IADIS International Journal on WWW/Internet
Vol. 13, No. 2, pp. 17-33
ISSN: 1645-7641

FUTURE DIRECTIONS IN MOBILE GOVERNMENT

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ABSTRACT

Powered by the rise and growing popularity of mobile computing and mobile communication technologies, mobile government (m-government) has recently evolved as relevant sub-discipline of e-government. Mobile government offers new opportunities, as it employs capabilities of modern mobile end-user devices such as smartphones or tablet computers. At the same time, dynamic markets and vast technological advances raise various challenges for developers, operators, and providers of m-government solutions. To still make m-government solutions a sustained success, upcoming trends in m-government and mobile computing need to be recognized in time. This article facilitates an early recognition of future trends in m-government by surveying the current state of the art and by analyzing deployed m-government solutions from all over the world. From the findings of the conducted analysis, several actions are proposed that need to be taken to assure the future success of m-government. In particular, proposed actions target a transition of m-government applications from purely informational services towards fully transactional solutions. This way, the actions proposed in this article represent a roadmap to further develop m-government to an emancipated alternative to classical e-government.

KEYWORDS

Mobile Government, Mobile Technologies, E-Government, Smartphones, Survey.

1. INTRODUCTION

Powered by the emergence of information and communication technologies (ICTs), electronic government (e-government) has significantly gained relevance in modern societies during the past few decades. Provision of governmental and administrative procedures by means of electronic services is advantageous for both public administrations and citizens. In contrast to classical administrative procedures, e-government services can be accessed 24/7. This applies to both, informational e-government services that provide citizens with relevant information, and transactional e-government services that enable citizens to carry out entire procedures electronically. In addition, electronic processes are typically more cost-efficient and help

public bodies to save money. It is hence unsurprising that e-government solutions have had an influence on the societies of many countries and have changed the interaction between governments and citizens.

From a technical perspective, ICTs must be regarded as key enablers of e-government. Accordingly, provided e-government solutions have always been influenced by available technologies and the current state of the art. For many years, e-government solutions have mainly relied on web technologies. Accordingly, e-government services have been provided in the form of static websites or interactive web applications. Nowadays, web-based e-government solutions can be found all over the world (United Nations 2014).

During the past few years, mobile computing has emerged as new predominating computing paradigm. Enabled by the availability of powerful mobile end-user devices and communication networks, mobile computing is gradually replacing the classical computing paradigm. The trend towards mobile computing has also affected the field of e-government. During the past years, mobile government (m-government) has emerged as a sub-discipline of e-government. The term m-government subsumes initiatives and solutions that employ mobile technologies to provide governmental services (Kushchu and Kuscu 2004).

Compared to classical e-government, m-government raises various additional opportunities. First and foremost, m-government perfectly fits the always-on mentality of modern societies, where information, services, and resources are expected to be available everywhere and any time. By relying on mobile technologies, governmental services can be made accessible 24/7 and independent from the citizen's current context. Second, modern mobile end-user devices feature various technologies that are typically not available on classical end-user devices. This enables completely new use cases and application scenarios. Finally, m-government can also be advantageous in regions that suffer from a lack of reliable wire-based communication infrastructures. This applies to several developing countries in Africa, where mobile communication networks are often more developed than wire-based infrastructures. There, m-government services are often the only opportunity for public administrations to efficiently communicate with citizens.

Unfortunately, the emergence and growing popularity of m-government raises several issues too. For instance, the plurality of mobile end-user devices and mobile operating systems increases costs for the development of reliable client software based on mobile apps. Furthermore, dynamic markets and frequent technological improvements render the development of sustainable m-government solutions difficult (MobiForge 2014). In general, mobile computing is often driven by ephemeral trends, which requires fast decisions, short release cycles, and flexible solutions. To enable fast decision-making processes and the development of appropriate m-government solutions, awareness of current trends and the early perception of future directions in mobile computing is essential.

This article addresses this problem and facilitates fast and correct decisions with regard to m-government by surveying and analyzing the current state of the art. Concretely, this article surveys current m-government solutions, identifies relevant trends, and determines necessary actions to be taken. This way, this article paves the way for successful future m-government solutions.

The remainder of this article is structured as follows. Section 2 discusses related work on the topics addressed in this article. In Section 3, the methodology followed for the conducted survey is introduced. Subsequently, m-government solutions from all over the world are surveyed in Section 4. In Section 5, surveyed m-government solutions are analyzed by means of five criteria. Subsequently, Section 6 presents obtained results and discusses findings

derived from these results. From the yielded findings, current trends are identified and necessary future actions to be taken are derived in Section 7. Finally, conclusions are drawn in Section 8.

2. RELATED WORK

In 2007, the introduction of the Apple iPhone has had a considerable impact on the way, users access information and electronic services. Featuring an innovative user interface, the Apple iPhone was the first smartphone that represented an emancipated alternative to classical end-user devices such as desktop computers or laptops. At the same time, mobile communication networks have been improved significantly. With the introduction and broad adoption of 3G technologies, permanent broadband access to the Internet had become reality. The availability of powerful mobile end-user devices and mobile communication networks has leveraged mobile computing, which nowadays represents one of the predominating computing paradigms.

