Phil Diegmann

Bachelorarbeit
im Fach Allgemeine Wirtschaftsinformatik

Systematic Development of mHealth Apps: Lessons Learned During Development of a Mobile Frontend for ePill

Themensteller: Jun.-Prof. Dr. Ali Sunyaev

Vorgelegt in der Bachelorprüfung
im Studiengang Wirtschaftsinformatik
der Wirtschafts- und Sozialwissenschaftlichen Fakultät
der Universität zu Köln

Köln, August 2013

Table of Contents

Index of Abbreviations

app	abbreviation for Application
app user	the intended audience for the app
CDN	**TODO: DEFINITION!**
CSS	**TODO: DEFINITION!**
DNS	**TODO: DEFINITION!**
eHealth	"a paradigm involving the concepts of health, technology, and commerce, with commerce and technology as tools in the service of health"[1]. Belonging to the field of telehealth.[2]
ePill	a patient-centered health IT service which offers information on pharmaceuticals and aggregation of data in context
framework	can contain source code, tools and libraries, which together provide specific or common but abstracted functionality
frontend	visible user interface for the app user
HECAT	Health Education Curriculum Analysis Tool[3]
HIT	abbreviation for Health Information Technology
HTML	**TODO: DEFINITION!**
IDE	abbreviation fro Integrated Development Environment
JSON	**TODO: DEFINITION!**
mHealth	"medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices".[4] Also known as m-Health.
mHealth apps	"aim at providing seamless, global access to tailored health IT services and have the potential to alleviate global health burdens."[5]
MVC	Model-View-Controller Architecture **TODO: DEFINITION?**
information security	Prevention from unauthorized access to information. In this context especially sensitive, personal information

---

1 Martínez-Pérez, de la Torre-Díez, Isabel, López-Coronado (2013), p. 2

2 cf. Martínez-Pérez, de la Torre-Díez, Isabel, López-Coronado (2013), p. 2

3 http://www.cdc.gov/HealthyYouth/HECAT/

4 World Health Organization (2011) cited by Martínez-Pérez, de la Torre-Díez, Isabel, López-Coronado (2013), p. 2

5 Dehling, Sunyaev (2013), p. 1

OS	operating system
SDK	abbreviation for software development kit. Bundled software and tools for developing with or for a specified OS or Framework
sensitive information	information, which is personal. Can be related to financial, health or otherwise personal relevant information[6]
telehealth	delivery of medical- or health-related information or services via telecommunication technologies
usability	"extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use"[7]
use value	the utility of consuming a good or service
user interface	**TODO: DEFINTION!**
W3C	**TODO: DEFINITION!**

[6] Suggested by Future of Privacy Forum, Center for Democracy & Technology (2011), p. 6, although the definition varies

[7] Yeh, Fontenelle (2012), p. 64 as quoted from ISO 9241-11 (1998)

List of Tables

1. Introduction

1.1 Research Problem

TODO: REVISE!

While it has become easy to develop a mobile health (mHealth) application (app), there is much more to it than just the aspects of the app's core functionality. Currently only very few guidelines, best practices and systematic development approaches for mobile app development can be found. And even less can be found for the specific area of mHealth apps.

Security leaks or even abuse of private and sensitive information can lead to great harm for the app user and to legal issues for the developer. Abuse of personal health related information can result in loss of reputation (e.g. sexual transmitted diseases) or financial drawbacks and decreased chances of employment (e.g. chronic diseases, genetic dispositions)[8]. With poorly developed apps, there is a chance of security leaks and hence for data abuse. Thus the risk for app users increases. A study[9] has shown that only very few mHealth apps entail little or low risk for the app user. Self-publishing through modern sales channels like Google Play (http://play.google.com) or the iOS App Store (http://appstore.com) and the availability of easy-to-use Integrated Development Environments (IDEs) lower the barriers for entry. Even one-man developers or small teams are now able to easily publish apps with little development effort. Without fundamental knowledge of privacy and security aspects, there is an increase in the non-professional development of mobile apps with inadequate security aspects.

The usability, especially in critical situations, is another undervalued aspect in many non-professional developments. While fancy colors might look appealing to the developer himself, it might lead to confusion for the app user or even to a lack of operability for visually impaired people.[10] Also the need for a intuitive user interface might not be considered as important as it should be.

---

8 cf. Dehling, Sunyaev (2013), pp. 6-7

9 cf. Njie (2013), pp. 19-20

10 cf. Badashian et al. (2008) p. 108

Knowledge of data privacy acts and laws is a premise for a legal, safe and fair development for the developer and the app user. Multiple layers of data privacy laws in Europe on international, national and state level require a certain legal knowledge.[11] Also the benefit of and the need for a privacy policy seems to be ambiguous for many non-professional developers.[12]

This lack of guidelines for mobile app development and of specific guidelines for privacy and usability sensitive apps is only superficially considered by most of the literature. The beforehand highlighted aspects of usability and information security are just two of multiple possible requirements. Current research seems not to state which specific requirements, if any, distinguish mHealth apps from other apps or which are needed to be more accented.

