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MOBILE GOVERNMENT

E-GOVERNMENT FOR MOBILE SOCIETIES

STOCKTAKING OF CURRENT TRENDS AND INITIATIVES

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Abstract: During the past decades, mobile technologies have influenced our lives significantly. In the typical western 'always-on society', people are used to be available round the clock and to have access to services everywhere and anytime. Governments react on this demand by offering services through additional mobile communication channels. Such activities have become commonly known under the term mobile government (m-Government) and are usually regarded as a subset of e-Government.

This survey aims to identify current trends and initiatives in the field of m-Government. Therefore, the document first provides a general introduction to the topic and presents commonly used terms and notations. The study also presents enablers and challenges of m-Government and introduces critical success factors. To get a comprehensive overview of the current global situation, several m-Government projects from different countries and regions are briefly sketched. Furthermore, relevant studies, articles, and scientific publications on m-Government are presented and discussed.

The variety of ongoing projects and activities, and the high interest of the scientific community substantiate the topicality of m-Government. With the increasing popularity of smartphones, new impulses and developments can be expected. This will also raise new challenges that need to be overcome in order to make m-Government a future success. This survey attempts to contribute to this success by emphasizing the importance of m-Government and by identifying potentials for further activities.

Contents

1. Introduction

In the recent years and decades, the emergence of information and communication technologies (ICT) has significantly influenced the interaction between citizens and governmental authorities. Positively influenced by the private sector and driven by the objective to treat citizens rather as customers than as supplicants, governmental authorities have developed ICT based services that ease the interaction and communication between public authorities and citizens. The application of information and communication technologies for these purposes has become commonly known under the term 'Electronic Government' or 'e-Government' and is currently widely used.

During the past few years, mobile technologies have experienced a vast increase in terms of popularity. The current hype of mobile technologies is mainly substantiated by two factors. First, during the past years the bandwidth of mobile communication networks has been increased continuously, which has allowed for higher data transmission rates at lower costs. At the same time, the permanent miniaturization of electronic components has facilitated the development of powerful mobile handheld devices. These advancements have recently led to the introduction of smartphones – powerful mobile phones that are usually equipped with a touch screen for comfortable user interaction and several additional features and gimmicks.

The "always on" nature of mobile phones and their continuously increasing set of supported features predestine these devices for e-Government purposes. Using mobile phones within e-Government processes is actually not a completely new idea. Attempts to integrate these devices into governmental services have already been made as soon as the first generation of mobile phones has captured the market. These initiatives have become known under the term 'Mobile Government' or 'm-Government'. Nevertheless, with the recent technological advances and the resulting rise of smartphones, m-Government has again become a topic of interest and is currently subject to several projects and activities in various countries.

In this study we want to contribute to this important topic by providing an overview of current trends and developments in the field of m-Government. The main objectives of this study, the used methodology, and the general structure of the document are described in the remainder of this section.

1.1. Objectives of this study

The general purpose of this study is to provide a comprehensive overview of, and introduction to the wide field of m-Government. By having a more detailed look at past and current activities in this area, the reader should be provided a deeper insight into the topic. Furthermore, current trends and possible future developments will be identified. The aim of this study is to have a look on m-Government from different perspectives. Therefore, the following objectives have been defined.

1.1.1. Motivate

One basic purpose of this study is to emphasize the importance and relevance of m-Government. By discussing its various advantages, different potentials of m-Government shall be identified. After reading this study, the reader should be aware of the importance of m-Government and its capability to enhance administrative and governmental procedures.

1.1.2. Impart basics

In order to obtain a basic understanding of the topic and to allow for a common terminology, another objective of this study is to define commonly used notations and to differentiate related terms and expressions. Furthermore, several different existing classification approaches for m-Government services shall be introduced.

1.1.3. Discuss potentials and limitations

One main goal of this study is to discuss success and acceptance factors of m-Government as well as different barriers and challenges that still have to be overcome in order to make m-

Government a success. It shall be ensured that remaining problems and challenges are not viewed from a technical perspective only. Instead, also the user's and citizen's perspectives shall be considered. This way, the study shall not limit itself to the identification of technical feasibilities, but shall instead provide the reader with a comprehensive picture of the current situation.

1.1.4. Show the project perspective

Another fundamental objective of this study is to view m-Government from the project perspective. Already completed as well as currently ongoing projects in the field of m-Government shall be listed and briefly summarized. This study shall not describe all relevant projects in detail but instead give an overview of basic findings, experiences, and outcomes of these activities. This way, the reader shall get a detailed overview of ongoing activities in the wide area of m-Government.

1.1.5. Show the scientific perspective

Last but not least, another goal of this study is to provide an extensive list of scientific publications and literature about m-Government and other closely related topics. By doing an intensive literature research, relevant scientific topics in the field of m-Government shall be identified. Furthermore, the present state of knowledge and research in the area of m-Government shall be determined. This way, the reader shall be provided with a comprehensive overview of relevant scientific work in the field of m-Government.

1.2. Methodology

The entire study is based on facts that have been collected during an intensive literature and web research, whereby the focus has been laid on freely available publications. All of the studies, papers, and articles that have been analyzed during the research phase of this study are listed in Section 8 of this document. The study basically summarizes the main findings and outcomes of these publications and discusses different approaches and methods being proposed by the authors of these contributions.

This study aims to give an overview of m-Government activities and initiatives from all over the world. Nevertheless, there is a slight focus on mobile government solutions in Europe as activities and developments in the European Union potentially have a larger impact on the Austrian situation than comparable developments in other regions or continents do.

1.3. Document structure

The remainder of this study is structured as follows. Section 2 of this document provides some definitions of basic terms that repeatedly occur in this study. Particularly the term 'm-government', which is often used in quite different contexts, is specified in more detail. Furthermore, this section differentiates several unambiguous and often misused terms related to mobile government. Subsequently, Section 3 introduces several approaches to classify m-Government services by means of various criteria. Hence, together with Section 2, this section deals with the objectives defined in Section 1.1.2.

Accordingly, Section 4 of this study aims to achieve the objectives being defined in Section 1.1.3 by focusing on drivers, enablers, and barriers of m-Government. Enablers of mobile government are introduced and different success and acceptance factors of m-Government services are identified. Finally, also possible barriers and future challenges of m-Government solutions are depicted.

Section 5 contains an overview of m-Government projects and initiatives from all over the world. By giving a deeper insight into past and current m-Government activities, this section considers the objectives that have been defined in Section 1.1.4. Similarly, Section 6 deals with the objectives given in Section 1.1.5 and contains an extensive list of scientific publications, related articles, and studies on m-Government.

Basic findings of this study are finally summarized in Section 7, which concludes this document. Furthermore, this section aims to identify future trends and provides an outlook to further possible activities. Relevant references are provided in Section 8.

2. Definitions and differentiations

The term ‘m-Government’ – being commonly used as abbreviation for the term ‘Mobile Government’ – comprises a broad spectrum of services and initiatives. This section aims to summarize the various meanings and interpretations of m-Government and tries to find a common definition.

In general, the term ‘m-Government’ comprises the terms ‘mobility’ and ‘e-Government’. In the following subsections, definitions of these two expressions are provided first. Subsequently, the term ‘m-Government’ is defined.

2.1. E-Government

Before finding a proper definition for the term e-Government, it is important to appropriately distinguish between the related terms ‘government’ and ‘governance’. Kumar et al. have already mentioned that these terms are often used interchangeably, which sometimes leads to misunderstandings. According to the distinction they made in their publication [1], *‘government is an institutional superstructure that society uses to translate politics into policies and legislation’*. Contrary, they state that *‘governance is the outcome of the interaction of government, the public service, and citizens throughout the political process, policy development, program design, and service delivery’*. Kumar et al. conclude that *‘governments are specialized institutions that contribute to governance’* and that *‘governance is the outcome of politics, policies, and programs’*.

Based on the given distinction between government and governance, Kumar et al. refer to e-Government as *the ‘government’s use of information technology to exchange information and services with citizens, businesses, and other arms of government’*. Similar definitions of e-Government can be found in other m-Government related publications as well. For instance, Trimi et al. state that *‘e-Government refers to the use of wired Internet technology by public-sector organizations to better deliver their services and improve their efficiency’* [2]. Holden et al. state that the conception of e-Government generally refers to the use of information and communication technologies (ICTs) in government operations, so that government services are provided electronically 24 X 7 [4]. Thus, Holden et al. already include one of the benefits of e-Government into its definition, namely the theoretically permanent availability of services. Carroll adds to the definition given by Holden et al. that *‘e-Government may refer to activities at federal, regional and local government levels’* and that *‘it may also refer to internal activities (within government), and external relations’* [3].

Although the definition of e-Government differs slightly depending on the particular publications and authors, there is obviously common consent that e-Government refers to the provision of information and services by governments using information and communication technologies. It is important to note that no limitation regarding the used technology is made.

2.2. Mobility

As already suggested by the term ‘mobile government’, m-government aims to bring mobility to e-Government processes. To get a deeper understanding of what mobility means in the context of e-Government, a more precise definition of this term is required. In his contribution [5], Roggenkamp has reflected upon mobility and its various interpretations and meanings.

Roggenkamp states that there are basically three levels of mobility: a social level of mobility, a physical level of mobility, and virtual mobility being added by the introduction of information and communication technologies. Furthermore, Roggenkamp defines three different types of mobility. According to his definitions, spatial mobility refers to the extensive movement of people and the mobility of objects, symbols and space itself. In contrast, temporal mobility refers to the moving of time slots according to a flexible and dynamic prioritization of tasks. Modern networking technologies like SMS or e-mail support asynchronous communication and

hence allow for a dynamic scheduling of communication tasks. While spatial mobility and temporal mobility cover the aspects 'where' and 'when' of an interaction, contextual mobility being the third type of mobility defined by Roggenkamp refers to *'the modalities, in which and how this interaction occurs'*.

In [5], Roggenkamp splits up mobility once more into three different sets: device mobility, user mobility, and service mobility. Device mobility is defined as *'the continued access to services with a device while moving'*. Furthermore, according to Roggenkamp user mobility *'refers to location- and device independent service access apart from the mobility without physical constraints'*. Finally, service mobility is defined as *'the capability to provide a certain service irrespective of device and user'*.

Roggenkamp also provides a very important distinction of the two often interchangeably used terms 'wireless' and 'mobile'. While 'mobile' basically describes the ability to communicate anytime and anywhere, 'wireless' just refers to the fact that a device is without wires. For instance, a PC being connected wirelessly to a WLAN is still not able to provide the same degree of mobility than a smartphone.

2.3. M-Government

Simply put, m-Government is a combination of the two concepts e-Government and mobility that have been described and defined in the previous sections. The general idea of m-Government is to make use of mobile technologies in order to enhance existing e-Government procedures and services and to develop new mobile approaches in this field of application.

Although the intention of m-Government is quite intuitional, m-Government is defined in various slightly different ways in many publications. An early and often cited definition of m-Government has been given by Kushchu et al. who claimed that m-Government *'may be defined as a strategy and its implementation involving the utilization of all kinds of wireless and mobile technology, services, applications and devices for improving benefits to the parties involved in e-government including citizens, businesses and all government units'* [6].

Antovski et al. [7] provide a rather loose definition of m-Government. They simply state that *'m-Government is largely a matter of getting public sector IT systems geared to interoperability with citizen's mobile devices'*. A similar definition is given in [3], where the author states that *'m-Government involves the provision of public sector services via mobile technologies'* but amends that *'m-Government involves interaction where the contexts are unknown, where accessing government services might be one of several activities being undertaken and where the physical constraints of interacting with mobile devices limit the amount and type of information that might be located and accessed'*. In contrast, Misra [8] provides a short and concise definition of m-Government by stating that *'m-Government is public service delivery including transactions on mobile devices like mobile phones, pagers, and PDAs'*.

Although several slightly different definitions of m-government can be found in literature, there is common consent that m-Government is a subset of or complement to e-Government. M-government is no replacement or successor of e-Government; it aims to enhance existing e-Government services using new mobile technologies and to extend the set of offered services. Another interesting perspective has been recently defined by Misra [9], who states that the development of web-based e-Government can be subdivided into three sub-phases. The first phase called 'Customer Service' was e-commerce inspired and lasted from the year 1995 to the year 2000. This first phase was then followed by a second phase named 'Virtual Agency', which was portal inspired and lasted from the year 2000 to the year 2005. According to Misra, we are currently in the third phase, which is technology inspired and called 'm-Government'.

Kumar et al. [1] claim that m-Government is a technology-specific sub-category of e-Government. According to their definitions, there exist other similar sub-categories like u-Government (Ubiquitous Government) or g-Government (GIS/GPS applications for e-Government).

There are almost as many slightly differing definitions of m-Government as there are publications on this topic. However, the following two principles are part of nearly each definition and hence can be seen as common consent:

- m-Government denotes the utilization of mobile technologies for electronic governmental services. The focus lies on both, the enrichment of existing e-Government services, as well as the development of new approaches using mobile approaches.

- m-Government is a subset or extension of e-Government. m-Government is no successor of or replacement for classical e-Government approaches but aims to enrich the set of offered electronic governmental services by means of mobile technologies.

3. Classification of m-Government services

Most given definitions of m-Government are rather loose and hence comprise a wide spectrum of mobile governmental applications and initiatives. Several attempts have been made to put these various activities in the field of m-Government in order by introducing different classification schemes for m-Government services. This section describes some of the most important classification approaches that can be found in literature.

3.1. User interface

One possible approach to classify m-Government services is according to their user interface. Misra [8] distinguishes between web-based m-Government services and non-web m-Government. Web-based services are already known from e-Government, where interaction between authorities and citizens usually occurs through a web browser running on the citizen's client system and displaying content like web forms being hosted on the particular public authority's server.

While the web-based presentation of information and the interaction with citizens through web forms have proven their reliability in many e-Government systems, the situation is more complicated on mobile devices. Modern smartphones or other comparable mobile devices are usually equipped with a web browser. However, because of the limited hardware resources of these devices, the usability of their integrated browsers is in general worse compared to desktop PC systems or laptops. Especially the reduced screen size and limited input capabilities often make interaction with web sites through mobile web browsers troublesome.

In consideration of the given limitations of mobile devices, many m-Government services forbear from relying on web technologies. Instead, these services make use of other mobile technologies being available on mobile devices. For instance, various m-Government services – especially in developing countries – currently rely on short text message service (SMS) only and can thus be classified as non-web m-Government. Other examples for these kinds of services are those relying on voice-based input and output.

Reliable and usable interaction with users is one of the challenges of m-Government. While classical e-Government services mainly rely on web technologies, m-Government services usually make use of a broader spectrum of technologies being available on mobile phones. A classification of m-Government services according to their user interface technology seems thus reasonable.

3.2. Participants

Another often followed strategy to classify m-Government services is according to the participants being involved in the particular service or procedure. In [10], the matrix shown in Table 1 illustrates which types of participants basically exist in the m-Government ecosystem and indicates possible relations between the different parties. Those relationships, for which the most significant potential for m-Government is expected, are highlighted.

	Government	*Business*	*Citizen*	*Tourist*
Government	**G2G**	**G2B**	**G2C**	**G2T**
Business	**B2G**	B2B	**B2C**	**B2T**
Citizen	C2G	C2B	**C2C**	C2T

Table 1 – Classification according to participants

According to *Table 1*, one core field of application is the communication with direction to the citizen. In contrast, less potential is expected for citizen-initiated communications. A similar kind of classification of m-Government services has also been used in various scientific publications.

In [1], Kumar et al. extend the relations shown in *Table 1* by the type 'government to its employees (G2E)'. A similar classification of m-Government services has also been applied by Kim et al. in [11].

3.3. Type of transaction

The type of transaction that is carried out within an m-Government process is another key property of an m-Government service that may be used for classification purposes. According to Norris et al. [13] there are three different types of transactions in e-Government. This classification has been adapted for m-Government services by several authors for instance in [12] and [14]. The following three types of transaction are identified:

- *Informational transactions* basically include the publishing and broadcasting of messages to end-users. In the context of m-Government, this includes for instance the sending of alert messages to citizens by governments in case of emergencies. Informational transactions are one-way; hence there is typically no possibility for receivers of published information to reply or to directly interact with the sender.

