native apps have a major advantage over web applications the ability to leverage device-specific hardware and software. This means that native apps can take advantage of the latest technology available on mobile devices and can integrate with on-board apps such as the calendar, contacts, and email. However, this is a double-edged sword: while mobile technology is wildly popular, it is also constantly changing and highly fragmented. This makes the task of keeping up with the pace of emerging technology onerous and costly, especially on multiple platforms.

3.2.2 Mobile Web Apps

A mobile web app is a web application formatted for smartphones and tablets, and accessed through the mobile device's web browser. Like a traditional web application, a mobile web app is built with three core technologies: HTML (defines static text and images), CSS (defines style and presentation), and JavaScript (defines interactions and animations).

Since web apps are browser-based, they're intended to be platform and device independent, able to run on any web-enabled smartphone or tablet. A mobile web app is normally downloaded from a central web server each time it is run, although apps built using HTML5 (described below) can also run on the mobile device for offline use.

However, significant limitations, especially for enterprise mobile, are offline storage and security. While you can implement a semblance of offline capability by caching files on the device, it just isn't a very good solution. Although the underlying database might be encrypted, it's not as well segmented as a native keychain encryption that protects each app with a developer certificate. Also, if a web app with authentication is launched from the desktop, it will require users to enter their credentials every time the app it is sent to the background. This is a lousy experience for the user. In general, implementing even trivial security measures on a native platform can be complex tasks for a mobile Web developer. Therefore, if security is of the utmost importance, it can be the deciding factor on which mobile technology you choose.

3.2.3 Hybrid Mobile Applications

Hybrid development combines the best (or worst) of both the native and HTML5 worlds. We define hybrid as a web app, primarily built using HTML5 and JavaScript, that is then wrapped inside a thin native container that provides access to native platform features. PhoneGap is an example of the most popular container for creating hybrid mobile apps.

For the most part, hybrid apps provide the best of both worlds. Existing web developers that have become gurus at optimizing JavaScript, pushing CSS to create beautiful layouts, and writing compliant HTML code that works on any platform can now create sophisticated mobile applications that don't sacrifice the cool native capabilities. In certain circumstances, native developers can write plugins for tasks like image processing, but in cases like this, the devil is in the details.

On iOS, the embedded web browser or the UIWebView is not identical to the Safari browser. While the differences are minor, they can cause debugging headaches. That's why it pays off to invest in popular frameworks that have addressed all of the limitations.

You know that native apps are installed on the device, while HTML5 apps reside on a Web server, so you might be wondering if hybrid apps store their files on the device or on a server? Yes. In fact there are two ways to implement a hybrid app.

TABLE 3.2: The Mobile App Comparison Chart: Native vs. Mobile Web vs.Hybrid

	Native	**HTML5**	**Hybrid**
App Features			
Graphics	Native APIs	HTML, Canvas, SVG	HTML, Canvas, SVG
Performance	Fast	Slow	Slow
Native look and feel	Native	Emulated	Emulated
Distribution	Appstore	Web	Appstore
Device Access			
Camera	Yes	No	Yes
Notifications	Yes	No	Yes
Contacts, calendar	Yes	No	Yes
Offline storage	Secure file storage	Shared SQL	Secure file, shared SQL
Geolocation	Yes	Yes	Yes
Gestures			
Swipe	Yes	Yes	Yes
Pinch, spread	Yes	No	Yes
Connectivity			
Connectivity	Online and offline	online	Online and offline
Development skills			
language	Objective C, Java	HTML5, CSS, Javascript	HTML5, CSS, Javascript

- Local - You can package HTML and JavaScript code inside the mobile application binary, in a manner similar to the structure of a native application. In this scenario you use REST APIs to move data back and forth between the device and the cloud.
- Server - Alternatively you can implement the full web application from the server (with optional caching for better performance), simply using the container as a thin shell over the UIWebview.