1.2 Objectives of this Thesis

TODO: REVISE!

The purpose of this thesis is to discover, identify and report issues and challenges of the development of mHealth apps by developing a mobile frontend for the ePill system (developed by the University of Cologne, http://epill.uni-koeln.de). ePill is a patient-centered health IT service which offers information on pharmaceuticals and aggregation of pharmaceutical data in context.

During the development of a mobile frontend for ePill, all requirements can be addressed more easily than in a completely theoretical context. As a side effect, a mobile app for ePill will increase the accessibility for the ePill system in general and thereby increase the possible user value. Especially in critical situations in which one does not have one's desktop computer at hand, a mobile easy-to-use app can be of value.

---

[11] cf. Directive 95/46 of the European Parliament and of the Council (October, 24th 1995), Directive 2002/58 of the European Parliament and of the Council (July, 12th 2002) cited by Future of Privacy Forum, Center for Democracy & Technology (2011), p. 16

[12] cf. Njie (2013), p. 20

The experiences made during the development refer to general mobile app development, but also to the specific development of mHealth apps.

Mainly this thesis aims to describe the planning and the development process and discuss all discovered issues and challenges for planning and developing mHealth apps. One sub-objective is to give a short overview about the state of research on guidelines and important factors of mHealth app development. Subsequently, this thesis aims to highlight specific characteristics of mHealth apps and focus on them during the development as well in the conclusion. **TODO: REVISE LAST SENTENCE**

2. The ePill System

2.1 The System in general

The ePill system (http://epill.uni-koeln.de) was developed by the University of Cologne to improve the readability and comprehensibility of instruction leaflets of medical drugs. Additionally ePill aims to provide further information on adverse reactions and interactions of different medical drugs. ePill emphasizes an easy readability and access to informations.
ePill is currently a prototype of a system, used only for research purposes and is only actively used by the University of Cologne. Therefor it is only localized in German and contains only pharmaceuticals available in Germany. ePill utilizes the "GELBE LISTE PHARMINDEX"[13], provided by Medizinische Medien Informations GmbH MMI.

There are three major functions covered by the system: Searching for pharmaceuticals, display information on pharmaceuticals and supplementing services.[14] The search enables the user to find corresponding pharmaceuticals depending on specified parameters in the underlying database. As an extend, the display functionality enables the user to read the leaflet information in an optimized fashion. Finally supplementing services are provided to refine the displayed information (e.g. select the level of detail of the displayed information), linking pharmaceuticals as well as other information and aggregate pharmaceutical information (e.g. interactions).

An integration and personalization depending on the current user's health records was not implemented due to the arising privacy and trust challenges.[15, 16]

The system uses a Model-View-Controller (MVC) architecture[17] and utilizes a relational

---

13 http://www.gelbe-liste.de

14 cf. for this paragraph Dehling, Sunyaev (2012), p. 2

15 cf. Kaletsch, Sunyaev (2011) cited by Dehling, Sunyaev (2012), p. 2

16 cf. Kaletsch, Sunyaev (2011), pp. 5-6

17 cf. Dehling, Sunyaev (2012), p. 3

database **TODO: CITE?** as persistent data storage.[18] The data is organized in an atomic way. Products are any pharmaceuticals, whereas they contain specific molecules, which themselves may have specific adverse reactions with other molecules.
With this atomized organization of the pharmaceutical information, it becomes more easily to compare different pharmaceuticals and have very consistent information about molecules and adverse reactions for different pharmaceuticals.

2.2 The Web Application

The web application of the ePill system introduces itself highly customizable to the user. It offers the user the choice between a default view, a customizable view and an expert view. The default view aims to provide all necessary information in a compact way. The customizable view offers more choices for the elements to be displayed. The expert view activates all options for the most detailed information level. The pharmaceutical informations to be displayed can be fine tuned for every view. ePill offers four different presets varying from only the most basic up to all available information. These presets can be further customized by afterwards selecting or deselecting items. Additionally the font-size can be set to normal, bigger and biggest to support visually impaired users.

Three columns shape the layout. The leftmost column contains the main navigation for searching, pharmaceutical listings, basic functionality like help pages and settings as well as extended functionality like interactions research and adverse reaction lookup or pharmaceutical comparisons. The centered column contains the current content. This column has tabs, which can be assigned different contents. With this tabular layout, e.g. multiple, different search queries can easily be switched and held in parallel. The rightmost column can be used to dynamically display or hide specific information. Depending on the beforehand selected view, the left or right columns are hidden or visible. The website also offers the user on the pharmaceutical detail page to explain any term as well as a shortcut to the page's top.

