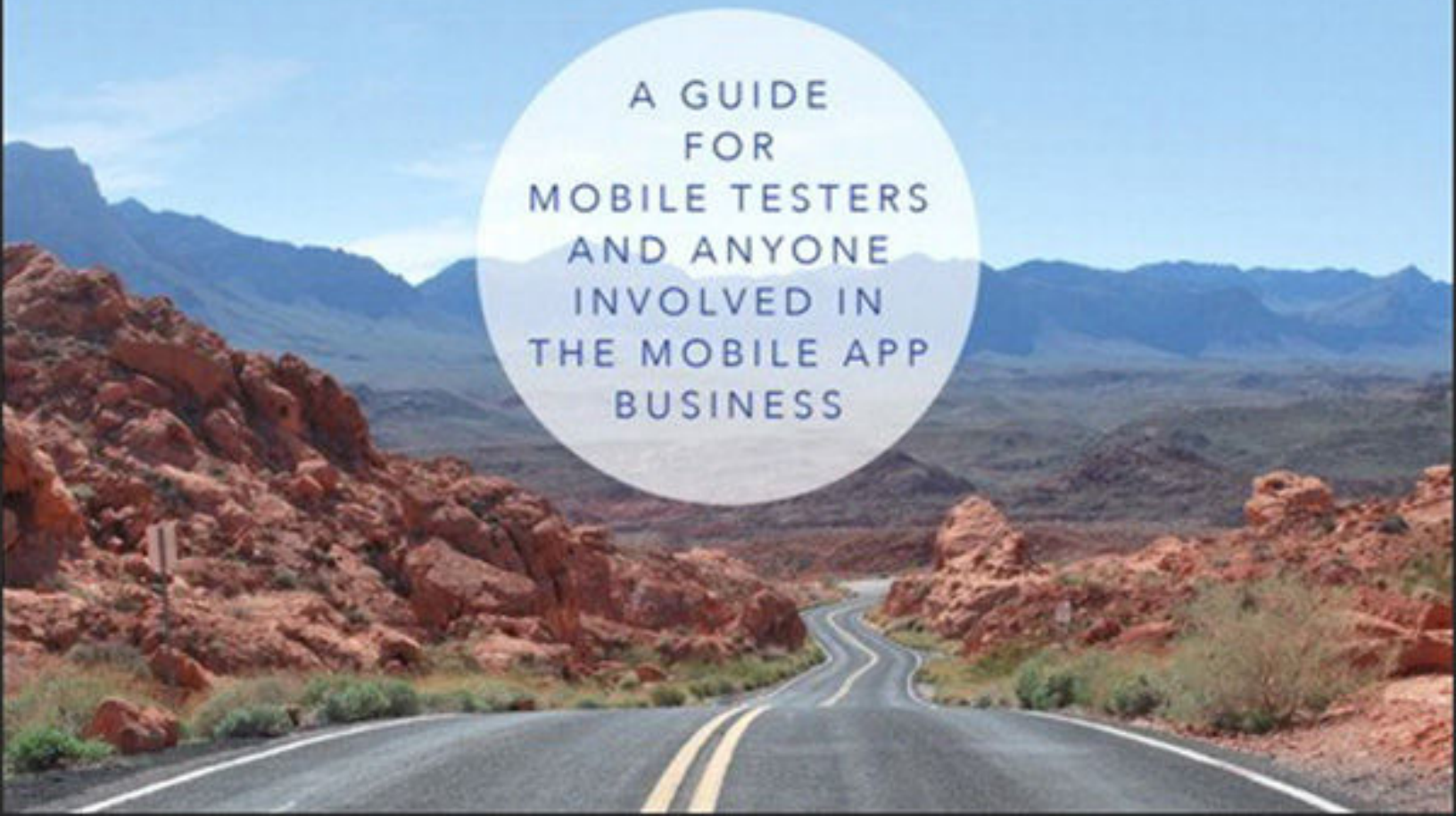
DANIEL KNOTT

HANDS-ON MOBILE APP TESTING

A GUIDE FOR MOBILE TESTERS AND ANYONE INVOLVED IN THE MOBILE APP BUSINESS



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Hands-On Mobile App Testing

A Guide for Mobile Testers and Anyone Involved in the Mobile App Business

Daniel Knott

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For my wife, Sarah. Thank you
very much for your support and
encouragement while I wrote this book.

Contents

Preface

Mobile phones have been around since the middle of the 1970s. The devices have of course changed profoundly since then, but the biggest change came in 2007 when Apple presented its first iPhone. From that moment on, the mobile smartphone market has known only one direction—UP! Eight years later, touch devices such as smartphones and tablets have become ubiquitous. More than two million apps are available for download in the stores of the biggest vendors, and this number is still rising.[1] There are apps for every aspect of our lives, ranging from photos and music, to office applications and games, and on to fitness and health. But what about the quality of those apps? Are they reliable, trustworthy, easy to use, well developed, and tested?

1. iOS Store numbers, www.engadget.com/2014/06/02/apples-wwdc-2014-in-numbers-40-million-on-mavericks-and-more/; Android Play Store numbers, www.appbrain.com/stats/number-of-android-apps. Numbers are from June 2014.

This book is a practical guide to mobile testing for anyone who works in the mobile business, but it is especially aimed at mobile testers.

Why I Wrote This Book

It all started in 2010 when I had the opportunity to work on my first mobile project. The mobile team I worked in was responsible for developing a mobile Web app, a native Android app, and a native iOS app. This was the company's first mobile project and a completely new testing environment for the quality assurance department. Together with a colleague, I had the chance to build a mobile testing strategy from scratch. We evaluated several test automation tools to see which one fit best in our software development lifecycle. At that time, mobile testing tools were few and far between, and at a very early development stage. We then tried several testing approaches and tools. Of course we failed with some of them, but in the end the whole team, the company, and our customers were happy.

Another reason why I wrote this book was because of my blog, www.adventuresinqa.com. I started blogging in 2011 after giving a presentation at the Agile Testing Days in Potsdam, Germany. This was my first talk at a major testing conference, and I was the only speaker on the agenda who spoke about mobile testing. After my presentation I was very

busy for the rest of the conference as a lot of people approached me to ask about mobile testing, the approaches I use, what kind of tools I use, and so forth. The huge interest in and the lack of knowledge about mobile testing convinced me to start writing a blog. The goal was to share my knowledge of mobile testing and to exchange views and ideas with other mobile testers, while also improving my written English skills. So far I've written about 90 posts covering mobile apps and testing, and I never expected so many people from around the world to take an interest in my blog. The feedback I've gotten so far has been great, and it convinced me to take the next step.

That step is what you're reading: a book about mobile testing that captures my practical experience and knowledge for anyone involved in the mobile business. I hope you enjoy reading this book and can learn something new about the mobile testing business.

Who Should Read This Book?

This book is aimed at anyone who is interested in mobile apps and mobile testing, ranging from junior to expert mobile testers who are already involved in mobile development teams.

This book is also ideal for software test managers who need to manage mobile testing teams or to select a mobile test strategy. It's also great for software testers who are new to this topic and want to switch to mobile technologies.

Software developers who want to know more about mobile testing and testing their mobile apps have also come to the right place.

This book is also intended for product managers looking to gain further insights into the challenging job of mobile testing.

Topics Covered in This Book

This book contains the following chapters:

- **Chapter 1: What's Special about Mobile Testing?** The first chapter focuses on the special characteristics of mobile testing. It provides an introduction to mobile user expectations, mobile data networks, mobile devices, and why mobile testing is software testing.
- **Chapter 2: Introduction to Mobile Devices and Apps** Chapter 2 introduces mobile data networks and what is important to know about

them. The chapter also describes the mobile device evolution from dumb phones to the current smartphones. Furthermore, this chapter introduces the different types of apps and possible app business models.

- **Chapter 3: Challenges in Mobile Testing** Chapter 3 is all about mobile testing challenges and how to handle them. There are challenges such as the customer, device fragmentation, sensors and interfaces, system apps, and mobile browsers. Each section of the chapter provides solutions for handling those challenges in your daily business as a mobile tester.
- **Chapter 4: How to Test Mobile Apps** Chapter 4 is all about how to test mobile applications. This chapter explains the differences among emulators, simulators, and real devices. It also explains where to test a mobile app. Furthermore, this chapter provides several functional and nonfunctional approaches to testing a mobile app. In addition, this chapter presents mobile testing mind maps, mnemonics, and checklists to improve your mobile testing efforts.
- **Chapter 5: Mobile Test Automation and Tools** Chapter 5 covers the topic of mobile test automation, which is a very important one. The chapter introduces the different test automation tool types and approaches. It provides ideas for how to select the right mobile test automation tool for your test environment. Additionally, the chapter provides an overview of the current state of mobile test automation tools for Android and iOS.
- **Chapter 6: Additional Mobile Testing Methods** Chapter 6 provides an overview of additional mobile testing methods such as crowd and cloud testing. Both methods are explained, including the pros and cons and where it makes sense to use them in your mobile testing approach.
- **Chapter 7: Mobile Test and Launch Strategies** Chapter 7 deals with the topic of mobile test and launch strategies. It is very important for developers of mobile apps to have both in place in order to develop, test, and launch a mobile app with high quality. This chapter provides lots of ideas about and examples of how to establish mobile test and launch strategies.

- **Chapter 8: Important Skills for Mobile Testers** Chapter 8 describes the required skill set of a mobile tester. Furthermore, the chapter provides ideas and solutions on how to improve the skills of a mobile tester.
- **Chapter 9: What's Next? And Final Thoughts** Chapter 9 is the final chapter of this book and deals with possible topics that software testers may have to handle in the near future. The chapter contains topics such as the Internet of Things, connected homes, connected cars, and wearables. At the end, five key success factors are provided.

Each chapter focuses on the practical side of mobile testing. Sure, there will be some theoretical parts, but most of the content is based on real-life experience as a mobile tester.

How to Use This Book

This book is a practical guide to mobile testing. You can read it from front to back to get an overview of mobile testing, or you can jump straight to the chapters you're most interested in. There's one important piece of advice you should bear in mind while reading this book: make sure you have at least one mobile device next to you so you can try out the things you read.

If you want to get started with the test automation tools mentioned in this book, now would be a good time to get your computer.

Acknowledgments

Thanks to Tobias Geyer for being my dedicated reviewer. Without your contribution, encouragement, help, feedback, and critical questions this book would not have become what it is.

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Thanks to Andrew Rennison for being my great copy editor, for your help and constant contribution to my text.

And last but not least, I want to say thank you to all software testers out there for sharing your knowledge of various software testing and mobile testing topics. Thanks for your contribution to the community and all of the time and effort you put in.

About the Author

Daniel Knott has been working in the field of software development and software testing since 2003. He started his career as a trainee at IBM where he was involved in enterprise software development and testing.

After his time at IBM, Daniel studied computer science at the University of Applied Sciences in Wiesbaden, Germany. Software testing became a passion during his time at university and is the reason he chose a career in the field. Daniel has worked at several companies in various industries where he was responsible for testing Web, desktop, and mobile applications. During a number of projects he developed fully automated testing frameworks for Android, iOS, and Web applications. Daniel is a well-known mobile expert, a speaker at various conferences in Europe, and a blog author (www.adventuresinqa.com).

Furthermore, Daniel is the founder and organizer of two local software testing user groups in central Germany. One is the Software Test User Group Rhein Main (www.stugrm.de) and the other is the Rhein Main Mobile Quality Crew (www.meetup.com/Rhein-Main-Mobile-Quality-Crew).

Chapter 1. What's Special about Mobile Testing?

Before I start describing the unique aspects of mobile testing, I'd like to share a true story with you.

What's special about mobile testing? Someone asked me this exact question several years ago while at a testing conference. I started talking about mobile technologies, apps, how to test them, and what's special about mobile testing. The guy simply smiled at me and said, "But it's software just on a smaller screen. There's nothing special about it." He was really arrogant and didn't see the challenges presented by mobile testing. No matter which arguments I used to convince him, he didn't believe in the importance of mobile technologies, apps, and testing.

I met the same guy again in 2014 while at a testing conference where he talked about mobile testing. He spoke about the importance of apps and how important it is to test them.

As you can see, it's very easy to underestimate new technologies. As a software tester it's especially helpful to be curious about learning something new and exploring new technologies to broaden your skills.

So let's come back to the initial question: What's special about mobile testing? I think I can assume you have at least one mobile device, namely, a smartphone. Or maybe you have a tablet, or even both. If you look at your device(s), what do you see? Just a small computer with little shiny icons on its screen? Or do you see a very personal computer with lots of sensors and input options that contains all of your private data? Please take a minute to think about that.

My smartphone and tablet are very personal computers that hold almost all of my data, be it e-mails, SMS, photos, music, videos, and the like. I can access my data no matter where I am and use my smartphone as a navigation and information system to find out more about my surroundings. For that reason I expect my apps to be reliable, fast, and easy to use.

In those three sentences I described my personal expectations of mobile devices and apps. But you may have entirely different expectations, as does the next person. And this brings me to the first special characteristic or unique aspect of mobile testing: user expectations.

User Expectations

In my opinion, the user of an app is the main focus and main challenge for mobile teams. The fact that every user has unique expectations makes it difficult to develop and deliver the "right" app to customers. As several reports and surveys have shown, mobile users have far higher expectations of mobile apps than of other software such as browser applications.[1] The majority of reports and surveys state that nearly 80% of users delete an app after using it for the first time! The top four reasons for deletion are always bad design, poor usability, slow loading time, and crashes immediately after installation. Nearly 60% of users will delete an app that requires registration, and more than half of users expect an app to launch in under two seconds. If the app takes more time, it gets deleted. Again, more than half of users experience crashes the very first time they start an app. An average user checks his or her mobile device every six minutes and has around 40 apps installed. Based on those numbers, you can deduce that mobile users have really high expectations when it comes to usability, performance, and reliability. Those three characteristics were mentioned most often by far when users were asked about their experience with mobile apps.

1. http://offers2.compuware.com/rs/compuware/images/Mobile_App_Survey_Report.pdf

Currently there are more than two million apps available in the app stores of the biggest vendors. A lot of apps perform the same task, meaning that there's always at least one competitor app, which makes it very easy for consumers to download a different app as it's just a single tap away. Here are some points you should keep in mind when developing and testing a mobile app:

- Gather information about your possible target customer group.
- Ask your customers about their needs.
- Your app needs to solve a problem for the user.
- Usability is really important.
- Your app needs to be reliable and robust.
- App performance is really important.
- Apps need to be beautiful.

There are, of course, a plethora of other things you should take into account, but if you pay attention to these points, your users are likely to be happy.

You've probably already heard of the KISS principle.[2] KISS is an acronym for Keep It Simple, Stupid and is always a useful reminder—especially for software projects—to not inflate the software with just another function or option. Keeping it small, easy, and simple is best in most cases and is likely to make your customers happy. Inspired by KISS, I came up with my own principle for mobile apps: KIFSU (see Figure 1.1). This abbreviation is a good mnemonic to help you cover customer needs and a constant reminder not to inflate apps with useless functions.

2. http://people.apache.org/~fhanik/kiss.html

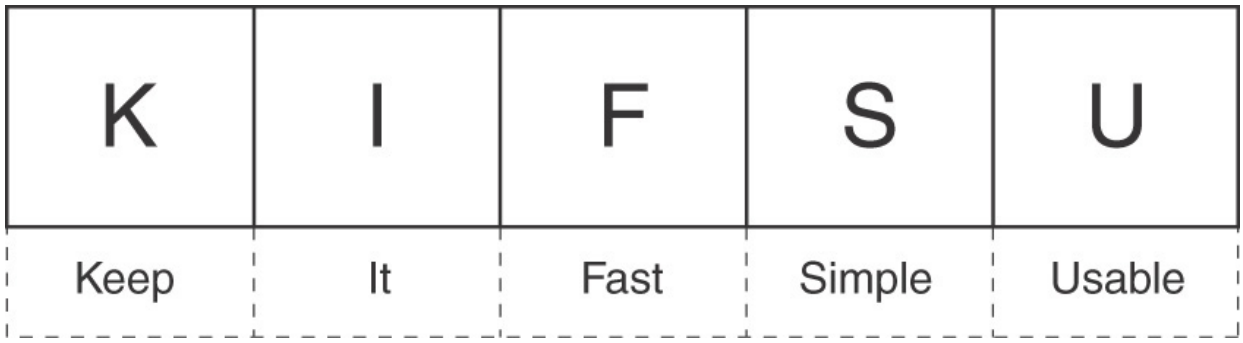

Figure 1.1 *KIFSU*

Mobility and Data Networks

Another challenge mobile apps have to deal with more than software running on computers is the fact that users are moving around while they use apps, which often requires an Internet connection to fetch data from the backend and serve the user with updates and information.

Mobile apps need to be tested in real life, in real environments where the potential user will use them. For example, if you're testing an app for snowboarders and skiers that accesses slope information, one that is able to record the speed of the current downhill run and makes it possible for users to share records directly with their friends, you need to test these functions on a slope. Otherwise you can't guarantee that every feature will work as expected.

Of course, there are parts of an app that you can test in a lab situation, such as slope information availability or whether or not the app can be installed, but what about recording a person's speed, the weather conditions, or the Internet connection at the top of a mountain?

The weather conditions on a mountain, in particular, can be very difficult to handle as they can, of course, range from sunshine to a snowstorm. In such scenarios you will probably find lots of bugs regarding the usability and design of an app. Maybe you'll also find some functional bugs due to the temperature, which may have an impact on your hardware and, in turn, your app.

As I already mentioned, the speed and availability of Internet connections could vary in such regions. You will probably have a good network connection with high speed at the top of the mountain and a really poor one down in the valley. What happens if you have a bad or no Internet connection while using the app? Will it crash or will it still work? What happens if the mobile device changes network providers while the app is being used? (This is a common scenario when using apps close to an international border, such as when snowboarding in the Alps.)

All of these questions are very hard to answer when testing an app in a lab. You as a mobile tester need to be mobile and connected to data networks while testing apps.

As you can see, it's important to test your app in real-life environments and to carry out tests in data networks with different bandwidths as the bandwidth can have a huge impact on your app; for example, low bandwidth can cause unexpected error messages, and the switch between high and low bandwidth can cause performance issues or freezes.

Here's an exercise for you. Take any app you want and find three usage scenarios where the environment and/or network connection could cause problems.

Mobile Devices

Before you continue reading, pick up your mobile device and look at it. Take your device in your hand and look at every side of it without turning it on. What do you see?

You will most likely see a device with a touch-sensitive screen, a device with several hardware buttons with a charger, a headphone connection, and a camera. That's probably it—you're not likely to have more than five hardware buttons (except for smartphones with a physical keyboard).

In an era when the words *cell phone* have become synonymous with smartphone, it's important to remember that there used to be other types of

cell phones, so-called dumb phones and feature phones that have lots more hardware buttons for making a call or typing a message. With a conventional dumb phone you are only able to make a call, type a message, or store a contact list; they're not usually connected to the Internet. The more advanced ones, the feature phones, have games, a calendar, or a very basic Web browser with the option to connect to the Internet. But all these phones are really basic in terms of functionality and expandability as users aren't able to install apps or easily update the software to a newer version, if it all. Both types of phones are still available, especially in emerging markets, but since 2013 more smartphones have been sold worldwide than dumb phones or feature phones,[3] and this trend is likely to continue as time goes on. In fact, in the next couple of years dumb phones and feature phones will be a thing of the past.

3. www.gartner.com/newsroom/id/2665715

The phones we use nowadays are completely different from the "old" ones. Current smartphones are mini supercomputers with lots of functionality in terms of hardware and software. They're packed with various sensors such as brightness, proximity, acceleration, tilt, and much more. Besides that, all modern smartphones have both front- and rear-facing cameras, various communication interfaces such as Bluetooth, near field communication (NFC), and Global Positioning System (GPS), as well as Wi-Fi and cellular networks to connect to the Internet. Depending on the mobile platform and mobile manufacturer, you may find an array of other hardware features.

From a software point of view, smartphones offer lots of application programming interfaces (APIs) for manufacturers, developers, and users to extend smartphone capabilities with apps.

If you just focus on the major mobile platforms, iOS and Android, there are plenty of hardware and software combinations that mobile testers have to deal with. The fact that there are so many combinations is known as fragmentation. Mobile device fragmentation is a huge topic and yet another challenge when it comes to mobile testing.

You can't test your app with every possible hardware and software combination. And the fact that you should test your app in a real environment makes it even more impossible. Mobile testers need to find a strategy to downsize the effort of testing on different devices and to find a way to test on the right devices.

But how can that be accomplished? By testing on just one mobile platform? By testing on just the latest device? By testing with just the latest software version?

Before you define a strategy, you should keep in mind that every app is unique, has unique requirements, has other problems to solve, and has a unique user base. With these points in mind, you can ask yourself the following questions to find the "right" mobile devices for testing:

- Who is my user base?
- How old is the average user?
- How many men or women are in my target user group?
- Which platform is used most among that user base?
- Which device is used most?
- Which software version is installed on most of the phones?
- What kind of sensors does my app use?
- How does the app communicate with the outside world?
- What is my app's main use case?

Of course, there are lots more questions to ask, but if you answer most of the ones I suggest, the list of possible devices you should consider testing is much shorter.

In later chapters I will describe other techniques for selecting the right devices for mobile testing.

Mobile Release Cycles

Now that you know how to find the right devices for testing your app, it doesn't mean that the process is over. To be honest, it's never going to end!

The main mobile manufacturers release a new flagship phone with more features every year. In and around those releases they bring out other phones for different user scenarios and user groups. This is especially true in the Android world where every new phone comes with a new version of the operating system packed with new features, designs, or APIs. There are multiple software releases within the course of a year, ranging from bug fixes to feature releases. You as a mobile tester need to be sure that your app will run on the latest hardware and software.

But how should you handle these situations? By buying every phone that appears on the market? By constantly updating to the latest operating system version?

Again, the most important factors are your target customer group and the app you're testing. When you know that your target group always uses the latest and fastest phones on the market, you need to buy those phones as soon as they appear. Regardless of whether or not your target group is up-to-date, you should always monitor the mobile market.

You need to know when the main vendors are due to release new flagship phones that a lot of people are likely to buy. You also need to know when the operating systems receive patches, new features, or new design patterns.

So the answer to the question of whether you need to buy every phone and constantly update the operating systems is yes and no. Of course you don't need to buy every phone that's on the market, but you should consider updating to the latest operating system version. When doing so, keep in mind that not every user will install the update. Many people don't know how to do that, or they don't care about new versions. You need at least some phones that are running older versions of the operating system to see how the app reacts in that environment. Older versions of the operating system are also needed to reproduce reported problems and bugs.

A good way to manage all this is to stick with the same operating system version on the phones that you have and buy new phones with the latest software version. This of course leads to another problem—it's really expensive! Not every manager wants to spend so much money on mobile devices when a phone is going to be used for only a couple of months. A solution for that is to rent devices. There are several providers and Open Device Labs where you can rent a device for a certain period of time (a list of providers can be found in Chapter 3, "Challenges in Mobile Testing"). Another way to rent devices is the mobile device cloud as there are a number of providers who give mobile testers exclusive access to the physical devices they have made available in the cloud. Just use your search engine and check them out.

In the mobile projects I've worked on, we always had the top ten to 15 devices used by our target user group in different variations for developing and testing. This was a good number of devices that covered nearly 90% of our target group. With those ten to 15 devices we were able to find most of the

critical bugs; the remaining 10% of devices we didn't have were of no major consequence to the project or user expectations.

In order to handle the fast pace of mobile release cycles, you should keep the following things in mind:

- Monitor the mobile device and software market.
- Know when new phones will be rolled out.
- Find out about the new features of the operating systems.
- Keep an eye on your target customer group to see if new devices are showing up in your statistics.
- Think twice before updating a phone to the latest operating system version.
- Buy new phones with the latest operating system version.
- If buying is not an option, rent the devices.

Updating, buying, and maintaining all of your devices is a challenging task and should not be underestimated! At some point, depending on the number of test devices used within a project, this could be a full-time job.

Mobile Testing Is Software Testing

Let's come back to the story I told at the beginning of this chapter when the guy at the conference didn't believe in the importance of mobile testing. He had the attitude that mobile testing is not real software testing. In his opinion, mobile apps were only small programs with less functionality and no real challenges when it comes to software testing. But this is definitely not the case. If you look at the topics I described in this chapter, you should have an initial impression about the challenging job of a mobile tester. Mobile testing is totally different from testing software applications such as Web or desktop applications. With mobile apps, physical devices have far more influence over the software that is running on them when compared to other software such as Web applications. Because there are so many different smartphones available on the market, mobile testers need to focus a lot more on hardware during the testing process. In addition, users moving around and using different data networks force mobile testers to be on the move while testing.

Besides the hardware, user expectations play an important part in the daily business of a mobile tester and need to be taken seriously.

There are many more topics and issues mobile testers need to know about in order to help the whole team release a successful app. The rest of the chapters in this book will cover the following topics:

- More challenges for mobile testers and solutions to those challenges
- How to test mobile apps systematically
- How to select the right mobile test automation tool
- The different concepts of mobile test automation tools
- How to find the right mobile testing strategy
- Additional mobile testing methods
- Required skills for mobile testers

Keep the topics from this chapter in mind as a starting point. Keep your app simple and fast (remember KIFSU). Test while you're on the move, and test on different devices based on your target customer group.

Summary

The first chapter of this book mentioned some very important topics from the mobile testing world. As you have seen, mobile testing is completely different from testing on other technologies such as laptops or desktop computers. The biggest difference between mobile and other technologies is that the mobile user is on the move while he or she is using your product. Therefore, it is very important to know about the different data networks and the different types of mobile devices.

This chapter also provided a first overview of mobile users' high expectations. It is really important to keep KIFSU in mind when designing, developing, and testing a mobile app. It will help you to focus on the important elements and not waste time on unnecessary features that your users won't use.

And last but not least, this chapter should remind you to never underestimate a new technology. Be open-minded and curious to improve your daily work life.

Chapter 2. Introduction to Mobile Devices and Apps

Before I dive deeper into the testing chapters, I'd like to introduce you to the history of mobile devices and cellular networks. This may sound a bit boring, but as you will see by the end of this chapter, it's really important to know the background of the mobile world and to have thorough knowledge of former mobile technologies. Later in this chapter I describe the different mobile app types and the app business models and provide you with a short overview of the current state of mobile app stores.

Let's start with the word *mobile*. It comes from the Latin word *mobilis*, which itself is derived from the Latin verb *movere*, "to move"—to be able to move around freely and easily by walking, driving, or flying.

This definition sounds really simple and comprehensible, and I'm sure you had something similar in mind. If you look at the word *mobile* from a technological point of view, it's not quite as simple due to the vast changes in the way people have begun to use mobile technologies over the past few decades.

So let's go back a few decades in time.

Overview of Mobile Networks

Before we can communicate with any kind of mobile device, a communication infrastructure must be available. The mobile infrastructure is currently in its fourth generation, known aptly as 4G or LTE (Long-Term Evolution).[1] Before that we saw the generations 0G, 1G, 2G, and 3G, and each generation was a milestone at its time of introduction.

1. www.etsi.org/technologies-clusters/technologies/mobile/long-term-evolution

The zero generation—the early predecessors—included just analog radio communication and was mainly used in the 1960s. It is also known as the Mobile Radio Telephone System. Communication at this time was half duplex, meaning that only one person was able to talk at a time while the other listened. The zero generation consisted of different mobile technologies such as Mobile Telephone Service (MTS), Mobile Telephony System D (MTD), Advanced Mobile Telephone System (AMTS), and Offentlig Landmobil

Telefoni (OLT). The cell phones were really heavy and were installed mostly in trucks, trains, and other vehicles. The phone consisted of two parts, the **transceiver** (transmitter and receiver) and the **head**. The transceiver was responsible for establishing the connection to the local transmitter stations, and the head was wired to the transceiver and consisted of dial keys, a display, and a handset. This generation had a lot of problems with connectivity and had limited numbers of subscribers.