- *Transactional services* are usually bi-directional. Citizens are able to interact with the particular authority directly. In e-Government, this interaction is often based on web applications. Using this type of service, users are able to carry out governmental procedures completely online.

- *Operational services* refer to operations that take place within a governmental authority. An example in the field of m-Government is a police officer being equipped with appropriate mobile devices that allow him or her to connect directly to the police's central databases and services.

3.4. Purpose

Another possible classification of m-Government services can be applied according to the services' intended purposes. Zálešák [15] has identified four main purposes for m-Government in the public sector:

- *M-Communication* aims to improve the communication between governments and citizens. Reliable information and communication channels are key requirements for a functioning society. However, especially in developing countries, reaching citizens is often difficult for governments. Mobile devices and appropriate m-Government services allow governments to easier get in contact with their citizens.

- *M-Services* basically comprise m-Transactions and m-Payments. M-Services extend the scope of m-Communication and allow the processing of transactions between citizens and governments.

- *M-Democracy* comprises initiatives to improve the democratic participation of citizens using mobile devices. This includes for instance activities in the fields of m-Voting or political decision-making processes. Lallana emphasizes the importance of m-Government for democracy in one of his articles [17]. He states that there are basically

two ways how m-Government can help to promote e-Democracy. According to Lallana, m-Government *'can strengthen existing democracies by enhancing existing representative institutions'*. Furthermore, m-Government *'can help create a more vibrant civil society'*.

- *M-Administration* aims to improve internal governmental operations within and between public authorities and agencies.

In [16], the authors extend the list proposed by Zálešák [15] by two more purposes. They claim that m-Banking – the provision of financial service through mobile technologies – and m-Health – the usage of mobile technologies in health services – are also important purposes of m-Government, especially in developing countries.

3.5. Phase of development

Another interesting approach to classify m-Government services has been introduced in [16]. The authors claim that there are two phases in the development of m-Government services and propose to classify services according to the phase to which they belong.

In the first phase, m-Government services are developed that *'provide through mobile devices what is already available through a computer based application'*. The goal of this phase is to make the usage of existing services independent from the citizen's availability of a desktop computer, laptop, or similar device.

In the second phase, m-Government services are developed, which *'provide those services and services which are only possible through wireless and mobile infrastructure'*. The authors claim that this is actually the more crucial phase in the development of m-Government.

4. Drivers and obstacles of m-Government

Thanks to remarkable advances in mobile computing, m-Government has recently become a contemporary issue. Frequent releases of new mobile devices with enhanced processing power and extended capabilities inspire developers to regularly show up with innovative ideas for m-Government services. Supplementary to technological advances, there are several other factors that influence the development of m-Government as well. This section introduces aspects that enforce the move towards mobile government and shows which factors are critical for the success and acceptance of new mobile governmental services.

Beside drivers and enablers, several barriers and challenges of m-Government can be identified. This section will also have a look at issues that threaten to impede the expected future success of m-Government and have to be overcome.

4.1. Enablers

Beside the already mentioned technological enhancements in the field of mobile computing and communications, there are several other factors that contribute to the increasing popularity of m-Government. The most important and most frequently mentioned aspects are sketched below.

4.1.1. Mobile communication technologies

Mobile communication networks are the key technology for any mobile service as they are responsible for any data transmission from or to mobile end devices. The development of the first analogue mobile communication networks has already started in the 1950's. However, these networks of the first generation were difficult to use and had a very low data transfer capacity. Furthermore, there was usually no compatibility between isolated solutions of different countries. These unsolved issues had a negative effect on the penetration of mobile phones.

In 1982, the 'Group Spécial Mobile (GSM)' was founded to develop a common pan-European mobile communication standard. In the early 1990's, the new GSM standard of the second

generation (2G) was implemented and slowly started to replace existing analogue networks. With the introduction of GSM, the world-wide success story of mobile communication had begun. By the end of 2008, 1.050 GSM networks had already been established in 222 countries with 3.5 billion subscribers in total [18]. Especially in several developing countries in Asia, the number of mobile subscribers is still growing rapidly.

GSM was intended for telephone services and thus mainly designed for the transmission of voice. Beside telephony, text messaging (SMS) has become another popular GSM application and is still heavily used especially by younger people. With the growing customers' demands for more sophisticated mobile applications (e.g. Multimedia Messaging Service – MMS), network providers were forced to apply new technologies in order to increase the capacities of their networks. Advanced 2G technologies like GPRS (General Packet Radio Service) and EDGE (Enhanced Data Rates for GSM Evolution) have been applied to allow for higher data transmission rates. In consideration of 2G technologies' reduced data transfer rates, the Wireless Application Protocol (WAP) has been developed in order to make web content available on mobile devices.

Although already GPRS and EDGE have allowed for basic mobile Internet and web access through WAP, only the introduction of the third generation protocol UMTS (Universal Mobile Telecommunications System) has finally leveraged the success of mobile Internet. Compared to 2G technologies, UMTS and related technologies like HSDPA (High Speed Downlink Packet Access) allow for significantly higher data transmission rates. So far, 3G networks have been rolled out mainly in developed countries (e.g. European Union, Japan, Australia, and United States of America). In other regions, especially in developing countries in Asia and India, GSM (2G) is still the leading technology for mobile communication.

With current 3G technologies, data transfer rates that allow for reliable mobile Internet access are achievable. Nevertheless, mobile network providers still aim to optimize the performance of their infrastructures. Currently, the new data transfer technology LTE (Long Term Evolution) is about to capture the market in several developed countries. It is to be expected that this trend will continue and new enhanced mobile communication technologies will be introduced frequently. This will pave the way for new mobile applications that require high data transfer rates. Powerful mobile communication networks can thus be identified as an important enabler of complex m-Government applications.

4.1.2. Powerful mobile devices

Together with the continuous advancements of mobile communication technologies, hand-held devices like mobile phones have developed considerably. While mobile phones in the 1990's basically supported telephone and text messaging services only, modern smartphones provide users a comprehensive and flexibly extensible set of features and functions. This includes mobile access to the Internet, web browsing, GPS applications, calendar and time management tools, games, and many more.

Smartphones are not the only kind of mobile devices that currently experience increased popularity. Also other mobile hand-held devices such as navigations systems, e-book readers, tablet PCs, or the Apple iPad are currently gaining popularity. However, from the current point of view, mobile phones seem to be the most appropriate end devices for m-Government services. Thus, in this study the main focus will be laid on these devices.

The worldwide popularity of mobile devices in general and in particular of mobile phones is basically substantiated by two reasons. First, as mentioned above, mobile communication networks are nowadays available almost anywhere – even in developing countries. In these countries, mobile phones are often the only opportunity to communicate electronically because of missing fixed line communication infrastructures. In developed countries, mobile phones satisfy the needs of the modern western 'always-on society'. Especially in business life, being available anytime and everywhere has often become mandatory to remain competitive. Mobile phones and other mobile devices satisfy this need and allow for flexible and efficient communications.

The second reason for the popularity of mobile devices is the constantly increasing set of supported features and functionality. These developments have been enabled by the ongoing miniaturization of electronic components, the development of enhanced I/O technologies like touch screens, and by advances in battery technology. Mobile phones of the first generations came with relatively low computational power and small internal memory capacities. In contrast, modern smartphones are already equipped with CPUs running at up to 1 GHz and internal memory of several hundreds of MB. These improved processing and storage capabilities pave the way for the operation of more complex applications on the mobile device. Thus, the increased popularity of mobile devices and their still increasing hardware equipments can be identified as important enablers of m-Government services as well.

4.1.3. Growing mobile markets

Considering available statistical data, it becomes apparent that in the future, mobile communication technologies will play an important – and in several countries even leading – role. According to [18], the worldwide number of mobile subscribers has grown from 640 millions in the year 2000 to 3.978 billion in the year 2008.

To identify the fastest growing markets, the worldwide distributions of mobile subscribers for the years 2000 and 2008 have been listed in *Table 2*.

Global cellular subscribers	*2000*	*2008*
Africa	2%	9%
Americas	8%	11%
Asia Pacific	31%	43%
Eastern Europe	4%	11%
Western Europe	33%	13%
Middle East	4%	6%
North America	18%	7%

Table 2 – Worldwide distribution of mobile subscribers; data taken from [18]

Analysis of the data provided in [18] turns out that Africa, Asia, and Eastern Europe have been the fastest growing markets between the years 2000 and 2008. It is to be expected that this trend will continue especially in developing countries in Asia and Africa.

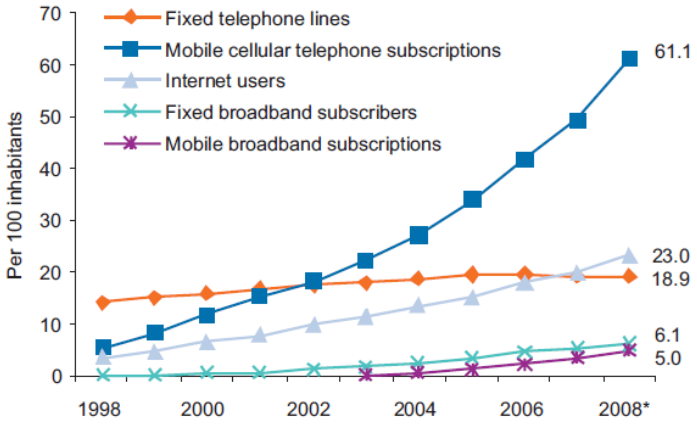

Figure 1 – Global growth of telecommunication and ICT infrastructure; taken from [129]

Similar statistical data has been in presented by the International Telecommunication Union in [129]. Figure 1 illustrates the global growth of communication and ICT infrastructures and emphasizes the significant increase in mobile cellular telephone subscriptions. A comparison between the number of global fixed line subscribers and the number of mobile cellular subscriptions is shown in Figure 2. According to this chart, the number of global mobile cellular subscribers has exceeded the number of fixed line subscription in 2002. In 2008, already 4.1

billion mobile subscribers have been registered compared to only 1.27 billion of fixed line subscribers.

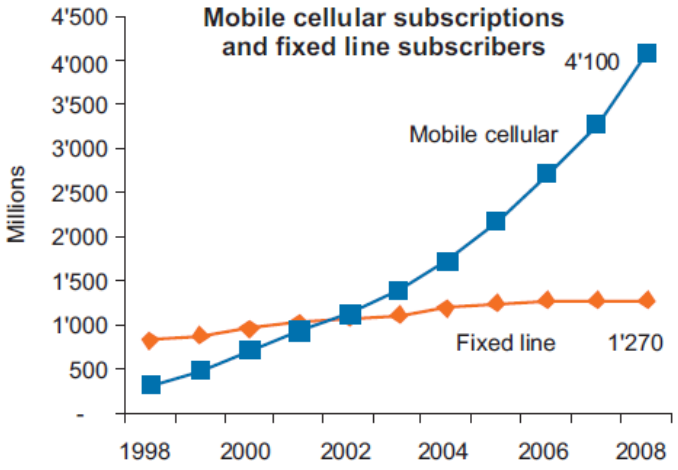

Figure 2 – Comparison of mobile cellular subscriptions and fixed line subscribers; taken from [129]

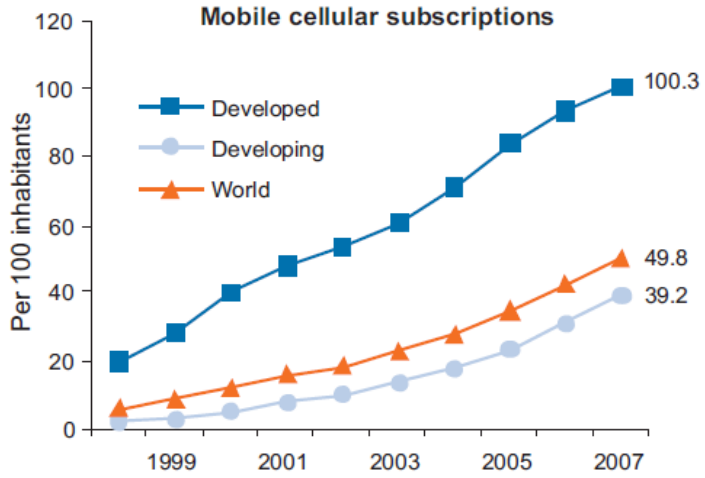

Figure 3 – Mobile cellular subscriptions in developing and developed regions; taken from [129]

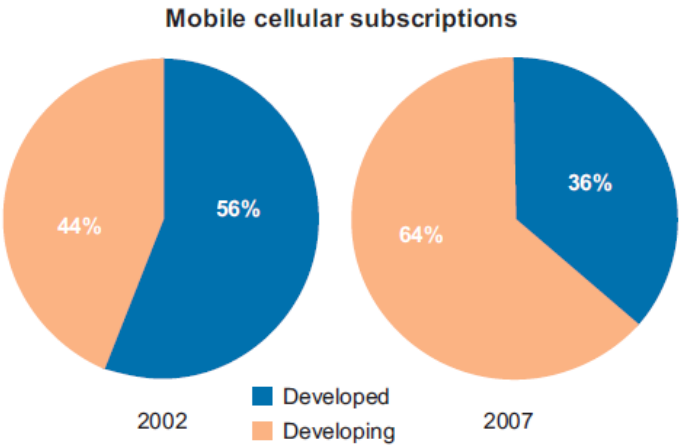

Figure 4 – Mobile cellular subscriptions in developing and developed regions; taken from [129]

Figure 3 shows that the mobile penetration is actually increasing in both developed and developing regions. The vast growth of new mobile users in developing countries is also illustrated in Figure 4. While in 2002 only 44% of all global mobile subscriptions have taken place in developing regions, this percentage rate has grown to 64% in 2008. Finally, Figure 5 shows the mobile penetration of several world regions. Again, it becomes apparent that the increase of mobile subscribers is indeed a global phenomenon.

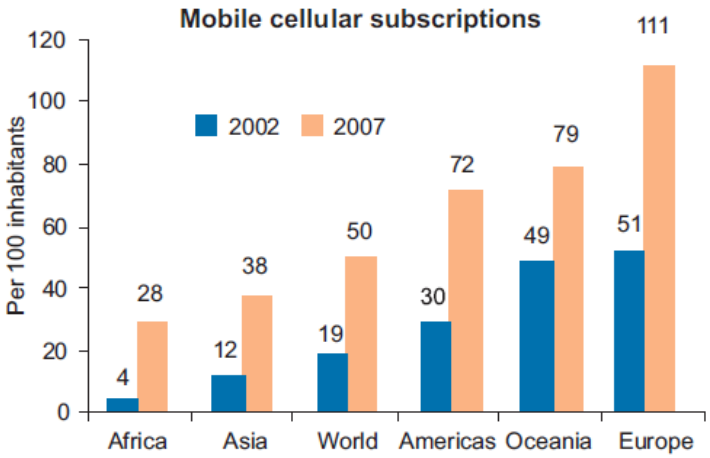

Figure 5 – Growth of mobile cellular subscriptions in different world regions; taken from [129]

Mobile communication technologies have an enormous potential especially in developing countries with weak fixed line communication infrastructures. In many regions, mobile networks are the only possible communication channel for citizens to communicate with each other over larger distances or to get in contact with governmental institutions and authorities. Governments of developing countries have identified this issue and therefore rely on m-Government services to get in contact with their citizens. Growing mobile markets especially in developing countries are therefore an important driver for m-Government related activities and initiatives.

Besides developing regions, mobile technologies show a high potential for developed countries too. Figure 5 illustrates that for instance in Europe a mobile penetration rate of 111% has already been reached in 2007. This facilitates the introduction of m-Government and offers people the opportunity to access services everywhere and anytime.

4.1.4. Advantages of m-Government

So far, advancements in the development of powerful communication networks and mobile end devices have been identified as relevant enablers of m-Government. Certainly, these mentioned points are important as they form the technological basis on which all m-Government services are built on. However, the sole ability to do something is usually not enough; people need to see a personal benefit, otherwise offered services are not accepted [19].