The specific content layout is very consistent. Headlines are made salient and the ar-

[18] cf. Dehling, Sunyaev (2012), p. 5 for this and the following two sentences

rangement of common sections are congruent. Changes in settings are apply with no delay and without a page reload. Any changes are applied congruent with the chosen layout and other related settings.

Although this web application is not optimized for mobile applications and designed with a desktop computer in mind, it can be accessed by nearly any modern mobile computing device, like a smart phone or a tablet, and can therefor categorized as a mHealth application. This assumption is important to the following section, to clarify the differences between this web application and the mobile client, because with this assumption we can categorize on the same level and focus on the essential differences.

3. What is mHealth?

3.1 Definition

TODO: MORE DETAIL!

mHealth, also known as m-Health, is an abbreviation for mobile health and is a refinement of eHealth (or e-Health, an abbreviation for electronic health), which itself belongs to the field of telehealth.[19]

eHealth is defined as "a paradigm involving the concepts of health, technology, and commerce, with commerce and technology as tools in the service of health"[20].

Telehealth means the delivery of medical- or health-related information or services via telecommunication technologies.

mHealth in detail is defined as "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices"[21]. The introduction of smart phones like the Apple iPhone or any Android device led to a greater audience and the evolution of mobile tablets further increased the audience for mHealth purposes. A study[22] relied on the Health Education Curriculum Analysis Tool (HECAT)[23] to group different mHealth apps together. This study illustrates the distribution of apps in different categories. As Tab. 3-1 illustrates most of the available apps in 2011 in the Apple App Store in the United States of America belonged to the Physical Activity area, whereas drug-related and safety-related apps (like ePill) are the least two.

---

19 cf. Martínez-Pérez, de la Torre-Díez, Isabel, López-Coronado (2013), p. 2

20 Martínez-Pérez, de la Torre-Díez, Isabel, López-Coronado (2013), p. 2

21 World Health Organization (2011) cited by Martínez-Pérez, de la Torre-Díez, Isabel, López-Coronado (2013), p. 2

22 cf. for this and the first following sentence West et al. (2012)

23 http://www.cdc.gov/HealthyYouth/HECAT/

24 Apps could be added to multiple categories

25 cf. West et al. (2012), p. 5, Table 2

HECAT content area	**n**	**%**[24]
Physical Activity	1108	33.21
Personal health and wellness	962	28.84
Healthy eating	651	19.51
Mental and emotional health	414	12.41
Sexual and reproductive health	243	7.28
Alcohol, tobacco, and other drugs	131	3.93
Violence prevention and safety	96	2.88

Tab. 3-1: HECAT Content Area App Distribution (N = 3336)[25]

From February to May of 2012, a Study by d'Heureuse et al. (2012) found several ten thousands of apps in the Google Play Store as well as the Apple App Store just in the "Health" categories.[26] This study shows the potential of mHealth for a broader healthcare supported by mobile devices. From March to May of 2012, the total number of apps increased by an average of 6.4% (Google Play Store) and 4.5% (Apple App Store) per month.[27]

3.2 mHealth App Categories

Although the Tab. 3-1 listed categories for mHealth apps, it focusses on content and less on the specifics for mHealth apps on other possibly important topics, such as information security or usability. Other literature focusses on data practices and privacy risks with a more technical aspect[28].

Njie (2013) concludes that most of the mHealth apps deal in any way with directly or indirectly (e.g. via usage behavior) sensitive information. Therefor ten levels of privacy risks were developed and a sample of 43 mHealth and fitness apps were assigned to the different levels. Tab. 3-2 illustrates the characteristics of every level as well as the distribution of the 43 analyzed apps.

---

[26] cf. d'Heureuse et al. (2012), p. 20, Figure 5

[27] cf. d'Heureuse et al. (2012), p. 20

[28] cf. for this and the following three sentences Njie (2013), pp. 13-14

The risk levels are based on the one hand on the information available to the app and on the other hand on security precautions implemented by the developer to prevent unauthorized access to this information. An important differentiation is also in the anonymity or identifiability of the information accessible by third parties. The higher the accessibility or the identifiability or the possible harm done by this information, the higher the risk level.

As stated by Istepanian, Jovanov, Zhang (2004), another categorization is possible. They categorized mHealth applications into administrative connectivity, financial connectivity or medical connectivity.[29] Because of the lack of smart phones and a far lesser availability of mobile devices in 2004 compared to today, this article cannot take the recent development in mobile devices into account. Nevertheless the categorization is still appropriate. The administrative connectivity handles appointments, electronic patient records and any non-financial transactions, the financial connectivity handles all financial transactions like purchases, billing or any financial services.[30] The third connectivity, the medical connectivity, handles mobile monitoring and diagnostics.