The first-generation (1G) cellular network was an improvement over the zero generation and was introduced in the 1980s. 1G still used analog radio signals to transmit information using the Advanced Mobile Phone Service (AMPS) or Nordic Mobile Telephone (NMT) technology. The first networks were launched in Japan, followed by Denmark, Finland, Norway, Sweden, and the United States. A couple of years later other countries built up their 1G network infrastructure. The biggest advantage over the zero generation was that 1G was able to accommodate up to ten times more users by dividing the local area into smaller cells. This generation had its drawbacks when it came to security as users were able to listen to someone else's conversation and hack the system to make free calls.

The biggest improvement in mobile communication networks was introduced with the second generation of cellular networks. 2G was first launched in 1991 in Finland using the GSM (Global System for Mobile Communications) standard.[2] A couple of years later CDMA (Code Division Multiple Access) was launched in the United States.[3] These new standards formed the basis of today's mobile communication infrastructure and offered three main advantages over their predecessors:

2. www.etsi.org/technologies-clusters/technologies/mobile/gsm
3. www.etsi.org/technologies-clusters/technologies/mobile/w-cdma

- For the first time ever, communication was digital and encrypted.
- 2G was way more efficient and provided better global cell phone coverage.
- Data services were introduced, the most commonly known one being the SMS.

The 2G network was built mainly for voice and text communication and only has slow data transmission. After the 2G networks were established, mobile services usage increased and data transmission became too slow. To achieve higher data transfer rates, the 2G network was extended with the

GPRS (General Packet Radio Service)[4] and EDGE (Enhanced Data rates for Global Evolution)[5] standards. GPRS is also called 2.5G and EDGE, 2.75G. Both technologies have higher data transfer rates (GPRS = 56 Kbit/s up to 115 Kbit/s, EDGE = up to 236 Kbit/s) than the normal 2G network and are the predecessors of the 3G network.

4. www.etsi.org/index.php/technologies-clusters/technologies/mobile/gprs

5. www.etsi.org/index.php/technologies-clusters/technologies/mobile/edge

The third generation of mobile networks (3G) has been around since 2001 and is an evolution of the existing 2G networks. The third generation uses the UMTS (Universal Mobile Telecommunications System)[6] and CDMA2000 standards. 3G offers high-speed data transfer rates up to 21 Mbit/s depending on the user's current location. This high data transfer rate allows smartphone, tablet, or computer users to make video calls, watch mobile TV, and surf the Internet while on the move. The 3G networks with their high-speed data transfer rates have had a major influence on the success of mobile devices and apps.

6. www.etsi.org/technologies-clusters/technologies/mobile/umts

The fourth generation of mobile communication networks accommodated the huge amounts of data now being transferred over the network by increasing data transfer rates even further. The 4G network is basically divided into two standards: WiMAX (Worldwide Interoperability for Microwave Access)[7] and LTE. WiMAX offers a download transfer rate of up to 128 Mbit/s and an upload rate of up to 56 Mbit/s. LTE offers download rates of up to 100 Mbit/s and an upload rate of up to 50Mbit/s. If both standards are fully implemented, the download speed can increase to 1 Gbit/s.

7. www.wimaxforum.org/index.htm

Depending on your network provider and country, your smartphone is connected to either a WiMAX or LTE network. If your phone supports 4G networks, you will see a little LTE or 4G icon in the status bar of the phone.

The fifth generation of mobile networks is currently under development. Several research groups have been formed to describe and develop the next generation of mobile communication and architecture. However, this standard will not be available before 2020.[8]

8. http://europa.eu/rapid/press-release_IP-13-159_en.htm

This was a high-level overview of the technology behind mobile networks, but even this high-level view is important when you start testing your app in

different networks using different standards. It's important to know what kind of network standards are available and which network speeds are provided. Further information on how to test the different data networks will be provided in later chapters. I highly recommend that you use this knowledge in your daily app testing.

Mobile Devices and the Year 2007

Prior to 2007 most phones were so-called feature phones (as described in Chapter 1, "What's Special about Mobile Testing?") whose functionality could not be extended with software (apps). Not all of them were able to connect to the Internet, even when the mobile networks were able to handle data transmission. At that time Nokia, Motorola, BlackBerry (Research in Motion), and some other mobile manufacturers dominated the mobile device market. Most of the devices had a small screen and a physical keyboard and were good just for making a call or typing a text message. However, those devices were no fun to use when trying to surf the Web or search for contacts within the phone.

The smartphone revolution started in January 2007 when Apple launched its first iPhone. Steve Jobs presented the first generation of the iPhone with the following sentence: "Today, Apple is going to reinvent the phone."

And Steve Jobs was right. The mobile device market has of course changed dramatically since 2007. Just one year later, Google presented the first Android smartphone developed by HTC, the HTC Dream (also known as T-Mobile G1). In the following years lots of other manufacturers built their own Android smartphones with different Android software versions.

When Apple announced the iPhone, only Google was fast enough to adapt and build another mobile platform. However, Microsoft and BlackBerry (Research in Motion) have updated their mobile technologies to close the gap between themselves and Apple and Google, but until now they still haven't managed to catch up.

Since 2007, smartphones have constantly been improved with new hardware and software features, and sometimes it's hard to follow all the new features that are rolled out into the mobile market.

You need to know what's inside a smartphone to get an overview of its physical parts and what each of them does. This knowledge will help you

understand the devices you want to test, which in turn will help you test more effectively.

If you look at the mobile device next to you, you will see a small, thin, and flat or curved piece of glass, plastic, or metal. All the hardware that is needed to bring this little thing to life is packed into the small case and is not seen by the user. But what's inside?

A typical smartphone consists of the following hardware components:

- Mainboard or logic board
- CPU (central processing unit)
- GPU (graphics processing unit)
- Memory
- Different antennas and interfaces:
  - Cellular network chips to connect to 2G, 3G, or 4G
  - Wi-Fi
  - NFC (near field communication)
  - GPS (Global Positioning System)
  - Bluetooth
- Various sensors (not necessarily all of the ones in this list):
  - Ambient light sensor
  - Proximity sensor
  - Acceleration sensor
  - Gyroscope
  - Magnetic sensor
  - Pressure sensor
  - Temperature sensor
  - Humidity sensor
- Battery
- Vibration motor
- Slot for additional memory card
- Slot for SIM card

Here are the parts you can see when you have your smartphone in your hand:

- Smartphone case
- Touchscreen
- Hardware buttons (power button, volume up and down button, navigation buttons)
- Headphone jack
- Speakers and microphones
- Charger/USB connector
- Front and rear cameras
- Flash

If you want to get more detailed information about a specific phone, just use the Internet and search for "teardowns" of the device or check out the device manufacturer's Web site. The hardware I listed also applies to tablets with some variations.

As a mobile tester, it's very important that you know all the possible components within a mobile device. This knowledge is needed to identify and narrow down problems or bugs that could be related to the device hardware or your app.

The Big Two

As mentioned in the previous chapter, other mobile platforms such as Windows Phone and BlackBerry have very little market share compared to Android and iOS.[9] As of February 2015, market shares were as follows: Android, 55.26%; iOS, 23.82%; Windows Phone, 2.32%; and BlackBerry, 1.66%. The missing 17% includes devices running Symbian, Series 40, and other outdated mobile operating systems.

9. Exact figures on market share can be found here: http://gs.statcounter.com

> **Important**
>
> These figures will of course vary depending on geographical location, but they're a good indicator of the big picture.

Since BlackBerry and Windows Phone have very little market share, I'll focus on the big two for the rest of the chapter: iOS and Android.

What are the differences between the two operating systems? What do they have in common? Table 2.1 compares the operating systems based on certain criteria.

Criteria	Android	iOS
Company	Google	Apple
OS family	Linux	OS X, Linux
Programmed in	C, C++; apps in Java	C, C++; apps in Objective-C, Swift (since iOS 8)
Source model	Open source	Closed source
Open source	Kernel, UI, and some of the standard apps	iOS kernel not open source but based on open-source Darwin OS
Manufacturer	LG, Samsung, HTC, Sony, ASUS, Motorola, Huawei, . . .	Apple
Customizability	Almost everything can be changed	Very limited
Widgets	Yes, on the desktop as well as in the notification center	Yes, within the notification center
Interfaces	Touchscreen	Touchscreen
Voice commands	Google Now	Siri
Maps	Google Maps	Apple Maps
Video chat	Hangout	FaceTime
Available languages	32 languages	34 languages
App store	Google Play, Amazon, Samsung, . . .	Apple App Store

Table 2.1 *Comparison of Android and iOS*

As you can see, both platforms have lots of technologies, functions, and apps in common, such as apps for voice commands, maps, video chats, e-mail, a calendar, and much more. But if you look at the source model and

programming languages, you'll notice the main differences. Parts of the open-source Android operating system are written in C and C++. Android apps are written in Java. iOS is also written in C and C++ and is closed source. iOS apps are written in Objective-C or Swift. iOS uses the open-source Darwin operating system as a system basis, but the finished iOS version as we know it is closed source.

Another obvious difference between the two is the manufacturers. Apple produces iOS devices on its own, whereas Google gives other manufacturers the opportunity to build their own hardware devices based on the Android operating system. The manufacturers are able to extend the raw Android operating system and build a customized Android version tailored to the hardware.

Mobile testers need to know all about the tailoring of the different hardware manufacturers because the user interfaces on Android can differ a lot and therefore influence the behavior of an app. The fragmentation of Android devices and software versions is one of the main challenges that mobile testers need to handle. However, there is also a pure Android device available on the market as Google cooperates with some hardware manufacturers to build their Nexus devices.

Last, I want to point out the differences between the user interfaces. Both platforms provide touch interfaces that have lots of gestures in common such as swiping, tapping, pinch, and zoom, but each has its own UI and design patterns. For complete instructions check the Android design guide[10] and the iOS design guide.[11] With each new version of the operating system, check those guidelines again, because changes are likely. These patterns must be followed in order to publish an app. If your app doesn't follow the guidelines, it may well be rejected from the app store, which is more likely to happen in the Apple App Store than in the Android app stores. To get an overview of possible reasons why an app is rejected from an app store, look at the "Common App Rejections" page provided by Apple.[12]

10. https://developer.android.com/design/index.html

11. https://developer.apple.com/design/

12. https://developer.apple.com/app-store/review/rejections/

Another good reason to follow the design principles is to make customers happy because they know how to use the platform-specific features such as

swiping from left to right to switch views, or to pull down to refresh the current view.

When the device has booted, both platforms present a home screen to the user that is similar to a computer desktop. While the iOS home screen contains only rows of app icons spread over several home screens, Android gives the user the ability to customize the home screen with apps and widgets.[13] Widgets are able to display more information on the desktop, such as content from the e-mail app, Twitter, or the weather. Widgets can be resized and placed wherever the user wants to have them. Since iOS 8, users are able to place widgets in the iOS notification center as well.

13. https://developer.android.com/guide/topics/appwidgets/index.html

Both home screens have a dock section at the bottom of the screen to pin the most important apps that are available on every home screen. Also, both platforms have a status bar that is available at the top of the screen and displays device-relevant information such as the battery status, the network strength, the current time, and any notifications from installed apps. Again, on Android the status bar can display more information such as received e-mails, messages, phone calls, or reminders linked to installed apps.

If you're familiar with only one platform, you should buy or rent the unfamiliar one to learn everything about it. You will need to know as much as possible about the major platforms to succeed in the long run as a mobile tester.

What Types of Apps Exist?

If you unlock your phone to get to the home screen, you will see your installed apps. But which types of apps do you have installed? Are they native, hybrid, or Web-based applications? If you just look at the app icon, you probably can't tell. Maybe you can find out by tapping on an app icon to open it.

Let's try it out. Get your mobile device, unlock it, and open an app of your choice.

What do you see? Is a browser window shown, or is the app visible in full-screen mode? If you see a browser window, your app is a Web-based application.

But can you see the difference between a hybrid and a native app? That will depend on how well the hybrid app is developed and optimized for your phone.

In the following section I will describe the different mobile app types and list the pros and cons of each of them.

Native Apps

Native apps are programmed with a specific programming language for the specific mobile platform. For example, Android apps are developed in Java, whereas iOS apps are written in Objective-C or Swift. Native apps have full access to all platform-specific libraries and APIs in order to take advantage of all the features a modern smartphone has to offer. Assuming the user has granted the necessary permissions, the app has direct access to the camera, GPS, and all the other sensors. Developers are able to build apps that make use of system resources such as the GPU and CPU to build powerful apps. Native apps generally exhibit excellent performance and are optimized for mobile platforms. In most cases, native apps look and feel great and are able to support every possible gesture on the touchscreen.

App distribution is also quite simple as you can upload your native app to the app stores of the different vendors and start selling it. Some app store vendors have an approval process, meaning that it can take some time until your app is available. The same process applies when an already released app is updated, which can be a problem especially when you want to fix a really urgent bug in your app.

Pros:

- Native apps have full access to platform-specific hardware and software features.
- Native apps have good performance because they are optimized for the specific mobile platform.
- Native apps have a good look-and-feel.
- Native apps offer good usability if the platform UI guidelines are met.
- Native apps have full access to all touch gestures (if implemented).
- Native app distribution is easy. Users can search for your app.
- Native apps can store data offline.

Cons:

- The amount of development work increases with each supported platform because each platform needs its own code base.

- The approval process can be quite long.
- Updating a released app may take some time (which is annoying when it comes to urgent bug fixes).
- Development costs can be higher.
- You must share 30% of your app revenues with the platform provider.

Hybrid Apps

Hybrid apps, as the name suggests, are apps that consist of different Web technologies such as HTML or JavaScript. Once the Web part has been built, developers are able to compile this code base to the different native formats: Android, iOS, Windows Phone, or BlackBerry. To compile the Web code into native mobile code, developers need to use a hybrid development framework such as PhoneGap.[14] Such frameworks offer APIs to access the device-specific hardware features within the Web part of the app.

14. http://phonegap.com/

How does such a framework work?

> **Important**
>
> The description here is a very simplistic view of hybrid mobile frameworks.

The framework builds a so-called bridge to the Web code via an HTML rendering engine. A small part of the app runs on the native operating system and communicates with the Web code in the rendering engine via the bridge. With the aid of this bridge, the Web code can access some of the native hardware features.

The HTML content or components of hybrid apps can be hosted on a server. This approach makes it very easy to make small updates without updating the whole app through the app store submission process. Storing the information and elements on the server has one big drawback; however, the content and elements don't work when the phone is offline. These parts are available only if the device is connected to a data network. However, you can put all the content and elements into the app for full offline support, but then

small online updates are no longer possible. If your team is developing a hybrid app, keep those points in mind.

Pros:

- There is one code base for different mobile platforms.
- Frameworks offer access to hardware features.
- Small updates can be performed on the server.
- App distribution is easy.
- Users can search for your app.

Cons:

- Performance is bad when the content and components are accessed from the server.
- Meeting the design guidelines of the different mobile platforms is not easy.
- Platform-specific features can't be developed, because they may not be available on the other platforms.
- The approval process may be long.

A nice comparison of different mobile development frameworks can be found on the "Mobile Frameworks Comparison Chart" Web site.[15]

15. http://mobile-frameworks-comparison-chart.com/

Web Apps

A mobile Web app is a Web site that can be accessed from the device's Web browser. Such Web sites are optimized for mobile browser usage and are independent of the mobile platform. Mobile Web apps are developed with Web technologies such as HTML and JavaScript, particularly with HTML5,[16] CSS3, and JavaScript.[17]

16. http://dev.w3.org/html5/html-author/
17. www.w3.org/Style/CSS/

HTML5 offers developers the capability to implement mobile Web sites with animated and interactive elements. They can integrate audio or video files and use positioning features as well as some local storage functionality. The use of HTML5, CSS3, and JavaScript makes it easy to develop mobile Web apps. Furthermore, mobile Web apps require no app store approval and can be easily and quickly updated.

However, mobile Web apps have some drawbacks. For example, they offer only very limited to no access to the device hardware features such as proximity or acceleration sensors. Mobile Web apps have no access to the camera, compass, microphone, or any kind of notifications. They tend to be slower than native or hybrid apps because they need to download all the information that is shown on the screen.

Depending on the mobile browser, mobile Web apps can work and behave differently because not all mobile browsers support the full standards of HTML5, CSS3, and JavaScript. This can have a major influence on the mobile Web app, meaning that different mobile Web browsers need to be covered during the testing process.

To summarize, Web apps have the following advantages and disadvantages:

Pros:

- Popular technologies are used for development.
- Web apps are faster and cheaper to implement than native and hybrid apps.
- They are mobile platform independent.
- There is easy access to them via a Web browser (no installation required).
- No app store submission is required.
- The updating process is fast and easy.

Cons:

- There is limited access to hardware features.
- There is limited offline behavior.
- Large media files such as images or videos can take a long time to download.
- They have different Web browser support for the HTML5, CSS3, and JavaScript standards.
- They are not as convenient to use as native apps.
- There is limited usage of touch gestures.
- Users can’t find the app in the app stores.

Business Models of Mobile Apps

Where's the money in mobile apps? And how can you test to make sure money is being earned? These two questions are important when developing and testing an app. Nearly every app developer and company wants to make money from in-app purchases!

You therefore need to test the payment models to be sure that the mobile app is generating revenues, which in turn means that you need to be aware of current business models:

- Freemium
- Paid
- Transaction

Freemium

The freemium model is designed to reach as many users as possible.

Once the app is installed, there are several ways to generate revenues out of the free app:

- The most widely used approach is the free version of the app. The free version is limited, such as in terms of functionality or content. If a user wants to have full functionality, he or she can download the enhanced (paid) version of the app. This approach is the most widely used freemium app model.
- The second most used approach for generating revenues is selling advertisements within the app. There are different kinds of advertisement formats that can be added to an app in order to generate revenues. Advertisements are part of nearly every free app and can often be really annoying and frustrating for the user. Think very carefully before adding ads to an app as you run the risk of losing customers. Developers can implement ad frameworks such as AdMob[18] or iAd.[19]

18. www.google.com/ads/admob/

19. http://advertising.apple.com/

- The third approach for generating revenues is the "in-app purchase." This is often used within gaming apps where new levels or more tools can be bought to have more fun with the game. Lots of newspaper apps also offer in-app purchases to get the latest version of their daily news. Some apps can become ad free if the user pays for it.

Paid

The paid business model is quite simple: before users can download the app, they have to pay for it. This is a common use case for gaming apps or apps that fulfill a special task such as applying filters to images to make them look like Polaroids.

Transaction

In the transaction business model the user pays only after completing a transaction with the app. An example of a transactional app is Google Wallet, where users are able to send money to another account using their credit or debit card.[20] Once the transaction is complete, a small fee is paid that depends on the transaction amount.

20. www.google.com/wallet/

Choosing a Business Model

Research carried out by Gartner shows that freemium apps containing in-app purchases are downloaded the most (approximately 90%) from the app stores, whereas paid apps are downloaded far less frequently.[21] Developers therefore need to put some thought into their app's business model and price.

21. www.gartner.com/newsroom/id/2592315

When choosing a business model for your app, make sure you keep the different app types in mind. Not every model can be applied to every app type. For example, if you want to develop a paid mobile Web app, your app needs a login to identify the user's subscription so as to gain access to the paid content. The login function may not be necessary within a native or hybrid app because payment is made within the app store.

App Stores

App stores form the core of the mobile world where apps can be downloaded and reviewed. Without the app stores, smartphones wouldn't be as intelligent and functional as we want them to be. At the time of writing, the app stores of the biggest mobile platforms—Google[22] and Apple[23]—contain more than two million apps. So far more than 100 billion app downloads have been counted. These are huge numbers that are bound to increase in the future.

22. Google Play store, https://play.google.com/store

23. Apple App Store, https://itunes.apple.com/us/genre/ios/id36?mt=8

Besides the big two app stores from Apple and Google, there are other stores sponsored by device manufacturers and network operators. The following list is not complete but contains some other app stores for the different mobile platforms:

- Amazon
- AT&T
- China Mobile
- Mozilla
- Samsung
- T-Mobile
- Vodafone

But why are there so many different stores? Especially in the Android world there is more than one app store available, such as the Amazon[24] and Samsung[25] stores. The answer to this question is simple: every app store provider wants to make money out of the mobile app business!

24. www.amazon.com/mobile-apps/b?node=2350149011

25. http://apps.samsung.com/

Let's take the Samsung store as an example. Since the launch of its Galaxy device series, Samsung has grown to become one of the biggest and most successful Android device manufacturers and has sold and continues to sell millions of devices around the world. Having its own app store preinstalled on every Samsung phone is a huge advantage because it directs potential mobile app customers straight to Samsung and away from Google. If millions of users use this store, the store generates traffic, which means it can sell ads. On top of that, app sales via the app store allow Samsung to generate additional revenues. In most of the app stores, 30% of the sale price goes to the platform provider, and the same applies to in-app purchases.

I think this is indicative of why there are so many different mobile app stores. If you search the Internet, I'm sure you'll find even more of them.

The other mobile platforms also have app stores. BlackBerry apps can be downloaded from the official BlackBerry World,[26] and Windows Phone apps can be downloaded from the Microsoft Store.[27]

26. BlackBerry World, http://appworld.blackberry.com/webstore/?d=android&o=m&countrycode=US&lang=en

27. Microsoft Store, www.windowsphone.com/en-us/store

Before a mobile team distributes an app in the biggest stores, they should think about the goals of the app. Maybe there are other stores that are better suited to their app than the big players. For example, some stores offer a better revenue share than the usual 70% (developer revenues)/30% (store provider revenues) split, or they offer better app targeting, for example, in different markets such as Africa or Asia.

However, uploading an app to one of the stores requires one thing in particular—knowledge of the store's review and publishing process. Your app needs to fulfill the review and publishing guidelines of the various vendors and app stores; otherwise your app is very likely to be rejected.

Knowledge of the different review guidelines will allow you to better support your team while developing and releasing your app. The review and publishing guidelines of the major mobile app stores can be found on the following Web sites:

- Amazon Appstore Guidelines (https://developer.amazon.com/help/faq.html)
- Apple App Store Guidelines (https://developer.apple.com/app-store/review/)
- BlackBerry World Guidelines (http://developer.blackberry.com/blackberryworld/vp_checklist.html)
- Google Play store Guidelines (http://developer.android.com/distribute/googleplay/publish/preparing.html)
- Samsung App Store Guidelines (http://developer.samsung.com/distribute/app-submission-guide)
- Windows Phone Store Guidelines (http://msdn.microsoft.com/en-us/library/windows/apps/br230835.aspx)

Summary

Chapter 2 covered the evolution of mobile data networks and mobile devices. It is very important to know the differences among the data networks, their speed, and their technologies. This knowledge is required when testing a mobile app while you are on the move.

Besides the data networks, knowledge about mobile devices and their evolution is also very important. A mobile tester must know all the hardware

and software components of a modern smartphone in order to test mobile apps in various situations and with different hardware and software combinations.

In a later section of this chapter I explained the different app types that are currently available on the market. The differences among a native, hybrid, and Web app as well as their pros and cons should be clear by now.

The different business models for mobile apps were explained. The closing section of this chapter dealt with the different mobile app stores that are available for each platform and what is important to know about them.

Chapter 3. Challenges in Mobile Testing

In Chapter 1, "What's Special about Mobile Testing?" I described the unique aspects of mobile testing, covering user expectations, data networks, mobile devices, and mobile release cycles. But there are, of course, other topics that make mobile testing a special and challenging job.

This chapter contains more mobile testing challenges together with their possible solutions.

The Customer

As I mentioned in Chapter 1, customers and their expectations are one of the main challenges for mobile developers and testers.

To satisfy customers, it's really important that you gather information about your possible target customers and their needs. If you release an app without any kind of knowledge of your target group, the app will most likely not be installed or it will receive really bad reviews. This leads to fewer downloads, and customers may even download an app from your competitor.

In order to handle the customer challenge, you need to gather as much information about your potential users as possible. This, in turn, means that you need to incorporate the specifics of your target group, such as age, gender, and geographical background, during the development and testing process. You need information such as the following:

- Gender
- Age
- Monthly income (important for possible app business models)
- Educational background
- Geographical background (e.g., do they live in a city?)
- What apps they use and what kind
- Smartphone habits (how often they check their smartphone)
- Whether they use a competitor's apps and if so, how, and are they happy with them
- What devices they use

Important

Be careful when asking people personal questions as you could end up infringing upon privacy laws.

Another way of getting information about your target group is to conduct interviews: invite your customers to your office and ask them about their mobile usage and habits. If you encounter problems getting the answers to all of these questions or are not allowed to ask your potential customers directly, you can use services such as Mobile Personas[1] to get general information about the behavior of mobile users.

1. www.mobilepersonas.com/

If you gather, analyze, and group that kind of information, you will most likely have more than one type of person the app will be made for. To satisfy the different types of customers, it is helpful to create so-called personas[2] to represent their various needs. Personas were introduced by Alan Cooper[3] in 1998 in his book *The Inmates Are Running the Asylum*.

2. www.usability.gov/how-to-and-tools/methods/personas.html

3. www.cooper.com/journal/2008/05/the_origin_of_personas

Personas are fictional characters that are representative of your real customers. Personas are a common and very useful way to identify user motivations, expectations, problems, habits, and goals.

Personas can help you to make decisions about your app, such as feature set, possible gestures, and design. Personas can help a mobile team get a feel for their customers' needs and problems. You as a mobile tester can align your daily workflow to the persona description. Table 3.1 presents an example of a typical persona.

Information	Profile
Name	Martin
Gender	Male
Age	28
Monthly income	$3,000
Educational background	Master's degree in computer science
Location	Greater New York area
Uses the following apps	Twitter, Facebook, LinkedIn, Feedly, Spotify, Tumblr
Checks his smartphone . . . times a day	150
Devices owned	LG Google Nexus 5, iPad mini
Personal traits	Friendly, smart, polite, likes to meet friends

Table 3.1 *Possible Persona Description*

You can also write a persona description, such as this one:

> Martin is a 28-year-old tech-savvy male with a master's degree in computer science. He lives in New York and is a frequent smartphone user who checks his smartphone around 150 times a day. Martin uses apps like Twitter, Facebook, Spotify, and Tumblr. His monthly income is about $3,000. Martin is a friendly, smart, and polite person who likes to meet friends.

With the aid of personas and knowledge of their habits, it's a bit easier to test a mobile app as the testing process is more focused on customer needs than on the tester's expectations or habits.

Personas are a good way to handle the customer challenge when it comes to mobile testing. Once the personas are in place, the mobile team should try to find real customers who match the personas. Once you've found some customers, talk to them and ask them questions about your app and discuss possible additional features. Invite users to a usability testing session in your office. This way the users feel connected with the company and your app. Another way of getting user feedback or engagement is a beta testing phase. This is a common approach; some big mobile app vendors[4] invite customers

to test beta versions of new apps to collect feedback at an early development stage so they can improve the app before going live.

4. www.sonos.com/beta/screen/

Other valuable sources of information about your customers are the app stores of the different vendors and the ratings for and comments about your app. Read the comments carefully and learn from them. Of course, there may be lots of comments that don't deliver any useful insights. However, there are users who complain about usability, bugs, or problems you have never heard of, and those comments are extremely useful for you and your team. More information about app store reviews, ratings, and comments can be found in Chapter 7, "Mobile Test and Launch Strategies."