In the context of m-Government, this means that citizens need to see an advantage in doing transactions with governmental authorities with their mobile phones instead of using e-Government based solutions or personal consultations at administrative offices. Fortunately, m-Government provides several benefits for citizens compared to other approaches. The most important ones have been summarized in [10] and are briefly described in the following:

- Smartphones and comparable mobile devices are usually always carried and always on. Hence, these devices provide users the capability to communicate everywhere and anytime. In the context of m-Government, this means that citizens are able to continuously access m-Government services independently of the current time and their current location. This is a significant advantage compared to classical e-

Government based solutions that usually require citizens to sit in front of a PC and hence bind them to fixed locations. Compared to paper based administrative procedures in offices of public administrations, m-Government services – and of course also e-Government services – have the benefit to be accessible independent from office hours.

- The always-on characteristic of mobile phones makes not only m-Government services, but also citizens accessible anytime. Mobile phones can therefore be used to speed up the information flow between different parties involved in administrative procedures. For example, mobile communication networks can be used to broadcast urgent informational messages from the government to the people.

- The simplicity of using mobile communication technologies can improve several processes in terms of efficiency. This way, the usage of mobile technologies in governmental and administrative processes can help to save time and money.

- Mobile phones are usually very personal devices. While for instance computers are often shared within a family, mobile phones usually belong to one person only. Hence, when used within m-Government, these devices provide more personalization opportunities for targeting users.

- Smartphones and similar devices support different forms of interaction. For instance, many mobile phones may be alternatively controlled via voice. Likewise, mobile communication itself can be based either on voice or alternatively on text messaging. These choices between different types of interaction and communication can assist disabled people to access administrative and governmental services.

- In several developing regions, mobile penetration exceeds Internet penetration. Hence, mobile phones are the only available means for people to get in contact with administrative agencies and bodies electronically. In these areas, missing infrastructures often inhibit the application of classical e-Government services. In contrast, m-Government solutions based on available 2G mobile networks are feasible and an easy method for governments to get in contact with their citizens. M-Government is therefore a solution to the digital divide and can even strengthen democracy. The authors of [10] claim that *'in the long run, indicative of an effective m-government is the proactive participation of citizens in decision making, policy formulation and towards the end, nation building'*.

The above mentioned benefits of m-Government affect both citizens and governmental institutions. If developers of m-Government solution manage to ensure that all participants realize these various advantages, m-Government can become a great success. Thus, the various benefits of m-Government are of course also important drivers for its success.

4.2. Success and acceptance factors

Although there are various advantages of m-Government compared to e-Government or classical administrative procedures, the success of m-Government is no safe bet. The identification of critical success factors for m-government has been the topic of several publications.

According to Karan et al. the success of m-Government basically depends on five critical success factors [20]. In their contribution, Karan et al. have mainly analyzed the situation of m-Government in India. Nevertheless, their basic ideas and conclusions can be applied to other countries and regions as well. The five critical success factors of m-Government that have been identified by Karan et al. are briefly described below:

- *Infrastructural investment:* Infrastructural investment has been identified as one critical success factor for m-Government, especially in developing countries. Karan et al. report that in India, the development of required infrastructures is often impeded by

missing financial resources. No doubt, this situation can be found in other developing countries as well. Karan et al. suggest an intensification of public private partnerships (PPP) in order to include the private sector in the infrastructural development.

- *Regulatory and political environment:* In order to enable m-Government and to make it a success, Karan et al. claim that an appropriate legal framework has to be in place. This framework has to ensure that m-Government services are based on a solid legal basis. Furthermore, an appropriate policy framework for the telecommunication sector can allow for competitive market situations, which in turn may lead to better services for citizens.

- *Awareness and acceptance:* The development and rollout of m-Government services is only the first move. According to Karan et al., awareness and acceptance of offered services by both citizens and employees of government departments is crucial too. Hence, in order to avoid frustration on both sides, new m-Government services need to be well introduced and participating parties – i.e. citizens and employees of administrative bodies – should be provided with related information and training. Only if all participants are familiar with the available m-Government services, they will be willing to use these services and can benefit from them. Awareness and acceptance are therefore critical factors for the success of m-Government initiatives.

- *Security and privacy:* Certainly, security is an important requirement for any ICT system that deals with secure or privacy sensitive data. This applies especially to m-Government services because of several reasons. The previously mentioned point has emphasized the importance of acceptance of m-Government services by citizens. Crucial conditions for the acceptance of such services are security and privacy. M-Government services won't be accepted and used by citizens if they do not trust them. Users want to be sure that their personal data is processed securely by these services and cannot be accessed or stolen by unauthorized parties. Of course, this applies also to classical e-Government services, where citizen related data is processed electronically too. However, the situation is even more critical with m-Government, since mobile devices are especially prone to loss or theft and usually have only weak built-in security mechanisms. According to Karan et al., security and privacy are therefore critical success factors of m-Government services.

- *Equitable access:* In [20], equitable access to information is identified as '*one of the most vital principles in the emerging global information economy*'. Thanks to quickly growing mobile penetrations, mobile communication technologies and especially m-Government services have the power to contribute to the equitable access of information. According to Karan et al., equitable access is therefore another factor that will significantly impact the success of m-Government.

While Karan et al. classify success factors of m-Government rather coarse-grained into the five above-mentioned categories, Al-khamayseh et al. [108] provide a more differentiated list of critical success factors for m-Government. In their publication, they have identified the following fourteen factors: 'privacy and security', 'infrastructure', 'user needs and preferences', 'quality and user friendly applications', 'e-Government', 'acceptance', 'cost', 'standards and data exchange protocols', 'coherent m-Government framework', 'high mobile penetration', 'infrastructure management', 'm-Government awareness', 'access', 'strategy', 'IT literacy', 'm-Government portals and exclusive gateways', 'private sector partnerships', and 'legal issues'.

The identified success factors have been ranked according to their importance for successful m-Government. 'Privacy and security' have been considered as the most important factors followed by 'infrastructure'. Also 'user needs and preferences' as well as 'quality and user friendly applications' have been considered to be of significant importance for the success of m-Government. The provided ranking emphasizes the demand that m-Government applications should be mainly driven by user needs. Only if users are supplied with user

friendly applications that satisfy their personal needs and process their private data securely and reliably, these applications will be a success.

The identification of success factors for m-Government applications has also been the topic of several other scientific publications e.g. in [109] or [110]. Although these contributions have a look at this topic from a slightly different point of view, the identified success factors are similar to those found in the above-mentioned publications.

Besides security and privacy considerations, awareness and acceptance have been identified as critical success factors of m-Government services. In [21], El-Kiki gives an adequate summary of research done by Carroll [3] and identifies the following factors that significantly influence the acceptance of m-Government service:

- *Availability:* Availability is of course a basic requirement. Only functionalities and features that are actually available can be accepted. However, one basic finding of [3] is that availability does not automatically imply usage. Citizens use available technologies if they are able to fit their needs and not just because they are available.

- *Effort involved:* Carroll [3] found out that users are often unwilling to invest required effort in getting familiar with complex or lengthy tasks. Hence, to ensure that m-Government services are accepted by citizens, these services need to be simple and intuitively usable.

- *Convenience:* Another basic finding of the study conducted by Carroll [3] is the less surprising fact that people generally tend to prefer convenience. This finding holds a considerable potential for m-Government services. If communication and interaction with public administrative authorities can be improved in terms of convenience using m-Government services, there are good chances that these services will become accepted.

- *Input and output mechanisms:* Unfortunately, mobility requirements do often conflict with usability requirements. For instance, mobile hand-held devices like smartphones should not exceed a certain size in order to remain convenient and portable. On the other hand, interaction with mobile devices becomes more and more difficult with decreasing screen and keyboard sizes. For the acceptance of m-Government services it is therefore crucial that appropriate input and output mechanisms are available.

- *Privacy and security issues:* Trust in the security of available services is an important factor for the acceptance of these services. According to El-Kiki [21], for instance m-Voting was no success in England *'only because people could not surmount the psychological barrier of using an unofficial messaging method to fulfill an official task'*. Since m-Government services often deal with security or privacy sensitive citizen related data, users want to be sure that their data cannot be compromised or misused by unauthorized parties. In order to reach a high degree of acceptance of m-Government, it is therefore crucial to convince users of the security and reliability of these systems.

- *Lack of public sector services:* Another relevant acceptance factor for m-Government services is the number of available offers. Only with an appropriate number of m-Government services citizens get the chance to use them frequently and get used to this kind of communication and transaction. Certainly, also the quality of the offered services matters. In her study [3], Carroll found out that users quickly get frustrated when the design of the used service's interface is difficult to use and hard to understand.

In several publications it has been shown that the success of m-Government applications depends on different critical factors. One of the most crucial factors is user acceptance. Only if m-Government applications are accepted by users, these applications have the chance to

become successful. Therefore, the most important objective for m-Government services is to focus on and to satisfy user needs and requirements. At the same time, m-Government solutions need to gain users' confidence and trust by applying secure and reliable tools and methods to ensure that privacy or security sensitive data remains protected.

4.3. Challenges and barriers

Recent technological developments and growing mobile markets seem to pave the way for a worldwide application of m-Government services. So far, enabler and drivers of m-Government as well as critical success and acceptance factors have been identified. Although there are manifold reasons why m-Government will play an important role in the near future, there are still some issues and challenges left to overcome. Some of the most relevant and often mentioned challenges and barriers of m-Government are briefly discussed in the following.

In [1], Kumar et al. identify two critical issues for m-Government applications. First, they state that appropriate mechanisms regarding privacy and security are crucial. This requirement especially applies to the airwave based communication channels that are usually even more subject to interception than wire-based communications. Furthermore, Kumar et al. identify accessibility as another critical issue. They propose the implementation of the Voice Extensible Markup Language protocol [22] to make m-Government services accessible for disabled users as well.

Trimi et al. [2] extend this list of challenges and issues in m-Government by several additional points. They claim that there is a need for improving interoperability and integration. According to their contribution, *'the public sector is legacy-system driven, not process-oriented driven'* and therefore *'a radical reengineering of processes and supporting information systems is required that demands many technical, semantic, organizational, and managerial changes'*.

According to Trimi et al., another barrier of m-Government is potential tensions between governments and service providers especially from the private sector: *'governments are not very receptive to private and public service providers who may contribute to innovative electronic service delivery'*. In [2], missing e-Government infrastructures and institutional structures are identified as further future challenges of m-Government. Furthermore, the already mentioned points security, privacy, and accessibility are extended by the aspect usability. Especially small screens and keypads of mobile devices are mentioned as challenges for future mobile solutions.

Another detailed study of the different barriers to m-Government is provided by El-Kiki in the course of a survey analysis [21]. According to El-Kiki's contribution, barriers to m-Government can be classified into the categories 'Organizational', 'Technical', 'Governance', and 'Social'.

As claimed in [21], organizational barriers comprise various issues like bureaucratic problems, the *'lack of cooperation among public organizations'* or *'interoperability issues between different departments'*. Another interesting barrier to the success of m-Government is the lack of user-centric approaches. According to the results presented by El-Kiki, governments often take *'citizens as granted, thinking that they will accept and use a new service as long as it is provided by the government'*. Furthermore, the offered *'service is structured by the goals of the administration, not the goals of the citizen users'*.

The *'absence of combined e-business / e-governance models'* and *'the lack of sustainable business models'* have also been mentioned as severe organizational barriers to m-Government solutions. The *'reluctance of authorities to alter traditional ways of dealing with their customers'* is another issue. Often, not only citizens but also public authorities need to be assured of the benefits of m-Government solutions. According to El-Kiki, also economic and financial barriers often hinder the success of m-Government services. *'High development costs'*, *'lack of infrastructural investments'*, and *'low budget for m-Services'* are the most mentioned problems in this context. Finally, also legal aspects can hinder the success and

acceptance of m-Government services if appropriate legal frameworks are missing in the particular country.

Beside the just mentioned issues, also technical barriers can pose a threat to the success of m-Government. Vast and frequent advancements in the ICT sector are often difficult to be followed by people. This may result in a *'lack of familiarity with mobile technologies'* in general, but also in a '*lack of technical knowledge among IT personnel'* [21]. According to El-Kiki, other technical barriers are *'the lack of interoperability'*, *'the competition between access channels'*, but also the *'lack of backend process integration'* and *'the absence of ability to bundle information and materials/service together'*.

While, according to [21], there are hardly any governance barriers so far, social barriers can also pose a serious threat to the acceptance of m-Government services. In order to make m-Government services accessible to all people, these services must be as simple to use as possible. Besides a good usability, it is also important that *'people understand why they should use a mobile service'*. Other social barriers to m-Government mentioned in [21] are security and privacy concerns. According to El-Kiki, *'privacy fears are a substantial barrier'* and *'security is another area of concern'*. El-Kiki emphasizes the importance of security for m-Government by concluding that *'if there is no sound solution to security, e-Government and m-Government will be a dream'*.

5. Case studies

The steadily increasing worldwide popularity of mobile phones and related mobile technologies has paved the way for various m-Government initiatives and activities all over the world. In this section, a selection of successful m-Government projects is introduced. The set of presented projects is basically limited to those activities that have been introduced in former m-Government related studies such as [10], published articles, and related scientific publications. The initiatives being presented in the following subsections are grouped according to the geographic region, in which they have been applied. At the end of this section, relevant trends and conclusions that have become apparent from the considered case studies are summarized.

5.1. Worldwide activities

5.1.1. FrontlineSMS

FrontlineSMS [23] is a concept that has been developed by Ken Banks in 2005. It aims to improve communication capabilities in regions with underdeveloped infrastructures and to provide users with convenient electronic communication capabilities. The FrontlineSMS software is available as open source and uses GSM networks and SMS technology for communications. According to the project website [23], '*FrontlineSMS turns a laptop – or desktop – computer and a mobile phone or modem into a two-way group messaging hub*'.

FrontlineSMS currently experiences a considerable popularity and is used by various NGOs all over the world especially in developing countries and regions. Because of the success of FrontlineSMS' fundamental idea that can be applied in different fields of application, several sister organizations of FrontlineSMS have already been founded. The various sister organizations aim to offer solutions for different specific use cases. For instance, FrontlineSMS:Medic attempts to support health care workers in developing regions by providing them with enhanced communication capabilities based on the FrontlineSMS concept. FrontlineSMS:Medic is an excellent example of a successful m-Health project.

5.1.2. CelloPhone

In developing countries and regions, missing equipment often makes even simple medical tests like blood counts infeasible. The CelloPhone project, which has been a winner of Vodafone Americas Foundation's Wireless Innovation Project™ in 2009 [27], offers a solution to this issue in the form of a mobile phone based diagnostic tool.

This low-cost tool is capable to conduct basic diagnostics such as Complete Blood Count, CD4 T Lymphocyte count, as well as diagnosis of Malaria and TB. The obtained diagnostic results can be transmitted to a central database using SMS technology. This way, CelloPhone helps to significantly improve health care services in various developing countries and regions.

5.1.3. Simpill

Simpill [32] is a sophisticated pill container that automatically delivers an SMS to a central server instance when being opened. This way it can be remotely checked whether patients take their medication on time. If no SMS is received, a text message with a reminder notification is sent to the patient or to the patient's family.

This system is already in use in several countries all over the world and mainly used by tuberculosis and HIV/AIDS patients as timely medication is crucial for them.

5.1.4. Ushahidi's mapping application

Ushahidi's Mapping Application [35] is an open platform for information collection, visualization, and interactive mapping. It is mainly indented for crowdsourcing the collection of crisis information. The platform allows anyone to submit a piece of information through mobile devices such as smartphones. Additionally, information can also be provided through e-mails or web forms. One possible use case for Ushahidi's Mapping Application is for instance the tracking and visualization of the spread of epidemics.

5.1.5. Bridge*it*

The goal of the Bridge*it* project [56] is to provide teachers in underdeveloped regions of the world with teaching material. Digital video content in mathematics, science, English, and life skills is available on a central server and can be selected for delivery using mobile phones.

5.1.6. Telecom without borders

Functioning telecommunication networks are crucial especially in emergency or crisis situations. The NGO 'Télécoms sans Frontièrs' (Telecoms without Borders) [59] uses mobile technologies to re-establish vital communication networks in crisis situations. One of their most important and helpful equipment is a set of mobile satellite phones that allow for successful communication lines even if local infrastructures are destroyed. This emphasizes the importance of mobile technologies in particular during crisis situations.