There are there different sub-categories for mHealth applications: The content, the information security risk-level and the overall connectivity function. For the content-category as well as the connectivity-category, multiple assignments are possible. Combined these sub-categories form a specific grouping of mHealth apps. Depending on the categorization in the privacy risk, one can easily take care for precautions. With the categorization into a HECAT content area, one can identify the target audience more precisely as well as with the help of the connectivity category.

3.3 Classification of the ePill Web Application

ePill is to be categorized in the beforehand mentioned HECAT content areas mainly as "Alcohol, tobacco, and other drugs", because of the purpose to inform about (medical)

---

[29] cf. Istepanian, Jovanov, Zhang (2004), p. 6

[30] cf. for this and the first following sentence Istepanian, Jovanov, Zhang (2004), p. 13

[31] cf. Njie (2013), p. 13

Level	Risk	Characteristics	%
9	Highest	address, financial information, full name, sensitive or embarrassing health (or health-related) information, information that a malicious actor could use to steal or otherwise cause a user to lose money	40
8	High	geo-location	
7	Medium-high	DOB, ZIP code, any kind of personal medical information	
6	Medium	risk evaluated to be between level 5 and level 7	32
5	Medium	email, first name, friends, interests, weight, information that is potentially embarrassing or could be used against a person (e.g., in employment)	
4	Medium	risk evaluated to be between level 5 and level 3	
3	Medium-low	anonymized (not personally identifiable) tracking (e.g., app usage), device info, a third party knows the user is using a mobile medical app	28
2	Low	risk evaluated to be between level 3 and level 1	
1	Low	any kind of anonymized data that does not include medical health-related data or personally identifiable information	
0	No		0

Tab. 3-2: Privacy Risk Levels of mHealth Apps (N = 43)[31]

drugs. Additionally, ePill informs about adverse effects and interactions, so it also belongs to the content area of "Violence prevention and safety".

The ePill web application is not connected to any electronic patient records, nor does it store any user related information, like the last searched pharmaceuticals. But it does not utilize SSL-encryption. Therefor it might not be collecting information or storing anything, but third parties could collect user specific information by monitoring.
Setting this information into context with the risk levels developed by Njie (2013), the ePill web application could be categorized as level three, if SSL-encryption would be utilized. If that would be the case, third parties could retrieve browser and OS specific information, but not data sent and retrieved with each request like pharmaceutical information. Without encryption, all data sent and retrieved is visible to possible eavesdropper.

With information about searched pharmaceuticals, one could assemble a overall picture of the ingested drugs and therefor extrapolate possible diseases. Still, all data is anonymized. Having in mind, that ePill still is in early prototyping and assuming, that the SSL-encryption will follow, the risk is more of a medium to low level. Dealing with only anonymous data and protecting them with encryption leaves only very less room for serious risks. We would therefor categorize ePill in terms of privacy risk levels as a level two.

Although ePill does not fit absolutely in any of the connectivity categories, it fits best in the medical connectivity. Because of the aim to provide pharmaceutical (therefor medical) information, it belongs definitely to the medical connectivity category.

Concluding this categorization, we would suggest to categorize the ePill web application as a low privacy risk, drug- and safety-related medical connectivity mHealth application. The ePill web application lacks a optimization for mobile devices but all categorizations match their definition. The HECAT content area is by definition not limited to mobile devices and privacy risks are in many ways the same for mobile apps and web applications.

3.4 Why is a special Focus on mHealth Apps warranted?

mHealth apps differ in some way from general (mobile) applications but also from eHealth applications. While mHealth apps can be used in many different situations and with very different intentions, the special focus on e.g. equality of all users and accessibility for all possible users are not as important for other areas of mobile apps as they are for mHealth apps.

mHealth apps are defined to "aim at providing seamless, global access to tailored health IT services and have the potential to alleviate global health burdens."[32], which means, that they should be accessible by mostly all possible users, whereas other types of apps do not necessarily need to be accessible by any user. We want to stress, that accessibility does not only mean usability (especially for elderly people), but also e.g. different social layers or cultures.

---

[32] Dehling, Sunyaev (2013), p. 1

Furthermore, mHealth apps deal with medical- or health-related information and have therefor to deal with sensitive information and have to address privacy risks and concerns. As pointed out by Njie (2013) and already referred to in Tab. 3-2, many mHealth apps deal with highly sensitive data and have serious privacy risks. Dehling, Sunyaev (2013) illustrate the possible damages through leaks, manipulation or loss of information.[33]

To address these concerns and issues in a mHealth project, they need to be made clear and experiences must be shared as well as interpreted. The following chapter will present all experiences made during the development of a mobile frontend for ePill in a structured way. We will list all theoretical preconditions, outline the analysis as well as the implementation of the mHealth app. Afterwards we will validate the product and give an overview about the lessons we learned.