Customer Summary

Do the following in order to maximize the chances that you will satisfy your customers:

- Gather user information.
- Create personas.
- Use personas while testing.
- Invite customers to usability tests.
- Interview customers about your product.
- Invite customers to be beta testers.
- Check the app store reviews and learn from the useful comments.

Mobile Platforms and Fragmentation

In the previous chapters I explained the different mobile vendors and mobile platforms, so you now know what's inside a mobile device. You also know that for some mobile platforms there is more than one mobile device manufacturer.

Fragmentation is a huge problem in the mobile world and especially in the Android world. Based on the numbers from OpenSignal,[5] nearly 19,000 Android devices are available on the market. It's simply not possible and, as you will see, not necessary to test on all of those devices. This problem isn't just limited to Android; other mobile platforms such as iOS, Windows Phone, and BlackBerry are also affected by fragmentation. The possible hardware and software combinations on those platforms can also be a problem.

5. http://opensignal.com/reports/2014/android-fragmentation/

The next several sections of this chapter present some solutions for handling fragmentation while testing.

Mobile Device Groups

One solution for handling device fragmentation in your mobile testing project is to group your mobile test devices. If the devices are grouped, you can test on only some devices (one to three) from each group, which helps you downsize the amount of testing work. I've adopted this approach in all of my mobile proj-ects and it has proven very efficient. Based on your target customer group, you can create three device groups (this example assumes that the target group is really tech savvy).

The first group has the highest priority: A. Devices in this group are most likely to be new devices with powerful hardware and a big screen with a high resolution and pixel density. They also usually have the latest operating system version installed. Devices in this group must be fully supported by your app in terms of functionality, design, and usability.

- **Group 1, Priority A:**
  - High-end devices
  - Dual/quad-core CPU
  - RAM >=2,048MB
  - Display size >=5″
  - Retina, full HD display
  - Latest operating system that is available for the device

The second group has medium priority: B. Devices in this group are midrange devices with average hardware such as a smaller CPU, screen resolution, and size than the devices in group A. The operating system version is probably less than one year old. The devices in this group should fully support the app in terms of functionality and usability. The design doesn't need to be perfect for this group due to the smaller screens.

- **Group 2, Priority B:**
  - Midrange devices
  - Dual-core CPU
  - RAM <2,048MB

- Display size <5″
- No Retina or full HD display
- Software less than one year old

The third group has low priority: C. Devices in this group have a small CPU and a small screen resolution and density. The software version is more than one year old. Devices in this group still have to fully support the app in terms of functionality, but the design and usability may differ from the other groups because the hardware may be too slow to provide sufficient responsiveness.

- **Group 3, Priority C:**
  - Slow devices
  - Single-core CPU
  - RAM <1,024MB
  - Display size <4″
  - Low screen resolution
  - Operating system more than one year old

Once you have defined device groups, you need to make sure you keep them current by monitoring the mobile device market for new devices that match your target groups. On the other hand, you can remove older devices from your device groups if your customers don't use them anymore. And last but not least, you need to check your group criteria from time to time to make sure they still sufficiently cover your customer spectrum.

With the aid of such device groups, you'll find it much easier to handle device fragmentation and have the right devices for testing.

A nice Web page provided by Google is "Our Mobile Planet,"[6] where you can get information based on the country, the age, the gender, and the behavior of users. Such information can be used when the target customer is unknown.

6. http://think.withgoogle.com/mobileplanet/en/

Important

Device groups may vary greatly from project to project!

Mobile Device Labs

Depending on the mobile app project, you may need lots of devices for testing, which is of course very expensive and time-consuming. A good alternative to buying all of your testing devices is to rent them.

You can use mobile device labs or device clouds to rent the testing devices you need. However, before you rent test devices, keep the device grouping in mind to downsize the amount of testing required for all those virtual and physical devices.

Currently there are plenty of mobile device lab providers that offer mobile test devices within the cloud. Mobile developers and testers are able to upload the app file to the cloud, select the devices, and start manual or automated testing.

The main advantage of such services is that you don't have to worry about buying new devices and maintaining them. However, before choosing a mobile cloud provider, you should check whether the provider offers testing on real devices, simulators, or emulators.

A mobile cloud testing provider should:

- Test on real devices
- Be able to use emulators or simulators as well
- Not use jailbroken or rooted devices
- Be able to test on different mobile platforms if possible
- Be able to write test automation scripts in different programming languages
- Offer continuous integration
- Have some performance monitoring in place
- Generate a test report at the end of the test cycle

Testing your mobile app in the cloud on emulators or simulators can be very annoying due to performance issues. Using emulators or simulators on a local machine is often already fairly slow; using them on the Internet via a Web GUI can be even slower.

Even if the provider offers testing on real devices, it's still possible that the performance may not be the same as when testing on a local physical device. The latency may be too high, which can lead to very slow reactions on the

device. Scrolling, tapping, or just loading the app can take a long time, which may have a big impact on your testing and the subsequent results.

Another thing to look out for when choosing a cloud provider is to make sure you have exclusive access to the physical devices and that your app is deleted once the test session is complete. Check that the provider offers a private test cloud; otherwise your app may still be installed on the test devices for subsequent customers to see. Discovering such an issue while evaluating a provider is a clear warning sign that should not be ignored. If security and privacy are important to you, consider picking another provider.

The following providers offer a mobile device test cloud:

- AppThwack (https://appthwack.com/)
- CloudMonkey LabManager (www.cloudmonkeymobile.com/labmanager)
- Keynote Mobile Testing (www.keynotedeviceanywhere.com/)
- Mobile Labs (http://mobilelabsinc.com/)
- Perfecto Mobile (www.perfectomobile.com/)
- Sauce Labs (https://saucelabs.com/)
- Testmunk (www.testmunk.com/)
- TestObject (http://testobject.com/)
- TouchTest (www.soasta.com/products/touchtest/)
- Xamarin Test Cloud (http://xamarin.com/test-cloud)

Important

This list is by no means complete. Just browse the Internet to search for more providers that fit in your environment.

If you don't want to buy every testing device for your company or don't want to use a cloud provider (or maybe you're not allowed to use one), there is another way of getting physical mobile devices: ODLs, or Open Device Labs.

Open Device Labs were introduced by the mobile community with the aim of establishing physical stores where mobile testers, developers, and anyone involved in the mobile business can obtain devices for testing purposes. The primary goal of these Open Device Labs is that everyone can borrow devices

for free! In order to make this idea successful, Open Device Labs need device donations from individuals or companies who want to support the mobile community. Depending on your geographical region, you might have an Open Device Lab nearby. The Web site[7] provides a nice map that shows you where your nearest Open Device Lab is located. You should definitely try them!

7. http://opendevicelab.com/

Chapter 7 includes mobile test labs and Open Device Labs as part of the mobile testing strategy and also provides further information on this topic.

In this part of the chapter you have learned that there are three possible solutions to the problem of how to handle mobile fragmentation:

- Grouping the devices you need for testing
- Mobile device labs in the cloud
- Using physical devices from an Open Device Lab

Sensors and Interfaces

Every smartphone has a variety of sensors and interfaces that can be accessed by the installed apps to provide useful features to users. The actual sensors and interfaces used depend on the app's specific use case. The installed sensors and interfaces are really complex and are potentially susceptible to electrical interference.

As a mobile tester it's your responsibility to ensure that the implemented sensors and interfaces are used correctly. It's also important to verify that failing sensors don't affect the app in a negative way.

Ambient Light Sensor

The ambient light sensor is able to determine how much light is available in the current location and automatically adjust the screen's brightness by means of software in order to prolong the device's battery life.

If your app makes use of the ambient light sensor in any way, you should test your app in different locations with different prevailing light situations. For example, test your app in a dark room, outside in the sunshine, or at your workplace to see if the app responds correctly. Be creative with your testing environments.

Different locations could include:

- A dark room

- Your workplace with a desk lamp on
- Outside in the sunshine
- Rooms with different lights on the ceiling

Proximity Sensor

Another little helper is the proximity sensor, which determines how close the phone is located, such as to a face or surface. It can be used to automatically turn off the display without any physical contact. This prevents you from accidentally clicking or touching buttons on an active screen. It's also useful for saving battery life.

Make sure you also test the usage of the proximity sensor in different locations with different light situations as well as with different kinds of surfaces to see whether the app is using the sensor correctly.

Different locations and surfaces could include the following:

- A dark room
- Your workplace with a desk lamp on
- Outside in the sunshine
- Your hand moving over the display
- Your hand close to the display
- The device moving toward your face
- The device's display moving toward a mirror or pane of glass

Acceleration Sensor

The acceleration sensor detects changes in the device's movement. The most common use case for this sensor is when the device is rotated between portrait and landscape modes. This sensor is used in nearly every app if the developers implemented a portrait and landscape view. If both modes are supported, you should change the orientation of the device a lot during testing. By doing so, you will probably find lots of UI glitches because the UI elements could be moved to a different position. It is also likely that the app will crash, for example, when data is fetched from the backend while a UI refresh is being performed.

Gyroscope Sensor

The gyroscope sensor is used to either measure or maintain the orientation of the device. Unlike an accelerometer, which measures the linear acceleration of a device, a gyroscope measures the device's exact orientation. This means that the device is able to detect 360-degree motion. Thanks to the accelerometer and gyroscope sensors, the device is able to operate on six axes—left and right, up and down, forward and backward—and track roll, yaw, and pitch rotations.

The combination of both sensors is mostly used in gaming apps such as flight simulations to control a plane with real physical movements. Keep the six axes in mind when testing your app, and test each axis separately as well as multiple axes at once to be sure the app is responding correctly.

Magnetic Sensor

A magnetic sensor is able to measure the strength and orientation of magnetic fields around the device. This sensor is mostly used by apps that require compass information, such as for navigation. With the aid of this sensor the device is able to determine the direction in which it's facing: west, east, north, or south.

If your app uses the magnetic sensor, you should also test it in different locations. For example, if you're using the app in a building where you're surrounded by lots of metal, the magnetic sensor may deliver false information or data, which can lead to adverse side effects in your app.

Different locations could include the following:

- Inside a building
- Outside on the street
- When stuck in traffic
- Near buildings with lots of metal

Pressure, Temperature, and Humidity Sensors

These three sensors are not included in every smartphone yet, but they will be soon. All three sensors can be used to collect more data about the user's current location to provide apps with useful information such as the current temperature, current altitude based on atmospheric pressure, and humidity.

These sensors are used, for example, by outdoor or weather apps. Again, make sure you test these sensors in different locations with different temperatures, pressures, altitudes, and humidities. You can, of course, simulate pressure or humidity in a test lab situation to check that the sensors are working correctly, but testing them in real situations could produce side effects that aren't likely to happen in a lab.

Location Sensor

You certainly know the location sensor, better known as GPS. Thanks to GPS, apps can determine the current device location. GPS is used in lots of different kinds of apps such as map apps, camera apps, and social media apps. Users can share their current location with apps and send their current position, for example, to friends to let them know where they are.

If your app uses GPS to determine the device's current position, be sure that the GPS sensor is switched off after use. Otherwise the device's battery will be empty very soon.

GPS functionality should of course be tested in various locations, such as in the countryside or in downtown sprawl with lots of huge buildings. In both scenarios you may find that the current location is incorrect or not found by the GPS sensor. This is especially true in cities due to interference caused by surrounding buildings. If the GPS signal is not strong enough to determine the current location, check that the Wi-Fi or network-based location finding feature of the phone is activated to locate the phone. A low GPS signal can also cause performance problems within your app due to difficulties in calculating the current position. When testing the GPS function of your app, keep an eye on the temperature of your device. Using GPS will heat up your device, consume lots of battery, and therefore possibly influence the performance of your app. I also recommend that you turn GPS off to see how your app reacts to this scenario.

Touchless Sensor

Another sensor that is not built into every smartphone is a touchless sensor. In most cases this sensor is built into the front of the device to accept touchless gestures from a finger or a hand. What this means is that you can swipe between photos in your photo gallery simply by waving your hand over the screen. Or you can answer a phone call by holding the device next to your ear without touching the answer button.

If your app supports touchless gestures, be sure every gesture also works at different angles.

Sensors Summary

Most of the sensors just described are influenced by the user's current location and surroundings. Any kind of movement is very important while testing your app and the device's sensors. It's also useful to test the sensors in combination with one another to check that your app responds correctly to changes of sensor data.

Possible sensor tests could include the following:

- Walk while using the app as this simulates back-and-forth motion.
- While walking, suddenly stop for a few moments before continuing on your way.
- Shake and rotate the device.
- Simulate vibrations as if you're on a train or in a car.
- Perform extreme movements such as spinning or rotating the device.
- Use the app outdoors in sunny, cloudy, and dark locations.
- Use the app indoors with normal light or under a lamp.
- Wave your hands in front of the device.
- Test the edge cases, for example: GPS coordinates 0,0; temperature at 0 degrees; waterproof devices in areas with high humidity.
- Check to see if the app can be used on devices that don't have built-in sensors and interfaces.

While performing these tasks, watch out for app crashes or freezes. Check that the UI elements are visible and displayed correctly on the screen, especially in different light situations. Keep an eye on the performance of the app and the smartphone's battery lifetime as well.

Touchscreen

The biggest and most important interface in smartphones is the touchscreen. Thanks to the touch-sensitive screen, users can use one or more fingers on the device to create gestures that the phone is able to convert into commands.

> **Important**
>
> The description of touchscreen technologies here is simplified. If you want to get more detailed information about them, please do some online research.

There are basically two kinds of touchscreen technologies available. The first is the resistive screen that is made out of various layers and reacts to pressure. Usually this kind of touchscreen is made for use with a stylus. Whenever you have to sign for a parcel delivery, you probably sign on a resistive screen. This technology has one big drawback: it doesn't support multitouch gestures.

That is the reason why the second technology, capacitive touchscreens, is used in smartphones. Capacitive screens react to touch rather than pressure and support multitouch gestures.

Capacitive screens consist of an insulator, which in most cases is glass coated with a transparent conductor like indium tin oxide. Since the human body is also an electrical conductor, touching the capacitive screen results in a distortion of the screen's electrostatic field. This distortion is then converted into data that the device hardware is able to understand.

The following gestures are possible on a capacitive touchscreen:

- **Touch:** Touch the screen with a fingertip.
- **Long touch:** Touch the screen for a longer time.
- **Swipe:** Move your fingertip over the screen.
- **Tap:** Briefly touch the screen with a finger.
- **Double tap:** Briefly touch the screen with a fingertip twice.
- **Drag:** Move a finger over the screen without losing contact with the screen.
- **Multitouch:** Use two or more fingers on the screen at the same time.
- **Pinch open:** Touch the screen with two fingers and move them apart.

- **Pinch close:** Touch the screen with two fingers and bring them closer together.
- **Rotate:** Use two fingers on the screen and rotate them. Some apps, such as map apps, will rotate the content in the app.

The variety of possible touch gestures poses a special challenge while testing a mobile app. You should keep all the possible touch gestures in mind and use them while testing. A good way to see if an app can stand up to touch gestures is to use multiple fingers on the touchscreen at the same time. You should also perform several different touch gestures very quickly on the screen to see how the app reacts and handles the inputs. Also watch out for performance issues or UI glitches that can happen while using multitouch gestures.

One important factor to note about touchscreens is the current weather conditions. They can affect your fingers and prevent touches from being registered properly. Therefore, it's a good idea to also use the different gestures in different weather conditions such as on cold or hot days or on a day with high or low humidity to see how the app reacts to your gestures on the touchscreen.

Microphones

Another way of communicating with your app is by using your voice or sound. Most smartphones have more than one microphone installed. Usually there are up to three microphones, one at the front, one at the back (near the camera), and one at the bottom of the device. The three microphones ensure very good voice recording from all possible angles and regardless of the phone's position.

When testing sound inputs via the microphone, make sure you do the following:

- Test voice input indoors with normal sound and in noisy situations.
- Test the app indoors with more background noise such as in an office or restaurant.
- Test the app outdoors with background noises coming from a street or cars.
- Check that the app can handle the user muting and unmuting the phone or the microphone.

- Start other apps that generate sounds, such as music apps, and check the behavior of your app.
- Use the volume up and down buttons to increase or decrease the sound level and check the behavior of the app.
- Check that voice inputs are processed correctly.
- If the voice input is stored on the phone, check that playback is working properly.
- Test the voice input in a real-life environment (the purpose of the app).

While testing the sound inputs in all the different surroundings, watch out for input delays or distortion in the recording or playback mode. Keep an eye on the performance of the app and the phone to see if the device freezes or crashes due to a lack of hardware resources (especially when saving the inputs). And don't forget to check the digital rights management (DRM) when working with voice or sound inputs.

Camera

A typical smartphone has at least one camera, usually located at the back of the smartphone. However, most of today's smartphones already have two cameras: a rear-facing and a front-facing camera. The rear camera is used to take high-resolution pictures, and the front camera is mostly used for video chatting with a lower resolution. Also, most of the rear-facing cameras have a flash included.

Cameras are used in a variety of mobile apps for taking pictures or videos. Some apps use the camera as a scanner to capture information using OCR (optical character recognition) or other kinds of shapes. Good examples of this include QR (Quick Response) codes, scanning apps, or apps that scan business cards to transform them into digital contacts in your phone. Some apps just use the LED flash to act as a flashlight.

If your app uses the camera, test it with a variety of mobile devices that match your target customer group. Every smartphone has a unique camera with a unique lens, flash, and resolution. The different resolutions of the camera have an impact on the image size. The higher the resolution, the bigger the pictures are. Be sure to test the camera function with different resolutions and camera types in order to see if the app is able to process both small and large images.

Besides that, you should check the performance of the app while the camera mode is activated. The camera takes up a lot of the device's hardware resources, which can have an adverse impact on the app and cause it to crash or freeze. Heavy camera use can heat up the camera sensor and can cause hardware damage, so be sure that this is not possible within your app. Finally, don't forget to test that the app can use an image stabilizer to prevent the camera from taking blurry pictures. The same applies to video capturing within your app.

System Apps

Most preinstalled apps from device manufacturers are system apps. There are often preinstalled apps such as a contact app, a phone app, a calendar app, and the like. However, on most of the mobile platforms users are able to install apps that replace the system apps. The main reasons users do this is bad usability or the lack of functionality on the part of the system apps. If you check the app stores of the different vendors for calendar apps, for instance, you'll find plenty of apps with far more features than the preinstalled ones.

A really interesting example of this is keyboard apps on smartphones. Such apps are likely to have an impact on your app. On Android phones and tablets (and, since iOS 8, also on iOS devices), users are able to replace the preinstalled keyboard app with special keyboards that offer a totally different way of typing and keyboard layouts. There are conventional tap keyboards (like QWERTY), keyboards with different layouts (multiple symbols per key), keyboards with tap-slider functions, and keyboards that offer a swiping method to insert text.

Changing the keyboard can have an influence on your app. For example, the keyboard may be much taller than the standard one and therefore hide UI elements that are important to interact with, or the screen might not recognize that it needs to scroll. You may come across important keys that are missing from the keyboard, thus possibly rendering your app unusable in some cases. It is also possible for settings to get lost within your phone, and your app might cause freezes or crashes.

This is just one example of how replaced system apps can have an impact on your app. If your app interacts with one of the preinstalled system apps, keep in mind that users are able to replace them with other apps. You need to

have an overview of popular apps that replace system apps in order to test their integration and interaction with your app.

Internationalization (I18n) and Localization (L10n)

Another challenge that needs to be handled during the mobile development process is the internationalization (I18n) and localization (L10n) of mobile apps. I18n is the process of designing software applications in such a way that they can be adapted to various languages and geographical regions throughout the world, without changing the code base and while the software is running (some apps and some mobile platforms require a restart).

L10n is the process of adapting the internationalized software to a specific language or region by adding locale-specific elements or translating the text.

It's really important to test both I18n and L10n if your app is designed to be used in different countries. You must be sure that the different languages will not break your UI elements or have an influence on the app's usability.

> **Important**
>
> Many languages have their own character set, and one word can have a very different width and height.

Have a look at the example word *logout*. If you compare the word with translations from Germany, France, Turkey, and Russia, you will see lots of difference in characters, width, and height:

- Logout (English)
- Ausloggen (German)
- Déconnexion (French)
- Çıkış yap (Turkish)
- (Russian)

Both the German word *Ausloggen* and the French word *Déconnexion* are much longer than *Logout*. The Turkish version even consists of two words. As a sample, Asian languages can be used as "short" languages, while German and Portuguese are considered "long" languages. All translations can lead to a UI glitch or even break your design rules. When testing an app in different languages, check that every text translation will fit into the UI elements and

that every screen has the same look-and-feel. Also check that the different characters and font types can be stored in the local database.

The same applies to date formats that are used within apps. Depending on the country or region in question, different date formats are also used. You need to check that the correct format is shown depending on the region settings of the phone. You should also test the parsing from one date format to another.

The following date formats are commonly used:

- DD/MM/YYYY (Day/Month/Year)
- DD.MM.YYYY
- DD-MM-YYYY
- MM/DD/YYYY (Month/Day/Year)
- MM.DD.YYYY
- MM-DD-YYYY
- YYYY/MM/DD (Year/Month/Day)
- YYYY.MM.DD
- YYYY-MM-DD

If your app is going to be used in different countries or regions in the world, make sure you add the important languages based on your target customer group in order to provide a good user experience. When testing the app, you need to check it in every language. You also need to check that the language switch is working to be sure that only a single language is shown depending on the device's language settings. Also check the fallback language of your app. To test this, change the device language to one that is not supported and check that the app uses the implemented fallback language. Languages and date formats should never be mixed up within the app. If you want to test if the used language is correct, you should ask a native speaker in order to avoid using misleading translations or text that is simply wrong.

Important

The different languages and date formats must be considered during the design phase of the app so that designers can plan the look-and-feel of the app in all of the provided languages. Late changes due to translation issues can delay the release date of the app or negatively affect the app's design.

Mobile Browsers

If you're testing a mobile Web app, you will of course need to do so in a mobile Web browser. Mobile Web browsers are optimized to display Web content such that they can be accessed on smaller screens. Unfortunately, there is more than one mobile Web browser available in different versions of the different mobile platforms. Besides that, the browsers use different layout engines such as the following:

- Blink (www.chromium.org/blink)
- Gecko (https://developer.mozilla.org/en-US/docs/Mozilla/Gecko)
- Presto (www.opera.com/docs/specs/)
- Trident (http://msdn.microsoft.com/en-us/library/aa741312(v=vs.85).aspx)
- WebKit (www.webkit.org/)

Depending on the layout engine, browser settings, and browser version, mobile Web apps may look and behave very differently. This is especially the case for the different browser layout engines. Every browser layout engine handles standards like HTML, CSS, and JavaScript differently. Not every browser has implemented the complete feature set or the latest version of the various languages (HTML, CSS, JavaScript), which can lead to differences in behavior.

To be sure that your mobile Web app works on different browsers, test it on different mobile platforms such as Android, iOS, Windows Phone, or BlackBerry together with different browser versions. This is of course the same problem native apps have: fragmentation. However, testing mobile Web apps can be more difficult because now you have another variable added to your testing matrix: the different Web browsers. This means that you have to focus on the different browser versions, mobile platforms, and operating system versions.

The mobile Web browsers listed in Table 3.2 are available for the different mobile platforms. To see which browser layout engine is used by which browser version, check the browser vendor Web sites.

Browser	Creator	Layout Engine	Available for
Chrome (www.google.com/intl/en/chrome/browser/mobile/)	Google	WebKit (iOS), Blink	Android, iOS
Safari (https://developer.apple.com/safari/)	Apple	WebKit	iOS
Internet Explorer Mobile (http://windows.microsoft.com/en-us/internet-explorer/browser-ie#touchweb=touchvidtab1)	Microsoft	Trident	Windows Phone
BlackBerry (http://us.blackberry.com/devices/features/getting-started.html)	Research in Motion	WebKit	BlackBerry
Android Browser	Different	WebKit	Android
Dolphin Browser (http://dolphin.com/)	MoboTap	WebKit	Android, iOS
Firefox Mobile (www.mozilla.org/en-US/firefox/android/)	Mozilla	Gecko	Android
Opera Mobile (www.opera.com/mobile)	Opera Software	Presto, Blink	Android, iOS

Table 3.2 *Overview of Mobile Browsers*

Important

Not every browser is available on every platform. Table 3.2 shows the most used mobile Web browsers.[8] The table is not complete.

8. http://akamai.me/1EQZbP0

As you can see, testing a mobile Web app on different mobile browsers can also be a real challenge. To keep the amount of testing work needed for mobile Web browsers to a minimum, you should create mobile browser

groups or add mobile browser requirements to the device groups. If you create browser groups, prioritize them based on your target customer group and only test your Web app within these groups.

Summary

Chapter 3 was one of the first hands-on chapters of this book. You are now able to create your own personas based on the information about your target customer group and the usage of your app. Those personas will help you to focus your development and testing efforts on your target group and not waste time on unnecessary features.

In addition to personas, you now know how to handle device fragmentation in the mobile world. Testing your app on every mobile device is not possible or economical. Based on your target group, you can define so-called mobile device groups to test only on the devices within each group. This will help you to downsize the testing effort dramatically. Another approach to handling device fragmentation is to use mobile device labs.

As you know, mobile devices are packed with lots of sensors and interfaces, and if your app uses them, you need to test them as well. Testing the different sensors and interfaces was another big topic in this chapter. For each sensor and interface, testing ideas were provided.

When your app is available in different countries and supports different languages, the section "Internationalization (I18n) and Localization (L10n)" should help you remember to test your app against those languages and settings related to locations from around the world.

The chapter closed with an overview of the different mobile browsers that are currently available on the market.

Chapter 4. How to Test Mobile Apps

In the previous three chapters you learned a lot about the mobile app world, ranging from the different network types, app types, business models, app stores, customer expectations, and challenges for mobile testers to device-specific hardware elements. In this chapter you will learn how to test mobile apps. This is a hands-on chapter, and I suggest that you have at least one device with an app of your choice next to you while reading it.

Use your newly acquired knowledge to test the app and see if you can find bugs or other discrepancies.

Emulator, Simulator, or Real Device?

Before you start to test an app, there's one important question to answer: Are you going to test it on a real device, in a simulator, or in an emulator?

Mobile device emulators, such as the Android Emulator,[1] are desktop applications that translate the instructions of the compiled app source code so that the app can be executed on a desktop computer. The emulator acts exactly like the mobile device hardware and operating system, thus allowing the developer and tester to debug or test the application. Since the app is executed on a computer, not all of the mobile-specific hardware elements such as the sensors or touch gestures can be emulated. However, emulators can be very useful at an early stage of the development process in order to obtain quick feedback about the implemented features.

1. http://developer.android.com/tools/help/emulator.html

Simulators, such as the iOS simulator,[2] are less complex software applications that simulate a small subset of the device's behavior and hardware. In contrast to emulators, simulators are only similar to the target platform and simulate the real device's hardware, making them much faster than emulators. It is also not possible to test device-specific hardware elements with simulators. However, simulators are useful at an early stage of the development process in order to obtain feedback about the implemented features.

2. https://developer.apple.com/library/ios/documentation/IDEs/Conceptual/iOS_Simulator_Guide/Introduction/Introduction.html

The biggest difference between a simulator and an emulator is that a simulator attempts to duplicate the behavior of the mobile device, while an emulator tries to duplicate the entire inner architecture of the mobile device and is therefore closer to the target platform. Depending on the mobile platform, vendors provide either a simulator or an emulator. Apple and BlackBerry (Research in Motion) offer a simulator; Google and Microsoft provide an emulator.