3.2.4 Conclusion

Mobile development is a constantly moving target. Every six months, there's a new mobile operating system, with unique features only accessible with native APIs. The containers bring those to hybrid apps soon thereafter, with the web making tremendous leaps every few years. Based on current technology, one of the scenarios examined in this article is bound to suit your needs. Let's sum those up in the following table:

3.3 Cross-Platform Development Tools

3.3.1 PhoneGap

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LaTeX is easily able to professionally typeset documents that run to hundreds or thousands of pages long. With simple mark-up commands, it automatically sets out the table of contents, margins, page headers and footers and keeps the formatting consistent and beautiful. One of its main strengths is the way it can easily typeset mathematics, even *heavy* mathematics. Even if those equations are the most horribly twisted and most difficult mathematical problems that can only be solved on a super-computer, you can at least count on LaTeX to make them look stunning.

3.3.2 Titanium

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3.3.4 Xamarin

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Chapter 4

Introduction to Cross-platform Development with Xamarin

Part 1 - Understanding the Xamarin Mobile Platform Part 2 - Architecture Part 3 - Setting Up A Xamarin Cross Platform Solution Part 4 - Dealing with Multiple Platforms Part 5 - Practical Code Sharing Strategies Part 6 - Testing and App Store Approvals

4.1 Understanding the Xamarin Mobile Platform

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4.2 Architecture

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4.3 Setting Up A Xamarin Cross Platform Solution

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4.3.1 Code Sharing Options

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4.3.2 Portable Class Libraries

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4.3.3 Shared Projects

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4.3.4 .NET Standard

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4.4 Dealing with Multiple Platforms

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4.5 Practical Code Sharing Strategies

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4.7 Cross-Platform User Interfaces with Xamarin.Forms

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4.7.1 eXtensible Application Markup Language (XAML)

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Testing and App Store Approvals

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Chapter 5

Introduction to Microsoft azure

5.1 Connected Services in Xamarin Studio

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5.2 Azure App Services

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5.2.1 A (not so short) Introduction to LaTeX

If you are new to LaTeX, there is a very good eBook – freely available online as a PDF file – called, "The Not So Short Introduction to LaTeX". The book's title is typically shortened to just *lshort*. You can download the latest version (as it is occasionally updated) from here: `http://www.ctan.org/tex-archive/info/lshort/english/lshort.pdf`

It is also available in several other languages. Find yours from the list on this page: `http://www.ctan.org/tex-archive/info/lshort/`

It is recommended to take a little time out to learn how to use LaTeX by creating several, small 'test' documents, or having a close look at several templates on: `http://www.LaTeXTemplates.com`

Making the effort now means you're not stuck learning the system when what you *really* need to be doing is writing your thesis.

5.2.2 A Short Math Guide for LaTeX

If you are writing a technical or mathematical thesis, then you may want to read the document by the AMS (American Mathematical Society) called, "A Short Math Guide for LaTeX". It can be found online here: `http://www.ams.org/tex/amslatex.html` under the "Additional Documentation" section towards the bottom of the page.

5.2.3 Common LaTeX Math Symbols

There are a multitude of mathematical symbols available for LaTeX and it would take a great effort to learn the commands for them all. The most common ones you are likely to use are shown on this page: `http://www.sunilpatel.co.uk/latex-type/latex-math-symbols/`

You can use this page as a reference or crib sheet, the symbols are rendered as large, high quality images so you can quickly find the LaTeX command for the symbol you need.

5.2.4 LaTeX on a Mac

The LaTeX distribution is available for many systems including Windows, Linux and Mac OS X. The package for OS X is called MacTeX and it contains all the applications you need – bundled together and pre-customized – for a fully working LaTeX environment and work flow.

MacTeX includes a custom dedicated LaTeX editor called TeXShop for writing your '**`.tex`**' files and BibDesk: a program to manage your references and create your bibliography section just as easily as managing songs and creating playlists in iTunes.

5.3 Active Directory Authentication

If you are familiar with LaTeX, then you should explore the directory structure of the template and then proceed to place your own information into the *THESIS INFORMATION* block of the **`main.tex`** file. You can then modify the rest of this file to your unique specifications based on your degree/university. Section 1.5 on page 4 will help you do this. Make sure you also read section 1.7 about thesis conventions to get the most out of this template.