[33] cf. Dehling, Sunyaev (2013), p. 7

4. The Development of the mobile Client

4.1 Preconditions

4.1.1 Norms for mobile Apps

As already mentioned, ePill is currently only used in Germany, therefor we will focus on laws applicable in Germany. These laws are namely the Telekommunikationsgesetz, the Telemediengesetz, the Directive 95/46/EG as well as the data protection act of North Rhine-Westphalia. The Telekommunikationsgesetz and Telemediengesetz are laws by state, whereas Directive 95/46/EG is a european directive, specified by the respective Member States.
German federal states have their own data protection acts. In this thesis we will focus on the data protection act of North Rhine-Westphalia as ePill is located in North Rhine-Westphalia.

As the topmost layer of laws, the Directive 95/46/EG defines more general directives. Article 4 defines national law applicable, if the natural or legal person, the controller[34], is located on a Member State's territory[35] or if any of the processing takes place on a Member State's territory[36]. Furthermore it is required, that the controller asks the user to consent to the use and collection of data[37], explicitly "data concerning health and sex life"[38] shall not be processed. Only if the user consents explicitly[39] or if the processing is done by a healthcare professional under national law and for preventive medicine, medical diagnosis or treatment or for the management of health-care services[40].

This is refined by the the Telemediengesetz. § 13, section (1) states, that the controller

---

34 cf. The European Parliament and the Council of the European Union (1995), Article 2, (d)

35 cf. The European Parliament and the Council of the European Union (1995), Article 4, 1., (a) and (b)

36 cf. The European Parliament and the Council of the European Union (1995), Article 4, 1., (c)

37 cf. The European Parliament and the Council of the European Union (1995), Article 7, (a)

38 The European Parliament and the Council of the European Union (1995), Article 8, 1.

39 cf. The European Parliament and the Council of the European Union (1995), Article 8, 2., (a)

40 cf. The European Parliament and the Council of the European Union (1995), Article 8, 3.

has to inform the user in a commonly understandable manner about the data which is collected and the form of processing of this data[41]. For a legal consent, the controller has to ensure, that the user is aware of his consent, that the consent is minuted, that the content of the consent is always available to the user and that the user can revoke his consent[42].
§§ 91, 93 and 94 of the Telekommunikationsgesetz states the same laws[43].
Also the data protection act of North Rhine-Westphalia constitutes the same laws[44], with the only restrictions, that its scope is limited to North Rhine-Westphalia.

Therefor ePill should explicitly inform the user that no data is stored and only anonymized transacted to find matching results, to comply with the stated laws.

4.1.2 Best Practices

The World Wide Web Consortium (W3C) has published a document in 2008, which states the basic best practices for developing for the mobile web. This document states 60 best practices, which shall ensure a minimum quality level for mobile web applications. These best practices emphasize the need of regard of the device's capabilities and supported technologies[45].
This document focuses on mobile web development[46], which has of course differences to native app development (e.g. the usage of frames and the accessibility of the device's specific features), most of the best practices are applicable in both development environments.

For this specific project, which does not need more specific device capabilities, like positioning and navigation features, we can focus on best practices related to the user interface, input and navigation methods as well as general best practices. Depending on the framework chosen, some of the best practices are already dealt with by the framework or

---

41 cf. Bundesregierung der Bundesrepublik Deutschland (2007), § 13, section (1)

42 cf. Bundesregierung der Bundesrepublik Deutschland (2007), § 13, section (2)

43 cf. Bundesregierung der Bundesrepublik Deutschland (1996), Section 2, §§ 91, 93, 94

44 cf. Der Innenminister des Landes Nordrhein-Westfalen (2000), Section 1, §§ 2, 4, 5

45 cf. World Wide Web Consortium (2008), e.g. 2., 11., 21., 42.

46 cf. World Wide Web Consortium (2008), Abstract

at least supported. E.g. a thematic consistency[47] is provided by native apps by default and by frameworks such as the TouchKit for Vaadin as well. Although they can be overridden, they provide a consistent theme. Wessels, Purvis, Rahman (2011) support the importance of a consistent appearance, also in comparison to a desktop application, if existent[48]. Lica (2010) further limits this to specific elements and points out, that mobile apps should provide just enough functionality to be useful and should not replicate the desktop optimized website[49].
Other best practices like utilizing a navigation bar at the page's top[50] for the main navigation have already become a standard across different platforms and frameworks.

Best practices which are mainly determined by implementations of the developer, like the usage of colors[51] or the chosen input methods[52] are often supported by the different platforms or frameworks but cannot be guaranteed by those. Even if different input methods like a number pad for numeric inputs are provided by the framework or platform still need to be adapted and utilized by the developer to act in line with the best practices.

World Wide Web Consortium (2008) furthermore specifies a "Default Delivery Context"[53], which defines the minimal capabilities for mobile devices which should be supported. Tab. 4-1 illustrates the minimal capabilities suggested by W3C.
Nowadays it will be hard to match all of the requirements. E.g. a total maximum page weight of 20 kilobytes corresponds to the average file size of a 200 by 120 pixel JPEG-compressed file is abut 10 kilobytes[54] and two images would already exceed the maximum page weight. With mobile devices like a Samsung Galaxy S3 which has a minimum of 720 pixel wide display, 120 pixels are far too less.