As you have learned in the previous chapters, mobile testing requires movement and different hardware, meaning that you need to test your app on physical devices to be sure that everything works together in real-life situations.

Emulators and simulators should be used only for very basic tests such as simple functionality (is the button clickable?) or to make sure the look-and-feel of the app is OK.

Manual Testing versus Automated Testing

There's another important decision to make: Are you going to test the app purely with automated tests, purely with manual tests, or with a combination of both? This decision depends on your app.

Simply performing test automation will not work and is not sufficient for several reasons. Not every mobile-device-specific function can be automated —for example, location data—and other environmental sensor data is really hard to test in a lab situation. Because of these limitations, your app will most likely contain lots of bugs and problems that your customers will find.

Only performing manual testing can work, but it's also not sufficient. You should perform only manual tests of your app if it meets the following criteria:

- Your app is very simple and basic.
- Your app has only very limited functionality.
- Your app is available for only a limited time in the app stores.

In all other cases you should combine manual and automated testing. Before performing test automation, you should always do manual testing. Every new feature must be manually tested systematically on different devices. Once you've completed manual testing, you can then define the parts of the app that require test automation.

In Chapter 5, "Mobile Test Automation and Tools," I describe the different mobile test automation concepts, explain how to select a mobile test automation tool, and provide you with an overview of possible tools.

"Traditional" Testing

Mobile applications are software applications. Besides testing the mobile-specific functions and elements, it is still necessary to test mobile apps in the same way you test Web or desktop applications. You still need to design the test cases, manage the test data, and of course run the tests.

If you look at Figure 4.1, you can see the typical actions/steps that should be taken during the software quality assurance process. There are two types of software quality assurance measures: product focus and process focus. The product focus phase is used to find bugs, whereas the process focus phase aims to protect the software from bugs.

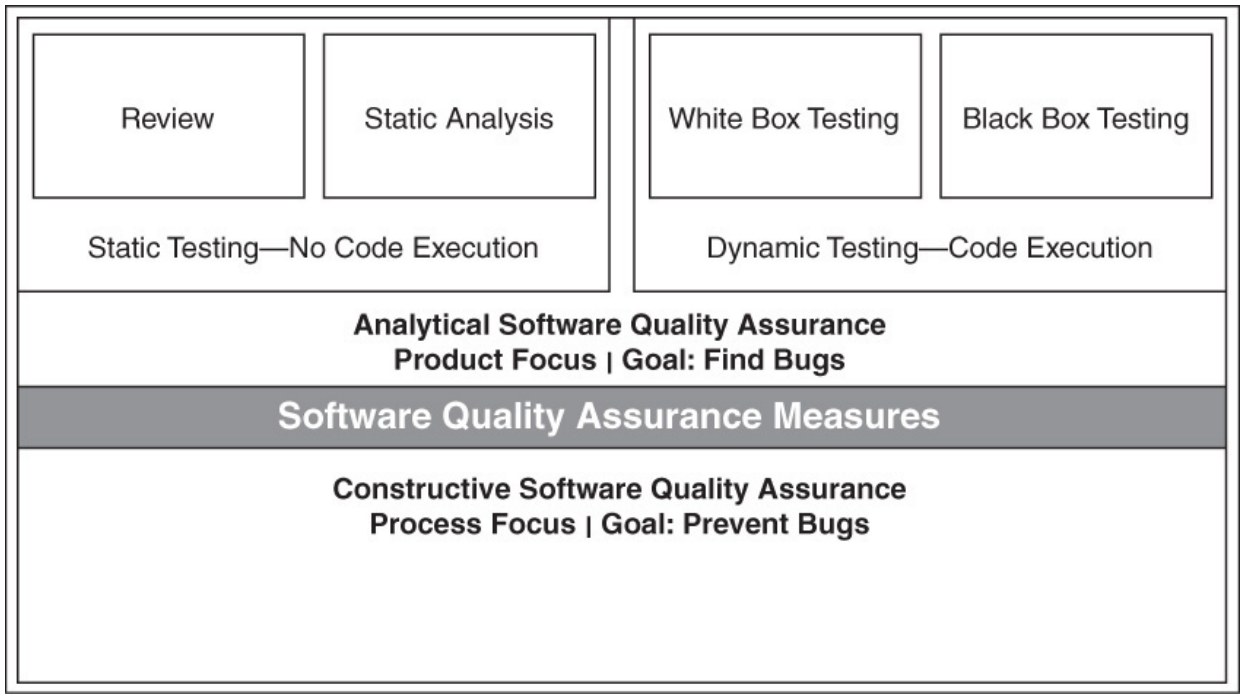

Figure 4.1 *Software quality assurance measures*

The process focus phase of software quality assurance covers the methods, languages, tools, guidelines, standards, and processes with which the software is developed. In this phase, software testers are responsible for making sure, for example, that the guidelines, development methods, and tools as well as the standards are met during the whole development process. They

should guide and help developers and other team members in fulfilling the defined processes in order to prevent any bugs from arising.

The product focus phase is divided into static testing and dynamic testing.

In static testing, the software is not executed. Testers and developers should perform reviews during this stage of the software development process, either code reviews before committing the code to a repository or reviewing the documents and specifications before development starts. During the static phase, the application code will be checked with tools to see if it matches coding guidelines or contains any memory leaks or race conditions.

The following list contains some Java static analysis tools:

- Checkstyle (http://checkstyle.sourceforge.net/)
- FindBugs (http://findbugs.sourceforge.net/)
- Lint (http://tools.android.com/recent/lint)
- PMD (http://pmd.sourceforge.net/)

> **Important**
>
> There are static analysis tools available for nearly every programming language, just have a look for them on the Internet.

In dynamic testing, the application code is executed to see how the application behaves while being run. Dynamic testing is again split into two types: white box testing and black box testing.

White box testing is a way of testing software with knowledge of the internal structure of methods and classes. White box testing is usually done by developers who test their code on a unit level, in most cases using tools such as JUnit,[3] TestNG,[4] XCTest,[5] or similar unit testing tools.

3. http://junit.org/
4. http://testng.org/doc/index.html
5. https://developer.apple.com/library/prerelease/ios/documentation/DeveloperTools/Conceptual/testing_with_xcode/Introduction/Introduction.html

White box testing techniques include the following:

- Statement coverage
- Path coverage

- Branch coverage
- Decision coverage
- Control flow testing
- Data flow testing

Black box testing is a way of testing software without any knowledge of the internal structure of the methods or classes. This approach is usually done by software testers who need to know what the software should do and don't need to know how the software actually does it. Writing test cases and planning testing activities are important parts of black box testing. There are test design techniques that should be considered in order to develop the right test cases, for example, boundary values, decision tables, and equivalence class partitioning.

Boundary value testing was developed from the experience that bugs occur on the boundaries and edges of conditions and lists. These bugs may cause the software to crash, freeze, or behave incorrectly.

Decision tables will help you to split complex applications and conditions into smaller sections, which prevents you from forgetting important features. They help you obtain an overview of the critical elements of the feature set.

Equivalence class partitioning is a technique used to define test cases that uncover error classes. Equivalence class partitioning helps you reduce the number of test cases that need to be developed during your testing activities. This approach is typically used to test possible inputs of the application.

More examples of black box testing techniques follow:

- Cause-effect graph
- Error guessing
- State transition analysis
- All-pairs testing
- Exploratory testing

Important

This section gives just a very brief overview of possible testing methods and techniques. I roughly summarized the foundations of software testing and analysis, so if you're not familiar with the different test techniques, methods, and approaches, I highly recommend that you read some software testing books or take a testing class such as ISTQB[6] foundation level or Black Box Software Testing.[7]

6. www.istqb.org/
7. www.testingeducation.org/BBST/

Mobile-Specific Testing

In this part of the chapter you will learn how to test your app in different categories and ensure that it is robust, stable, usable, and as free of bugs as possible. Please use the knowledge you gained in Chapter 3, "Challenges in Mobile Testing," as well when testing your app. Keep the sensors, networks, gestures, customers, languages, and system apps in mind.

Before you continue reading, get your mobile device out of your pocket and start an app so that you can try out the things you're about to read.

Mobile Functional Testing

Testing the functionality of your app should be the first thing you do. Execute the designed test cases with your mobile app to make sure that the features and requirements have been correctly implemented. Besides testing your test cases, it is important that you also test the defined acceptance criteria.

Test to make sure that all the functions perform as they should, for example, inputs, outputs, tappable buttons, navigation, and data processing. Test the functionality in different mobile user scenarios and environments. Keep the sensors and interfaces of a mobile device in mind while testing the functionality (see Chapter 3 again).

Furthermore, use the quality assurance measures to test the functionality of your app in a static and dynamic way.

Important

Testing the functionality is one of the most important aspects of every software project. Depending on your app, functional testing will be different in every project.

Mobile Usability Testing

Usability, especially mobile usability, is a huge, complex, and important topic. Within your mobile development team you should have a usability expert who covers this part of the development process. Good usability requires lots of refining, intense user research, and even more testing with real users. It is important that your app be easy to use; otherwise it might end up with low ratings, which cause damage to the app's and possibly your company's reputation. To avoid such reputation damage, mobile testers can perform the actions described in this part of the chapter in order to help the team develop a usable app (keep KIFSU in mind).

The following links are a good starting point if you want to learn more about mobile usability:

- Usability heuristics (www.nngroup.com/articles/ten-usability-heuristics/)
- Mobile usability (www.nngroup.com/articles/mobile-usability-update/)
- Google Best Practices (www.google.com/think/multiscreen/#mobile-best-practices)
- Usability principles and techniques (www.usability.gov/what-and-why/index.html)
- Mobile user interface and usability design principles (www.neobytesolutions.com/mobile-user-interface-and-usability-design-principles/)

Or you can refer to the following book:

- *Mobile Usability* by Raluca Budiu and Jakob Nielsen (www.nngroup.com/books/mobile-usability/)

Less Is More

When testing the usability of an app, the design principle "Less is more" is a good starting point. Check the app for useless navigation elements and buttons. If you find any, talk to your team or the usability expert and get them removed. The same applies to text and words. Remove them if they are not required to interact with the app. Try to focus on the primary content of the app. Keep the goal and the problem the app should solve in mind, and get rid of anything that is distracting.

Self-Explanatory

Check if the app is self-explanatory. Ask yourself these questions: Is the user able to see the elements with which he or she can interact? Is every element on the screen clear and understandable? This aspect of usability testing gets more difficult over time because the more you work with the app, the more blind you will become to things that are not self-explanatory. You will most likely be used to potential usability issues. In that case it makes sense to ask colleagues not involved in the app development process or your customers for early feedback.

Pay Attention to Patterns

Every app should follow a usability and design pattern. If such a pattern is in place, verify that your app follows those rules. If there is no pattern available, keep an eye on the look-and-feel of the app. Same type-elements such as buttons or text labels should have the same spacings, sizes, and colors. Check that all of the elements are accessible, for example, that buttons can also be tapped by a person with thicker fingers and on different screen sizes and densities. Also check the default patterns that are provided by the mobile platforms as your app should at least follow those patterns.

Allow Mistakes

In order to provide a truly usable app, your app must allow users to make mistakes. If a user, for example, misses a required input field, provide friendly and useful error messages. Check that the error messages are not too generic and that they describe the error in a way that people without a technical background can easily understand. Furthermore, nice error highlighting should be in place to show the user the mistake he or she made. Keep your target customer group in mind when verifying error messages as this will have an impact on the wording. Besides that, your app should provide undo and go back actions in order to offer the user an easy way to correct errors. Another approach may involve user input recommendations or so-called type-ahead searches, which provide the user with possible input solutions; for example, when he or she is typing "New Y," the app will suggest New York as a possible input.

Check Workflows, Details, and Navigation

If your app follows a special workflow, check that it follows the same workflow in every section. Keep an eye on the details of those workflows. Be sure that buttons, labels, and other elements are big or small enough to be used. Screen division is important, so check the app on smaller and bigger screens. Don't forget to check the app for important details. Are they prominent enough? Is the user able to find them? Also keep an eye on visual transitions such as animations or elements that fade in or out. Is the transition of those elements smooth or does it feel choppy? Make sure you also use slow devices to check that all of your animations are smooth enough.

Check that the main navigation and sub-navigation of the app are easy to use. Are there any unnecessary taps that the user must perform in order to reach his or her goal? Check that the navigation has no unnecessary steps, and check to see if some of the steps can be combined. Is the navigation doable with one hand? Ask people who have different hand sizes and are left- or right-handed to perform this task. Have the platform-specific navigation patterns been met?

Check the Wording

Verify that the text used within the app is clear and easy to understand. Ask different people if they understand the wording and the feature behind it. If your app contains text, it must be free of typos as they can be very embarrassing and have an impact on your store reviews and ratings as well as your reputation. If your app supports more than one language, be sure the text fits into every UI element and that the translation is correct. Don't forget to test your app for placeholder texts like "Lorem ipsum" or any other default texts from developers or designers.

Check Consistency

A really important task within mobile usability testing is to check for consistency. Verify that your app is consistent in every section or view. As I already mentioned, the UI elements must have the same look-and-feel, the same text, spacings, colors, and images. Furthermore, it is really important to check that your app is consistent over all of the supported mobile platforms such as iOS, Android, Windows Phone, or BlackBerry, not just in terms of navigation or patterns (each mobile platform has its own rules), but by ensuring that the texts, colors, and images are the same. Make sure you also check the consistency of any offered Web or desktop applications that provide a different view to your application.

All of your applications must follow the corporate identity guidelines of your company in order to lend a familiar look-and-feel to your product; otherwise the user may get confused. Ask for your corporate identity guidelines, which will include topics such as colors, fonts, logos, images, and text.

Write It Down

While testing your app, it is important that you write down everything that feels different or somehow jumps out at you, no matter how trivial it may seem. Detailed observations are really important and will help improve the app. You can create screenshots of the entire screen using the mobile-platform-specific button combination or screen capture videos with a Web cam while using the app to show these "wrong" things to your product owner or developer so that you can discuss them.

An important point is: don't give up writing down such things, even if the product owner or the developer rejects your findings time and time again. Fight for those things and keep raising them. However, do be careful with your bug reminders as it is likely that your complaints will be ignored if you constantly raise the same issues. I suggest that you collect and categorize rejected bugs and present them as an improvement story to your product manager or developer for one of the next releases. Another approach would be to include fixes of old bugs in every release to improve the mobile app and clean up the bug pool. Talk to your team and find the solution that works best with your app.

Testers need to be curious and tenacious, and your customers will love you for that!

Accessibility Testing

As you have learned from the previous chapters, lots of people around the world are using mobile devices and mobile apps in their daily life. Apps are used for a whole range of different reasons, such as navigation, hotel bookings, ticket purchases, listening to music, or playing games.

When developing and testing an app, did you think about people with disabilities?

There are many people out there who are visually, audibly, physically, and/or cognitively impaired. Making mobile apps accessible is not easy and it's a lot of work, but it doesn't just benefit people with disabilities; it also improves your company's reputation and increases your user base.

It is therefore very important that everyone involved in your mobile app development process be aware of accessibility and know about the accessibility requirements of mobile apps. There are four types of impairment that are relevant to mobile app development: visual, auditory, physical, and cognitive.

Visual Impairment

People with visual impairment may be blind, have limited vision, be color-blind, or have a color deficiency. Due to their visual impairment, they may not be able to see all of the buttons, labels, text, and other elements in your app and are therefore unable to access or control the app correctly.

To adapt your mobile app for visually impaired people, you can implement the following features:

- Make all elements available for screen readers. Nearly every mobile platform offers the option to use a built-in screen reader to read out the content and the elements of the mobile app. If there are no built-in screen readers available, you can install them from third-party vendors.
- Every mobile platform offers a built-in feature to enlarge the font size of the entire phone and apps. Implement your app in such a way that the font size can be adjusted while retaining a pleasant layout.
- Every mobile platform offers a feature to change the foreground or background color of the screen, or to change the contrast. Therefore, you should use colors, brightness, and contrast of the UI elements that work with the different foreground and background settings.
- Built-in screen magnifiers can be used to enlarge the elements on the screen to make them easier to read.
- Another way of helping visually impaired people is through the use of voice recognition. This allows mobile users to control the entire mobile app through voice commands.

Auditory Impairment

Some people have trouble hearing, meaning that they don't hear if someone calls them or if they receive audio notifications, instructions, or any other kind of audio content.

To help people with hearing problems, you can do the following:

- Use the built-in vibration or visual notification to inform users when they receive a call, message, or any other notification.
- If your app relies on video content, use subtitles to inform the user about the content of the video.
- Implement adjustable sound or volume controls. This is really important for people with a hearing aid.
- If your app generates any sounds, implement a feature to switch the device to mono audio. This will help people who can hear with only one ear.

Physical Impairment

Physically impaired people have problems performing gestures with their hands. They are not able to use gestures such as pinch, tap, or swipe to control the elements on the phone or within the mobile app.

To help them use your app, you can do the following things:

- Use voice recognition as this allows mobile users to control the entire mobile app through voice commands.
- Implement a feature to increase or decrease the speed of pressing buttons as this will make it easier for physically impaired people to control your app.

Cognitive Impairment

Cognitively impaired people may have problems related to attention, communication, memory, computation, and reading skills. Those people experience problems, for example, with understanding complex navigations or instructions that they need to follow within an application.

To help them use your app, you can do the following things:

- Implement an easy and intuitive user interface. Make it as simple as possible to understand and use.
- Use screen readers in combination with simultaneous text highlighting.
- Implement an auto-text feature for input fields so that preloaded and defined text elements are already in place.
- Implement your app in such a way that cognitively impaired people have enough time to complete an operation.

Accessibility Guidelines

As you have seen, accessibility testing is a really challenging task, and you and your team need to find a way to support such features. If your app is accessible, it is very important that you test it with people who have such impairments in order to be sure that the requirements have been correctly implemented. Providing an accessible app will increase your user base and improve your reputation.

The W3C created an accessibility initiative that covers most of the accessibility concerns. You can find information at www.w3.org/WAI/ or

www.w3.org/WAI/mobile/. To get detailed mobile accessibility information for the different mobile platforms, check the manufacturers' Web pages.

The guidelines for Android can be found here:

- Android accessibility guide (http://developer.android.com/guide/topics/ui/accessibility/index.html)
- Android accessibility testing (http://developer.android.com/tools/testing/testing_accessibility.html)

The guidelines for iOS can be found here:

- iOS accessibility introduction (https://developer.apple.com/library/ios/documentation/UserExperience/Conceptual/iPhoneAccessibility/Introduction/Introduction.html)
- Accessibility on iPhone (https://developer.apple.com/library/ios/documentation/UserExperience/Conceptual/iPhoneAccessibility/Accessibility_on_iPhone/Accessibility_on_iPhone.html)
- iOS accessibility testing (https://developer.apple.com/library/ios/technotes/TestingAccessibilityOfiOSApps/TestingtheAccessibilityofiOSApps/TestingtheAccessibilityofiOSApps.html)

The guidelines for Windows Phone can be found here:

- Windows Phone accessibility guide (www.windowsphone.com/en-us/how-to/wp8/settings-and-personalization/accessibility-on-my-phone)

The guidelines for BlackBerry are here:

- BlackBerry accessibility guide (http://ca.blackberry.com/legal/accessibility.html)

Battery Usage Testing

While testing a mobile app, you need to test battery consumption during use. If your app consumes too much power, users will delete it and move on to another one.

To test your app's battery usage, you can run through the two scenarios described in the following sections.

Fully Charged Battery

In the first scenario, you have a fully charged battery. After installing and starting the app, leave it open and put the device in standby mode (your app is now running in the foreground). Now you have to wait a couple of minutes (or hours) to see whether the app is consuming lots of battery. Check the battery usage from time to time and note the battery level. You should do this with different devices to get better results, and don't forget to close any other apps that are running on the device to eliminate any side effects they may cause. The same test should be done when the app is running in the background. To put the app in the background, just start it and then close it (by pressing the home button or close button). On most mobile platforms, the app will now run in the background or multitask mode. Again, check the device from time to time to monitor the app's battery usage.

Use the smartphone hardware features (if used within your app) such as GPS or other sensors and check the battery level of your device while using those features. It's important that your app switch off device features once they are no longer needed. If your app doesn't do this, it will consume lots of battery. Check that the app is not sending any unnecessary requests to a backend system while running in the background or foreground. Unnecessary requests will have an impact on battery life. To check this, use a proxy tool such as Charles[8] or Fiddler[9] to send all your requests and communications from the device through your workstation to the backend system.

8. www.charlesproxy.com/

9. www.telerik.com/fiddler

While using the device and the app, check to see if the device gets hot. In some cases device-specific features will cause the device and battery to heat up, which will have an impact on your device hardware and may ultimately damage it.

Also check that your app really is closed after removing it from the multitask thread. To verify this, open the mobile-specific app system settings and check that your app is not currently running there.

Low Battery

The second scenario you should test is when the battery of the phone is nearly empty, when it has 10% to 15% of its capacity left. In this battery state, most mobile devices switch off features such as network connections, GPS, and sensors in order to prolong the battery life. If your app uses any of those features, check how it handles this low battery state. Watch out for freezes, crashes, and performance issues.

On some devices you can activate a power-saving mode that switches off sensors or Internet connections. Again, don't forget to check how your app handles this power-saving mode.

A really important test is to see how your app handles a completely empty battery. Use your app until the phone battery dies. Then plug in a charger and start the phone again. Once the phone has booted up, check your app for data loss or data corruption. The app should work as expected and no data loss or corruption should occur.

You should also test your app in the transition from a good to a bad battery state. Most devices will pop up an alert informing the user that the battery is nearly empty. This transition can have an impact on your app, so check it for freezes, crashes, and performance issues. The same should be done the other way around. Use your app while the battery is charging as this can also impact the app.

Battery Consumption Tools

Some mobile platforms offer a battery usage statistic to see which app is consuming the most battery. Android, for example, provides such an overview to see the current state of the battery (see Figure 4.2). Use this tool for your battery state testing; it's really useful for mobile testers!

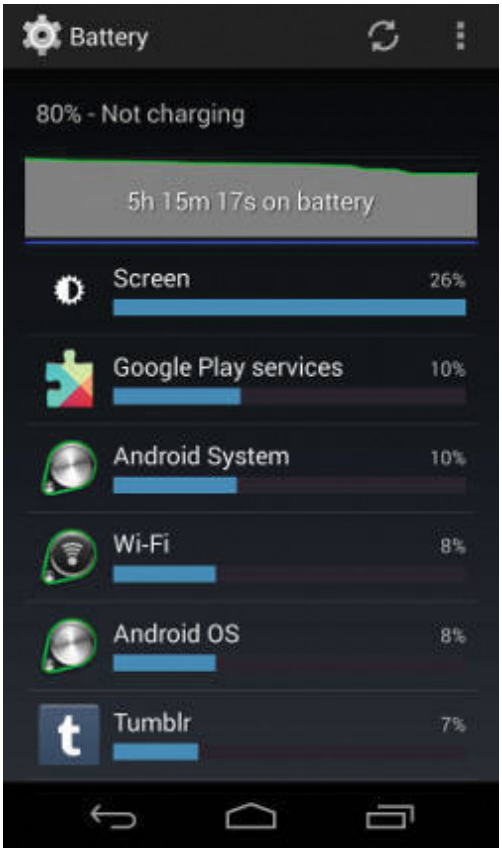

Figure 4.2 *Android app battery usage overview*

If you or your developers want to constantly measure battery consumption during your project, there are tools available for that. For Android there is a tool called JouleUnit.[10] JouleUnit is an open-source energy profiling tool for Android apps that finds any unnecessary battery usage of apps when they are running. It also measures the usage of the CPU, Wi-Fi, or display brightness. The tool basically has the same structure as JUnit tests and is really easy to integrate within your development environment so you can get early feedback about the battery consumption of your app.

10. https://code.google.com/p/jouleunit/

iOS allows you to use the energy usage function within Instruments[11] to profile the energy usage of your app. Instruments is part of the Xcode development environment and is free for testers and developers.

11. https://developer.apple.com/library/mac/documentation/developertools/conceptual/instrumentsusergu ide/Introduction/Introduction.html

There are a couple of useful documents online about energy usage within Instruments:

- Energy Usage Instrument (https://developer.apple.com/library/ios/documentation/AnalysisTools/Reference/Instruments_User_Reference/EnergyUsageInstrument/EnergyUsageInstrument.html)
- Logging energy usage in iOS (https://developer.apple.com/library/ios/recipes/Instruments_help_articles/LoggingEnergyUsageinaniOSDevice/LoggingEnergyUsageinaniOSDevice.html)

Battery testing is easy to do and should be part of your tool chain. Combine the manual with the profiling approach to get good results.

Stress and Interrupt Testing

Stress and interrupt testing is an important part of the mobile testing process. With the aid of tools, mobile testers are able to determine any potential performance or stability issues exhibited by an app. To test your app against interrupts, you can manually trigger lots of notifications to the device while using the app. Notifications can be incoming messages, calls, app updates, or push notifications (software interrupts). Furthermore, pressing the volume up and down buttons or any other kind of hardware button is also an interrupt (hardware interrupt) that can also have an impact on your app.

Doing all of these tasks manually is a lot of work and very time-consuming. In most cases, these test scenarios can't be done manually because it is very hard to simulate fast and multiple user inputs with one or two hands. But it can be done with the aid of tools, and it is really easy to integrate them into the development and testing process.

For Android apps, a tool called Monkey[12] can be used which is part of the Android SDK (Software Development Kit). Monkey can run on either a physical device or an emulator. While running, it generates pseudo-random user events such as a touch, click, rotate, swipe, mute, Internet connection shutdown, and much more to stress-test the app and see how it handles all those inputs and interrupts.

12. http://developer.android.com/tools/help/monkey.html

The package name of the Android .apk file is needed to be able to run Monkey; otherwise it will execute its random commands to the entire phone instead of just the app under test.

With access to the app code, the package name can be found in the AndroidManifest.xml. If only the compiled .apk file is available, mobile testers can use the Android Asset Packaging Tool[13] (aapt) to get the package name from the app. aapt is located in the build-tools folder of the installed Android SDK version.

13. http://elinux.org/Android_aapt

The path to aapt may look like this:

Click here to view code image

```
/../daniel/android/sdk/build-tools/android-4.4/
```

With the following command, the package name can be read out from the .apk file:

Click here to view code image

```
./aapt d badging /daniel/myApp/myApp.apk | grep 'pack'
...
package: name='com.myApp' versionCode='' versionName=''
...
```

When the package name (in this case `com.myApp`) is available, execute Monkey with adb[14] (Android Debug Bridge):

14. http://developer.android.com/tools/help/adb.html

Click here to view code image

```
./adb shell monkey -p com.myApp -v 2000
```

The number 2000 indicates the number of random commands that Monkey will perform. With an additional parameter `-s` for seed, Monkey will generate the same sequence of events again. This is really important for reproducing a bug that may occur when running Monkey.

For iOS apps there is a similar tool called UI AutoMonkey.[15] UI AutoMonkey is also able to generate multiple commands to stress-test an iOS app. To use UI AutoMonkey, a UIAutomation Instruments template must be configured within Xcode. After the template is configured, a JavaScript file needs to be written to tell the tool how many and which commands should be executed during the stress testing session (see Listing 4.1).