5.1.7. Donations via SMS

In various countries, donations can be simply made using mobile phones and text message services. For instance, in the United States an SMS based donation system has been established in the aftermath of Hurricane Katrina by the Wireless Foundation and the American Red Cross. By sending a SMS with a predefined key word to a given number, customers were enabled to easily make a donation of $5.00 [60].

Similar systems exist in other countries too and facilitate the process of making donations during humanitarian relief campaigns significantly.

5.2. Europe

5.2.1. Mobile e-ID and mobile e-Signature

Within e-Government processes that involve citizens and public authorities, the secure and reliable authentication of citizens is often crucial. Since username/password based authentication schemes suffer from several security issues, user authentication in e-Government applications often relies on a hardware-token based two factor authentication. For instance, in several European countries hardware tokens such as smart cards are used for that purpose. In order to successfully authenticate, users need to prove to be in possession of the smart card and to be aware of the PIN that protects the security credentials stored on card.

With the emergence of mobile phones, several initiatives have been started that aimed to use the mobile phone and the SIM module as hardware token of choice instead of a smart card. These initiatives have for example led to the development of mobile phone based user authentication solutions in Finland, Norway, Estonia, and Austria [86].

In Norway, the mobile telecom provider Telenor Mobile has developed a SIM based PKI solution in 2000 and 2001. All SIM cards that have been issued since this date store a secret cryptographic key and support the generation of qualified electronic signatures. These SIM cards can be used to sign special SMS messages. The signature creation functionality is protected by a secret 4-digit PIN code that is exclusively known to the owner of the phone.

Being faced with low demand, the entire associated PKI infrastructure has been taken over by Norwegian banks in 2006. The service has been re-launched under the name BankID [87]. The main objective of the BankID service is the electronic signature based user authentication for online banking processes. In order to successfully authenticate at online banking web portals, users have to enter their phone number first. Subsequently, an SMS containing a signature request is sent to the user's mobile phone. The user has to trigger the signature creation process on the mobile device by entering the secret PIN. If the created signature has been returned to and verified by the online banking system successfully, the user is granted access to his account in the online banking web portal. Although primarily intended for online banking, this mobile phone based authentication scheme would basically also be suitable for e-Government processes.

In Finland, a user authentication scheme based on qualified electronic signatures generated on mobile phones has been introduced [93]. The goal of this initiative that had been started in 2005 was to offer an alternative to smart card based authentication methods. In the Finnish approach, electronic signatures are generated by the mobile phone's SIM card. Hence, the mobile phone acts as secure signature creation device.

To leverage the use of the Finnish e-ID approach, a central authentication and payment service named VETUMA has been introduced by the Finnish Ministry of Finance in 2006. VETUMA offers a uniform interface and can be used by third party applications to easily integrate e-ID functionality. In [94], it has been reported that in principle mobile signatures can be completed across borders and between different mobile operators and mobile signature service providers.

Estonia follows an approach similar to the Finnish one. The mobile e-ID solution called Mobiil-ID [88] has been started in 2007 and ports functionality originally provided by e-ID smart cards to SIM cards. This way, mobile phones can be used to authenticate at web portals and to create electronic signatures.

To authenticate at web portals, users have to provide username, password, and mobile phone number first. The identification and authentication process itself is processed by a central service named DigiDocService that may be used by web portals to access the functionality provided by Mobiil-ID through a uniform interface. After receiving an authentication request from a web portal, the DigiDocService first verifies the user's certificate using the OCSP protocol. Subsequently, the authentication data is sent to the user's mobile phone. The user signs the obtained authentication data by entering the secret PIN. The signed authentication data is returned to the DigiDocService, which verifies it and notifies the requesting web portal about the successful completion of the authentication process.

In Austria, mobile phone based e-ID solutions also have a long tradition. First attempts to offer country-wide solutions for secure user authentication based on mobile phones have been made in 2004 with the introduction of the so called 'A1 Signatur' [89]. In contrast to other mobile phone based e-ID solutions that have been discussed above, 'A1 Signatur' did not create electronic signatures directly on the mobile device. Instead, these signatures were computed in a hardware security module (HSM) connected to a central server.

If users wanted to log-in to a web portal using ‘A1 Signatur’, they had to enter their username, password, and mobile phone number first. The authentication data to be singed was then sent to the central server. The server prepared the data to be signed and sent an SMS containing a TAN to the user’s mobile phone. The user had to enter the obtained TAN at the web portal in order to trigger the creation of the electronic signature in the central HSM. Finally, the signed authentication data was returned to the web portal.

Because of low demand on this service and changed legal circumstances, the ‘A1 Signatur’ project was stopped in 2007. In 2009, another mobile e-ID approach has been introduced in Austria. The ‘Mobile Phone Signature’ [90] again aims to make use of the various benefits provided by mobile technologies and offers Austrian citizens access to services based on qualified electronic signatures. From the user’s point of view, the ‘Mobile Phone Signature’ is similar to the ‘A1 Signatur’. Again, signatures are computed in central hardware security modules. The user’s mobile phone simply acts as second communication channel that is used to deliver a SMS containing a reference code and a one-time password. This secret password can then be used by the receiver to complete the signature creation process in the central HSM.

Beside these projects that have been mainly driven from public bodies and authorities, there are also a couple of initiatives from the private sector that offer mobile ID solutions. One of the most relevant competitors is Valimo [98], a Gemalto [99] company headquartered in Finland. The mobile ID solution offered by Valimo is based on electronic signatures created on mobile handhelds such as mobile phones and supports both, user authentication and the creation of electronic signatures. Valimo’s mobile ID solution is currently applied in several countries, for instance in Latvia [97] and Sweden [100].

In Lithuania, a mobile electronic signature solution has been in place since 2007 [101]. Usage of this mobile ID requires users to replace the SIM cards in their mobile phones. The Lithuanian mobile ID can be used in several scenarios including the authentication at bank portals [102].

The usage of mobile phones as secure e-ID token and secure signature creation device are complex and related topics. In consideration of several initiatives also from the private sector, it is to be expected that mobile ID and mobile signature will be topics of increasing importance in the near future.

5.2.2. Tartu mCity

The City Government of Tartu, Estonia, has launched the mCity project in order to better the life of Tartu’s inhabitants with the help of mobile technologies [10]. The mCity project comprises activities and initiatives in public transport, neighborhood watch, as well as education and healthcare.

For instance, the city of Tartu and the city of Tallinn have started to develop an electronic payment system for public transportations. Thanks to a co-operation with all three Estonian mobile operators, tickets for public transport can now be purchased using mobile technologies.

Another initiative of Tartu’s mCity project is mobile neighborhood watch. In case of events and issues such as missing persons, in which many eyes are required, the police control center sends out SMS notification to taxi drivers, bus drivers, and other companies and individuals participating in this project.

Furthermore, the Tartu public library uses SMS notifications to inform customers about the availability of books and other media. People in waiting lists are notified immediately as soon as the book they want to borrow becomes available.

5.2.3. USE-ME.GOV

Usability-Driven Open Platform for Mobile Government (USE-ME.GOV) is an m-Government project that has been carried out between 2004 and 2006 by a European consortium

consisting of governmental bodies, research institutions, universities, and several technological companies. According to [92], the goal of this project was to '*encourage public administrations to provide access to new e-Government services at any time and anywhere through the use of Internet in the mobile communications technologies, and a next-generation open service platform for mobile users that can be shared by networked authorities and institutions in terms of technical infrastructure, information as well as a framework for commercial exploitation*'.

5.2.4. SMS security alerts

In London, UK, businesses can register at a SMS service offered by London's Metropolitan police. For instance, in case of incoming bomb alerts or similar security threats, registered businesses are informed and warned immediately by SMS.

5.2.5. BuitenBeter

BuitenBeter [106] is a smartphone app for iPhone and Android smartphones that offers a direct communication channel between citizens and local governments. Issues in the public space such as destroyed or malfunctioning infrastructure components can be easily reported by citizens using BuitenBeter. This project has been launched in Eindhoven in April 2010 and has immediately scaled up nationwide in the Netherlands. Because of its success, it is already planned to port the app to other mobile platforms as well.

5.2.6. Agroportal

In [95], a one-stop shop for the provision of m-Government services for the Greek agricultural sector has been introduced. The service named Agroportal aims to supply its target group with recent related news, frequently asked questions, and a list of useful links. Agroportal also aims to enable the electronic submission of applications by users, the processing of the submitted applications by the responsible public authority, and the delivery of the application response back to the user. In general, Agroportal attempts to improve and facilitate the communication between users and between users and governmental authorities.

5.2.7. Ask Brook

Ask Brook [31] provides free and confidential information on topics related to sexual health in UK. Besides its web presence, Ask Brook also offers SMS based service. After sending a text message with a defined content to a certain phone number, senders immediately receive information regarding sexual health services in their area. Furthermore, standardized responses to questions about pregnancy, contraception, and similar topics can be selected.

5.2.8. TextaParent

TextaParent [49] is an Irish web platform that aims to improve the communication between schools and parents. After registering an account, school principals can send mass SMS messages to parents in case of unexpected events like changes, closures or cancellations. The service can also be used to send regular notifications and reminders or to facilitate communication in emergency cases.

5.2.9. Call Parents

Call Parents [52] is an automatic parent notification system mainly used in the UK. It enables school staff to deliver parents relevant information using text messages. Call Parent also supports alternative delivery methods like e-mail or automated phone calls and basically aims to establish a reliable communication channel between school and parents.

5.2.10. Mobile examinations

Ultralab at Anglia Polytechnic University, the phone company Orange, and CWA New Media in New Zealand have developed a mobile exam system [55]. The system allows students to answer questions through a mobile phone. The questions are automatically generated and asked by a so called robot, which saves time for teachers and allows for efficient examination processes.

5.2.11. Disaster alert system

In the Netherlands, a SMS based disaster alert system has been introduced in 2005 [64]. This system uses the cell broadcast (CB) functionality of mobile GSM networks. CB allows the broadcast of text messages to all mobile phones in one GSM cell and has been used in parallel to other warning systems such as sirens and broadcast messages on radio and television.

5.2.12. Emergency SMS text service for impaired citizens

In Northern Ireland, the police service offers a SMS based emergency service for citizens with disabilities [67]. This service enables people with disabilities to contact the police service in case of emergencies via SMS. This can especially be helpful for people with hearing or speech difficulties, who are unable to use the emergency phone number.

Similar services are also available in various other countries. For instance, in Great Britain deaf citizens can register for a similar service called emergencySMS [68]. In the Netherlands, deaf citizens of Amsterdam receive SMS messages in case of hazardous or toxic fires and similar threats that are usually indicated by sirens [69].

5.2.13. Flood warnings

Venetians frequently suffer from floods in the city of Venice. Therefore, the city government has launched a SMS based service that informs citizens when high tides are to be expected [70].

5.2.14. Tax return via SMS

In 2003, a SMS based tax return system has been introduced in Norway [73]. Norwegians receive a prefilled tax form every year per post. In many cases, this tax form is returned unchanged. The introduced SMS based service allows Norwegians to notify the responsible administrative agency via SMS if there are no changes to be applied to the prefilled form. This saves costs and time as the original paper based form does not need to be returned any more.

A similar approach has been followed in Sweden [74]. Swedes can agree to the data entered in a prefilled paper based form by sending a SMS. Alternatively, they can also use phone or Internet for this purpose.

5.2.15. Gateway Sweden

The Gateway Sweden project [74] aims to improve the custom clearance process in Sweden. Lorry drivers receive an SMS as soon as their cargo has been cleared. The SMS includes a reference number that can be shown in case the drivers are stopped for checking.

5.2.16. Dial-a-Buoy

The Irish Marine Institute offers an SMS based project called Dial-a-Buoy [80]. Subscribers of this service receive weather data collected from five floating weather stations around the Irish coast. The Dial-a-Buoy service is intended in particular to those involved in water borne activities.

5.2.17. mobGAS

The European Commission's Joint Research Center offers an application named mobGAS to track the individual emissions of greenhouse gases [81]. The application can be run on different mobile phones and computes emissions based on activities entered by the user. This way, mobGAS contributes to the awareness of the connection between different activities and greenhouse gas emissions.

5.2.18. Mobile tickets

In Spain, Malaga's municipal transportation company EMT has introduced a mobile bus ticket system [82]. Mobile tickets are received with and stored on mobile phones. The ticket price is charged from the customer's phone bill or deducted from a pre-paid phone card.

In Austria, train tickets can also be bought by mobile phone [104]. The ticket can be ordered via mobile phone either per SMS message or via WAP and is paid through the mobile phone bill. The ticket is sent to and directly stored on the mobile device.

Spain and Austria are only two examples for countries where mobile ticketing systems have been applied successfully. Similar projects and initiatives can be found in various other countries as well.

5.2.19. Bus Text Message Service

In the UK, the Aberystwyth University and Traveline Cymru offer a SMS based information system (Bus Text Message Service) [83] that informs citizens at bus stops when their next bus will arrive. Citizens can send an SMS with the unique ID of their bus stop to the service and immediately receive a text message telling them when their next bus will arrive.

5.2.20. Mobile parking fee payment system

Several cities in Europe offer their citizens mobile parking fee payment systems. These systems enable car drivers to pay for parking simply by sending an SMS. Such systems can be found for instance in Austria [107], Estonia [10], or Sweden [2].

5.2.21. Job acquisition via SMS

In the city of Stockholm, Sweden, a SMS based system has been set up to acquire temporary workers [85]. Whenever a temporary worker is needed, SMS messages are sent out to registered will-work-temps. The one who answers first acquires the job.

5.2.22. Access to medical records

In Sweden, the medical care section of the Uppsala County Council enables citizens to get web based access to their personal medical records [85]. Access to this privacy sensitive data requires a secure user authentication. The applied authentication scheme is similar to the one frequently used in the course of m-Banking and makes use of SMS technology.

In order to get access to the personal medical records, users have to register first. During the registration process, the user's mobile phone number is stored in the system together with newly created username/password based account data. After completion of the registration process, the user can be authenticated reliably. To do so, the user first enters username and password. If these credentials can be verified successfully by the system, a SMS containing a one-time password (TAN) is sent to the user's mobile phone. Finally, the user has to enter the received TAN code in order to successfully complete the authentication process.

According to [85], a similar authentication system has been set up by the Swedish Customs in order to give infrequent exporters a web based opportunity to register exports and imports.

5.2.23. BlueTo

In Torino, Italy, a location based m-Government service based on Bluetooth technology has been established [96]. The main purpose of this service is to provide citizens and tourists with information related to their current location. In total, three applications have been developed that are accessible to users at different locations. For instance, the 'Welcome Application' is an introductory tourist guide for people who are about to visit Torino. This service is available at the Torino Airport and in a tourist office situated in the city center.

5.2.24. Examination results via SMS

In several European countries, examination results can be obtained via SMS. This saves time and forwards information on results to students as soon as they are available. For instance, Malta, which is amongst the leading European countries regarding SMS based m-Government, offers such a service to its citizens [103].

5.2.25. NFC mobile payment

In Poland, the mobile operator PTC launched a mobile payment pilot in 2010. Trial participants were enabled to make payments with their NFC-enabled smartphones in various stores, restaurants, gas stations, and other retail outlets. The pilot has been run for four months and received positive feedback [105].

5.3. North America

5.3.1. Zumbido

Zumbido [29] is an m-Health project that has been started in Mexico. Zumbido aims to establish a communication network between HIV and AIDS patients using mobile phones. Participants of the network can send text messages that are automatically delivered to all other members of the network. This way Zumbido provides HIV and AIDS patients with a meaningful and lasting support network that helps to overcome social isolation and facilitates information and experience exchange.

5.3.2. My California on the Go

'My California on the Go' has already been introduced in 2001 and supplies citizens with regular updates on energy warnings, traffic jams, state lottery results, and press releases from the governor's office [2].

5.3.3. HealthyToys

In the United States, people can send a text message with the text 'healthytoys' followed by the name of the toy to a predefined number. From the obtained answer the sender can verify whether the particular toy contains toxic chemicals or not.

5.3.4. Government of Canada Wireless Portal

Canada offers a portal for several mobile services that has been developed in the 'Government of Canada Wireless Portal' project [84]. Service and information currently available include border wait times, Canadian company capabilities, a currency converter, current exchange rates, and many more.