---

47 cf. World Wide Web Consortium (2008), 1.

48 cf. Wessels, Purvis, Rahman (2011), p. 2

49 cf. Lica (2010), p. 66

50 cf. World Wide Web Consortium (2008), 8.

51 cf. World Wide Web Consortium (2008), 26., 27

52 cf.World Wide Web Consortium (2008), 55., 56., 57.

53 cf. World Wide Web Consortium (2008), 3.7 Default Delivery Context

54 Tested with 60% compression rate and a random photograph

Parameter	Value
Usable Screen Width	120px
Markup Language Support	XHTML Basic 1.1 delivered with content type application/xhtml+xml.
Character Encoding	UTF-8
Image Format Support	JPEG. GIF 89a.
Maximum Total Page Weight	20 kilobytes.
Colors	256 Colors, minimum.
Style Sheet Support	CSS Level 1. In addition, CSS Level 2 @media rule together with the handheld and all media types.
HTTP	HTTP/1.0 or more recent.
Script	No support for client side scripting.

Tab. 4-1: Default Delivery Context[56]

Also nearly any mobile browser supports client side scripting (e.g. JavaScript). For more detail, http://caniuse.com has compatibility lists of different browser features for nearly any browser. The parsing of JavaScript Object Notation (JSON) for example is supported by 93.41% of all mobile browsers[55].

Nevertheless, minimizing the total page size is still a concern. Wessels, Purvis, Rahman (2011) points out, that smaller pages lead to faster load times and therefor provide a more efficient experience for the user[57]. Nicolaou (2013) suggests different approaches to reduce page size as well as load time: Scripts and markup should be minified[58] and included inline[59] where possible. Preloading components and reducing DNS lookups can also result in a faster user experience[60].

Generally, Nicolaou (2013) recommends using a Content Delivery System (CDN), putting

---

55 cf. http://caniuse.com/#cats=JS_API, JSON parsing

56 cf. World Wide Web Consortium (2008), 3.7 Default Delivery Context

57 cf. Wessels, Purvis, Rahman (2011), p. 1

58 cf. Nicolaou (2013), p. 49

59 cf. Nicolaou (2013), p. 50

60 cf. Nicolaou (2013), pp. 48, 49

style sheets at the page's bottom and scripts at the bottom and using resized images rather than scaling them via HTML or CSS[61].

A study by Dahanayake et al. (2010) came to the result, that 71% of all responding web developers knew about the best practices, but only 11% said, that they understand these, 56% have a vague understanding and 33% do not under stand the best practices [62].

Ayob, Nurul Zakiah binti, Hussin, Ab Razak Che, Dahlan (2009) adjusted and combined four different guidelines for application development, namely Shneiderman's Golden Rules of Interface Design, Seven Usability Guideline for Mobile Device (Abid Warsi, 2007), Human-Centred Design (ISO Standard 13407) and Mobile Web Best Practices 1.0 (W3C). From those guidelines, they developed the Three Layers Design Guideline for Mobile Application[63]. This guideline consists of three phases, which themselves represent different contexts, namely analysis (and the context of use), design (the context of medium) and testing (the context of evaluation). Tab. 4-2 illustrates this guideline.

This thesis will follow the Three Layers Design Guideline, as it is the latest guideline and combines multiple approved other guidelines. The third phase will likely be shortened due to the temporal restrictions for this thesis. The exact process we followed will be outlined in the following sections 4.2, 4.3, 4.4, 4.5 and 4.6 and the experiences made will be discussed in section 5.

4.1.3 Internal requirements

4.2 Analysis

4.2.1 Assignment of a mHealth App Category

The mobile app does not differ from the web application in terms of privacy risks, content or connectivity because it has exactly the same functions and does also not store any data

---

61 cf. Nicolaou (2013), pp. 49, 50

62 cf. Dahanayake et al. (2010), p. 85

63 cf. Ayob, Nurul Zakiah binti, Hussin, Ab Razak Che, Dahlan (2009), p. 430

64 cf. Ayob, Nurul Zakiah binti, Hussin, Ab Razak Che, Dahlan (2009), p. 430, Table IV

	Phase	Context of Use and Activities
1	Analysis	**Use**: Specify user and organizational requirements
		1. Identify and document user's tasks 2. Identify and document organizational environment 3. Define the use of the system
2	Design	**Medium**: Produce design solution
		1. Enable frequent users to use shortcuts 2. Offer informative feedback 3. Consistency 4. Reversal of actions 5. Error prevention and simple error handling 6. Reduce short-term memory load 7. Design for multiple and dynamic contexts 8. Design for small devices 9. Design for speed and recovery 10. Design for "top-down" interaction 11. Allow for personalization 12. Don't repeat the navigation on every page 13. Clearly distinguish selected items
3	Testing	**Evaluation**: Evaluate design against user requirements
		1. Quick approach 2. Usability testing 3. Field studies 4. Predictive evaluation

Tab. 4-2: Three Layers Design Guideline for Mobile Application[64]

and serves the same purpose for connectivity.
We plan to implement every request to the server to be optimized for SSL-encryption as soon as the server is capable of accepting and responding with SSL-encryption.