15. https://github.com/jonathanpenn/ui-auto-monkey

Listing 4.1 *UI AutoMonkey Script*

Click here to view code image

```
config: {
  numberOfEvents: 2000,
  delayBetweenEvents: 0.05,    // In seconds

  // Events that will be triggered on the phone
  eventWeights: {
    tap: 30,
    drag: 1,
    flick: 1,
    orientation: 1,
    clickVolumeUp: 1,
    clickVolumeDown: 1,
    lock: 1,
    pinchClose: 10,
    pinchOpen: 10,
    shake: 1
  },

// Probability that touch events will have these different
properties
  touchProbability: {
    multipleTaps: 0.05,
    multipleTouches: 0.05,
    longPress: 0.05
  }
},
```

If the script is written, it can be executed within Xcode. At the end, both tools generate an overview of possible errors and problems within the app.

> **Important**
>
> Please visit the tool manufacturer's Web site for installation instructions.

As you can see, these tools make it simple to stress- and interrupt-test a mobile application. Besides that, using them is a huge benefit for mobile testers as it helps the team build a reliable and robust mobile app. By the way, it's useful to combine battery testing with stress and interrupt testing to see how the battery is used when lots of interrupts and user inputs are triggered throughout the app.

Performance Testing

Performance testing is one of the key testing areas in every software development project and especially for mobile apps. If you remember the high user expectations described in Chapter 1, "What's Special about Mobile Testing?," mobile performance testing is a really important and critical part of app development. Mobile users expect an app to start/load within two seconds; otherwise they are unhappy and may delete it.

Testers and developers can use performance tests to discover potential bottlenecks in their software application. Normally, performance testing is done on servers or backend systems to check how the systems or software can handle huge numbers of requests, to meet acceptable results for the users.

Performance tests must be executed in a defined state of the application with hardware resources that are equal to the live backend environment. The collected data must then be analyzed to find possible bottlenecks and problems in the software. Performance testing is a complex topic that should never be underestimated or postponed to the end of the project; it should be done as early as possible. Key performance figures should be part of the requirements phase of app development in order to start planning right from the beginning.

For mobile apps, performance tests are more complex and need to cover more systems in order to get meaningful results that improve performance.

The typical mobile app relies on a backend system (server) with which it communicates. The app sends requests to the server, which then handles those requests and sends back a response. To send a simple request to a backend system, there are three critical performance areas that need to be covered:

- The server
- The mobile data networks
- The mobile device and app itself

To test the performance of mobile apps, you need to performance-test at least the backend system and the app itself. It is not possible to test the performance of the mobile data networks, and it makes no sense for you as a mobile tester. The network speed and latency can be simulated during the testing phase, but the network speed will be totally different while a user is on the move in real data networks.

In this chapter, I want to focus on performance testing of the mobile app itself. Keep the backend system performance in mind and look for further information on the Internet. There are plenty of good tools available to help you set up a performance testing suite. If you want to do performance testing within your project and use tools to do so, keep the following steps in mind as they will help you to define a clear strategy:

1. Plan performance tests early in the development phase.
2. Design the performance tests for your app.
3. Prepare test data and infrastructure (these should be the same as for the live environment).
4. Execute the performance tests.
5. Collect, analyze, and evaluate the data.
6. Find potential bottlenecks and refine the app.
7. Monitor the application changes again to see if the refinements were good enough.

Mobile App Performance Testing

When testing the performance of a mobile app, keep it simple and focus on the UI of the app. For example, use a stopwatch and measure the application launch or the delays between certain operations. Measure the loading time of the content such as images, text, or animations that need to be created or processed by the app. Perform those tests several times and note the performed steps in order to reproduce and track possible performance issues. Also, write down how often the problem occurred. If it happens all the time, that's fine; that is an easy fix. But some problems, especially performance problems, may happen only three out of ten times. It's therefore important to find the bug and reproduce the behavior.

While testing the app, write down everything that seems slow as it could be a potential performance issue. Manual performance testing should be done on several devices with different hardware specifications in order to get meaningful results.

Another test that should be done is a comparison between the current app version that is live and available for download in the app stores and the new release candidate app. Compare both versions in terms of app launch time and

all other areas. The new release candidate should not be slower than the current version; otherwise the app will get bad feedback from users.

> **Important**
>
> The comparison should be done on the same hardware; otherwise the results will differ.

If your app contains third-party elements such as advertising or news feeds, check that those elements have no impact on the performance of the app. As an example, you can use a Web proxy tool like Fiddler to send the third-party request to a time-out to see that it has no impact on the app's performance.

Another way to test the performance of the app is to profile and measure the process and operation time of the code. There are plenty of profiler tools available to check the app code for potential bottlenecks and performance issues. This task should be done by the developers, so encourage them to use such tools.

To summarize the simple mobile app performance tests:

- Measure the app's launch time.
- Check for delays during operations or user interactions.
- Measure the loading time of the content.
- Note everything that seems slow.
- Test on different hardware, especially on slower phones.
- Compare the live app version with the new release candidate.
- Check for third-party elements.
- Use profiling tools to measure the process and operation time of methods and classes.

As you can see, these are simple steps to test the performance of a mobile app. If you want more complex and detailed data about the performance of the app, the backend, and the data networks, you'll need to use a performance testing tool or solution that covers all parts. There are plenty of mobile app performance providers available, so search for them on the Internet and see which one best fits your development and test environment.

Standby Testing

Standby testing is really easy and simple to do but can show some nice crashes, freezes, and UI glitches within the app. While the app is running, put the device into standby mode by pressing the off button once. Depending on the app under test, wake up the device after a couple of seconds, minutes, or hours to see how the app reacts upon wake-up. Most apps fetch data updates from the backend system after a wake-up to refresh the current UI. It's possible for a bug to prevent the app from displaying the newly fetched data correctly, or it may freeze or crash. If a UI view update mechanism is implemented, you must make sure this mechanism works after the device wakes up and fetches the latest data.

Also test the scenario of not having an Internet connection while the app is in standby mode. To test that, open the app, close the device's Internet connection, and put the device into standby. After a certain amount of time, wake up the device and check the behavior of the app. It will probably check for updates, but there is no Internet connection. In this case, the app must show a proper error message to the user, informing him or her of the current situation.

Don't forget to check that the device is able to communicate with device-specific hardware elements after waking up. Feel free to get creative when testing the app for standby and wake-up problems.

Installation Testing

The installation process is the first impression a mobile customer has of an app. If the installation fails due to errors or problems, the customer will not try to download the app again and will move on to another one. To avoid such problems, installation testing must be made part of the mobile testing process and should be performed at least before a new version is due for release.

To test your app for installation problems, perform the following tasks:

- Verify that the app can be installed successfully on the local storage or memory card of the device.
- Check that the installation works with different Internet connections such as Wi-Fi or mobile data networks.
- Change the Internet connection (Wi-Fi to 3G, for example) while the app is installing.

- Switch to other apps while the app is installing.
- Switch the device's Internet connection off, for example, to airplane mode, while the app is installing.
- Try to install the app when there is not enough space left on the local storage.
- Try to install the app via data cable or syncing from mobile-specific software applications.

When performing those actions, watch out for error messages in the app as well as crashes and freezes.

When the app successfully installs, mobile testers should also test the other way around by testing the uninstall process. So uninstall the app and check that it is completely removed from the device with no data left on the hardware or local storage. To verify that the app was removed completely, check the device's memory and folders for leftover data. Another way to verify that the app was removed successfully is to install the app again and to check that, say, a user is not logged in automatically or that the app doesn't show any data from the previous installation. These tests are really important because some devices are shared within a company or family and leftover data can lead to serious trouble.

Some mobile platforms offer different ways of uninstalling an app, so you have to test all of them. While uninstalling the app, watch out for error messages, crashes, and freezes.

Update Testing

As you have learned in the previous sections, testing an app during the install and uninstall processes is really important. Besides installing and uninstalling an app, users are also able to update the app from one version to another. During this update process, lots of things can go wrong and need to be tested before a new app version is submitted to the app stores.

Testing the update process includes scenarios such as the following:

- Logged-in users should not be logged out from the app after the update is installed.
- The update will not affect the local database; that is, existing data will not be modified or deleted.
- The app is in the same state as before the update was installed.

- Testing the update process will simulate the update process in the app stores.

You should also test the update process from a far older app version to the latest one to see what happens to the app. While doing update testing, keep an eye out for error messages, crashes, freezes, and performance issues right after the update.

In the following two sections, I will describe how to perform update testing on iOS and Android. Nevertheless, if you are testing a Windows Phone, BlackBerry, or any other kind of app, you should of course do update testing as well.

iOS Update Testing

There are two ways of simulating the update process for iOS apps. The first one can be performed with iTunes by following these steps:

1. Build an ad hoc version of the app that is currently live in the Apple App Store.

   HINT: This version must have the same bundle identifier (package name or structure of the app classes) as the new app.

2. Be sure that no older version of the app is installed within iTunes and on the test device (sync with iTunes to be sure).
3. Drag the app from step 1 into iTunes and sync the version to your test device.
4. Launch the app and do some manual testing to make sure that the app is working.
5. Build the new release candidate version of the app, drag it to iTunes, and sync it to the device. iTunes should confirm that the older version will be removed.

   HINT: Do *not* delete the old build! In the next step iTunes will install the new app over the old one and simulate the update from the App Store.

6. Launch the new version of the app and check that everything is OK.

The second way of testing the update process for iOS is to use the Apple Configurator.[16] This tool is far easier to use, especially if you want to test the

update procedure on several iOS test devices such as an iPhone 4(S), iPhone 5(S), or iPad.

16. http://help.apple.com/configurator/mac/1.7/?lang=en

1. Build an ad hoc version of the app that is currently live in the Apple App Store.

   HINT: This version must have the same bundle identifier as the new app.

2. Be sure that no older version of the app is installed on the test device.
3. Use the tool to install the app from step 1 to the devices for which you want to check the update process.
4. Launch the app and do some manual testing to make sure that the app is working.
5. Build the new release candidate version of the app and install it with the tool. The update process will be simulated.
6. Launch the new version of the app and check that everything is OK.

For further information, please read the technical note TN2285[17] from Apple about testing updates on iOS devices.

17. https://developer.apple.com/library/ios/technotes/tn2285/_index.html#//apple_ref/doc/uid/DTS40011323

Android Update Testing

The same update testing can be done with Android apps. To test the update process for Android apps, you can use the adb tool located in the Android SDK folder:

1. Install the current Google Play store version of the app to the test device:

Click here to view code image

```
./adb install RELEASED_APP_NAME.apk
```

2. Check that this version works.
3. Build a release candidate of the Android app.

   HINT: Be sure to sign the release candidate with the Play store keystore.

4. Use the following command to install the new version of the app and to test the update procedure:

Click here to view code image

```
./adb install -r NEW_VERSION_APP.apk
```

The option `-r` means the app will be reinstalled and retain its data on the phone.

5. The new version of the app is now installed and can be tested.

As you can see, update testing is very easy to do. It's really important to perform these checks before submitting an app to the various app stores.

Database Testing

Apps use local databases, in most cases a SQLite[18] database, to persist data on the phone. Storing the data or the content of an app in a local database enables mobile apps to present the content when the device is offline. This is a huge advantage compared to mobile Web apps that rely on a stable Internet connection in order to work properly. The fact that mobile apps use databases means that mobile testers need to test them and the actions that will be executed on the database.

18. www.sqlite.org/

Local database testing can be performed manually or automated. The goal is to test data integrity while editing, deleting, or modifying the data. In order to achieve good database testing, you need to know the database model with the table names, procedures, triggers, and functions. With the help of database tools, you can connect to the device database to test and verify the data.

The following types of tests should form part of your mobile database testing:

- Database validation testing
- Database integration testing
- Database performance testing
- Procedure and function testing
- Trigger testing
- CRUD (Create/Read/Update/Delete) operations testing to make sure they will work on the database

- Testing that the database changes are shown correctly on the UI of the app
- Search and indexing function testing
- Database security testing
- Testing the database for migrations

Because databases and database testing are huge topics in themselves, I recommend further reading to gather more information about the different database technologies. The "Books about SQLite"[19] page contains lots of useful books on this topic.

19. www.sqlite.org/books.html

Local Storage Testing

Local storage testing has nothing to do with the app database; instead, you should check how the app reacts in different states of the device's local storage. Every device has a certain amount of storage capacity for music, images, apps, and any other kind of data that can be stored on the device. Some devices have only a single central and permanently installed local storage, and users are not able to extend those devices with additional storage. However, there are many devices that offer the possibility to extend the local storage, for example, with a microSD card.

When testing a mobile app, you should test the app together with different states of the local storage to be sure that the app can handle them properly. The following scenarios should be tested:

- Test the app when the local storage is full.
- Test the app when the local storage is full but the extended storage still has some space left.
- Test the app when the local storage has some space left but the extended storage is full.
- Test the app when both storage areas are full.
- Test the app when the local storage is nearly full. Perform some actions within the app that will write lots of data to the local storage in order to fill it up.
- Remove the device's extended storage and check the behavior of the app.

- If possible, move the app to the extended storage and check the behavior.
- Test the app when the local storage is empty.

When performing these scenarios, watch out for app crashes, error messages, app freezes, performance issues, UI glitches, and any other kind of strange behavior that could indicate a problem.

Security Testing

Security can be business critical—for example, when attackers steal your customer data—thus making it a very important part of the development and testing process of your mobile app. Security testing is a complex topic that requires knowledge in many different areas, such as client-server communication, software architecture, and system architecture. Because of its complex nature and the specialized skill set required, security testing is best done by experts. It includes methods such as manual or automated penetration testing with man-in-the-middle attacks, fuzzing, scanning, and auditing the software.

Penetration testing is an approach used to find security weaknesses in an application that allow access to its features and data. There are several open-source and enterprise tools on the market that can test the application for common vulnerabilities. A list of common security testing tools can be found on the OWASP (Open Web Application Security Project) page.[20]

20. www.owasp.org/index.php/Appendix_A:_Testing_Tools

With the aid of a proxy tool, an attacker can change or monitor communication between a client and a server. This allows the attacker to read sensitive data such as usernames and passwords or manipulate the behavior of the client by sending forged data to it. This method is known as a man-in-the-middle attack.

Fuzzing is a method to generate and send random data to a system in order to see how the system reacts to the data in preparation for a possible attack. Thanks to scanning tools, the system can be checked for known vulnerabilities that can be exploited in order to gain access.

Audits are most likely performed by certified security providers. With the help of the external partners, the application will be checked manually and automatically for vulnerabilities and possible attacks.

Recall that the default mobile app architecture includes the following:

- The mobile app itself
- The mobile data networks
- The backend system

You have three possible areas that need to be tested for security. It will be nigh on impossible to test the data networks for security, but the data network providers already do this to ensure a safe and secure communication environment. Therefore, two areas remain for security testing: the app and the backend. To simplify things, I want to focus on mobile app security testing.

Common App Security Mistakes

The following list contains the most common security problems of mobile apps:

> **Important**
>
> These points can be used during the development phase to check for common mistakes. However, looking for these common mistakes is not a replacement for expert security testing like that mentioned earlier.

- **Cache storage:** Sensitive data such as passwords or tokens is cached on the device.
- **Unintended local storage:** Sensitive data such as passwords, tokens, or credit card details is stored by accident.
- **Encryption:** Sensitive data such as passwords is not encrypted on the device storage.
- **Client-side validation:** Password verification is performed only on the client side.
- **Unencrypted communication:** Communication from the app to the backend systems is not encrypted.
- **Unnecessary app permissions:** Apps use permissions for device features that they do not need or use.

To avoid these mistakes, you should keep them in mind and test for them. To verify the cache storage of the device, test your app for inputs and data that

are not stored on the device. Check the device cache storage for data you just entered and verify that the data is cached for only a certain amount of time. To verify the cache storage, use an app that is able to look at the file system level and check that the cache folder of your app contains only the permitted data. Turn the device off and on again and check the device and app cache as both must be empty in order to ensure that there is no sensitive data left on the device. The same applies to data that is stored on the device by accident.

Check the device storage and files for data that is not allowed to be on the device. To verify the local storage of the device, use apps or developer tools that grant access to the local storage.

If your app uses a local database to persist the content or data such as the login credentials of your app, be sure that such data is encrypted in the local database. Check that a form of encryption is in place at the database level.

If your app uses a login to grant access to the features and content delivered from a backend system, be sure that the user is not validated on the client side. Validation should always be performed on the backend system. If the device gets lost and validation is carried out only on the client side, it is very easy for attackers to change the validation, to manipulate or steal sensitive data.

Most apps rely on a backend system for the user to send or receive information and data, to read the latest news, to communicate with friends in social networks, or to send e-mails. If the communication between the app and the backend contains sensitive, unencrypted data, it makes sense to encrypt it, such as with TLS (Transport Layer Security).

If an app wants to use a device-specific feature such as the camera or wants to synchronize contacts with the address book, special permission to access those elements is required. When developing and testing an app, keep an eye on those permissions. Use only the permissions your app really needs. Otherwise the user may not use your app, because he or she is skeptical about it or may feel like he or she is being watched. The use of unnecessary permissions can also be a vulnerability for the app and the data stored on the device. If you don’t know the permissions of your app, talk to your developers about it and ask critical questions about the permissions and their purpose.

Security Requirements Analysis

The security requirements analysis should be part of the first requirements analysis phase of each mobile app project. You should raise the topic as early as possible to avoid problems at the end of the project. The following list can help you with the security requirements analysis:

- Identify the possible user roles as well as their limitations and permissions within the architecture (app and backend).
- Does the user role have an impact on the existing security, for example, the backend?
- Is an external audit required? What should be part of this audit?
- What kind of security testing approaches and tools are required in order to achieve a good security level?
- Do we have enough skills for security testing?

This list is by no means complete. Depending on the app and its complexity, this list can be much longer.

A good source of valuable information about mobile security is the "OWASP Mobile Security Project" page.[21] The project collects information about mobile security such as the following:

21. www.owasp.org/index.php/OWASP_Mobile_Security_Project

- Mobile Tools (www.owasp.org/index.php/OWASP_Mobile_Security_Project#tab=Mobile_Tools)
- Mobile Security Testing (www.owasp.org/index.php/OWASP_Mobile_Security_Project#tab=Mobile_Security_Testing)
- Mobile Cheat Sheet (www.owasp.org/index.php/OWASP_Mobile_Security_Project#tab=Mobile_Cheat_Sheet)

This information can be very useful during both the security requirements analysis phase and the actual security testing phase.

Another interesting and useful part of the OWASP project is the list of "Top 10 Mobile Risks."[22] The list includes the following topics, with a good explanation of each topic and possible solutions:

22. www.owasp.org/index.php/OWASP_Mobile_Security_Project#tab=Top_10_Mobile_Risks

1. Weak Server Side Controls
2. Insecure Data Storage
3. Insufficient Transport Layer Protection
4. Unintended Data Leakage
5. Poor Authorization and Authentication
6. Broken Cryptography
7. Client Side Injection
8. Security Decisions via Untrusted Inputs
9. Improper Session Handling
10. Lack of Binary Protection

Mobile Security Testing Summary

Security testing is a complex and difficult part of the software development and testing process. It requires special skills and knowledge of technology to ensure that the software or app is secure against attacks and vulnerabilities. You as a mobile tester should always keep security testing in mind. Talk about the topic as early as possible in the requirements analysis phase. If you're not sure whether you can test the security of the app sufficiently, you should get some help from experts as early as possible in the process.

Keep the following points in mind to ensure a secure mobile app:

- Test the app for different inputs; for example, have a prepared list of possible attack strings available.
- Do penetration testing on the app and the backend system.
- Use a proxy, a fuzzer, and a scanner to verify each part of the app and the backend architecture.
- Check the app for common mistakes.
- Have a look at the OWASP Mobile Security Project and follow the guidelines set out there.
- Check the app's certifications.
- Keep up-to-date with the latest mobile technologies and security news.
- Hire experts.

> **Important**
>
> The security topics covered in this chapter are a very rough overview of possible things to consider. Mobile security is a huge and complex topic, so please scour the Internet for further information.

Platform Guideline Testing

Another topic you need to be aware of is the mobile-platform-specific guidelines. Each app has to follow such guidelines in order to meet the design, usability, and platform-specific patterns. If the app fails to follow these guidelines, it might be rejected from the app store. In addition, following the design principles will make your customers happy because they know how to use platform-specific features such as swiping from left to right to switch views, or to pull to refresh and update the current view.

It is important that such guidelines be included in the design phase of an app. Following the guidelines from the very beginning of the project will save you time at the end because you will encounter fewer bugs than you would by not following the guidelines.

When testing a mobile app, keep the platform-specific guidelines in mind. You should know them by heart or at least know where to find them:

- Apple iOS design resources (https://developer.apple.com/library/ios/design/index.html#//apple_ref/doc/uid/TP40013289)
- Apple iOS approval guidelines(https://developer.apple.com/appstore/resources/approval/guidelines.html)
- Android guidelines (https://developer.android.com/design/patterns/index.html)
- Windows Phone guidelines (http://dev.windowsphone.com/en-us/design)
- BlackBerry guidelines (http://developer.blackberry.com/design/bb10/)

> **Important**
>
> Make sure you're familiar with the latest mobile platform guidelines. They change with every new mobile operating system version that's released.

Conformance Testing

Conformance testing aims to ensure that the software meets a defined set of standards. These standards are defined by independent entities such as the European Telecommunications Standards Institute[23] (ETSI), the World Wide Web Consortium (W3C),[24] and the Institute of Electrical and Electronics Engineers (IEEE).[25]

23. www.etsi.org/
24. www.w3.org/
25. www.ieee.org/index.html

If your app has to implement defined standards, you must verify that those standards are met. It is important for you to be aware of those standards and that you know how to check them. However, the standards should already form part of your requirements analysis phase. When it comes to the development phase, talk to your developers about implementing the standards by asking questions, performing a code review, and walking through the defined standards documentation.

Depending on the mobile app type and purpose, an external institution may be required to verify your app in order to check that you correctly implemented their standards. This will be the case with medical apps or apps that are used by governments. In some cases, the app has to be tested for legal compliance.

> **Important**
>
> Keep conformance testing in mind and ask questions at the very beginning of the project.

Checking the Log Files

While testing your mobile app, connect your device to your computer and check the app's log files while using it. To get access to the log files, you need to install the developer tools on your computer so you can run the app in debug mode.

When checking the log files, watch out for errors, warnings, or exceptions that occur while using the app. Save the information from the log file along with steps for how to reproduce the problem and pass the information on to the developers. Log file information is extremely useful to developers for finding and solving problems. Besides looking for errors and crashes, you should look for sensitive data such as tokens or passwords that are visible in the logs.

When testing your app without a cable connection to your computer, and the app crashes or exhibits strange behavior, leave the app and the device in this state and connect it as soon as possible to your computer and the developer tools so you can check the log file for the error.

Before submitting an app to the app stores, you have to check the log files for debug information, warnings, and errors again. Debug information as well as warnings and errors should not be part of the release version of the app.

Also keep the log files of the backend systems in mind as they log different kinds of information such as requests and responses as well.

> **Important**
>
> Some bugs are visible only in the app's log files. Such bugs may not be shown to the user but could have a huge impact on the functionality of the app.

Be Creative!

Up until this point, this book has presented a systematic approach to mobile testing and its specifics. But everyone who has effectively tested software knows that most of the time, the really nasty bugs don't occur systematically. Bugs come in different shapes, sizes, and situations, and sometimes it's really hard to find them.

After you have tested your mobile app in a systematic way (or before starting with the systematic approach), it is useful to think out of the box. Lean

back, step away from all the test cases and systematic approaches, and just try to break it! Test the app for a limited time frame—30 minutes, for example—and try to find some bugs using your own creative approaches.

Be creative with your testing. Try to think of edge cases that are most likely to happen in the real world when lots of people will be using the mobile app in a totally different way from what you and your team expect.

Do crazy things with the app and the device. Rotate or flip the device, use more than one hand to interact with the app, and press buttons as fast as possible.

While doing that, watch out for any unexpected behavior, crashes, freezes, error messages that make no sense, and any other strange things. I suggest that you record this kind of test session because it is very likely that any bugs that occur will be hard to reproduce. Another approach can be pair testing, which involves one person testing the app while another person watches and takes notes about the performed tests.

Checklists, Mnemonics, and Mind Maps

This part of the chapter is all about reminders. Your daily testing business is stressful and there are so many things to remember, do, and explore. You may want to use some models or tools to prevent you from forgetting important aspects of your work. Three very nice approaches you can draw upon are

- Checklists
- Mnemonics
- Mind maps

Checklists

Every new feature that will be developed needs to be tested. Software testers usually define test cases in order to systematically test every new feature and avoid forgetting anything. When the test cases are finished, a software tester usually prioritizes the manual test cases for the test automation to extend the regression test suite and avoid manually testing the new feature over and over again. However, not every feature or test case can be automated because the test may be too complex and will most likely end up causing lots of maintenance work.

But what can you do if such a test or feature is critical for the app or the business? Never executing it again is simply not an option.

To help you avoid forgetting important things, you may find it useful to write a checklist with parts of the app that need to be manually tested again before going live or after a project milestone has been reached.

Checklists can be very generic and high level so that they can be used in several different projects, or they can be really low level with specific steps to test a certain feature.

The mobile testing checklist in Table 4.1 is a generic one that covers lots of important aspects of the mobile app testing process. This list can be used for several different mobile apps.

No.	Description	Expected Result
1	Test the app against the requirements and acceptance criteria.	The app must pass all the requirements and criteria.
2	Test on different platforms and operating system versions.	The app must work on the defined platforms and operating system versions.
3	Check the app in portrait and landscape modes.	The app must work in landscape and portrait modes. The UI must handle the orientation change.
4	Check the design guidelines for the platforms.	The app must follow the UI guidelines to provide a good user experience.
5	Check the development guidelines for the platforms.	The app must follow the development guidelines to pass the store requirements.
6	Test the app on different screen resolutions and screen densities.	The UI elements of the app must be shown in the correct positions. Elements have to work when touched.
7	Use the app in different networks (LTE, 3G, EDGE, GPRS, Wi-Fi).	The app must work at different network speeds. No crashes, no confusing error messages are allowed.

8	Test how the app handles a network change, such as from LTE to EDGE.	The change in network speed should not affect the app.
9	Use the app in airplane mode.	Proper error messages must be given to the user. The app must have access to locally stored data.
10	Use different network providers to test your app.	The app must work with different network providers and network technologies.
11	While fetching data from the backend service, shut down the device's Internet connection.	The app must show a proper error message.
12	Turn the Internet connection on and try reloading the data.	The app must fetch data from the backend system and update the UI.
13	Use device-specific hardware functions such as GPS, NFC, the camera, and other sensors.	The app must work with the hardware features of the phone.
14	Test the shutdown of hardware-specific functions within the app.	Check that GPS, for example, is turned off to avoid consuming too much battery.
15	Check battery usage while the app is running.	The app should not consume too much battery while running.

16	Check battery usage while the app is in standby.	Battery consumption should be low when the app is in standby.
17	Check the app's memory usage.	The app should not consume too much memory.
18	Compare the performance of a released app with the new release candidate.	The performance should improve or stay the same.
19	Test the app in different languages.	All elements must be visible on the screen. The UI must look the same in every language.
20	Check the app permissions.	The app should use only the permissions that are required for the app.
21	Check the local database.	The local database should be encrypted. Only required data should be stored.

22	Check the log files within the IDE.	The log files of the release candidate should not include any debug information, warnings, or errors.
23	Check that the app is signed with the correct and valid certificate.	The app must be signed with the company certificate.
24	Install, delete, and update the app on a real device.	Installing, deleting, and updating the app must work. Deleted apps must be removed completely; no data is allowed to be on the device. Updating the app should not affect the stored data and the current state of the app.
25	Check that the app can handle interrupts such as phone calls, SMS, or any other kind of notifications.	The app must handle the notifications correctly with no error messages or crashes.
26	Test the app while you are on the move, such as in a car, on a train, or in the countryside.	The app must work in different usage scenarios.
27	Track post-release actions.	Check user reactions; gather feedback and crash reports.