5.3.5. Text4Baby

Text4Baby [34] is a maternal health project that has been started in the United States. Since the US have very bad infant mortality rates especially within lower-educated minority populations, the Text4Baby initiative aims to provide young mothers with relevant information by SMS. Informative text messages such as reminders to get flu shots are sent three times a week before the birth. After the birth, further reminders about vaccinations and similar issues are sent frequently.

5.3.6. e2Campus

e2Campus [48] is a voice and text message based communication framework that facilitates communication between parents, teachers, staff, and other involved persons during emergency situations as well as during routine events. e2Campus is heavily used in the US especially in so called K-12 schools, i.e. during primary and secondary education.

5.3.7. Alert DC

In the US, a service called Alert DC [63] has been set up. This service provides citizens rapid text notifications and update information during a major crisis or emergency. Messages can be delivered by e-mail, mobile phone, BlackBerry, or wireless PDA. Messages are sent by authorized DC Homeland Security & Emergency Management personnel. The service is available to citizens in the District of Columbia.

5.3.8. My Mobile Virginia

My Mobile Virginia was one of the first wireless state portals in the United States that offered governmental services via mobile and wireless devices [2]. Basically, the portal has offered a variety of information such as emergency weather conditions, legislative information, and election notices. The provided information has been optimized for downloads on mobile and wireless devices.

5.3.9. 911 via SMS

Reacting on the popularity of text messaging, an emergency call center in Iowa, US, has started to accept and reply to emergency text messages [65]. Although it seems unreasonable to write a text message instead of calling in an emergency, this service might help deaf people to communicate. Furthermore, writing messages can be useful in cases when victims try to hide and get help without making a noise.

5.4. South and Central America

5.4.1. Dengue virus containment

In the Amazonas state of Brazil, fast and effective gathering and collection of data e.g. about current mosquito proliferation are crucial for the containment of the Dengue virus. Therefore, data exchange with health workers in the field is based on mobile technologies that allow for easy data gathering and fast data transmissions. This way, current data from numerous health workers can be collected and analyzed centrally. To further facilitate the data gathering process and allow for more meaningful analysis, data records are automatically supplemented with GPS information in the field.

5.4.2. Cell-PREVEN

Cell-PREVEN [37] is an interactive voice-response system that allows health workers in the field to access a central database. Data being stored in this database can be accessed and remotely be supplemented by recently collected data samples. All data transmissions are carried out with off-the-shelf mobile phones.

5.4.3. Virtual Health Pet

Virtual Health Pet has implemented a virtual pet residing on the user's mobile phone. It is basically comparable to a Tamagotchi but intended for a more serious purpose.

Virtual Health Pet is connected to an electronic health record system and frequently interacts with the patient to remind him or her to take medications. Furthermore, the virtual pet monitors the overall health status. If the patient does not interact in a timely manner the virtual pet triggers appropriate alert messages. As the Virtual Health Pet is linked to a health record system, it can also provide the patient with current information from the medical team.

5.4.4. Enhancing Nurses Access for Care Quality and Knowledge through Technology

The goal of the project 'Enhancing Nurses Access for Care Quality and Knowledge through Technology' [42] is to equip nurses in the Caribbean with PDAs in order to improve their information access capabilities. In the course of this project, training and similar services have been provided to nurses via PDAs, which has led to various achievements such as time savings and better access to information such as treatment support.

5.4.5. Farmer-to-Farmer

The Farmer-to-Farmer project [45] comprises various initiatives all over the world that aim to provide volunteer technical assistance to farmers in developing regions. One initiative of this project takes place in El Salvador and offers producers and consumers the possibility to transmit buy and sell offers through SMS messages. Alternatively, offers can also be made through a call center, in order to make the service accessible for illiterate persons too. By facilitating the information interchange between local producers and consumers, commercial activities can be developed without reliance on intermediaries.

5.5. Asia

5.5.1. Community Health Information Tracking System

Community Health Information Tracking System (CHITS) is an open source program that facilitates the collection and transmission of data in rural and underdeveloped regions. The developed system is based on SMS technology and allows health workers to report injuries and receive training and health surveillance through their mobile devices.

5.5.2. Chinese Aged Diabetic Assistant

The Chinese Aged Diabetic Assistant (CADA) [40] aims to support elderly diabetics in China. Smartphones are used to supply patients with relevant information and guidelines. Furthermore, these mobile devices can be used to enter data on measured glucose levels, which allows for a remote surveillance and tracking of patient data.

5.5.3. Acute Encephalitis Syndrome Surveillance Information Management System

This AESSIMS project [43] has been carried out in India. Its main purpose is to enable front-line health workers to report disease incidences via a combination of telephone and web technology. This way, disease outbreaks can be detected and identified in an earlier stage and appropriate actions can be taken more efficiently.

5.5.4. Mobile technology for fishermen

In the Indian coast of Kerala, the introduction of mobile technologies has significantly bettered the life of fishermen. Since fishermen can be already informed about current market situations while still being at sea, they can divert their boats to those markets that pay best.

The increased functioning of the market has raised fishermen's profit by 8%, while at the same time consumer prices fell by 4% on average. More information on this topic can be found in an article of the Washington Post [46].

5.5.5. Reporting absenteeism with SMS

In New Delhi, India, an SMS based initiative to counteract absenteeism from school has been started [51]. Whenever a child is absent in class, teachers send an SMS to the child's parents to inform them about the absence. The system is also used to deliver parents information about other related issues.

5.5.6. Exam results via SMS

As described in [54], university examination results can also be obtained by SMS in India. This service is powered by mVaayo [53] and allows students to send a SMS with 'RESULT' to a certain number. The service answers with an SMS containing the requesting student's results.

5.5.7. Text2Teach

The Text2Teach project [58] project aims to supply teachers with informative video clips that can be shown in class. The project basically consists of two phases. In the first phase, teachers can order video clips using their mobile phones. The video itself is then transmitted over a satellite link. In the second phase, teacher can load educational material directly on

their mobile phones. These phones are then connected to the TV set in class. New material can instantly be downloaded through the mobile phone using 3G technologies. The Text2Teach project has been successfully piloted in the Philippines.

5.5.8. Natural disasters alert system

Although Bangladesh is one of the poorest countries in the world it has a booming telecommunications sector. From the entire population of 144 million people, 44 million people own a mobile phone. In consideration of the omnipresent danger of natural disasters, Bangladesh has therefore recently introduced a SMS based cyclone alert system [61]. In case of approaching cyclones or floods, people are warned by SMS and supplied with further instructions. The Bangladesh Disaster Management Bureau expects that this alert system will help to reduce the number of victims significantly.

5.5.9. SMS emergency service

In China, SMS is used to alert citizens in case of natural disasters [62]. For instance, people get alerted in case of typhoons or warned and informed about bird flu outbreaks. Furthermore, China uses text messages to warn against supporting forbidden spiritual movements or participation in unauthorized protests. On the other hand, activists frequently use mobile technology to organize and coordinate such demonstrations and protests.

5.5.10. Multi-Q

In South Korea, the Multi-Q service [66] informs citizens about national disasters using SMS technology. The messages are sent out by the carrier to users that possess an appropriate end device. The goal of the Multi-Q initiative is to minimize casualties and damage from natural disasters such as tsunamis.

5.5.11. World Food Program

The World Food Program has launched a mobile phone based pilot project to distribute food to Iraqi refugees living in Syria [72]. Text messages containing so called virtual vouchers have been sent to refugees. These vouchers can be used to obtain food such as cheese and eggs, usually not being included in conventional aid baskets.

5.5.12. PAYBIR

The Philippines offer a service called PAYBIR [75] that allows citizens to pay their taxes through mobile phones. Initially being developed for business registrations, the service has later been extended to cover a broader set of taxes. PAYBIR makes use of G-Cash [76] technology, a micro payment service that turns a mobile phone into a virtual wallet.

5.6. Africa

5.6.1. Bloodbank-SMS

The availability of sufficient amounts of blood for transfusions is crucial for any hospital. In Kenya, several centralized blood banks are responsible for supplying district hospitals with blood. In order to guarantee an adequate supply, these hospitals have to frequently report the current status of their local blood repository.

Because of underdeveloped infrastructures, hospitals suffer from a lack of reliable electricity and phone lines, which makes frequent status updates often impossible. To tackle this problem, BloodbankSMS has been developed by Eric Magutu. The developed service allows health care workers from remote hospitals to report on the current status of their blood repository using SMS. Incoming status updates are collected at the central blood bank and graphically visualized through a web-based interface. SMS based alerts are triggered automatically when blood repositories at district hospitals fall below a predefined threshold.

5.6.2. Cell-Life

According to their web presence, Cell-Life is an NGO located in South-Africa that aims to *'improve the lives of people infected and affected by HIV in South Africa through the appropriate use of mobile technology'*. Cell-Life home care workers monitor patients in their homes. Relevant patient related data like medication or symptoms are transmitted by the health care personnel to a central server using mobile technologies. The transmitted data is stored in the central server and necessary responses to the received messages are sent.

5.6.3. Mobile Demographic Surveillance System

The Mobile Demographic Surveillance System (MDSS) is a project that aims to support medical field workers in surveying the 200.000 inhabitants of the Kilifi District in Kenya. Using mobile technologies, medical workers are able to remotely access the central database that contains all data being relevant for the survey. This saves time since data can be entered to the database directly and allows medical workers to stay in the field for longer periods of time.

5.6.4. mPedigree

Counterfeit of legal drugs is a serious issue especially in developing countries. In Ghana, the mPedigree project [25] aims to tackle this issue. Consumers can send the serial number that is printed on the bought drug to a defined and easy to remember short code using their mobile phones. Information about the authenticity of the bought drug is then sent to the consumer via SMS.

5.6.5. RapidSMS

RapidSMS [26] is a technology that has been deployed by UNICEF Malawi in order to address serious constraints within the national Integrated Nutrition and Food Security Surveillance (INFSS) System. This system suffered from slow data transmissions, incomplete and poor quality sets, and high operational costs. RapidSMS solves most of these problems by enabling efficient information exchange using SMS technology.

5.6.6. Text to Change

Text to Change (TTC) [28] is a health education initiative relying on mobile telephony. Using text-message based health education programs TTC aims to inform people in developing countries about topics such as HIV, AIDS, or malaria.

TTC started in Uganda but has soon expanded to other African countries and developing regions all over the world. This way, TTC helps to improve awareness on health by using mobile technologies.

5.6.7. Learning about Living

According to the Learning about Living project's website [30], Learning about Living has three basic goals. The first goal is '*to use ICT to educate young people on issues around adolescent reproductive health so that they can make informed decisions*'. Furthermore, the project aims to '*improve the information available on sex education and encourage debate*'. Finally, Learning for Living also wants to '*help to increase and improve gender equality in a country where male superiority is regarded as the norm*'.

The project has been carried out in Nigeria and uses mobile technologies basically for two of its initiatives. The MyQuestion initiative allows young Nigerian people to submit questions on the mentioned topics to trained counselors, who answer each question individually. Questions can be transmitted online, through a telephone hotline, or by text message. The second initiative that relies on mobile technologies is MyAnswer. Young people can win prizes by answering a monthly question correctly either online or by text messaging.

Learning about Living was a two-year project and was started in 2007. Its success can be seen by the fact that within the first five days more than 2.500 questions have been submitted through the MyQuestion service.

5.6.8. HIV Infoline

In South Africa, people can send a SMS with the text ‘HIV’ and their home town to a predefined phone number. An automatic service then responds with locations of near HIV testing centers.

5.6.9. Clinic Directory and Health Tips

This health application developed by AppLab and powered by Google SMS provides people in Uganda with timely, trusted, and accurate information on sexual and reproductive health. This way, this initiative contributes to an increased awareness of these topics by using mobile technologies [33].

5.6.10. Masiluleke

In South Africa, the project Masiluleke [36] aims to use mobile technologies to fight HIV and AIDS. In the course of this project, one million text messages are sent out per day to encourage people in South Africa to be tested and treated for HIV and AIDS.

5.6.11. Smile for You

Smile for You was a campaign that was started in South Africa in 2007. In South Africa, so called Please Call Me (PCM) text messages are very popular. These messages can be sent for free as operators subsidize them through selling advertising space in the unused space of these text messages.

In 2007, 50 free cleft lip and palate surgeries have been offered to children being too poor to afford them. Since a previous campaign that has relied on printed media and radio has led to twelve candidates for the surgery in total only, the Smile for You campaign has been launched. This campaign was based on informational messages in the advertising space of PCM messages. With the help of this campaign, in total 42 candidates could be found.

5.6.12. Map of Medicine for Kijabe hospital

The Map of Medicine [38] provides information on diagnosis and treatment through a web interface. During a pilot study, doctors of the Kijabe Hospital in Kenya were able to access the Map of Medicine using PDAs and got access to data on HIV, AIDS, malaria, TB, abdominal pain, and typhoid fever. The easy access to this information via PDAs has significantly improved efficiency and has led to reduced administrative costs.

5.6.13. Phones for Health

The objective of the Phones for Health program [39] is to equip health workers in local communities with handsets and special software. This software supports health workers in local communities to collect and enter health data. The handsets allow an easy transmission of collected data to central health information systems. Furthermore, the Phones for Health initiative supports health workers to order medicines, trigger public health alerts, and download treatment guidelines.

5.6.14. Mashavu

While in the US, there is in average one doctor for every 300 people, in Kenya there is one doctor for 50.000 people. The project Mashavu [41] aims to tackle this issue and to ease access to health care for children. In the course of the Mashavu initiative, several Mashavu stations have been established in developing communities. Children can visit these stations, where essential medical data such as age, height, weight, blood pressure, or lung capacity are collected and finally transmitted to a remote server. Since reliable infrastructures are often missing, mobile phones are mainly used to transmit the data. Medical professionals can then provide feedback and advice to the children’s caregivers over a web interface.

5.6.15. Google Trader

Google Trader [44] is a mobile phone based market place for people in rural areas in Uganda. Local producers and consumers often have problems to link with markets. Google Trader allows them to offer or buy goods with their mobile phones using SMS technology. Information about goods to sell and the offered price can be sent to a defined phone number via SMS. People who want to buy goods can query the system for available offers by sending a SMS based request to a certain phone number.

The goal of Google Trader is to increase transparency and enable small local producers to realize higher prizes when dealing with large traders. The project has been piloted in banana producing regions in Uganda. However, the concept of the Google Trader project can be easily adopted for other countries and regions.

5.6.16. Collecting and Exchange of Local Agricultural Content

The Collecting and Exchange of Local Agricultural Content (CELAC) project [47] aims to improve the information flow to farmers in Uganda. In the course of this project, SMS messages with valuable farming tips and related information about growing lucrative export crops have been sent out. The exchange of information between farmers in Uganda shall also help them to specialize in new and potentially more lucrative ventures.

5.6.17. Games4Life

Games4Life [57] is a project that has been started in Kenya. The goal of the project is to teach young people in Kenya about the risks and dangers of HIV and AIDS. This is done by means of games for mobile phones that have an informative character. The project has been initiated by the Dutch non-governmental organization Hivos in partnership with the Dutch telecom company KPN.

5.6.18. Violence prevention

In Kenya, mobile technologies have proven to be an appropriate tool for violence prevention [60]. During the presidential election in 2007, text messages have been the main technology used to report on actual and planned attacks between rival ethnic and political groups. This efficient reporting tool allowed for fast and effective countermeasures and has contributed to a successful election process in Kenya.

5.6.19. m-Pesa

The popular project m-Pesa [77] offers a mobile phone based noncash money transfer system for people with low income, who cannot afford an own bank account, or for those who have no access to financial infrastructures. The project has been launched in Kenya in 2007 and has been initiated by the local mobile network operator Safaricom in cooperation with Vodafone.

For each m-Pesa user, a virtual account is electronically maintained. So called m-Pesa agents act as interface between users and their accounts. Agents are for instance supermarkets or gas stations and allow users to deposit or withdraw money from their virtual account. Furthermore, m-Pesa enables its users to transfer money to other users, to pay bills, and to purchase prepaid airtime. Transactions are basically carried out by exchanging SMS messages between users or between users and agents.

The successful m-Pesa system, which has originally been developed for Kenya, has already been expanded to other African countries too. Since 2008, a slightly modified version of m-Pesa is available in Tanzania. In the near future, it is planned to introduce the system also in Ethiopia.