Therefor we would suggest to categorize the ePill mobile application as a low privacy risk, drug- and safety-related medical connectivity mHealth application.

4.2.2 The different Operation Systems

Android

iOS

Windows Phone 7 and 8

other

4.2.3 Possible Frameworks and Technologies

Xamarin

Vaadin

HTML 5, jQuery mobile and Phone Gap

Completely native

4.2.4 The Choice for Framework XYZ

4.3 The Planning Process

4.4 (The Design Process)

4.5 The Implementation Process

4.6 Validation of the mobile Client

5. Lessons Learned

6. Conclusion

Bibliography

Ayob, Nurul Zakiah binti, Hussin, Ab Razak Che, Dahlan (2009)

Ayob, Nurul Zakiah binti, Hussin, Ab Razak Che, Halina Mohamed Dahlan: "Three Layers Design Guideline for Mobile Application". In: *Information Management and Engineering, International Conference on*. 2009, pp. 427–431

Badashian et al. (2008)

Ali Sajedi Badashian, Mehregan Mahdavi, Amir Pourshirmohammadi, Minoo Monajjemi nejad: "Fundamental Usability Guidelines for User Interface Design". In: *Computational Sciences and Its Applications, 2008. ICCSA '08. International Conference on*. 2008, pp. 106–113

Bundesregierung der Bundesrepublik Deutschland (1996)

Bundesregierung der Bundesrepublik Deutschland: Telekommunikationsgesetz: TKG, 1996. http://www.gesetze-im-internet.de/tkg_2004/, visited on 09/07/2013

Bundesregierung der Bundesrepublik Deutschland (2007)

Bundesregierung der Bundesrepublik Deutschland: Telemediengesetz: TMG, 2007. http://www.gesetze-im-internet.de/tmg/, visited on 09/07/2013

Dahanayake et al. (2010)

Ajantha Dahanayake, Caroline Collier, Daniel Glenzer, Tanya Goette, Richard Welke: Mobile Website Engineering and Mobile Web Best Practices Guidelines: A Reality Check. In: Journal of International Technology and Information Management. Nr. 2, Jg. 19, 2010, pp. 79–IV

Dehling, Sunyaev (2012)

Tobias Dehling, Ali Sunyaev: Architecture and Design of a Patient-Friendly eHealth Web Application: Patient Information Leaflets and Supplementary Services. In: AMCIS 2012 Proceedings. 2012, pp. 1–8

Dehling, Sunyaev (2013)

Tobias Dehling, Ali Sunyaev: Information Security and Privacy Implications of mHealth Apps: An Overview. 2013, pp. 1–12

Der Innenminister des Landes Nordrhein-Westfalen (2000)

Der Innenminister des Landes Nordrhein-Westfalen: Gesetz zum Schutz personenbezogener Daten: DSG NRW, 2000. https://recht.nrw.de/lmi/owa/br_bes_text?anw_nr=2%5C&gld_nr=2%5C&ugl_nr=20061%5C&bes_id=4908%5C&aufgehoben=N%5C&menu=1%5C&sg=0, visited on 09/08/2013

d'Heureuse et al. (2012)

Nico d'Heureuse, Felipe Huici, Mayutan Arumaithurai, Mohamed Ahmed, Konstantina Papagiannaki, Saverio Niccolini: What's app?: a wide-scale measurement study of smart phone markets. In: SIGMOBILE Mob. Comput. Commun. Rev. Nr. 2, Jg. 16, 2012, pp. 16–27

Future of Privacy Forum, Center for Democracy & Technology (2011)

Future of Privacy Forum, Center for Democracy & Technology: Best Practices for Mobile Application Developers: App Privacy Guidelines. In: Future of Privacy Forum and the Center for Democracy & Technology. 2011, pp. 1–20

Istepanian, Jovanov, Zhang (2004)

R.S.H. Istepanian, E. Jovanov, Y.T. Zhang: Guest Editorial Introduction to the Special Section on M-Health: Beyond Seamless Mobility and Global Wireless Health-Care Connectivity. In: IEEE Transactions on Information Technology in Biomedicine. Nr. 4, Jg. 8, 2004, pp. 405–414

Kaletsch, Sunyaev (2011)