Table 4.1 *Generic Mobile Testing Checklist*

Important

This list is by no means complete; it is merely an example of what a mobile testing checklist could look like.

This checklist shows some possible generic mobile tests that could be executed on top of your systematic testing approach. It may also be useful to create a release checklist for the whole team so they don't miss anything important to the process. However, checklists can be really specific to cover a very special part of the app, such as the payment and billing processes, or the different sensors and interfaces.

Important

Be creative with checklists. Create your own checklists that are specific to your app and project.

Mnemonics

SFDPOT, FCCCUTSVIDS, and ISLICEDUPFUN are not typos. They're abbreviations for mnemonics. Mnemonics are learning techniques that aid information retention. When it comes to mobile app testing, each letter stands for a testing approach or technique used for software applications. Mnemonics are used to remember important aspects while testing software applications and are very useful for software testers because they are easy to remember and include powerful ideas and best practices on how to test software.

SFDPOT[26] is a mnemonic from Karen Nicole Johnson that she adapted from James Bach's mnemonic SFDPO[27] (better known as "San Francisco Depot") on mobile testing. Karen included the following points:

26. http://karennicolejohnson.com/2012/05/applying-the-sfdpot-heuristic-to-mobile-testing/

27. www.satisfice.com/articles/sfdpo.shtml

- **Structure:** Test what it's made of.
  - Can I download the app?
  - Can I download an update?
- **Function:** Test what it does.
  - Does the app or site perform the tasks or features it was designed to?
  - Does the app or site prevent, block, or not include features not intended on a mobile device?
- **Data:** Test what it does it to.
  - Does the app find time-related data based on the device time?
  - Does the app find locations based on my location (such as movie theaters or hotels)?
- **Platform:** Test what it depends upon.
  - Does the app use location services?
  - Does the app depend on any device settings?

- **Operations:** Test how it's used.
  - Does the app function when I am moving and traveling around?
  - What happens when I switch to Wi-Fi versus 3G?
- **Time:** Test how it's affected by time.
  - What happens if the time zone is switched?
  - What happens when my location is switched?

For each part, Karen wrote some questions to ask while testing a mobile app. Check out the full list of questions in her blog post "Applying the SFDPOT Heuristic to Mobile Testing." Use and adapt them to test your app.

Another mnemonic is FCC CUTS VIDS[28] by Mike Kelly, who noted down his ideas in tours to explore and test applications in several ways:

28. http://michaeldkelly.com/blog/2005/9/20/touring-heuristic.html

- **Feature tour**
  - Explore the application and get to know all the control elements and features.
- **Complexity tour**
  - Find the most complex parts of the application.
- **Claims tour**
  - Find all the information about the software that tells you what the product does.
- **Configuration tour**
  - Find all the ways to change the settings of the application.
- **User tour**
  - Imagine how the possible users of the application will use the software and what they expect from it.
- **Testability tour**
  - Find all features within the software that could be tested with the help of tools.
- **Scenario tour**
  - Imagine possible scenarios as to how the software will be used by its users.
- **Variability tour**

    - Try to find ways to change the application.
- **Interoperability tour**
    - Does the software interact with other software?
- **Data tour**
    - Find the data elements of the application.
- **Structure tour**
    - Gather as much information as possible about the application, such as the programming language, APIs, hardware, and so on.

The described tours are an excellent way of finding out possible settings, features, or configurations of the software application. Besides that, the tours cover the user's perspective and are ideal for exploring the application. All of the mentioned tours can easily be adapted to mobile apps.

Another great mobile testing mnemonic is I SLICED UP FUN[29] by Jonathan Kohl, who also adapted his mnemonic from James Bach's SFDPO for use with mobile apps. He covered very specific mobile areas that have to be tested during the development phase:

29. www.kohl.ca/articles/ISLICEDUPFUN.pdf

- **Inputs into the device**
    - Built-in keyboard/keypad
    - Touchscreen gestures and typing
    - Syncing with other devices
- **Store**
    - Submission specifications
    - Development guide
    - User guide for error handling, location services, permissions for user privacy items, accessibility, and so on
- **Location**
    - Geolocation errors
    - Movement, stopping suddenly
    - Connection issues due to interference
- **Interactions/interruptions**
    - Running multiple applications, multitasking

- Using other applications, then using the application you are testing (e-mail, calendar, texting, note taking, others)
- Notifications appearing

- **Communication**
  - Phone
  - Texting
  - E-mails
- **Ergonomics**
  - Small screens can be hard on the eyes.
  - A small device means there is no ergonomic help from a desk or chair—you often hunch over to interact with it.
  - It's not uncommon to get a sore back, fingers, or eyes when using a device for any length of time.
- **Data**
  - Types of input—see if the app uses special characters, different languages, and so on.
  - Media—see if the app depends on an outside source to play music, videos, or anything else.
  - Size of files—if the application uses outside files, try using different file types.
- **Usability**
  - Note and log any issues that make you uncomfortable, frustrated, angry, or upset while using the app.
- **Platform**
  - Android
  - iOS
  - Windows Phone
  - BlackBerry
- **Function**
  - Can you identify everything that the application does?
  - Have you worked through all the aspects of the app? Clicked every button? Filled in every form?

- Try a tour of the product to identify everything it does.

- **User scenarios**
  - How is this application supposed to be used?
  - What problems does it solve for users?
  - What are the goals of end users that this application helps them solve?

- **Network**
  - Wi-Fi
  - Wireless broadband
  - Dead spots

I SLICED UP FUN is a very good mnemonic, and mobile testers should know it in order to improve their testing work and to remember the important mobile aspects. Besides his mnemonic, Jonathan wrote an excellent book about mobile testing called *Tap into Mobile Application Testing*,[30] which is available on Leanpub and covers lots of mobile testing topics. The tour chapter is really interesting and an excellent source of knowledge.

30. https://leanpub.com/testmobileapps

The last mnemonic about mobile testing I want to mention is COP FLUNG GUN,[31] created by the company Moolya. This mnemonic covers the following topics and is worth looking at:

31. http://moolya.com/blogs/2012/04/121/Test-Mobile-applications-with-COP-who-FLUNG-GUN

- Communication
- Orientation
- Platform
- Function
- Location
- User scenarios
- Notifications
- Guidelines
- Gesture
- Updates
- Network

Important

Mnemonics are great approaches you can use to remind yourself of important things. They will help you organize your testing approach, testing strategy, and thoughts.

Mind Maps

Mind maps are another great way to visually organize information as they can help you to process your thoughts and ideas on certain topics such as mobile testing. Rosie Sherry, the woman behind Ministry of Testing,[32] a platform and professional community for software testers who lead the way in software testing content, training, and events, created and published two great mind maps about mobile testing. One of her mind maps is shown in Figures 4.3 through 4.8.

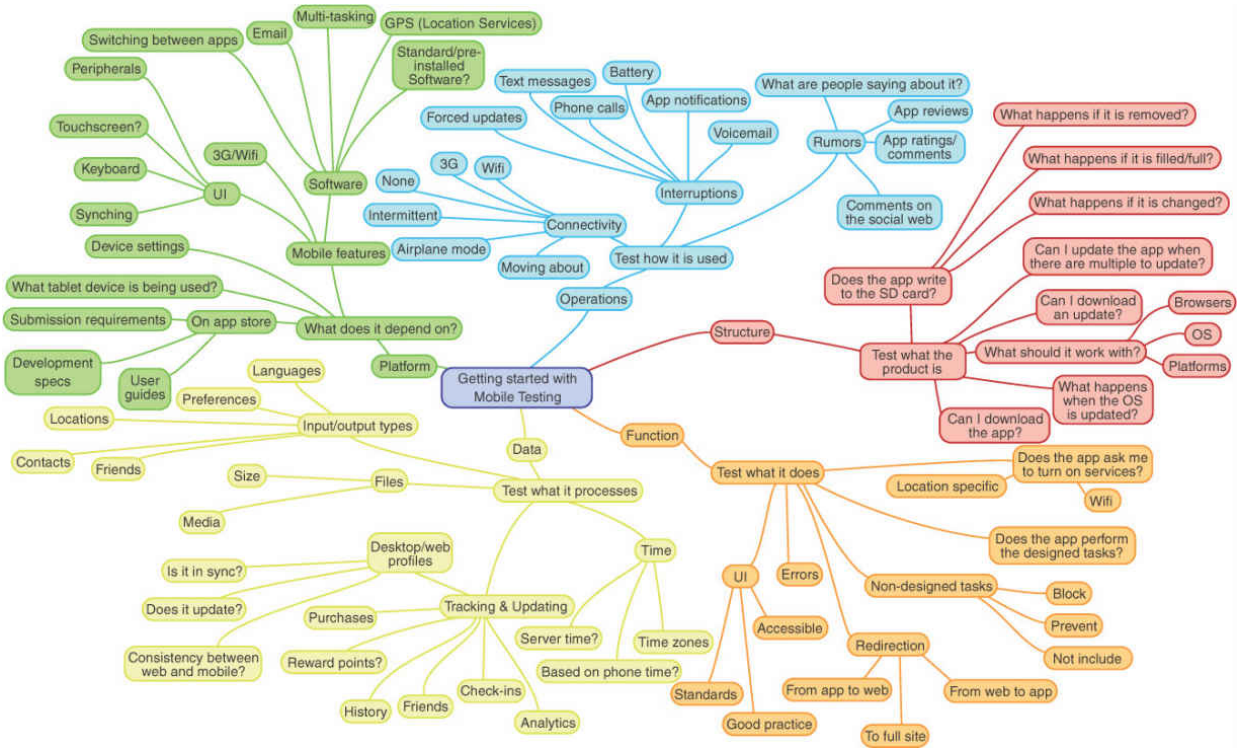

Figure 4.3 *Mobile testing mind map. Courtesy of Rosie Sherry and Karen Nicole Johnson. For a larger version of this image, see informit.com/title/9780134191713*

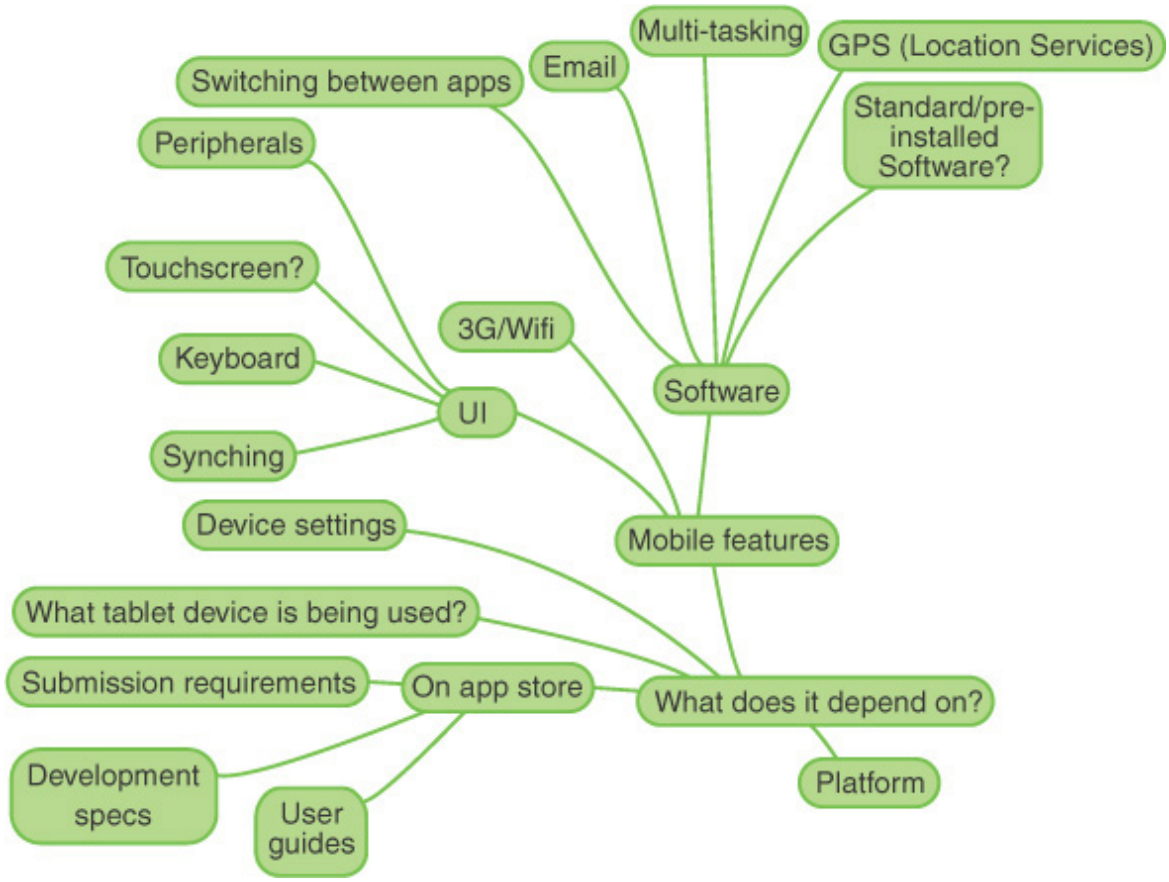

Figure 4.4 *Mobile testing mind map: mobile platforms. Courtesy of Rosie Sherry and Karen Nicole Johnson*

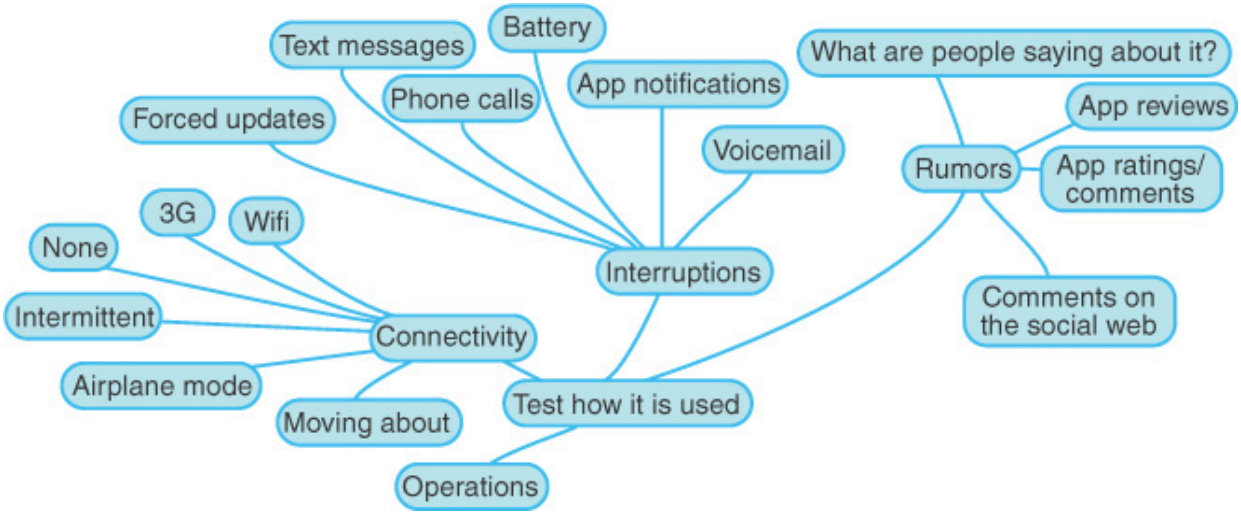

Figure 4.5 *Mobile testing mind map: mobile operations. Courtesy of Rosie Sherry and Karen Nicole Johnson*

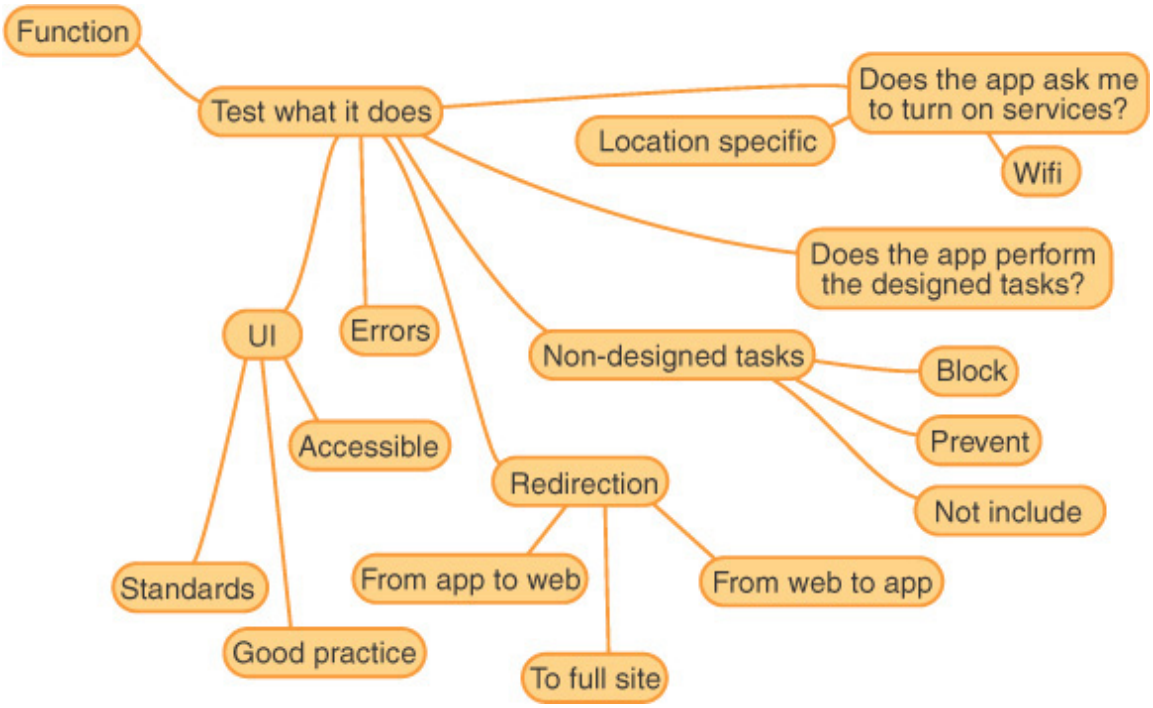

Figure 4.6 *Mobile testing mind map: mobile functions. Courtesy of Rosie Sherry and Karen Nicole Johnson*

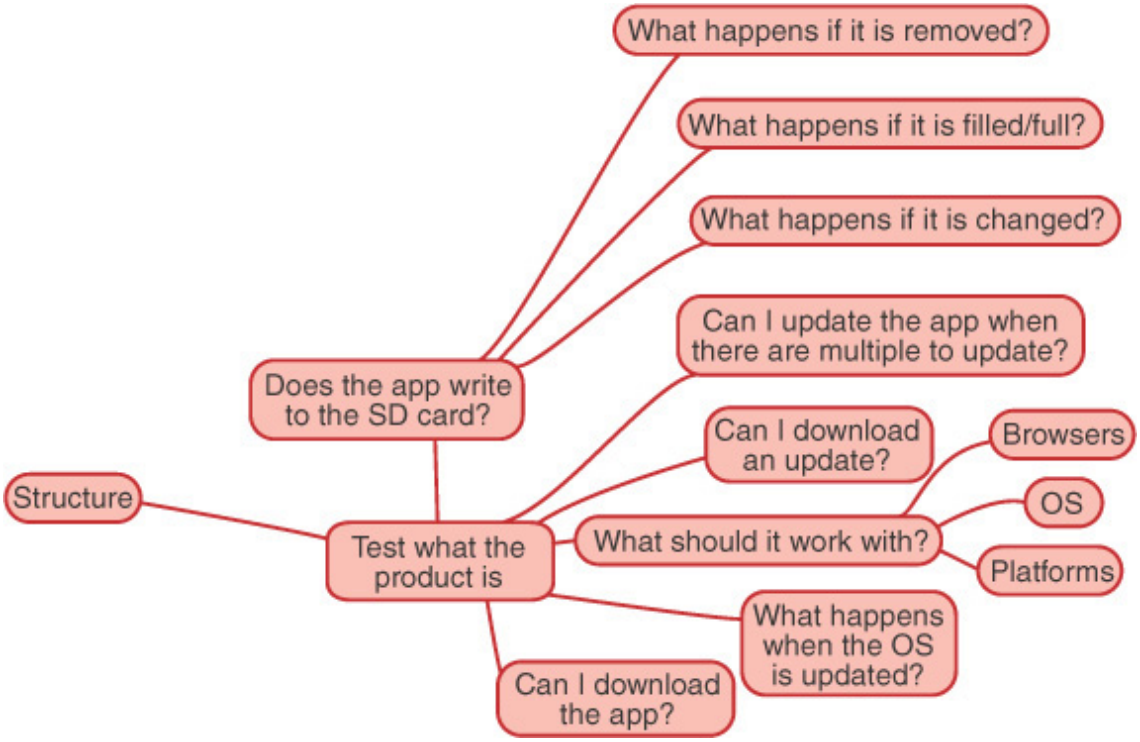

Figure 4.7 *Mobile testing mind map: mobile structure. Courtesy of Rosie Sherry and Karen Nicole Johnson*

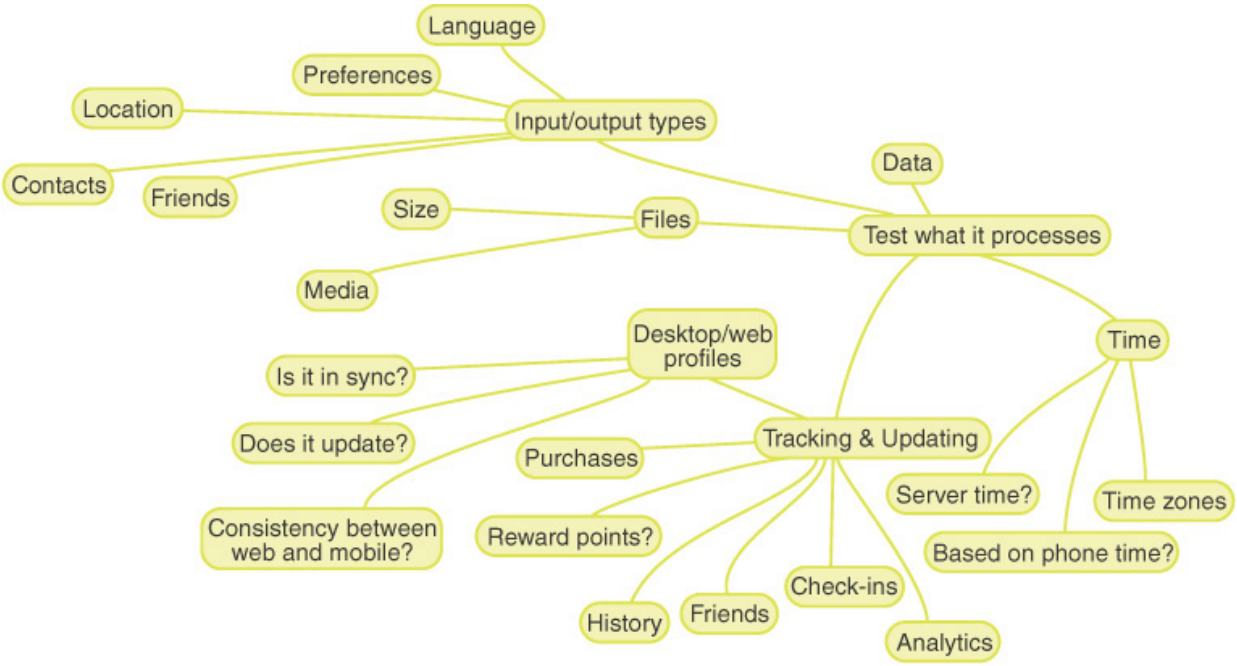

Figure 4.8 *Mobile testing mind map: mobile data. Courtesy of Rosie Sherry and Karen Nicole Johnson*

32. www.ministryoftesting.com/

Both mind maps can be downloaded in high resolution from Ministry of Testing 1[33] and Ministry of Testing 2.[34] The mind maps Rosie created are based on the mnemonic from Karen Nicole Johnson.

33. www.ministryoftesting.com/2012/06/getting-started-with-mobile-testing-a-mindmap/

34. www.ministryoftesting.com/2012/05/mobile-testing-course-pictures-and-a-mindmap/

Another great interactive mind map project is the Testing Map,[35] which covers lots of different areas of software testing and provides some really useful ideas.

35. http://thetestingmap.org/

Important

Try to create your own mind map based on your app by adding possible testing tasks. Furthermore, print it out and put it up in the office. That way, your colleagues will stand to benefit from it as well.

How to File Mobile Bugs

We've now come to the last topic in this chapter, "How to File Mobile Bugs." If you find a bug within a mobile app, you need to report it in order to get it fixed. Filing mobile bug reports requires some additional information that the developers need in order to reproduce and fix the bug.

But what is important when filing a mobile bug? What should a bug report look like? Before I answer those two questions, I want to raise another one: Why even send a bug report?

Bug reports are very important for the product owner, product manager, and the developers. First, a bug report tells the developers and the product owner about issues they were not aware of. It also helps to identify possible new features no one has thought of, and last but not least, it provides useful information about how a customer may use the software. All of this information can be used to improve your software.

Whenever you find something strange, if something behaves differently or looks weird, don't hesitate to file a bug report.

Let's come to the question of what a bug report should look like and what's important when filing it.

A bug report should contain as much information as possible in order to identify, reproduce, and fix the bug. That said, your report should only include information that's important to handling the bug, so try to avoid adding any useless information. Another important point is that you should describe only one error per bug report. Don't combine, group, or create containers for bugs. It's likely that not all of the bugs will be fixed at the same time, so refrain from combining or grouping them.

The information described in the following sections should be included in a bug report.

Bug ID

A bug must have a unique identifier such as a number or a combination of characters and numbers. If you're using a defect management tool, the tool will handle the bug IDs for you. If not, think about a unique ID system for your project.

- **Bad:** *123* is a unique ID, but you might have several projects whose IDs are the same.

- **Good:** *AppXYZ-123* is good because you're combining an ID with a project abbreviation and a number.

Description

Create a short but meaningful description in order to provide the developer with a quick overview of what went wrong without going into detail. You should, for example, include error codes or the part of the application where the bug occurred.

- **Bad:** "The app crashed," "White page," "Saw an error," "Bug"
- **Good:** "Error Code 542 on detail message view" or "Time-out when sending a search request"

Steps to Reproduce

This is one of the most important points. Provide the exact steps together with the input data on how to reproduce the bug. If you are able to provide this kind of information, the bug will be very easy to fix in most cases.

- **Bad:** "I tried to execute a search."
- **Good:** "Start the app and enter 'Mobile Testing' into the search input field. Press the search button and you'll see the error code 783 on the search result page header."

Expected Result

In this section you should describe what you expected to happen when the bug occurred.

- **Bad:** "It should work" or "I didn't expect it to crash."
- **Good:** "I expected to see a search results page with a scrollable list of 20 entries."

Actual Result

What happened when the bug occurred? Write down the actual result, what went wrong, or the error that was returned.

- **Bad:** "It just won't work."
- **Good:** "The search results page was empty" or "I got the error code 567 on the search results page."

Work-around

If you've found a way to continue using the app and avoid the bug, explain your steps. Those steps are important to know since the work-around could cause other problems or indicate a way in which the app should not be used. On the other hand, a work-around can be very useful for the customer support team in order to help customers solve the current problem until the bug gets fixed.

- **Bad:** "I found a work-around."
- **Good:** "If you put the device into landscape mode, the search button is enabled and the user can search again."