5.6.20. Mobile Money 2.0

In Uganda, up to 90 percent of the 5 million households do not have an own bank account. The lack of area-wide banking infrastructures especially in rural communities impedes even simple financial transaction for the majority of the population. On the other hand, Uganda has

a well developed mobile phone infrastructure. The Mobile Money 2.0 project [78] aims to provide citizens with financial services through their mobile phones. This way, well developed mobile infrastructures try to compensate missing banking infrastructures.

5.7. Australia

5.7.1. MGM Wireless

MGM Wireless offers a SMS based service for facilitating the communication between schools and parents [50]. Important information can be sent to parents or responsible caregivers by automatically generated SMS messages. The system features a relatively high degree of personalization. Each SMS takes into account information on the particular family and is hence personalized according to unique circumstances, history, culture, or language.

5.7.2. Firewatch

Fire incidents pose a serious risk to the inhabitants of certain Australia regions. In 2008, an e-mail and SMS based warning system has been introduced [71]. Citizens can register to this service and receive SMS or e-mail alerts whenever a fire has been detected within 15 kilometers of their homes.

5.7.3. mHITs

In Australia, the mHITs micropayment service [79] has been started in 2009 and enables citizens to transfer money using their mobile phones. The transaction process itself is based on SMS messages that are interchanged between mobile phones and hence allow for direct person-to-person payments.

mHITs can also be used to buy goods from online merchants and to pay parking fees or taxi fares. In general, mHITs based transactions are possible between individual users, users and POS merchants, and between users and online merchants.

5.8. Basic findings and global trends

The popularity and the various benefits of mobile services have led to a large number of m-Government projects and initiatives all over the world. The list of activities being introduced in Sections 5.1 to 5.7 tries to provide an overview of current activities but is far from being complete. Nevertheless, some global trends can be observed from the considered subset of past and current activities. The most relevant findings are discussed in the following.

One of the most apparent findings is the fact that SMS is still the most important technology in the context of m-Government applications. Although especially modern smartphones offer a broad spectrum of enhanced communication technologies, SMS is still the technology of choice in most m-Government applications. This seems reasonable for developing regions where smartphones are less common and mobile infrastructures are often not prepared for high data transfer rates. However, also m-Government processes in developed countries often rely on SMS technology. For instance, several mobile ID solutions in European countries involve the transmission of one-time passwords such as TANs by SMS.

In general, m-Government initiatives heavily depend on the country and the region, in which they are applied. Thus, significant differences can be found between solutions in developed countries such as EU Member States and those applied in developing regions in Africa or Asia. In developing countries, m-Government is an opportunity to provide governmental services to those, who have no access to other electronic communication facilities. The wide spread of mobile phones and mobile networks even in underdeveloped regions allows for an electronic communication channel between administrative bodies, NGOs, and citizens and thus helps to overcome the digital divide.

Contrary, in developed countries wire-based communication networks are usually available to all people. In these regions, m-Government is just one out of many opportunities to get in contact with public authorities. Hence, in developed countries m-Government is mainly used

for convenience reasons. Since mobile devices such as smartphones are typically always on, m-Government service are available to users at any time. Furthermore, additional functionality such as GPS facilitates more sophisticated services (e.g. location based services) on mobile devices compared to stationary desktop computers.

Although the motives to deploy and use m-Government services basically differ between developing regions and developed countries, m-Government can improve the life of citizens in both environments. Analysis of the different case studies that have been considered so far has shown that most m-Government initiatives and projects can be assigned to one of the following classes of service:

- *Health:* Although projects related to this topic exist in both, developing and developed countries, mHealth is especially relevant for underdeveloped regions with weak infrastructures. A variety of projects exist in Africa and Asia that aim to better health care of the poor especially in underdeveloped rural regions. Furthermore, mobile technologies are frequently used to improve citizen's awareness regarding health related topic such as HIV or AIDS. For this purpose, informative SMS messages are usually broadcasted to the people.

- *Education:* In the context of education, mobile technologies are frequently used to improve communication between schools, universities, students, and parents. Especially in developed countries in America and Europe several educational institutions make use of SMS to get in contacts with parents or to deliver personal information such as exam results in a timely manner. In developing regions, mobile technologies are used in the context of education for example to obtain electronic teaching material where wired communication lines are not available.

- *Agriculture:* mAgriculture denotes the use of mobile technologies in the agricultural sector. Several projects in developing regions have shown that mobile technologies can significantly enhance communication between producers and consumers and can contribute to improved market situations, which all participants can benefit from.

- *Security Alerts and Disaster Management:* In crisis situations, mobile technologies have proven to be an appropriate means of communication. Several projects all over the world make use of SMS messages to immediately notify citizens about imminent dangers. This includes warnings against natural disasters such as tsunamis or storms, as well as warnings against terror attacks. In the aftermath of disasters, mobile technologies are of importance as wired communication lines are often destroyed and mobile networks are the only way to communicate electronically.

- *Financial Services:* Several of the analyzed case studies aimed to enhance financial processes using mobile technologies. In developing countries, especially rural areas often lack from the availability of financial infrastructures. Thus, several initiatives aim to set up electronic financial services based on mobile phones. Also in developed countries, mobile technologies play an increasing role in financial services. In several countries citizens can use SMS based services to facilitate their tax declaration process. Additionally, several banks offer customers mobile phone based authentication mechanisms to their web portals and electronic banking (e-Banking) systems. In many cases, e-Banking transactions have to be authorized with one-time passwords (TANs) that are transmitted via SMS.

- *Transport:* In the transport sector, mobile technologies are mainly used in developed countries. In several European countries, parking fees can be paid using mobile phones and SMS messages. Several public transportation companies offer customers to purchase tickets via mobile phones. Again, in most cases SMS is the technology of choice.

- *Mobile ID and Mobile Signature:* Mobile ID and mobile signature are relevant topics especially in Austria, Scandinavia, and the Baltic countries. Several solutions exist in these countries that enable citizens to reliably prove their identity or electronically sign documents using their mobile phone. Secure user authentication based on qualified electronic signatures is especially important for governmental processes on the transactional level. Hence, mobile ID and mobile signature are important enabler technologies for transactional m-Government.

The presented case studies have shown that m-Government is already an important topic in many countries and regions. Mobile technologies have proven to be able to significantly contribute to peoples' welfare. Considering the fact that so far most initiatives rely on rather simple mobile technologies such as SMS, it can be expected that new advanced mobile technologies offered by modern smartphones will lead to improved service. It is therefore very likely that notable effort will be invested in more sophisticated m-Government activities in the future.

6. Literature overview

In consideration of the fact that the list of m-Government projects given in Section 5 contains only a small selection of past and current m-Government projects, it becomes apparent that m-Government is currently a topical issue all over the world. It is therefore less surprising that a lot of scientific and non-academic literature has already been published on this topic. This section introduces some relevant studies, articles, and scientific papers on m-Government that have been published during the past years.

6.1. Studies on m-Government

In the recent years, several studies and white papers on mobile government have been published in different countries and by various authors. These studies discuss topics of mobile government from slightly different points of view. Together, these documents provide an extensive and comprehensive introduction to and overview of m-Government. The following subsections briefly introduce different studies and summarize their most important conclusions, whereby focus has been put on most recent publications.

6.1.1. "Mobile Government 2010 and Beyond"

The white paper 'Mobile Government 2010 and Beyond' [10] has been published by Mobi Solutions Ltd [111], an Estonian mobile service provider founded in the year 2000. The study is subdivided into four parts.

The first part ('Relevance and Trends') emphasizes on the importance and relevance of m-Government by emphasizing its various advantages and benefits for instance compared to wire-based e-Government solutions. Furthermore, this part gives an overview of former studies on the topic of m-Government and summarizes their quintessence. The most important statements that have been extracted from the study research in [10] are cited in the following itemization:

- *'Evolution in mobile technology promises more innovative services and increasing global use expected by 2018'*
- *'m-Government is the new frontier in public service delivery'*
- *'SMS contributes to the use of e-Government'*
- *'m-Government offers benefits to the citizens'*
- *'Mobile communications bring change in the efficiency of government work'*
- *'Mobile industry and services revolutionize social and economic development'*

- *'The marketplace of mobiles, active mobile web users and spenders is growing'*
- *'SMS makes healthcare more flexible'*
- *'Students prefer SMS for communicating'*
- *'The young wish that more procedures would be available wireless'*

These core findings of the evaluation of former studies given in [10] are quite self-explanatory and circumstantiated by observations that have been made during analysis of various case studies in Section 5. Therefore, the above mentioned statements can make a valuable contribution to the identification of future trends and potentials of m-Government.

Part 2 of the white paper 'Mobile Government 2010 and Beyond' first introduces several main areas where m-Government services are currently in use. In particular, the fields 'Health', 'Education', 'Security', 'Agriculture', 'Banking', and 'M-citizen' are identified as topics of interest. Furthermore, the second part of the study provides a comprehensive list of m-Government projects from all over the world. Most of the listed initiatives are also briefly described in Section 5 of this document. Because of the Estonian background of the study's authors and publishers, the white paper especially focuses on m-Government initiatives in Estonia.

Part 3 of the white paper 'Mobile Government 2010 and Beyond' discusses the importance of user feedback for m-Government. The study comes to the conclusion that for the success of m-Government user acceptance is crucial. In order to get an understanding of users' points of view, the study reports on user feedback that has been collected in the course of different m-Government projects in Estonia.

Finally, the fourth part of the study sketches some future scenarios by identifying probable further developments and listing some challenges for future m-Government services. According to the white paper 'Mobile Government 2010 and Beyond', m-Government will support and lead to the following future trends:

- *Raising efficiency:* The increased usage of mobile technologies in governmental processes will improve their efficiency.
- *No citizen left behind:* m-Government will help to make governmental services accessible to all citizens, regardless of gender, age, nationality, income, or disabilities.
- *Customer expectations:* With advancing technologies, user expectations are usually increasing. m-Government will help to satisfy rising needs and expectations of citizens in the context of governmental services.
- *Collaboration:* As access to information and services is nowadays available almost everywhere and any time, collaboration between different organizations becomes more and more important in order to assure transparency and accountability and to remain collaborative and responsive.
- *Accessibility and broadband availability:* According to [10], accessibility and broadband availability have been identified as crucial factors within the public sector. Mobile technologies in general and m-Government services in particular can help to achieve these goals.
- *Multi-channel delivery:* Multi-channel accessibility has been identified as key for successful e-Government. Mobile government is therefore perfectly suitable to supplement e-Government services by offering a second mobile communication channel.

- *Strengthening participation and democratic decision-making:* Thanks to m-Government, citizens can be mobile without losing the opportunity to participate in governmental processes.

- *Digital economy and digital Europe:* Mobile technologies will help to strengthen Europe's economy and to recover from the economic crisis. Furthermore, the adoption of mobile technologies will help to trigger the take-off of an envisioned Digital Europe.

- *Development of mobile government in rural places:* In developing rural areas, mobile penetration usually exceeds Internet penetration significantly. Hence, mobile technologies allow governments to offer governmental services also to citizens who have no Internet access.

- *Location awareness:* The usage of global position information in mobile processes has been identified as important future trend. As modern mobile phones are often equipped with integrated GPS modules, such location based processes are expected to further gain in importance in future.

Besides these expected future trends, the study 'Mobile Government 2010 and Beyond' identifies the following challenges for a future success of m-Government:

- *Physical limitation:* Physical limitations such as small screen sizes and limited text input of mobile phones restrict the amount of easily exchanged information.

- *Cost:* As m-Government is a supplement of e-Government but no substitution, development, operation, and maintenance of m-Government services cause additional costs.

- *mDigital divide:* One of the greatest benefits of m-Government is its capability to reach also those who are not able to use classical e-Government services because of missing Internet infrastructures. Thus, m-Government can help to narrow the digital divide especially in developing rural areas. However, m-Government is still not able to reach all citizens. Hence, according to [10], '*this poses a challenge to m-Government to ensure that it is not just one more way in which the "haves" benefit at the expense of the "have nots"*'.

- *Mobile mindsets:* Many people associate mobile devices in general and mobile phones in particular mainly with fun and entertainment. It may therefore be difficult to motivate these people to use their devices for serious services such as m-Government.

- *Privacy and Security:* m-Government services often process privacy and security sensitive data, which citizens usually prefer to keep undisclosed. To assure user's trust, citizens therefore need to be convinced that their data and privacy is protected during m-Government procedures.

- *Responsibility managing exponential amounts of information and data overload:* Mobile technologies allow users to be connected anytime and everywhere. This leads to an increase in the number of circulating messages and may cause public service communications to be devalued or lost.

- *Resistance to organizational change:* Common habits, fear of new or unknown technologies, as well as security and economic factors pose serious threats to the success of future m-Government services. Hence, it is crucial to strive for broad acceptance of offered m-Government services. This can be achieved by motivating all participants involved in m-Government services and to point out the various benefits of mobile applications.

- *Lack of clarity around forward planning strategies:* To guarantee success of m-government, it is crucial to do a pragmatic planning that takes into consideration the different needs and requirements of different regions and countries. The authors of [10] conclude that '*technology is not the focus of planning, but the end user, be it worker or consumer*'.

- *Lack of mobile technology standards:* The white paper 'Mobile Government 2010 and Beyond' identifies the lack of mobile technology standards as a serious problem. Since nowadays often each government agency invests in different mobile systems to fit their specific needs, interoperability between different isolated applications may become an issue in the future.

- *Global standards:* As there are currently several different global standards and specifications, interoperability between country specific solutions are often an issue. The same problem can be observed in the e-ID domain, where currently much effort is made in the course of a pan-European project [112] in order to achieve interoperability between different EU Member State specific e-ID infrastructures.

Despite its Estonian focus, the white paper 'Mobile Government 2010 and Beyond' gives a comprehensive overview of the current situation of m-Government. The study concludes with the following basic findings:

- *'Mobile services are indeed useful to improve government, encourage citizen's empowerment and build democracy.'*

- *'The functions of m-Government allow to reduce previous barriers and therefore, to offer equal communication to every member of the community.'*

- *'As the trend shows the humankind is getting older, with low birth rate, the productivity of health system is dependent on information and communication technology.'*

- *'As with the improvement of technology, the public area where mobiles are used is widening, this leads to a solo device where different communication devices are integrated into one.'*

- *'Mobile communication industry is still at the beginning, so the transformation is yet to come. Although a lot has been achieved, the abilities of mobile phones remain vastly underused by the average owner and evidently by the government. Mobile applications have yet to really entrench in our lives.'*

6.1.2. "Security Issues in the Context of Authentication Using Mobile Devices (Mobile eID)"

In 2008, the European Network and Information Security Agency (ENISA) published a position paper titled 'Security Issues of Authentication Using Mobile Devices' [113]. This paper evaluates the security of modern smartphones and PDAs, especially in use-cases where these devices are used for electronic authentication purposes.

The paper starts with a technology review, in which relevant mobile technologies are briefly described. The authors emphasize the importance of SMS technology, which despite its simplicity is used in several mobile applications. Smart cards are identified as another technology of great importance for the mobile sector since these cards can be used to securely store secret credentials and carry out cryptographic operations. The two related technologies RFID (Radio Frequency Identification) and NFC (Near Field Communication) are mentioned as relevant communication technologies especially for future applications such as NFC payments. Finally, the paper's authors distinguish between three types of secure elements that are used to store private and secret keys: removable hardware, non-removable hardware, and software. The authors conclude that because of the manifold security-related

technologies that come with modern smartphones and PDAs, these devices '*could also serve as tools to improve the security of already existing applications*'.

The main part of ENISA's position paper contains discussions and considerations on security issues on mobile devices. This section starts with the following definition of the term 'security risk':

'*A security risk is the potential that a given threat will exploit the system's vulnerabilities. It is measured by the impact multiplied by the probability of the threat.*' [113]

In the following, the below mentioned assets that need to be protected on mobile devices are identified:

- *Sensitive/personal information:* This refers to any kind of sensitive information including personal information such as name or date of birth, biometric identifiers such as fingerprints, credentials such as private cryptographic keys, and information about the user's current location.

- *Access to bank accounts/money:* It is important to note that access to a bank account can in principal be independent from access to the account holder personal information.

- *Access to physical goods, personal property or buildings:* This includes also mobile phones themselves, as these devices can also be subject to lost or theft.