If you are new to LaTeX it is recommended that you carry on reading through the rest of the information in this document.

Before you begin using this template you should ensure that its style complies with the thesis style guidelines imposed by your institution. In most cases this template style and layout will be suitable. If it is not, it may only require a small change to bring the template in line with your institution's recommendations. These modifications will need to be done on the **`MastersDoctoralThesis.cls`** file.

5.3.1 WebAPI

This LaTeX Thesis Template is originally based and created around a LaTeX style file created by Steve R. Gunn from the University of Southampton (UK), department of Electronics and Computer Science. You can find his original thesis style file at his site, here: http://www.ecs.soton.ac.uk/~srg/softwaretools/document/templates/

Steve's **ecsthesis.cls** was then taken by Sunil Patel who modified it by creating a skeleton framework and folder structure to place the thesis files in. The resulting template can be found on Sunil's site here: http://www.sunilpatel.co.uk/thesis-template

Sunil's template was made available through http://www.LaTeXTemplates.com where it was modified many times based on user requests and questions. Version 2.0 and onwards of this template represents a major modification to Sunil's template and is, in fact, hardly recognisable. The work to make version 2.0 possible was carried out by Vel and Johannes Böttcher.

Chapter 6

Chapter Title Here

6.1 Welcome and Thank You

Welcome to this LaTeX Thesis Template, a beautiful and easy to use template for writing a thesis using the LaTeX typesetting system.

If you are writing a thesis (or will be in the future) and its subject is technical or mathematical (though it doesn't have to be), then creating it in LaTeX is highly recommended as a way to make sure you can just get down to the essential writing without having to worry over formatting or wasting time arguing with your word processor.

LaTeX is easily able to professionally typeset documents that run to hundreds or thousands of pages long. With simple mark-up commands, it automatically sets out the table of contents, margins, page headers and footers and keeps the formatting consistent and beautiful. One of its main strengths is the way it can easily typeset mathematics, even *heavy* mathematics. Even if those equations are the most horribly twisted and most difficult mathematical problems that can only be solved on a super-computer, you can at least count on LaTeX to make them look stunning.

6.2 Learning LaTeX

LaTeX is not a WYSIWYG (What You See is What You Get) program, unlike word processors such as Microsoft Word or Apple's Pages. Instead, a document written for LaTeX is actually a simple, plain text file that contains *no formatting*. You tell LaTeX how you want the formatting in the finished document by writing in simple commands amongst the text, for example, if I want to use *italic text for emphasis*, I write the `\emph{text}` command and put the text I want in italics in between the curly braces. This means that LaTeX is a "mark-up" language, very much like HTML.

6.2.1 A (not so short) Introduction to LaTeX

If you are new to LaTeX, there is a very good eBook – freely available online as a PDF file – called, "The Not So Short Introduction to LaTeX". The book's title is typically shortened to just *lshort*. You can download the latest version (as it is occasionally updated) from here: `http://www.ctan.org/tex-archive/info/lshort/english/lshort.pdf`

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It is recommended to take a little time out to learn how to use LaTeX by creating several, small 'test' documents, or having a close look at several templates on: `http://www.LaTeXTemplates.com`

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8.2.2 A Short Math Guide for LaTeX

If you are writing a technical or mathematical thesis, then you may want to read the document by the AMS (American Mathematical Society) called, "A Short Math Guide for LaTeX". It can be found online here: `http://www.ams.org/tex/amslatex.html` under the "Additional Documentation" section towards the bottom of the page.

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Chapter 9

Chapter Title Here

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Chapter 10

Conclusion

10.1 Goal Fulfilment

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10.2 Future Work

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Appendix A

Frequently Asked Questions

A.1 How do I change the colors of links?

The color of links can be changed to your liking using:

`\hypersetup{urlcolor=red}`, or
`\hypersetup{citecolor=green}`, or
`\hypersetup{allcolor=blue}`.

If you want to completely hide the links, you can use:

`\hypersetup{allcolors=.}`, or even better:
`\hypersetup{hidelinks}`.

If you want to have obvious links in the PDF but not the printed text, use:

`\hypersetup{colorlinks=false}`.

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