Reproducible

If you found a reproducible bug, that's fine, but does it occur every time? If it happens every time, that's great as it should be an easy fix for the developer. But if the bug occurs only 20% of the time, it is much harder to find a solution. Make sure you provide this information, as it is very useful for the developer and will prevent the bug from being closed with the comment "Can't be reproduced."

- **Bad:** "Sometimes"
- **Good:** "The bug occurs two out of ten times."

Operating System, Mobile Platform, and Mobile Device

Another important component of a bug report is information about the operating system, the mobile platform, and the mobile device. Write down the operating system, mobile platform, and device on which the bug occurred.

- **Bad:** "On Android" or "On iOS"
- **Good:** "Android, Version 4.1.2 Google Nexus 4" or "iOS, Version 6.1 iPhone 4S"

Mobile-Device-Specific Information

Mobile devices have lots of interfaces and sensors that could have an impact on your app. The battery could also affect the app you're testing. Write down all of this information in your bug report.

- **Bad:** No information

- **Good:** “GPS sensor activated, changed the orientation from landscape to portrait mode” or “Used the device in a sunny place” or “Battery state was 15%” or “Battery state was 100%.”

Browser Version

If your app is a mobile Web app and you found an issue, it’s very important to note the browser version where you found the bug as it may occur only in a certain browser version.

- **Bad:** “Google Chrome” or “Mozilla Firefox”
- **Good:** “Google Chrome version 45.35626” or “Mozilla Firefox 27.6”

Software Build Version

Another really useful piece of information is the current build version of the app where the bug occurred. This will prevent the developer from wasting time trying to reproduce a bug that’s already been fixed in the current code base.

- **Bad:** No information
- **Good:** “App build version 1.2.3”

Network Condition and Environment

When filing a mobile bug, it’s important to provide some information about the network condition and the environment in which the bug occurred. This will help to identify the problem more easily and will possibly show some side effects no one has thought of.

- **Bad:** No information or “Happened on my way to work”
- **Good:** “I was connected to a 3G network while I was walking through the city center.”

Language

If your app supports several languages, provide this information in your bug report.

- **Bad:** No information
- **Good:** “I was using the German-language version of the app.”

Test Data

A complete bug report must include the test data that was used to reproduce the bug. Simple test data can be login credentials with username and password. However, in some cases it is not enough to provide just a username and password. It is very likely that you need to provide complete test data sets, for example, as an SQL dump or a test data script that will generate the necessary data.

- **Bad:** No information
- **Good:** "Find the attached SQL script to put the database in the defined state" or "Enter 'Mobile Testing' into the search input field."

Severity

Every bug you find needs a severity level. Either your defect management tool will offer you some categories, or you have to define them with your team. It is important to give a bug a severity level as it will allow the team to prioritize their bug-fixing time so that critical and high-priority bugs will be fixed first. If this information is not provided, it takes much more time to find the bugs that need to be fixed before the release. The default severities are Critical, High, Medium, and Low.

- **Bad:** No information
- **Good:** "Critical" or "Medium"

Bug Category

In addition to the severity level, the bug category is also a very useful piece of information. The product owner or the developer can filter by category to get an overview of the current status of bugs per category. For example, if there are lots of UX bugs, this may be an indicator of a poor UI and UX or a missing design expert in the team, meaning that the app needs some more design improvements.

- **Bad:** "No information"
- **Good:** "Functionality" or "UX" or "Performance"

Screenshot or Video

Whenever you find a bug, try to create screenshots or a video to provide the developer with more information. When providing a screenshot, use an image-editing tool to mark the bug in the screenshot. A video is also a great way to describe a bug you've come across. It is also very useful to give the screenshot or the video a good name or description.

- **Bad:** "No screenshots or videos attached" or "Screenshot1.png"
- **Good:** "01_InsertSearchTerm.png, 02_SearchResultPageWithError.png"

Log Files

If your app crashes or freezes, connect the device to your computer and read out the log files. In most cases a stack trace will be shown with a description of the error. This kind of information is extremely useful for developers, as they know right away in which class the bug or the error has occurred.

- **Bad:** "No information provided when the app crashed."
- **Good:** "Provided the full stack trace in the bug report" or "Attached the log file to the report."

Tester Who Found the Bug

Write down your name or the name of the tester who found the bug. Developers or product owners may have some questions about the reported bug, and they will of course want to get in touch directly with the tester who found it. In most cases, this is automatically done by the defect management system where each user has his or her own account. If not, make sure you add your e-mail address and/or phone number.

- **Bad:** No information
- **Good:** "Daniel Knott, daniel@adventuresinqa.com"

Three More Points

As you have seen, there is a lot of information that should be included in a bug report. There are three other points you should keep in mind when writing a bug report.

The first one is *Don't get personal*. When filing a bug report, describe the software misbehavior rather than the developer's mindset or the quality of his or her work. Don't use offensive or emotionally charged words as those kinds of reports will be ignored by the developer and will end up causing bad blood within the team.

The second one is *It's not you*. It's not your fault that the bug occurred. It is the software that's broken, and you and your colleagues need to fix it.

And the third point is *Keep it simple*. Try to write your bug report in such a way that someone with no idea about the project or the app is able to understand the problem. If the bug report is that easy, every developer within the team will be able to fix it and nontechnical colleagues can understand the problem and will value your work.

App Quality Alliance

If you want to get further information about how to test your Android or iOS app, have a look at the nonprofit group App Quality Alliance site.[36] This group is headed by different core members and knowledge contributors such as AT&T, LGE, Microsoft, Motorola, Oracle, Samsung, and Sony Mobile. The main aim of the group is to work very closely with the industry to improve the quality of mobile apps.

36. www.appqualityalliance.org/

The group devised testing criteria for Android and iOS apps. You can download both PDF documents via the following links:

- Testing criteria for Android apps (www.appqualityalliance.org/AQuA-test-criteria-for-android-apps)
- Testing criteria for iOS apps (www.appqualityalliance.org/AQuA-test-criteria-for-iOS-apps)

Both documents contain lots of test cases that your app should run through before you submit it to the app stores.

The group also provides information about mobile app performance testing as well as best-practice guidelines for developing quality mobile apps. You can download both documents via the following links:

- Performance testing criteria (www.appqualityalliance.org/aqua-performance-test-criteria)

- Best-practice guidelines for developing quality mobile apps (www.appqualityalliance.org/AQuA-best-practice-guidelines)

The group's Web site is definitely worth checking out, and maybe you'd even like to contribute.

Summary

Chapter 4 is one of the main chapters of this book and contains lots of testing ideas and solutions that can be used in your daily working life. The chapter started with a description of the differences among emulators, simulators, and real devices and what is important to know about them. Before the hands-on part of the chapter I explained the difference between manual and automated testing as well as the role of traditional testing in the mobile testing business. If you are familiar with "traditional" software testing such as for Web or desktop applications, that knowledge is also useful for mobile apps. Lots of the testing approaches for Web or desktop applications are also valid for mobile apps such as white box and black box testing techniques. However, when it comes to mobile testing, there are more areas you need to test in order to be sure that your app is working on different levels and with different hardware and software versions. In this chapter I described the following mobile-related topics:

- Mobile usability testing
- Accessibility testing
- Battery usage testing
- Stress and interrupt testing
- Performance testing
- Standby testing
- Installation testing
- Update testing
- Database testing
- Local storage testing
- Security testing
- Platform guideline testing
- Conformance testing
- Checking the log files

I also provided checklists of sample test cases that can be executed, such as before the app is submitted to an app store. Furthermore, I showed different mnemonics and mind maps that can be useful for your mobile testing activities.

The chapter ended with a detailed overview of how to file a mobile bug with lots of do's and don'ts.

Chapter 5. Mobile Test Automation and Tools

This chapter is all about tools. I describe the different types and concepts of mobile test automation tools and give you some advice on where to automate and how to select a mobile test automation tool for your app and development environment. I also explain continuous integration and beta distribution tools.

This chapter doesn't cover how to install and configure the different mobile test automation tools. The reason for this is simple: The tools provide installation and configuration guides already, so you can just visit their Web sites to find all the information you need. Details about each tool will be provided in the relevant sections of this chapter.

The Flipped Testing Pyramid

Before I start with the mobile test automation tools, I want to briefly explain the test automation pyramid. Anyone who is involved in software testing and software test automation should know the test automation pyramid introduced by Mike Cohn.[1]

1. www.mountaingoatsoftware.com/

As you can see in Figure 5.1, the typical pyramid consists of three layers. At the bottom there is the automated unit testing layer; in the middle, the automated integration testing layer; and at the top, there is the automated end-to-end (E2E) testing layer (including the user interface tests). Each layer has a different size, indicating the number of tests that should be written within each stage. Manual testing is not part of the test pyramid; hence it is shown as a cloud for additional testing work.

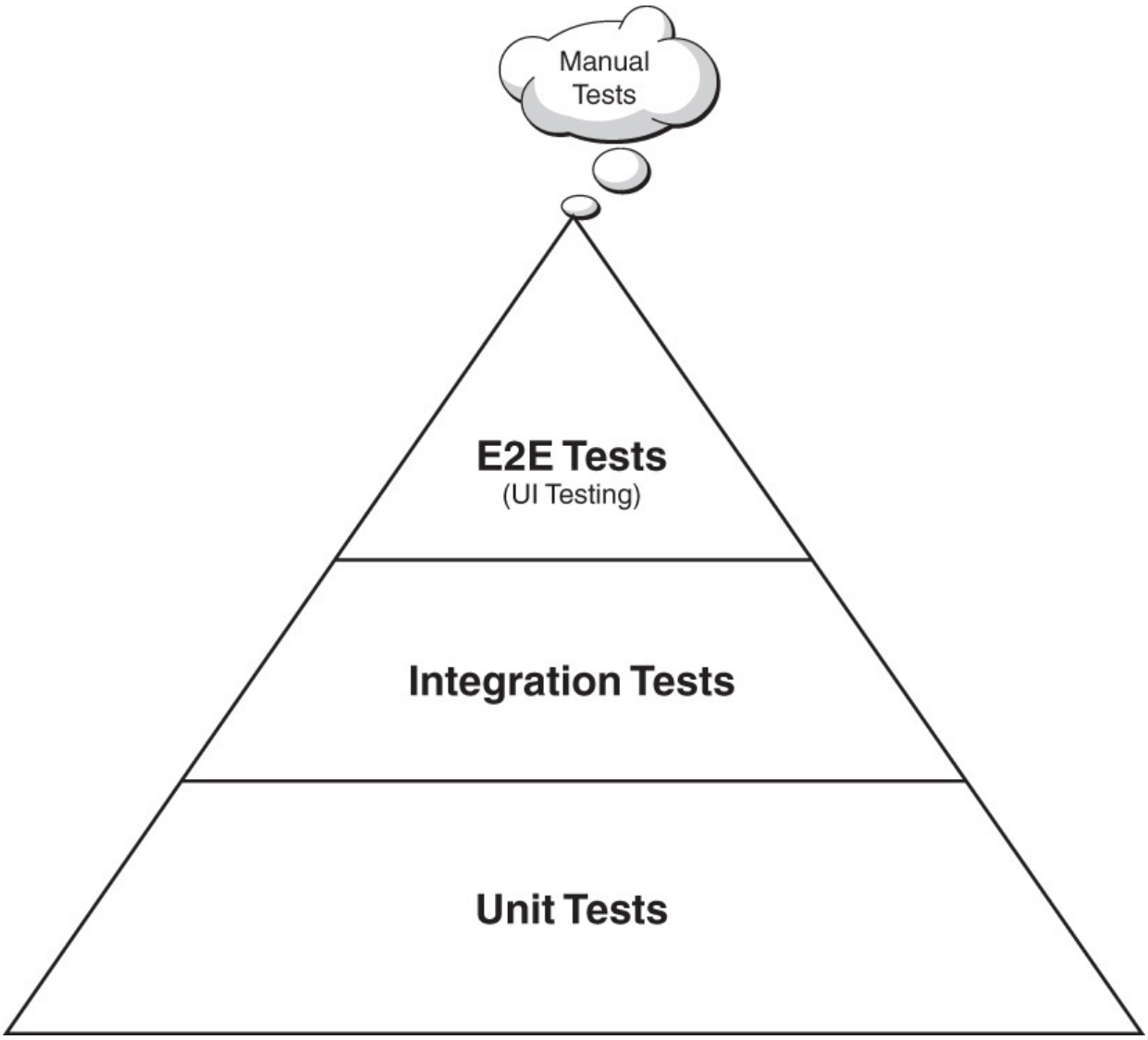

Figure 5.1 *Default test automation pyramid. Based on a figure by Mike Cohn.*

But this pyramid is not applicable to mobile apps and mobile test automation. As you learned several chapters ago, mobile testing requires a totally different set of tests—movement, sensors, different devices and networks—from other software such as desktop or Web applications. Lots of manual testing is required to be sure that a mobile app is working as expected in the different usage scenarios.

Mobile test automation tools are not currently as mature as their counterparts for Web and desktop applications, which leads to a flipped test automation pyramid. As the tools become increasingly mature, this pyramid is likely to flip back again because the default test automation pyramid is based

on a more stable foundation (see Figure 5.1). The default pyramid therefore can't be used as an indicator of test automation and manual testing in the mobile world.

The flipped testing pyramid looks like Figure 5.2.

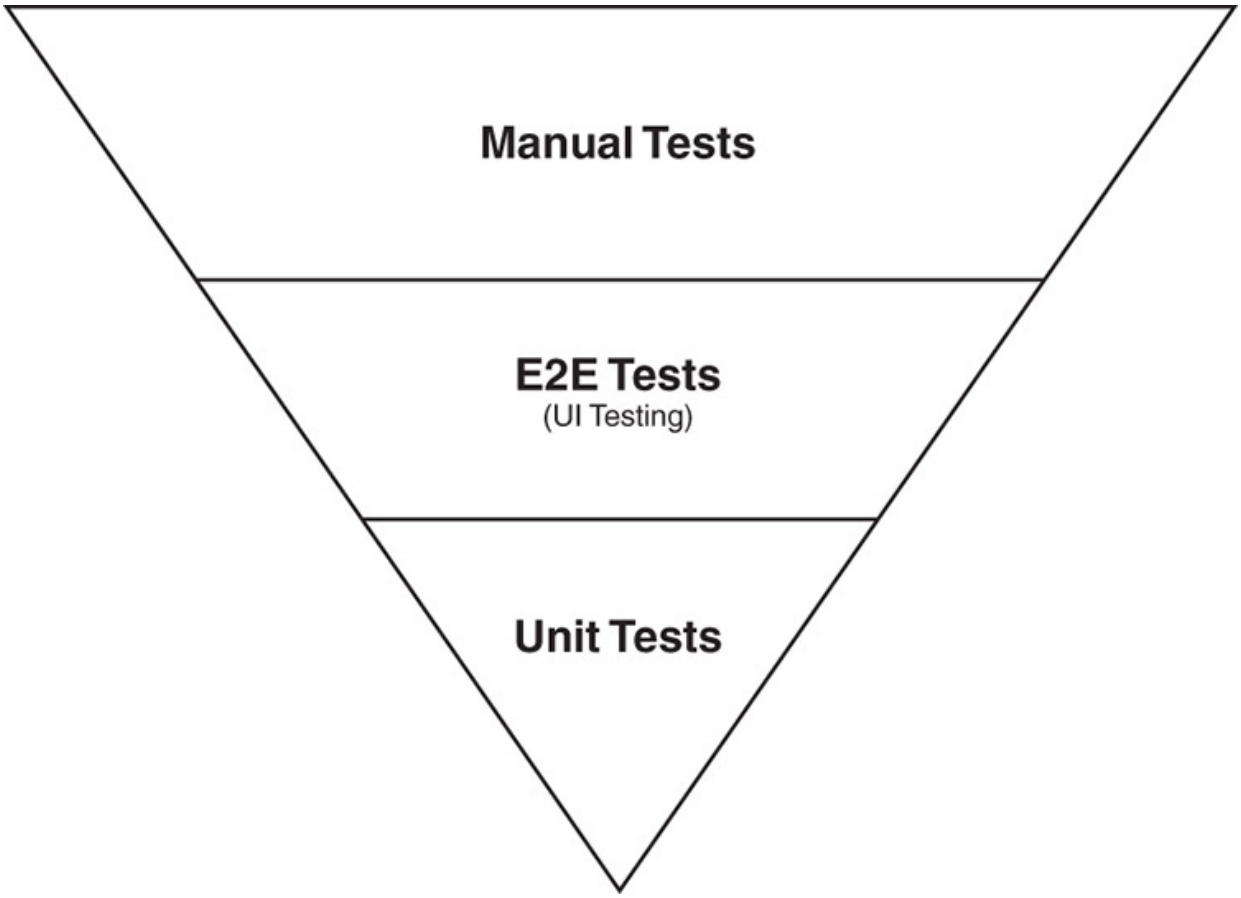

Figure 5.2 *The flipped testing pyramid*

In this version of the pyramid, the automated unit testing layer is the smallest one. This is the case because not every unit or method of mobile apps can be tested in an isolated manner. In some cases, different APIs, layers, or systems may need to be faked or mocked in order to get the small unit to work. This is also the case for every other software application, but in some cases mocking or faking other systems for mobile apps is much more complex. This is not efficient from a technical or economic point of view. However, it's no excuse for not writing mobile unit tests at all. The business logic of an app must be tested at the unit level.

The next stage is the end-to-end test automation layer. Within this layer, the app is tested from a user perspective to make sure the whole system is

working, from the app's user interface through to the backend system via a wireless network, including integration testing with different libraries or APIs. The integration testing layer is therefore part of the end-to-end layer.

The biggest change in this pyramid is that manual testing is part of it. Mobile testing requires lots of manual testing, and this can't yet be replaced by test automation or any other tools.

Nevertheless, mobile test automation is a really important topic, and every mobile tester should be able to write automated regression tests that provide fast feedback about the current quality state of an app. Furthermore, test automation helps the team build a reliable and robust mobile app that makes the customers happy.

The Mobile Test Pyramid

The flipped testing pyramid has no stable foundation, and mobile testing requires lots of manual testing, which is why I created my own mobile test pyramid consisting of four layers including manual and automated steps (see Figure 5.3). The biggest layer of the pyramid, manual testing, forms the strong foundation for every mobile app project, followed by end-to-end testing, beta testing, and a top layer comprising unit testing. The gray parts of the pyramid indicate the automated steps, and the white parts are the manual testing steps. The beta testing layer is new to the pyramid but essential to every mobile app project. Keeping the high expectations of mobile users in mind requires that this layer be part of every mobile project to get early feedback from your mobile customers. You can either use a crowd testing approach for your beta testing, or you can ask your colleagues to beta-test early versions of your app to provide important feedback.

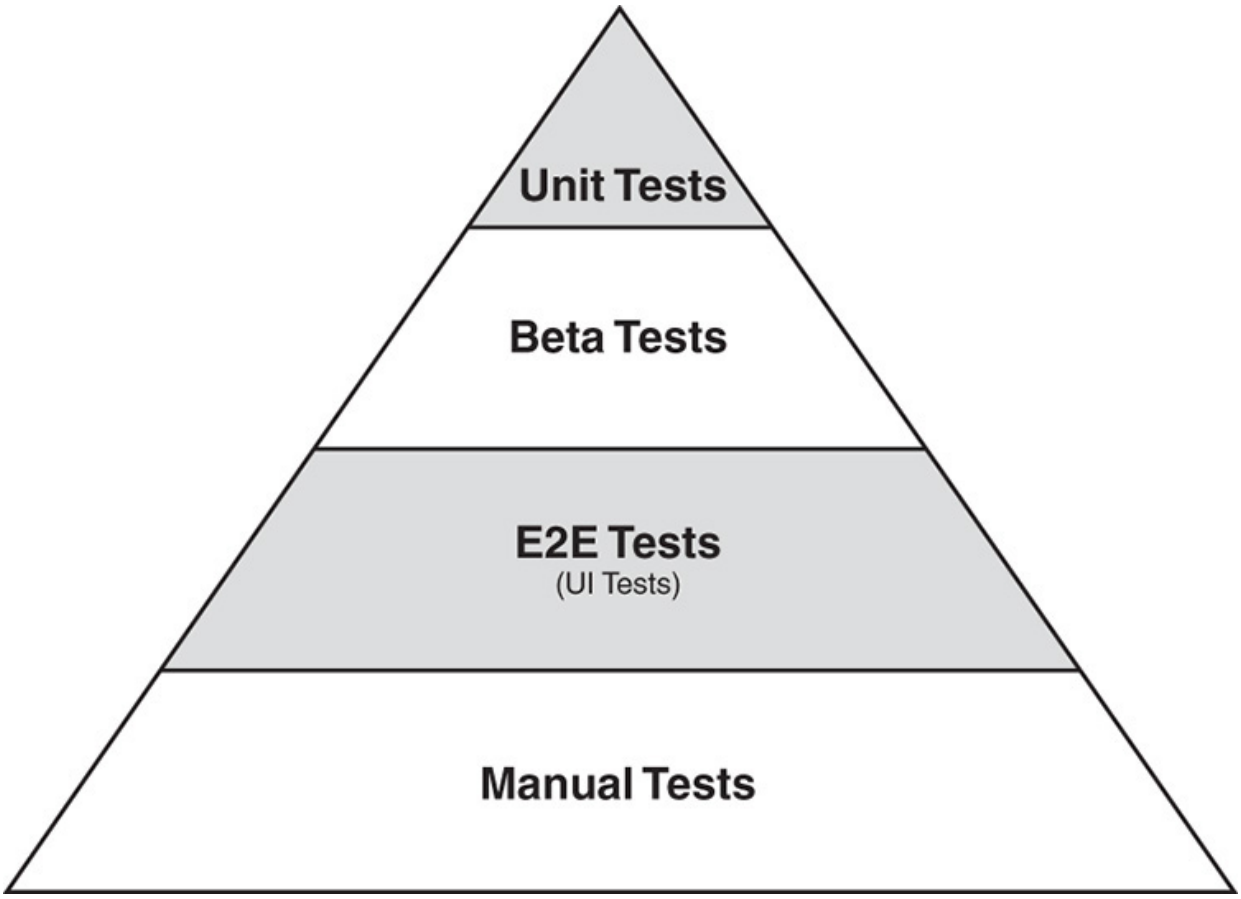

Figure 5.3 *The mobile test pyramid*

I have used this mobile test pyramid in several projects and it helped me set up a reliable, effective, and valuable testing process.

> **Important**
>
> Keep the problem of the flipped pyramid in mind and use the mobile test pyramid in your project to have a good mix of manual and automated testing.

In this chapter, I focus more on the end-to-end test automation tools because those are the tools mobile testers will most likely work with. However, some unit testing tools are also mentioned.

Different Types of Test Automation Tools

Before you start with mobile test automation, it is important that you understand the underlying architecture of the different mobile platforms. You need to know how to access the different objects of app-like buttons, labels, lists, views, and any other kind of element in order to interact with those elements during the test run.

You also need to be able to write code and build up reliable test automation suites that are integrated within your app's development pipeline.

When selecting a tool, you should know the different types and concepts of mobile test automation tools and how those tools access the different objects. This is important to know when selecting a tool for your needs and project because each approach has its pros and cons.

Image Recognition

Tools that use the image recognition approach compare images in order to drive the user interface of an app. When writing the test automation script, you take screenshots, for example, of buttons or labels that are embedded into your script. When the script is executed, the image recognition tool compares the current screen with the stored baseline image. If the stored image is found on the screen, the script will execute the programmed steps.

Those kinds of tools are really useful if the UI of the app doesn't change too often, is developed for several mobile platforms, and has exactly the same user interface and control elements. In that case, image recognition tools are a great and fast way of writing test automation for cross-platform mobile apps.

The biggest disadvantage of image recognition tools is the high maintenance involved with the test scripts. The scripts will not work if the orientation of the device is changed, such as from portrait to landscape mode, on bigger screens, or if the screen resolution changes. Another drawback is testing an app in different languages, which is not possible since the captured images are available only in one language and will not work with other languages.

Here are some examples of image recognition tools:

- eggPlant (www.testplant.com/eggplant/testing-tools/eggplant-mobile-eggon/)
- RoutineBot (www.routinebot.com/)
- Sikuli (www.sikuli.org/)

- TestObject (https://testobject.com/)

Coordinate-Based Recognition

Coordinate-based recognition tools rely on predefined *x* and *y* axis coordinates to access and interact with the UI elements of the app. If the coordinates of the element change, the whole script needs to be adapted to the new values. This has a major impact on the maintenance of the scripts in order to build reliable tests.

Here are some examples of coordinate-based recognition tools:

- MonkeyTalk (www.cloudmonkeymobile.com/monkeytalk)
- Perfecto Mobile (www.perfectomobile.com/)

OCR/Text Recognition

Mobile test automation tools that use the OCR and text recognition approach obtain the text of the control elements that are visible on the screen of the mobile device. To determine if the text is visible on the screen, OCR technology is used.

OCR and text recognition tools can handle different screen resolutions, orientations, and sizes. However, such tools can verify only text elements that are visible on the screen. If the text changes or is removed from the app, the UI element is very difficult (or impossible) to identify. You are not able to check if, for example, a UI view is visible, if a list is present, or if elements without text are shown on the screen. Another drawback of OCR recognition tools is that they are very slow because the whole screen needs to be scanned for the text.

Here are some examples of OCR/text recognition tools:

- eggPlant (www.testplant.com/eggplant/testing-tools/eggplant-mobile-eggon/)
- MonkeyTalk (www.cloudmonkeymobile.com/monkeytalk)
- Robotium (https://code.google.com/p/robotium/)
- SeeTest (http://experitest.com/)
- TestObject (https://testobject.com/)

Native Object Recognition

Tools that use the native object recognition approach detect the UI objects with a UI element tree. The UI elements can be accessed using XPath (XML Path Language), CSS (Cascading Style Sheet) locators, or the native object ID of the element. The native object recognition approach is very common in the different test automation tools covering native, hybrid, and mobile Web apps. This approach enables you to get access to the native elements such as buttons, labels, views, lists, and other kinds of UI elements. If the IDs or the locators are well defined and written, the test scripts are reliable in the event of changes and therefore reusable on other devices as well. This is a huge advantage compared to all of the other tools because the scripts do not depend on changes to the UI, resolution, orientation, or the device itself. The majority of the test automation tools support this approach for detecting the elements.

Here are some examples of native object recognition tools:

- Appium (http://appium.io/)
- Calabash (http://calaba.sh/)
- Espresso (https://code.google.com/p/android-test-kit/)
- Robotium (https://code.google.com/p/robotium/)
- Selendroid (http://selendroid.io/)
- Selenium (http://docs.seleniumhq.org/)
- TenKod EZ TestApp (www.tenkod.com/ez-testapp/)

Capture and Replay

Lots of tool manufacturers advertise capture and replay functionality. Tools that support this technology are able to record actions such as clicking, scrolling, swiping, or typing into a script. With the help of the replay function, the software will execute the exact same actions over and over again. This technology sounds great in theory, but in reality and day-to-day test automation work, capture and replay tools should be used and handled with care. But why?

I have worked with different capture and replay tools, and every tool presented the same problems. The captured scripts were not reliable at all. They were affected by UI, orientation, and screen resolution changes (most of them use coordinate-based or image-based recognition). The scripts were not

reusable from device to device or on different mobile operating system versions of the same mobile platform.

Often the scripts were not able to start because the device was not in a defined state, meaning that the tool was not able to replay the script. Often the scripts must be edited manually to be more stable and reliable. Another problem that always occurred was a timing issue as the tools were either too fast or too slow to interact with the application while the script was replayed. The only way to solve this issue was to add wait operations, but this is not a good approach for writing test automation scripts. Using wait or sleep operations is flawed and leads to unreliable test results.