- *Service availability:* The availability of the services being accessible through mobile phones constitutes an asset too.

After having identified the different assets that need to be protected, the authors of [113] provide a list of possible technical vulnerabilities of mobile devices in general, smart cards, as well as NFC and other contactless devices.

Considering mobile devices in general, two different vulnerabilities have been identified. First, the untrustworthy interface has been mentioned as serious vulnerability. Actually, this is no issue that is specific to mobile devices, but is well known from PCs and Laptops. As modern mobile devices have already become almost as complex as PCs, these devices are nowadays vulnerable to malware such as Trojans or viruses too. Hence, the trustworthiness of interfaces to mobile devices cannot be taken for granted any longer. Beside untrustworthy interfaces, theft and loss of mobile devices have been identified as other principal vulnerabilities. The inherent mobility and the small size of these devices make loss and theft much more likely compared to PC based systems.

Regarding smart cards, which have been shown to be an integral component of many mobile devices, in total again two vulnerabilities have been identified by the study's authors. A known vulnerability of smart cards is physical attacks. Attackers try to alter the behavior of the smart card by altering the card's environment in order to induce faults. By observing the altered card's behavior, attackers can then reveal secret data stored on the card. Although modern smart cards usually implement several countermeasures against this kind of attack, a number of successful physical attacks on smart cards have been reported. Side-channel attacks constitute the second vulnerability of smart cards. In this attacking scenario, side-channel information such as power consumption or electromagnetic radiation is observed during operation of the card. From this information and with the help of mathematical and statistical methods, attackers are again able to reveal secret information stored on or processed by the attacked smart card. Similarly to physical attacks, several countermeasures are available to hinder these attacks. Nevertheless, in many cases side-channel attacks can be successful.

In [113], two more general vulnerabilities are identified. Especially in procedures that involve communication with remote entities, man-in-the-middle-attacks pose a serious threat. In this

scenario, an attacker puts himself between two communicating parties and intercepts their messages. While both communicating parties assume to talk with each other directly, they are actually interchanging messages with the attacker only. This kind of attack can usually be countered efficiently by applying mutual authentication between involved communicating parties. Another serious threat is posed by cryptanalytic attacks that aim to target the security of used cryptographic algorithms. Such attacks can be avoided by using cryptographic algorithms that are commonly assumed to be secure.

Contactless devices such as NFC enabled mobile phones typically show several vulnerabilities. In [113], the study's authors identify the following issues related to the use of NFC devices:

- *Skimming* refers to the unauthorized reading of data through a contactless interface. For instance, a secret reading device could read data from an NFC enabled device that is unknowingly placed close to the reader.

- *Eavesdropping* is an attack, in which an unauthorized person observes and records the NFC based communication between two NFC devices.

- *Tracking* is a serious issue for NFC devices. Since most of these devices have a unique ID that is amongst others used to establish an NFC communication, the movements of people carrying an NFC device can be easily tracked.

- *Relay attacks* are basically man-in-the-middle-attacks applied to NFC and other contactless devices. A local reading device is made believe that it communicates with an NFC device in its local range, while in truth the NFC device is actually positioned at an arbitrary remote location.

- *Falsification of content* can be achieved by an attacker by writing content into the file system of the target NFC device. This way, for instance the unique ID of the attacked NFC device could be altered if no appropriate security mechanisms are applied.

Based on the identified vulnerabilities of smart cards, NFC based devices in particular, and mobile devices in general, the study's authors mention three different threats regarding the usage of mobile devices. Financial losses have been identified as the most obvious threat as they can result for instance from stolen personal information, direct attacks on online applications, or ticket duplication or falsification. Beside financial losses, privacy invasion is another threat. In this context, especially location profiles are mentioned to be an important issue. Finally, in scenarios where mobile devices are used for user authentication, document fraud has also been identified as a serious issue.

The ENISA position paper 'Security Issues of Authentication Using Mobile Devices' [113] finally provides the following general conclusions:

- The authors suggest that European governments should define privacy requirements for mobile technologies. In particular, the topics 'NFC Payment with Mobile Devices', 'Non-Payment NFC Mobile Applications', 'National ID Cards stored in Mobile Devices', and 'Location tracing with Mobile Devices' should be covered.

- Global standards should be followed instead of regional or local specifications in order to ensure a certain level of security and to facilitate interoperability between different solutions.

- Used cryptographic mechanisms should be based upon open, peer-reviewed scientific research in order to assure a high level of cryptographic security.

- Mobile devices should be used as trusted displays for the creation of electronic signatures.

- According to [113], '*the full integration of a national ID card into a mobile device is still a vision in Europe and it seems highly unlikely that a mobile device would constitute an individual's primary identity credential in the near future'*.

- MNOs, banks, and national ID card producers should co-operate in order to solve the problem of fundamental different personalization processes of mobile phones, payment cards, and national ID cards.

- End-users should be trained about the correct and secure usage of mobile devices in order to increase the awareness of security and privacy issues.

6.1.3. M-Government in Ireland 2008

In 2008, the O_2 [115] sponsored study 'm-Government in Ireland 2008' about the current situation of m-Government in Ireland has been published by iReach [114]. After a brief definition of m-Government, the study emphasizes the benefits that mobile broadband can bring for m-Government. In particular, 'faster access to services on the move', 'connectivity almost everywhere', and 'access to richer mobile applications' have been mentioned as core advantages of mobile broadband.

Subsequently, three main drivers of m-Government in Ireland have been identified by the authors. According to [114], cost savings, process efficiencies, and better access to public services for citizens are the most important factors that could pave the way for m-Government in Ireland. Considering the close relationship between e-Government and m-Government, the study also provides an overview of mandatory next steps in e-Government in order to push developments also in the m-Government domain.

The authors of the study identify healthcare, transport, agriculture, and tourism as the four current fields of interest for m-Government and provide several case studies from UK and Ireland that illustrate the benefits that m-Government application can bring in these fields of application. Finally, the study proposes possible future m-Government projects and initiatives that could contribute to a better Irish m-Government infrastructure. The authors suggest m-Government initiatives for the following topics:

- *m-Voting:* The study refers so several m-Voting projects and pilots that have been launched in different European countries such as Estonia, Lithuania, Spain, and UK. The authors claim that '*both e-Voting and m-Voting would have significant benefits to the Irish population*' and hence promote intensified activities in this area.

- *m-Education:* In the context of education, the study suggests the application of mobile technologies for two purposes. First, web based education applications currently available in Ireland should be migrated to a mobile platform. Second, the authors recommend learning a lesson from the Estonian city of Tartu, where m-Government applications in the field of education are already quite common.

- *m-Citizen:* Again, the study refers to a pilot project in the city of Tartu, where citizens can notify public authorities about grievances such as full trash-cans or broken park-benches in their living environment. The authors suggest using mobile technologies in order to engage citizens with the welfare of their living environment.

The study 'm-Government in Ireland 2008' concludes that '*the benefits of both e-Government and with it m-Government are added convenience and flexibility for both Government and Local Authority staff and members of the public*' [114]. For the special situation in Ireland, the study recommends examining of and learning from m-Government projects of other European countries and to adopt them according to requirements and needs of the Irish people.

6.1.4. Mobile tourism and mobile government – An inventory of European projects

The study 'Mobile tourism and mobile government' [116] has been published by the European Centre for Digital Communication (EC/DC) in 2006. The study introduces a set of projects from the domains m-Government and m-Tourism. In consideration of the fact that this study was already published in 2006, some of the presented projects are already out of date and are therefore not described in more detail in this document.

Beside the above mentioned presentation of different projects, the authors of the study provide some general thoughts about m-Government. For instance, the following basic advantages of mobile government compared to e-Government are mentioned in the study:

- *'Mobile technologies are seen as a possible channel to decrease the digital divide caused by the fact that not everybody has access to a PC and/or Internet connection. Mobile penetration has already surpassed Internet penetration.'*
- *'Mobile technologies allow for direct, person-to-person, communication.'*
- *'Individuals can be informed and/or consulted directly anywhere and anytime if needed. In case of emergencies, a dedicated person can be reached at any time, regardless of his/her current location.'*
- *'Mobile technologies are in favor of young citizens. This might create opportunities for establishing a lower threshold for interacting with governmental institutions.'*
- *'Advances in mobile technologies are growing very fast. So does the number of interaction channels that governments potentially can have with/from the citizens.'*

The study is concluded with the identification of different challenges m-Government has to overcome. The authors of [116] mention several issues such as infrastructural development, payment infrastructures, privacy and security, legal issues, accessibility, and the compatibility of mobile systems with existing e-Government systems.

6.1.5. Positive Contributions of Mobile Phones to Society

The study 'Positive Contributions of Mobile Phones to Society' [117] was written by Ibrahim Kushchu and published by the Mobile Government Consortium International in 2007. By evaluating and analyzing the situation of six different countries of the world, the study aims to emphasize on the contribution of mobile phones to citizens' individual lives and life in society. Although m-Government is actually not the main topic of this paper, the document is still interesting as it illustrates the power of mobile technologies to lead to significant changes in society. Furthermore, the author of the study has contributed to several relevant scientific publications on m-Government (e.g. [6], [7]) too.

The study examines the role of mobile phones in Brazil, China, India, Korea, Lithuania, and the United Kingdom. To provide the reader with the required background information, the author first presents the six countries' current situation regarding mobile phone penetration and availability of mobile infrastructure.

After this general introduction, the study reports on contributions of mobile phones to personal life and primary relations. The authors report that these contributions are very similar in all six examined countries and basically comprise six different components. According to [117], '*for each individual a mobile phone is a connection builder, brings convenience to our lives, reflects ones charisma, is a companion, helpful tool when caring about others and ourselves, and creates a culture'*.

However, mobile phones do not only influence the personal life of individuals, they also contribute to society in general. Based on observations from the six examined countries, the

study authors have classified the effects of mobile phones on societies into five categories. According to [117], '*mobile phones help to create an informative, connected, culturally innovative, participative, and converging society*'.

Finally, the study also discusses the economic and governmental impact of mobile phones on the six analyzed countries. The authors report that according to their observations, four areas with major direct influences can be identified. In particular, the use of mobile phones has a positive effect on infrastructure development, better business practices, and improvements in the public sector. Furthermore, according to [117] mobile phones positively influence the collective welfare of the individuals via social responsibility.

Although the study 'Positive Contributions of Mobile Phones to Society' does actually not bear a direct relation to m-Government, it is still interesting to observe how mobile technologies in general and mobile phones in particular can positively influence the life of individuals and societies. This emphasizes the great potential of m-Government to make valuable contributions to citizens' welfare.

6.2. Scientific publications

Because of its vast developments during the past years and the various challenges it rises, m-Government is of great interest in the scientific and academic domain too. In the recent years, several scientific papers on m-Government and closely related topics have been published. In this section, some of these papers are presented.

The analyzed scientific publications have been loosely grouped according to their topics and contents. The following subsections represent the different identified main topics and introduce related publications.

6.2.1. Identification of barriers and success factors

Most scientific publications on m-Government start with a short general introduction and motivation that contain plausible reasons for using m-Government. Nevertheless, several papers have been published that in particular focus on the identification of success factor and barriers for mobile government. Often, these papers provide a list of recommendations for the design and development of successful m-Government applications. Some papers on this topic are briefly sketched in the following.

In [108], Al-khamayseh et al. identify fourteen success factors of m-Government by doing an intense literature research. In order to rank their importance, the personal opinions of different experts on m-Government have been collected and evaluated.

Sandy et al. introduce a success factor model for m-Government, which aims to assist developers '*in planning and implementing m-Government services*' [110]. The authors define the following six main groupings, in which the identified success factors have been classified: cost, business re-engineering, education, acceptance, security, and access.

Various suggestions to overcome barriers to the success of m-Government are presented by El-Kiki et al. in [118]. The authors provide several social, organizational, and technical suggestions to assure the success of future m-Government applications.

In [20], Karan and Khoo identify infrastructural investment, regulatory and political environment, awareness and acceptance, security and privacy, and equitable acceptance as key success factors for mobile government. Although this paper has the current situation in India in perspective, the presented findings can be applied at least to other developing countries too.

In another scientific publication [21], El-Kiki reports on a survey that has tried to identify barriers to the success of mobile government. First, several acceptance factors of m-Government are defined including availability, convenience, privacy and security issues, or input and output mechanisms. The author lists several barriers to m-Government on the

organizational, technical, infrastructural, governmental, and social level and provides suggestions how to overcome these issues.

In [109], the authors El-Kiki and Lawrence again focus on user needs that should be satisfied by m-Government services in order to make them a success. The authors identify a comprehensive list of user requirements and classify them into five groups. Amongst others, the following user needs should be satisfied by m-Government services: value for money, accessibility, awareness, availability, reliability, usability, privacy, security, accountability, and transparency.

Beside the so far mentioned authors, also J. Carroll has discussed critical acceptance factors of m-Government services in several publications. In [3], Carroll examines how people are currently using mobile technologies in order to '*identify possible gaps that are likely to be satisfied by future electronic provision of government services*'. The obtained results show that the way how people are using mobile technology basically depends on their age and other sociocultural factors. In general, the following observations have been made:

- It turned out that having access to mobile technologies does not automatically imply that these technologies are used for a wide range of activities.
- Convenience is an important factor for users.
- Users are unwilling to invest effort in learning how to solve complex tasks with mobile phones. Hence, services must be intuitive and easy to use.
- Physical limitations of mobile phones such as small screen sizes and clumsy input capabilities influence usage negatively.
- Users want control over the traffic on their devices.
- Security and privacy concerns lead to distrust in mobile technologies.

Carroll suggests that these findings should be taken into account during design and implementation of m-Government services in order to achieve high user acceptance.

In [19], Carroll again has a look on m-Government from the users' perspective and concludes that '*the government can mandate the provision of these services but they cannot mandate their acceptance*'. Based on several observations regarding citizens' usage of mobile technologies, Carroll derives the following lessons for m-Government:

- Usually, the mobile phone is the mobile technology of choice. Physical limitations of these devices have significant impacts on the possible format and range of offerings.
- Mobile devices are used in different ways depending on the individual user needs. Providers of m-Government services have to take this into account and realize that 'one-size-fits-all' services are not able to satisfy individual user requirements.
- Citizens want to control traffic on their mobile device and in particular want to limit incoming information. Carroll concludes that therefore '*there is a need for co-ordination amongst the multiple levels of government that may provide m-Government services, given users' sensitivity to the amount of information they receive and the broad range of services that could be supplied using mobile technologies*'.
- While many m-Government services currently rely on one-way interactions, government should head for more complex m-Government models that employ different communication capabilities provided by modern mobile phones.

- Trust in the security of provided m-Government services is crucial. Carroll concludes that trust must be built so that all communication channels offered by mobile technologies are perceived to be trustworthy.

- Using personal technologies such as mobile phones for governmental services allows for efficient personalization of delivered information. Information can be easily prepared according to the special needs and preferences of users.

6.2.2. Case studies

The majority of scientific publications on m-Government actually present obtained results of and gained experiences from practical m-Government projects and initiatives from all over the world. In the following, a small subset of these publications is briefly sketched.

In [119], the authors introduce the City of Seattle's Mobile City Government Project and report on early observations. Similarly, Bremer et al. introduce an SMS based m-Government initiative in Mexico City in [120] and report on results and achieved benefits for citizens.

In [96], the authors present a location based service for m-Government solutions. The project has been launched in Torino, Italy, and has aimed to provide citizens and tourists with relevant information depending on their current location. Making use of Bluetooth technology, the introduced project sends location-based content to the users' mobile devices and provides them with relevant information.

Chatzinotas et al. provide a case study of an m-Government portal called Agroportal [95]. The authors especially focus on security mechanisms that have been applied in order to protect the portal. The paper is concluded with a list of security guidelines and policies, which should be followed by users in order to avoid security attacks.

The situation of m-Government in Macedonia has been discussed in several publications by Antovski and Gusev. In [7], the authors first propose an m-Government framework and identify the five principles interoperability, security, openness, flexibility, and scalability as important criteria for such frameworks. Subsequently, the authors focus on the Macedonian case and present a short survey on m-Government in this country. They conclude that '*citizens should be carefully educated in order to feel comfortable with m-Government*' [7]. The current situation of m-Government in Macedonia is also discussed in [121]. In this publication, the authors Antovski and Gusev additionally introduce the M-GOV project, which has been carried out at the Institute of Informatics in Skopje and has been '*designed to encourage the access to new mobile and wireless public electronic services*'.