Alexander Kaletsch, Ali Sunyaev: Privacy Engineering: Personal Health Records in Cloud Computing Environments. In: ICIS 2011 Proceedings. 2011, pp. 1–11

Lica (2010)

Liviu Lica: Mobile and Social: Ten Best Practices for Designing Mobile Applications. In: Informatica Economica. Nr. 3, Jg. 14, 2010, pp. 60–74

Martínez-Pérez, de la Torre-Díez, Isabel, López-Coronado (2013)

Borja Martínez-Pérez, de la Torre-Díez, Isabel, Miguel López-Coronado: Mobile health applications for the most prevalent conditions by the World Health Organization: review and analysis. In: Journal of medical Internet research. Nr. 6, Jg. 15, 2013, e120

Nicolaou (2013)

Alex Nicolaou: Best Practices on the Move: Building Web Apps for Mobile Devices. In: Communications of the ACM. Nr. 8, Jg. 56, 2013, pp. 45–51

Njie (2013)

C.M.L. Njie: Technical Analysis of the Data Practices and Privacy Risks of 43 Popular Mobile Health and Fitness Applications. In: Privacy Rights Clearinghouse. 2013, pp. 1–31

The European Parliament and the Council of the European Union (1995)

The European Parliament and the Council of the European Union: Directive 95/46/EC, 1995. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31995L0046:en:NOT, visited on 09/08/2013

Wessels, Purvis, Rahman (2011)

Andrew Wessels, Mike Purvis, Syed Rahman: “Usability of Web Interfaces on Mobile Devices”. In: *Information Technology: New Generations, Third International Conference on*. 2011, pp. 1066–1067

West et al. (2012)

Joshua H. West, P. Cougar Hall, Carl L. Hanson, Michael D. Barnes, Christophe Giraud-Carrier, James Barrett: There's an App for That: Content Analysis of Paid Health and Fitness Apps. In: Journal of medical Internet research. Nr. 3, Jg. 14, 2012, pp. 1–11

World Health Organization (2011)

World Health Organization: mHealth: New horizons for health through mobile technologies, 2011. http://whqlibdoc.who.int/publications/2011/9789241564250_eng.pdf, visited on 08/30/2013

World Wide Web Consortium (2008)

World Wide Web Consortium: Mobile Web Best Practices 1.0: Basic Guidelines, W3C Recommendation, 2008. http://www.w3.org/TR/2008/REC-mobile-bp-20080729/, visited on 09/09/2013

Yeh, Fontenelle (2012)

Shea-Tinn Yeh, Cathalina Fontenelle: Usability study of a mobile website: the Health Sciences Library, University of Colorado Anschutz Medical Campus, experience. In: Journal of the Medical Library Association. Nr. 1, Jg. 100, 2012, pp. 64–68

Erklärung

Hiermit versichere ich an Eides Statt, dass ich die vorliegende Arbeit selbstständig und ohne die Benutzung anderer als der angegebenen Hilfsmittel angefertigt habe. Alle Stellen, die wörtlich oder sinngemäß aus veröffentlichten und nicht veröffentlichten Schriften entnommen wurden, sind als solche kenntlich gemacht. Die Arbeit ist in gleicher oder ähnlicher Form oder auszugsweise im Rahmen einer anderen Prüfung noch nicht vorgelegt worden.

Köln, den 30. September 2013

Curriculum Vitae

Persönliche Angaben

Name:	Phil Diegmann
Anschrift:	Wipperfürther Str. 477, 51515 Kürten
Geburtsdatum:	06.02.1991
Geburtsort:	Wipperfürth
Familienstand:	ledig

Schulische Ausbildung

09/1998 - 07/2002	St. Antonius Grundschule in Wipperfürth
09/2002 - 07/2010	Engelbert-von-Berg Gymnasium in Wipperfürth, Abschluss: Abitur (1,5)

Studium

10/2010 - 09/2013	Universität zu Köln, Wirtschaftsinformatik, B.Sc.
10/2013 - 09/2015	Universität zu Köln, Information Systems, M.Sc.

Praktika und Berufserfahrung

02/2007	Krüger Industrieautomation GmbH, Wipperfürth (Praktikum)
04/2008 - 02/2011	Webergy Internet Software AG, Lindlar (Teilzeit)
02/2012 - 02/2014	Forschungsgruppe Informationssysteme und Lernprozesse, Universität zu Köln (Studentische Hilfskraft)
seit 08/2012	Selbstständig (IT-Beratung, Entwicklung und Design)

Sonstige Qualifikationen und Auszeichnungen

Sprachkenntnisse	Deutsch:	Muttersprache
	Englisch:	Fließend
	Französisch:	Gute Kenntnisse
	Spanisch:	Grundkenntnisse
seit 10/2010	Stipendiat der Studienstiftung des Deutschen Volkes	
seit 06/2012	Sitz im Ausschuss "Schule, Generationen und Soziales" der Gemeinde Kürten	