However, there are also some good qualities; for example, mobile testers who have no programming skills can use the tools to generate some basic test automation scripts with very little training. On the other hand, they are not able to modify the script afterward.

However, don't use capture and replay tools to build up a huge test automation suite for your mobile app; otherwise you will end up with a nonmaintainable test suite. I recommend that you use these kinds of tools as a starting point to record basic interactions within your app and get the UI selectors of the elements. The recorded UI selectors or IDs can then be used as a foundation for further programming to build up a test automation suite based on your own programming.

Tool Type Recommendation

Before I recommend a tool type and approach, I want to briefly summarize the mobile test automation tool landscape. Most of the tools are specific to a mobile platform, irrespective of whether they use the image, coordinate, OCR, or native object recognition approach. There are very few tools that support more than one mobile platform such as Android, iOS, Windows Phone, or BlackBerry. However, no tool is able to automate multiple mobile platforms with one test code base. There are some test automation tool providers who promise to be able to automate everything on every mobile platform, but that's not true. Every mobile platform has specific requirements for usability or navigation usage of an app, meaning that you also need to have multiple test code bases in order to automate them.

In most mobile projects, you have to deal with multiple code bases of different programming languages and test automation tools in order to build up

a testing and development pipeline.

In my opinion, a mobile test automation tool must be able to access the native object properties that are used to identify and to interact with the native elements. This is the best and most efficient way to write test automation scripts for mobile apps. Writing such test scripts requires more effort and programming skills, but the scripts are much more reliable and robust to changes and can be executed on different devices and screen resolutions.

You should therefore use native object recognition tools in your project based on the app type you are testing (native, hybrid, or Web apps).

> **Important**
>
> Remember that some mobile test automation tools support more than one recognition approach. Combine the approaches in your test scripts, but keep the pros and cons in mind as well as the fact that no tool is perfect.

What Should Be Automated?

When you have the task of determining which tests should be automated or not, keep one thing in mind: It is impossible to automate every feature or test case of a mobile app.

Now, you have to answer this question: What should be automated?

Creating a smart mobile test automation plan requires careful planning and design work that should be performed before automating a single test case. First, you should define a goal for your mobile test automation and determine what kinds of tests you want to automate. Keeping the mobile test pyramid in mind can help you to define the unit tests and end-to-end user tests. But you should still remember that you need lots of manual mobile testing and that not everything can be automated. However, you can turn some manual tests into automated tests to save time and testing effort.

Possible goals for your mobile test automation could be:

- Automate the business-critical parts.
- Automate user workflows and scenarios.
- Automate only complex app scenarios.
- Automate sequences that need to be repeated several times.

- Automate only the acceptance criteria.
- Build up a regression test suite.
- Automate only if it is economically reasonable.

If some test cases are performed only a few times, it's probably more economical to leave them for manual testing. If you're worried about forgetting them, add them to a checklist. Tests that need to be run frequently and require lots of inputs and actions should be automated. But don't create large and complex automated test scenarios as those kinds of tests are difficult to maintain, edit, and debug and are likely not to be stable. Keep the tests small and independent of one another.

It is also important to keep the critical parts of the app in mind such as the login or payment process as they have a huge impact on the app, your business, and the people who use it. If the critical parts are not well tested or automated, you may suffer a lot of damage to your reputation.

Another important factor when deciding which tests are to be automated is the time and the money involved. If you need lots of time to automate a mobile test scenario, ask yourself if it is worth automating as a lot of time spent on one specific scenario will cost lots of money. And is the invested time saved later on when the test is automated rather than manual? Ask yourself this question from time to time; you may find that it's OK to test manually.

When automating a test for a mobile app, keep the different mobile devices in mind. Only automate the tests that can be executed on every target device. Try to automate the tests in as general a manner as possible so you can execute them on several devices. And don't forget to automate with different languages if your app is going to be available in various countries. Use the UI element IDs to identify and drive those elements and to implement robust tests.

There is no generic answer to the question "What should be automated?" The answer will be different for every mobile app and depend on the app type, mobile platform, and app purpose.

Every mobile tester should keep the following points in mind when answering this question:

- It is not possible to automate testing of the entire app or all of its features.
- Define a goal for your test automation.

- Define end-to-end tests.
- Start test automation as early as possible together with the app development.
- Keep the time and the costs that are needed for the test automation in mind.
- Keep the tests small, fast, simple, and independent.
- Keep the different mobile devices in mind.
- Execute the tests as early as possible and as often as possible.

Important

Don't try to automate everything. Define test automation goals depending on your app and start automating those goals.

Emulator, Simulator, or Real Device?

The next question you need to answer is whether you should automate with emulators, simulators, or real devices. In Chapter 4, "How to Test Mobile Apps," I described the differences among emulators, simulators, and real devices when mobile testing is performed manually. My recommendation there was to use the emulators/simulators for very basic tests and to do manual testing on real devices. But is this also the case with mobile test automation?

Before I answer this question, let's have a look at the pros and cons of emulators/simulators and real devices.

Emulator/Simulator Pros

The biggest advantage of emulators/simulators is the price. Both are free to use and are part of the SDK from the different mobile platforms. Besides that, they are really simple to use and offer various options for developers and testers. After the emulator/simulator is installed, you can create the simulators/emulators using different configurations such as operating system versions or screen resolutions.

Emulator/Simulator Cons

If we look at the cons of the emulators/simulators, there are some more points that you should be aware of. Using emulators/simulators increases the risk of missing important bugs that occur only on real devices. Emulators/simulators are not the same as the real environment, which is a huge disadvantage. Additionally, emulators/simulators offer only a "plain" and simple mobile operating system. They offer no diversity in terms of the different devices, operating systems, and adaptations of the user interface. This is especially the case with Android where several device manufacturers change the UI of the Android system to suit their needs. From a hardware perspective, they also fail to offer a real device environment with all of the relevant sensors and interfaces.

The next disadvantage of mobile emulators/simulators is that the data networks are not real. Network speeds can be simulated, but this will not cover the real data networks with traffic loss or change in network speeds and technologies. And, finally, emulators/simulators do not offer the same performance as real devices in terms of CPU, GPU, memory, or sensors.

Every mobile tester should keep the following points in mind when using emulators or simulators within a project:

- It is risky not to test in a real environment.
- There is no diversity in terms of hardware and software.
- The network environment is simulated.
- There is no real device performance.
- There is no access to device-specific hardware elements such as the camera, GPS, or other sensors.

Real Device Pros

Testing on real devices offers lots of advantages compared to an emulator/simulator. The tests will be executed in a real user environment and therefore the results will be closer to a real user experience, including any discovered bugs. Testing on real devices also offers the option of using the full device's hardware, software, and device-specific features such as sensors, CPU, GPU, and memory. Using the real device for testing shows the real behavior in terms of performance.

The following points summarize the pros of using real devices for testing:

- Real device testing offers reliable test results.
- Real hardware and software features are used.
- The real user experience and app performance can be tested.
- Tests are done in real data networks.

Real Device Cons

Testing on real devices also has some disadvantages. The biggest one is the cost of buying all of the different mobile devices for developing and testing purposes. If you want to test on real devices, you have to buy new devices nearly every month in order to verify that your app runs on all the new features (hardware and software). In addition, you need someone who is responsible for maintaining all those devices. It's not enough just to buy them; you need to come up with a strategy for how to update the devices to newer versions and how to use them within your company.

The following points summarize the cons of using real devices for testing:

- The cost of having to frequently buy new devices is high.
- Maintenance of all the devices is time-consuming.

Where to Automate?

If we look at all the pros and cons, I think the answer to the question "Where to automate?" is pretty simple: on the real device!

Very simple and basic functional tests and test automation can of course be performed on an emulator/simulator to get fast feedback about the current state of a mobile app, and this is especially useful for developers.

However, if you as a mobile tester want to be sure that your app is using all the device-specific elements such as the hardware and software resources during the test automation session, you need to execute the tests on real devices. Executing the test automation scripts on real devices provides you with much better results in terms of reliability, performance, and real-world behavior of the app. Furthermore, you are able to execute the tests on several devices at the same time to quickly determine whether or not an app has a problem on a certain mobile device.

A good approach is to find a healthy mix of emulators, simulators, and real devices to get the best out of your test automation. It is enough if, for example, developers do their test automation on emulators and simulators because

scaling and executing test automation scripts in parallel on emulators/simulators is much easier and cheaper than on real devices. If you want to scale and build up an emulator/simulator matrix for your test automation, have a look at the Google TechTalk "Breaking the Matrix—Android Testing at Scale."[2]

2. www.youtube.com/watch?v=uHoB0KzQGRg

You as a mobile tester should write test automation scripts that will run on real devices as well as simulators/emulators.

> **Important**
>
> When selecting a mobile test automation tool, verify that the tool is able to execute the tests on both real devices and emulators/simulators.

How to Select the Right Mobile Test Automation Tool

So far you have learned about the different types of test automation tools as well as what should be automated and where the test automation should be performed. Now it is time to find the right mobile test automation tool for your app and your test and development environment.

When selecting a mobile test automation tool, you should keep some points in mind. The first point is that there is no "one size fits all" test automation tool available on the market. Every tool has its pros and cons, and not every tool is suited to every development environment and pipeline. Tool A could work well with project A but not with project B, meaning that the evaluation has to be repeated for every project.

To save some time in the tool evaluation phase, it is a good approach to implement a sample app that includes all of the elements your production app will have in order to see if the test automation tool is able to handle and interact with them. If the tool is able to fulfill all of your requirements for the sample app, you have probably found the right mobile test automation tool for your project.

The second point you should keep in mind is that mobile test automation requires programming skills in order to build up a robust, maintainable, and stable test automation suite. Do not use a capture and replay tool to compensate for a lack of programming skills; you will end up with a real

nightmare scenario because you can't fix the broken scripts. If you have no programming skills, try to learn them as you will need them in the future.

Besides developing a sample app to evaluate the mobile test automation tool, you can use the checklist in the next section with some selection criteria. This list will help you to find the tool best suited to your development and testing process.

Selection Criteria for a Test Automation Tool

The following points should be considered when selecting a mobile test automation tool:

1. Does the tool support different mobile app types (native, hybrid, Web apps)?
2. Which mobile platforms are supported (Android, iOS, Windows Phone, BlackBerry)?
3. Which recognition technology does the tool use (native, image, text, coordinate)?
4. Does the tool change the app you want to test (for example, by adding a server, instrumentation)?
5. Is the tool able to execute the tests on real devices as well as on emulators and simulators?
6. Is there a report available at the end of the test run?
7. Is the tool able to take screenshots while the tests are executed, and are those screenshots part of the test report?
8. Can the test suite be executed on several devices at the same time?
9. How long is the test execution time? Is it sufficient for your needs?
10. Does the tool support all of the UI and control elements of the mobile platform?
11. Is there support for a change of orientation from portrait to landscape and vice versa?
12. Is the tool able to awake the device from the sleep or standby mode?
13. Are all gestures supported, such as swipe, scroll, click, tap, or pinch to zoom?

14. Is the tool able to simulate native buttons such as the back or home button?

15. Does the tool use the device's soft keyboard to enter data?

16. Can the app be tested in several languages?

17. Does the tool require modification to match the real device (jailbreak, rooting)?

18. Does the tool support a programming language with which you are able to write test scripts?

19. Is the tool able to execute the tests from the command line?

20. Can the tool be integrated into your development environment (IDE)?

21. Can the tool be integrated into a continuous integration system?

22. Can the tool be combined with other tools such as a defect management or test management tool?

23. Is the tool able to connect to a test cloud provider in order to execute the tests within a cloud?

24. Is the tool well documented?

25. Is the tool open source or closed source?

26. Is there a large community/support behind the tool?

27. Since when has the tool been available on the market and is it used by other companies for mobile test automation?

28. Does the tool support cross-platform tests?

As you can see from the criteria list, there are lots of things to consider when selecting a mobile test automation tool. The evaluation phase is very important and should not be underestimated. If you choose the wrong tool (due to time constraints, for example) before the project starts, it is very likely that you will struggle with the tool during the project.

Point 18 in the list, "Does the tool support a programming language with which you are able to write test scripts?" is very important. You should try to find a tool that supports the programming language with which you are able to write code; this will reduce your learning curve because you need to become familiar with just the tool and not the programming language. You'll also save lots of time and money on additional training.

Important

Develop a sample app or use a checklist with your criteria to find the tool that best fits your test and development process.

Current State of Tools

This part of the chapter should give you an overview of possible mobile test automation tools. I selected mainly open-source end-to-end testing tools for the iOS and Android mobile platforms and tools that I have used in mobile proj-ects. Furthermore, I chose tools that are well known for mobile test automation and used by most companies. I will give you some recommendations and useful information about the tools and how to use them. I will not explain or describe the installation or configuration process of the tools because this information can (or will) be outdated soon. All of the mentioned tools require programming skills in order for you to be able to work with them efficiently.

And, as always, the list of tools mentioned here is by no means complete.

Android Tools

Most of the Android test automation tools are based on the Android Instrumentation Framework[3] from Google. To get started with Android test automation, you need to understand the view hierarchy of an Android app. You also need to know what kinds of components and elements the app uses as well as how all these elements are arranged on the screen and what they represent in the logical structure of the app.

3. http://developer.android.com/tools/testing/testing_android.html

Google provides a very useful tool called UI Automator Viewer[4] to inspect the app's view and layout hierarchy. This tool lets you view the properties—the name or ID of each UI component that is displayed on the screen. You need this kind of information (name or ID of an element) to write your mobile test scripts.

4. http://developer.android.com/tools/testing/testing_ui.html

You can find the UI Automator Viewer in the Android SDK location on your computer, for example:

Click here to view code image

```
/android/sdk/tools/uiautomatorviewer.sh
```

This tool is particularly important when the Android app code is not available and you just have the compiled .apk file to write your mobile test automation. However, some of the Android tools mentioned offer their own UI automator viewer that can be used to inspect the elements.

Robotium

Robotium[5] is the de facto standard open-source tool for Android test automation and was one of the first Android test automation tools on the market. Robotium is a black box tool that provides full support for native and hybrid Android apps. Robotium is an extension of the aforementioned Android Instrumentation Framework and provides a very simple and basic API for writing UI tests. It supplies the so-called `solo` object to call methods such as `clickOnText` or `enterText`. Check out the code in Listing 5.1 for some possible test actions.

5. https://code.google.com/p/robotium/

Listing 5.1 *Sample Code from Robotium*

Click here to view code image

```
/* Robotium will click on the text "Welcome" */
solo.clickOnText("Welcome");
/* Robotium will enter the string MySecretPassword into the input
field with the ID 2 */
solo.enterText(2, "MySecretPassword");
/* Robotium will click on the button with the label "Login" */
solo.clickOnButton("Login");
/* Robotium will simulate a click on the native back button */
solo.goBack();
```

Robotium requires only minimal knowledge of the app you want to test and provides excellent readability. By just reading the test methods you already know what is happening and what will be tested on the view of the device. The UI Automator Viewer supplies all of the view information you need to write your tests. Robotium tests are written in the Java programming language and can be executed on a real device or on emulators. Tests can be executed on only a single device at a time, and Robotium is able to test only the app

that is being tested, meaning that there is no way of testing outside this application. At the end of the test run a JUnit report is generated.

The written tests can be executed either from the command line, from an IDE, or from a continuous integration server using Maven, Gradle, or Ant.

If you want to know more about Robotium and how to get started, check out the Robotium wiki page:

- Robotium Getting Started (https://code.google.com/p/robotium/wiki/Getting_Started)

Also check out the Robotium project pages:

- Latest Robotium version and samples (https://code.google.com/p/robotium/wiki/Downloads)

Robotium Extensions

In 2014, the developer of Robotium, Renas Reda, founded the company Robot-ium[6] to provide the so-called Robotium Recorder, which allows developers and testers to record Robotium tests instead of writing the code manually.

6. http://robotium.com/

Another nice extension for Robotium is the ExtSolo[7] project from the company Bitbar. ExtSolo adds some very useful test methods to Robotium such as the following:

7. http://docs.testdroid.com/_pages/extsolo.html

- **`changeDeviceLanguage(java.util.Locale locale)`**: switches the current language of the device during the test execution
- **`setGPSMockLocation(double latitude, double longitude, double altitude)`**: sets the device's current GPS location
- **`turnWifi(boolean enabled)`**: turns Wi-Fi off and on, to see how the app handles the connection loss

Full API documentation is available here:

- ExtSolo API documentation (http://docs.testdroid.com/_static/extSolodocs/com/bitbar/recorder/extensions/ExtSolo.html)

Spoon

Spoon[8] is another powerful Android test automation framework, developed by the company Square.[9] Spoon is also an extension of the existing Android Instrumentation Framework. The main difference from Robotium is Spoon's ability to simultaneously execute the same tests on multiple devices or emulators. Spoon can execute the tests on every target (device or emulator) that is visible to adb (Android Debug Bridge) and is connected to the test server.

8. http://square.github.io/spoon/
9. https://squareup.com

The tests are also written in Java and can be executed from the command line, from an IDE, or from a continuous integration server. Spoon's structure and test code are also very simple, as you can see in the code in Listing 5.2.

Listing 5.2 *Sample Code from Spoon*

Click here to view code image

```
Spoon.screenshot(activity, "Login_Screen");
assertThat(password).hasNoError();
instrumentation.runOnMainSync(new Runnable() {
       @Override public void run() {
                      password.setText("MySecretPassword");
       }
});
```

After all of these tests have been executed on every device, Spoon generates a static HTML report with detailed information about each device and test (see Figure 5.4). The report compares the test results on the different devices in a nice overview. If screenshots are taken during the test run, Spoon generates an animated GIF image from them so you can see the executed test steps again in the test report.

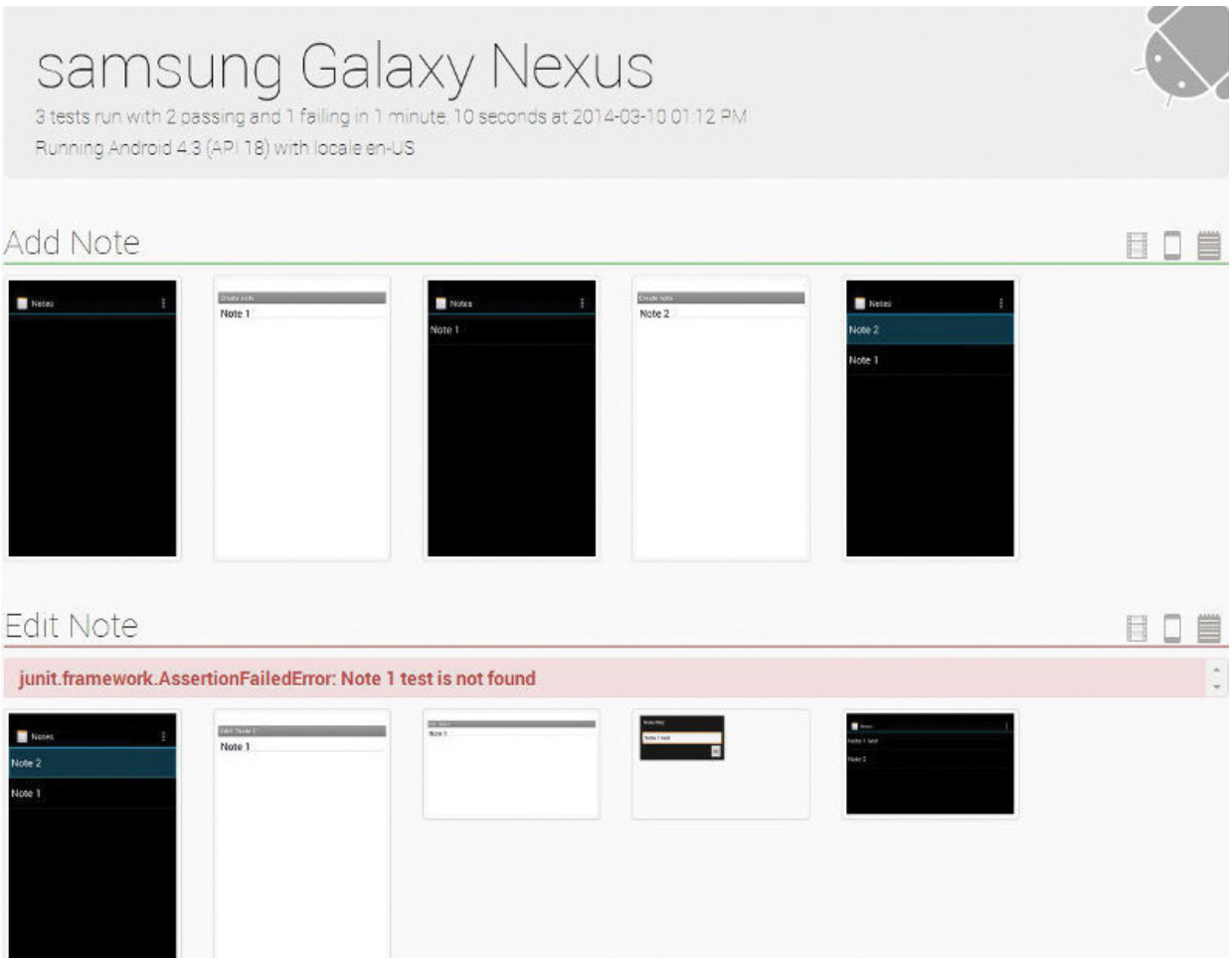

Figure 5.4 *Spoon sample report*

Spoon also requires very little knowledge of the code for the app you want to test. Spoon can be combined with other Android test automation tools, so you can, for example, use the screenshot function from Spoon and test methods from Robotium or Espresso.

The latest version of Spoon and an example test app can be found on GitHub:

- Spoon samples and latest version (https://github.com/square/spoon)

Selendroid

Selendroid[10] is a test automation tool for native Android, hybrid, or mobile Web apps. The name Selendroid comes from the words **Selen**ium and An**droid**. Selendroid is fully compatible with the JSON Wire Protocol,[11] and the tests are written using the Selenium 2 Client API.[12]

10. http://selendroid.io/

11. https://code.google.com/p/selenium/wiki/JsonWireProtocol

12. http://docs.seleniumhq.org/docs/03_webdriver.jsp

If you are familiar with writing automated tests with Selenium 2 for browser-based applications, it is very easy to write test automation code with Selendroid for Android apps. Selendroid is able to simultaneously execute and interact with multiple Android devices (real devices or emulators).

Listing 5.3 shows a code example.

Listing 5.3 *Sample Code from Selendroid*

Click here to view code image

```
WebElement loginButton =
driver().findElement(By.id("startLogin"));
WebElement passwordInput =
driver().findElement(By.id("password"));
passwordInput.sendKeys("MySecretPassword");
loginButton.click();
```

The UI elements of the mobile app can be found by different locator types, for example, by ID, name, link text, class, tag name, or XPath. To inspect the UI components of the app under test, Selendroid provides a very useful tool called Selendroid Inspector,[13] which provides a hierarchy viewer that lets you see the UI component properties. It is able to create a screenshot with the view locator, record the click actions on the mobile app, display the HTML source of a Web view, and provide a very useful XPath helper to identify the Web elements.

13. http://selendroid.io/inspector.html

In order to support different gestures, Selendroid uses the Advanced User Interactions API.[14] The written tests can be executed from the command line, from an IDE, or from a continuous integration server.

14. https://code.google.com/p/selenium/wiki/AdvancedUserInteractions

Selendroid can be fully integrated as a node into a Selenium Grid[15] for scaling and parallel testing. And, finally, the app under test will not be modified for automation purposes.

15. https://code.google.com/p/selenium/wiki/Grid2

Additional useful information on Selendroid can be found on the Web site:

- Selendroid getting started (http://selendroid.io/setup.html)
- Scaling Selendroid (http://selendroid.io/scale.html)
- Latest Selendroid version and samples (https://github.com/selendroid/selendroid)

Calabash for Android

Calabash[16] is a cross-platform mobile test automation framework for native and hybrid Android and iOS apps. The tool makes it possible to write automated UI acceptance tests in Cucumber.[17] With the help of Cucumber, you can express the behavior of the app you're testing using a natural language. This approach is called behavior-driven development (BDD), and it can be very helpful when business experts or nontechnical colleagues are involved in the acceptance criteria process.

16. http://calaba.sh/

17. http://cukes.info/

Cucumber uses Gherkin[18] as the domain-specific language (DSL) to annotate the behavior of the application.

18. https://github.com/cucumber/cucumber/wiki/Gherkin

Please refer to the code in Listings 5.4 and 5.5 for examples. Listing 5.4 shows a Cucumber (Gherkin) scenario using real text to describe the behavior of the application.

Listing 5.4 *Sample Gherkin Code*

Click here to view code image

```
Feature: As a user I want to login
  Scenario: Login using valid credentials
       Given I am on the login screen
       When I enter "Username" into the user field
       And I enter "PWD" into the password field
       And I click the login button
       Then I must see my user account
```

Listing 5.5 shows the Ruby code needed to map the real text into commands that the computer needs to understand in order to communicate and interact with the app.

Listing 5.5 *Sample Step Definition Code for One Gherkin Step*

Click here to view code image

```
When(/^I enter "(.*?)" into the user field$/)
do | username |
       fill_in("IDUserName", :with => "username")
end
```

As you can see, actual test automation is performed with Ruby and within the so-called step definitions. Gherkin is responsible for describing the behavior of the application, Ruby is needed for the actual coding, and Cucumber is the framework that executes everything together on the real devices or emulators. The Calabash tests can be executed from the command line, from an IDE, or from a continuous integration server.

Calabash supports a screenshot function, is able to use localization within the app, and supports different gestures.

Additional useful information about Calabash, Gherkin, and Cucumber can be found on the GitHub project page:

- Calabash for Android (https://github.com/calabash/calabash-android)
- Predefined step definitions for Android (https://github.com/calabash/calabash-android/blob/master/ruby-gem/lib/calabash-android/canned_steps.md)

Appium

Appium[19] is an open-source, cross-platform test automation tool for native, hybrid, and mobile Web apps. Appium supports the mobile platforms Android, iOS, and FirefoxOS. Like Selendroid, Appium uses the WebDriver JSON Wire Protocol to drive and to test the UI of the mobile apps. You can use several programming languages to write your test automation. Currently, Appium supports the following languages:

19. http://appium.io/

- C#
- Clojure
- Java
- JavaScript

- Objective-C
- Perl
- PHP
- Python
- Ruby

The written tests can be executed by emulators/simulators or real devices. The code in Listing 5.6 shows some of the test steps.

Listing 5.6 *Sample Appium Code*

Click here to view code image

```
WebElement loginText = driver.findElement(By.name("TextLogin"));
assertEquals("TextLogin", loginText.getText());
WebElement loginTextView =
  driver.findElementByClassName("android.widget.TextView");
assertEquals("TextLogin", loginTextView.getText());
WebElement button =
  driver.findElement(By.name("Login"));
button.click();
```

One of the main advantages of Appium is that the tool not only is able to communicate with the app being tested but is also able to start another app from the app under test, such as the camera app or the contacts app. Besides that, the app under test will not be modified when using Appium in order to automate it.

More information about Appium can be found on the GitHub page as well as on the manufacturer's page:

- Appium on GitHub (https://github.com/appium/appium)
- Appium introduction (http://appium.io/introduction.html)
- Appium API reference documentation (http://appium.io/slate/en/master)

Espresso

Espresso[20] is the Android test kit provided by Google. Espresso is based on an improved Instrumentation Test Runner called Google Instrumentation Test Runner[21] to make Android test automation more reliable and faster.

20. https://code.google.com/p/android-test-kit/wiki/Espresso