In [122], Song discusses an m-Government project that has been carried out Beijing, China. Inspired by the positive outcomes of the presented project, the author proposes '*a shift from Internet based e-Government to m-Government with a resulting growth in the fluidity of mobile interactions*'. Song also concludes that the success of m-Government requires organizational changes and the re-engineering of common processes: '*In being mobile, we should think beyond the potential of the mobile technology alone, rather we should think more about the meaning of mobile government as a reshaping of government itself*'.

Mobile government is also a topic in the Middle East and discussed in several scientific publications. For instance, Naqvi et al. report on m-Government initiatives in Oman [123]. The role of e-Government and m-Government in developing countries is discussed by Abanumy et al. [124] by presenting a couple of m-Government applications that have been launched in Saudi Arabia such as weather notifications or appointment reminders. In a recent publication [125], Alrazooqi et al. focus on the situation in Dubai and propose an m-Government solution for Dubai government.

This list of scientific publications on concrete case studies of m-Government projects could be arbitrarily continued. The plurality of publications on this topic emphasize the fact that m-Government is actually a hot topic all over the world. With the ongoing developments and the

growing penetration of mobile technologies, this trend is most likely to be continued during the next years.

6.2.3. Personalization

One key advantage of mobile devices such as smartphones is the fact that they are usually very personal devices. While desktop PCs are often shared between several individuals, mobile phones are usually unambiguously assignable to a certain person. Thus, mobile applications can be appropriately personalized in order to meet particular user needs and requirements. There are several scientific publications that discuss personalization issues on mobile devices. Some of them are briefly sketched in the following.

In [12], Hassan et al. introduce an adaptive mobile government framework. The proposed solution adapts content to be presented on users' mobile devices according to the personal context, mobile device context, connectivity context, and location context. By incorporating current information regarding these four contexts, the presented content can be optimized dynamically according to the user's current situation.

The importance of personalization in the context of m-Government has also been emphasized by Germanakos et al. in [126]. The authors introduce '*a new comprehensive user profiling, incorporating the User Perceptual Preference Characteristics that serves as the core element for filtering raw m-Government services content.*'

Al-khamayseh et al. [127] discuss the importance of personalization especially regarding the user's current location and propose '*a logical architecture for provisioning governmental location-based services to citizens*'. They conclude that '*personalization and location awareness techniques have the advantages of delivering the right service to the desired users who most benefit from it*' and that thus '*personalization and location awareness techniques should be added to the m-Government architecture as it improves it by helping delivering the services to the appropriate people efficiently and effectively*'.

The relevance of personalization in the context of m-Government is substantiated by several scientific publications. Especially location awareness is frequently mentioned as important input to personalization mechanisms of m-Government applications. Personalization and location based systems therefore form current and future topics of scientific interest.

6.2.4. Further relevant contributions

Of course, not all scientific publications on m-Government can be classified into one of the above mentioned categories. Actually, there are a plenty of contributions that have a look on m-Government from different perspectives. Below, further selected interesting publications are sketched briefly.

A recent contribution by Misra [8] provides a good definition of m-Government and lists its potentials, uses, and limitations. Having especially India in perspective, the author proposes an agenda of action in order to promote m-Government in India. Although the proposed agenda of action has been tailored to the special needs of India, several of the suggested activities can actually be useful for other countries too.

Kumar et al. provide a comprehensive introduction to m-Government in [1]. Similar to other authors, they identify privacy and security, as well as accessibility as critical issues for m-Government applications. They further identify mobile authentication, mobile payments, location-aware applications, city guides, and permit requirements as relevant future trends in m-Government.

Kahl et al. [130] discuss the importance of privacy for mobile communities by means of results of the PICOS project [131]. Although not being directly related to m-Government, the project has revealed the importance of the two crucial factors privacy and trust for mobile services. The authors elaborate on privacy issues of three exemplary mobile communities and show how their requirements have been identified and fulfilled in the course of the PICOS project.

In [14], Sheng et al. propose a framework that bases on the theory of Task-Technology-Fit. Currently available mobile technologies are compared with present m-Government tasks in order to derive possible m-Government applications. The authors identify several benefits and challenges of m-Government applications and finally conclude that in order to '*successfully implement m-Government, governments need to carefully monitor and analyze what the end-users want and what will be their benefit from using m-Government applications*'.

Various interesting scientific contributions have been made by Louis-Francois Pau. Although most of his publications do not directly focus on m-Government, they still provide a valuable contribution to an overall understanding of mobile markets. For instance, in [133] Pau has discussed the converging challenges of banks and mobile operators and has sketched possible future strategies for both of them. In a more recent publication [134], Chen and Pau have introduced '*a conceptual framework and a computational model for individual tariffs for mobile communication services'*. The authors claim that individual tariffs can be beneficial for both users and service providers.

In 2008, Sangwan, Chong, and Pau have analyzed the mobile market situation in China [135]. With their paper, the authors contribute to a better understanding of the complex Chinese mobile market. This may be helpful for designing and developing future m-Government services that attempt to fit the needs of China's fast growing mobile communication market.

6.3. Articles and other publications

Along with survey studies and scientific publications, m-Government has also been the topic of several articles, book chapters, and similar publications. In order to round out the overview on literature on m-Government, in the following some selected publications that are assumed to be worth reading are presented.

The potential of mobile communication technologies has already been identified in 2003 by Fritsch and Rannenberg. In their contribution [136] the authors identify the wide spread of technology as key requirement for successful e-Government. They conclude that mobile communication technologies offer a great opportunity because of their great popularity. After focusing on location-based services and presenting several related initiatives, the authors finally identify security and privacy as crucial requirements for mobile and location based governmental services.

In their book chapter '*Mobility and Identity*' [137], Royer, Deuker, and Rannenberg discuss the topics mobility and identity in more detail and show how modern communication technologies such as GSM enrich peoples' lives and identities by adding mobility. Putting the focus on location based services the authors discuss different aspects of mobility and identity from technological, governmental, economical, and socio-cultural perspectives and provide readers with a deeper understanding of the interdisciplinary nature of mobility and identity.

'*From E-government to M-government: Facing the Inevitable*' [6] is an article by Ibrahim Kushchu and M. Halid Kuscu that motivates and introduces the topic of m-Government. Although the article has already been published in 2004, most of the produced arguments such as identified drivers and challenges of m-Government are still relevant.

Trimi et al. provide a comprehensive overview of current trends in m-Government in their article '*Emerging Trends in M-Government*' [2] that has been published in 2008. They present a list of advantages of m-Government and report on different m-Government initiatives from different regions. Finally, the authors discuss several challenges and issues in m-Government and conclude that '*as the number of wireless users continues to increase, issues are resolved, and technology advances, more innovative m-Government applications will emerge and m-Government become an increasingly important aspect of government functions*'.

The relevance of m-Government for developing countries and regions has already been emphasized throughout this study. There are also several publications that discuss this topic.

For instance, Ghyasi et al. [128] report on benefits that mobile technology and m-Government can bring for developing countries. Several m-Government projects have also been introduced in [16] together with a list of potential drivers for the transformation from e-Government to m-Government.

Challenges for mobile identity management systems have already been discussed in 2006 by Royer and Rannenberg [132]. The authors review this topic from several different perspectives and identify various technical challenges such as usability issues, and security concerns. Since mobile identities play an important role in numerous m-Government services, this article actually covers an interesting aspect of mobile government.

Various authors define m-Democracy to be one of the most important purposes of m-Government. In his article [17], Lallana discusses the implications of m-Government on society in general and on democracy in particular. According to [17], m-Government can contribute to eDemocracy in two ways. '*First, it can strengthen existing democracies by enhancing existing representative institutions. Second, it can help create a more vibrant civil society.*' Lallana supports his statement with several practical case studies from different countries and finally concludes that '*political scientists not only have failed to measure the mobile phone's impact but have not yet begun to imagine that changes that it is bringing*'.

7. Conclusions and outlook

An intense examination of the topic mobile government shows that mobile-technology based solutions are already widely adopted all over the world. It can be expected that ongoing developments of mobile technologies and growing mobile markets will intensify this trend. The importance of m-Government is substantiated by the various activities in the field of mobile government. So far, this study has provided a detailed overview of ongoing m-Government projects and initiatives, and has introduced relevant literature on this topic. In this section, the core findings of this study are finally summarized. Furthermore, current trends are identified and an outlook to possible future developments and areas of interest is provided.

7.1. Core findings

The diversity of activities in the field of m-Government that have been sketched in this document shows that m-Government comprises a relatively wide spectrum. The examined pilot projects and scientific publications contain initiatives from various fields of application such as healthcare, financial services, or public administration. It has also been shown that m-Government has the power to significantly influence societies and strengthen democracy, which again emphasizes its relevance.

Although different use-cases usually make different demands on m-Government and hence different approaches are difficult to compare directly, several general findings have been obtained from the conducted literature research.

7.1.1. Mobile government to fight the digital divide

Mobile government is a global phenomenon. However, there are some significant differences between m-Government initiatives is developed countries and projects in developing regions. In underdeveloped African and Asian countries that suffer from missing wire-based infrastructures, mobile technologies are often the only opportunity for communication. Thus, mobile phones are often the only way for people to communicate with each other over longer distances and an efficient opportunity for governments to get in contact with citizens.

In Africa and Asia, mobile technologies are therefore frequently used for healthcare and educational purposes. Since 3G networks are often not available yet, the applied services are usually restricted to voice and SMS transmissions. Nevertheless, in several projects m-Government has proven to be an appropriate tool to facilitate the lives of people in developing countries and to fight the digital divide.

7.1.2. Mobile government for the ‘always-on society’

Missing wire-based communication infrastructures make mobile networks often the one and only alternative for remote communication in developing regions. In developed countries, usually multiple communication networks are available at the same time, especially in urban areas. Nevertheless, there are still a couple of reasons that make m-Government an important issue also in developed countries.

The maybe most important reason for m-Government in western countries is convenience. In the typical western always-on society, a rise of demand for services that are accessible anytime and everywhere can be observed. Mobile devices such as mobile phones are usually always carried and always on. Hence, these devices are perfectly suitable to act as end-point for services that shall be available and accessible independently of the user’s current location and context.

While m-Government initiatives in developing regions rely on rather simple approaches, solutions in developed countries are sometimes more sophisticated. This applies especially to e-ID based approaches that make use of mobile devices to reliably authenticate citizens and therefore usually imply the creation of electronic signatures.

7.1.3. SMS as technology of choice

The survey of past and current m-Government projects has shown that most services are still based on SMS technology. This seems reasonable for developing regions where smartphones and 3G networks are often not available. However, also in the USA or in many Member States of the European Union several m-Government initiatives have been found that actually rely on SMS technology.

There are several cases, in which even security-sensitive processes rely on SMS technology. For instance, in Austrian e-Government solutions, user authentication with mobile phones basically relies on text messaging.

7.1.4. User acceptance as key for success

The provided literature overview has shown that the identification of success factors for m-Government is an important topic also in the scientific community. People seem to have learned from e-Government, where well-intentioned solutions have often not led to the hoped success because of several reasons.

In various publications, user acceptance has been mentioned to be one of the most important factors for success. Therefore, it is crucial to rely on user-centric approaches and to offer m-Government services that precisely satisfy user’s needs. The current hype of smartphones and mobile technologies is a great chance to enlist citizens for m-Government. However, providers of m-Government services should be aware that a long-term success of m-Government service can only be achieved if user needs and requirements are considered and user’s acceptance can be won.

7.1.5. Context awareness as future topic of interest

Mobile technologies allow users to access services independent of the current context such as their current location. This affords service providers the opportunity to offer context aware services that take into account users’ context specific needs and requirements. The relevance of context aware solutions in general and location based systems in particular has for instance been emphasized by Fritsch and Rannenberg in [136], and also by Royer, Deuker, and Rannenberg in [137].

The inclusion of context awareness into m-Government processes is expected to be a future topic of interest as it allows for a potential increase of usability and convenience. Considering the fact that user specific context information has to be classified as privacy sensitive data, context awareness raises several challenges that will be have to be overcome in future.

7.1.6. Important prerequisites: security and privacy

Mobile government applications often include the transmission and processing of privacy or security sensitive data. As a matter of course, citizens want these data to remain undisclosed in order to protect their privacy. Unfortunately, experiences with certain m-government projects have shown that people often associate mobile phones with fun and not with serious tasks such as governmental transactions. Therefore, people sometimes refuse to use their mobile phones in the course of m-Government services, simply because they have no trust in the system's security and reliability.

It is thus less surprising that security and privacy are frequently mentioned challenges of m-Government systems. It has already been noted that user acceptance is crucial for the success of m-Government. Secure and reliable m-Government services that enhance the users' trust in mobile technologies can in turn be seen as important factors for user acceptance. Hence, only if offered services are secure and preserve users' privacy, m-Government can be successful.

7.1.7. Mobile government as field of scientific interest

The literature review that has been provided in this study emphasizes the great interest of the scientific community on m-Government. Despite the fact that only a selected subset of scientific publications has been analyzed in more detail, several trends and special fields of interest could be extracted.

A large number of publications actually discuss drivers, enablers, and success factors of m-Government and try to identify different challenges that threaten to hinder the future success of mobile services. Another topic of numerous publications is the presentation of pilot projects and the reporting on gained experiences. Finally, also content presentation and personalization issues have been identified as major fields of scientific interest.

Beside scientific publications, also several studies and white papers on m-Government are available on the Internet. Many of these studies have been published by different companies. This reveals the importance of m-Government also for the private sector.

7.2. A glimpse into the future

Without doubt, m-Government has great potential for future success. Several advantages of mobile phones such as their always-on characteristic, their personalization capabilities, or the growing global availability of mobile networks make these devices a promise for the future.

Despite all enthusiasm, there are still several challenges and issues left to be overcome in order to assure the future success of mobile government. In the following, some major obstacles that threaten to hinder the success of m-Government and that should be tackled in the near future are described. Finally, some expected future trends are briefly sketched.

In Section 4.3 of this document, several challenges and barriers of m-Government have been identified based on an intensive literature research. Although this list of issues is quite impressive, a plenty of successful m-Government projects have already been launched all over the world. Still, there is much left to be done in the future to improve existing and develop new powerful approaches.

For instance, with the emergence of smartphones users nowadays have more possibilities to modify and access their mobile phone's operating system and core functionality. This raises several issues as mobile devices get more prone to attacks and more vulnerable to malware. In order to maintain the security of SMS based m-Government approaches, it will therefore be crucial to guarantee that text messaging remains a secure and trusted service.

The demand for secure and reliable SMS services can actually be seen as a special case. In general, security and privacy have been identified as key factors for user acceptance. Only if m-Government services are secure and trustworthy, they will be accepted by citizens. There is obviously a high demand for mechanisms that allow for secure and reliable mobile

applications. The development of security and privacy preserving techniques for m-Government services is therefore an important task for the future.

Mobile phones are very personal devices, which are hardly ever shared between different users. This allows for highly personalized mobile applications, which in turn improves the usability and leads to better user acceptance. Furthermore, modern smartphones are equipped with various sensors that enable a rough determination of the user's current context. Several attempts have already been made to make use of information about the user's context for personalization purposes. With more powerful mobile devices and additional sensors the development of enhanced context-aware personalization methods will probably become an important field of research in the future.

Most m-Government services that are available so far basically rely on sort of server-client architecture. Information is usually exchanged between clients, e.g. mobile phones, and a central instance, e.g. a governmental agency. Fewer approaches are known that actually base on client-to-client communication. With the growing spread of NFC technology, this might change soon. The development of m-Government solutions that make use of NFC technology and the protection of such approaches will probably be an interesting topic in the near future.

Mobile technologies satisfy the needs of our society for efficient communications and permanent access to services. It is comprehensible that also governments aim to join the trend and make use of mobile technologies to improve their services for citizens. Throughout this study, the emerging importance of m-Government has been discussed from different perspectives. Past and current m-Government projects from all over the world have been presented and relevant literature on m-government has been reviewed. Although a lot has already been accomplished, there is still much left to do in order to make m-Government a success.

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