Interestingly, mobile government, i.e. the use of mobile technologies for e-government solutions, has been a topic of interest long before the introduction of the first powerful smartphones. This has especially applied to developing countries and regions, where mobile communication channels have often represented the only means for governments and public administrations to get in contact with citizens. In countries with missing fixed-line communication networks, m-government has hence already been a topic of interest in the pre-smartphone era.

The general interest in m-government has yielded twofold results. On the one hand, the interest in m-government has yielded various concrete m-government solutions all over the world. On the other hand, the growing relevance of m-government has also attracted the attention of the scientific community. Research on m-government has so far mainly focused on the identification of relevant success factors, enablers, and potential barriers for m-government. For instance, Karan and Khoo (2008) have focused on success factors for m-government. Concretely, they have identified infrastructural investment, regulatory and political environment, awareness and acceptance, security and privacy, and equitable access as crucial success factors for m-government. Al-khamayseh et al. (2007) have focused on this topic as well. They have listed 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 as relevant factors that influence the success of m-government solutions. Similar success factors have also been identified by El-Kiki and Lawrence (2006). Sareen et al. (2013) have especially focused on the Indian use case. Identified success factors for this concrete use case resemble those identified by other scientific works, even though several aspects specific for developing countries have been taken into account. A comprehensive survey on scientific literature targeting the identification of success factors for m-government has been published by Al-Hadidi and Rezgui (2009). This survey shows that most authors consider the success factors security, privacy, awareness, and user acceptance as critical for m-government solutions.

In addition to the identification of success factors, research on m-government has also focused on the identification of barriers and challenges that need to be overcome by m-government solutions. Similar to the identification of success factors, investigation of potential barriers for m-government has also been a topic of scientific interest from the beginning. For instance, Kumar and Sinha (2007) have identified two potential barriers of m-government solutions. Concretely, they have listed security issues imposed by airwave-based communication channels and accessibility issues imposed by technically limited end-user devices as potential barriers.

A more detailed analysis of barriers to m-government has been provided by El-Kiki (2007), who has classified potential barriers into the categories Organizational, Technical, Governance, and Social. According to El-Kiki (2007), organizational barriers include issues such as bureaucratic problems, the lack of cooperation among public organizations or interoperability issues between different departments. Another organizational barrier identified by El-Kiki is the lack of user-centric approaches, as 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*' and the offered *'service is structured by the goals of the administration, not the goals of the citizen users*' (El-Kiki 2007). Other organizational barriers to m-government identified by the author are the absence of combined e-business and e-governance models as well as the lack of sustainable business models. The reluctance of authorities to alter traditional ways of dealing with their customers has been identified as a potential barrier as well. El-Kiki (2007) has further concluded that economic and financial barriers can also hinder the success of m-Government services. High development costs, lack of infrastructural investments, and low budget for mobile services are the most frequently listed issues in this context. Finally, El-Kiki [2007] also identifies legal problems caused by missing legal frameworks as barrier to the success and acceptance of m-government. From a technical perspective, short release cycles and frequent advances in the mobile computing domain represent potential barriers. Other technical barriers identified by El-Kiki (2007) are lack of interoperability, competition between different access channels, as well as lack of backend-process integration and the absence of ability to bundle information, materials, and service together. El-Kiki (2007) has stated that social barriers also reduce the acceptance of m-government services. Accordingly, these services must be as simple to use as possible. Furthermore, it is also relevant that people understand why they should use a mobile service. Other social barriers to m-government identified by El-Kiki are security and privacy concerns. El-Kiki underpins the relevance of this aspect by concluding that *'if there is no sound solution to security, e-government and m-government will be a dream*' (El-Kiki 2007).

While El-Kiki (2007) provides a rather generic list of potential barriers, other works on this topic focus on more specific use cases and scenarios. For instance, Moon (2010) has focused on mobile emergency systems in Asia and identifies potential issues and challenges for them. From the identified challenges, Moon (2010) has derived four recommendations for facilitating and improving the implementation of m-government initiatives. While Moon (2010) focuses on a certain use case, Mengistu et al. (2009) focus on challenges that might arise when deploying m-government services in developing countries. Finally, Zefferer and Teufl (2011) have especially focused on potential barriers and challenges of smartphone-based m-government solutions. In particular, Zefferer and Teufl (2011) have identified the heterogeneous ecosystem of different mobile platforms as well as security and privacy issues on mobile end-user devices as potential barriers to the future success of smartphone-based m-government.

This brief overview of related scientific work shows that m-government has been a topic of scientific interest for many years. This article contributes to this topic by analyzing the current state of the art of m-government. This way, this article reveals if and how current m-government solutions are able to comply with identified success factors and to overcome potential barriers in practice.

3. METHODOLOGY

To identify current m-government trends and to derive necessary future actions, a thorough methodology has been followed. This is necessary, as current developments in m-government undergo frequent changes and are heavily influenced by dynamic markets and continuously changing circumstances. To deal with this situation, several consecutive steps have been carried out to systematically achieve the goals of this work.

The identification of relevant trends and the derivation of necessary actions to be taken have been based on a thorough survey of existing m-government solutions. The surveyed solutions are subsequently assessed by means of different criteria. From the results of this assessment, current trends are identified. Finally, necessary actions to be taken in order to pave the way for successful future m-government solutions are derived.

According to this methodology, the conducted survey represents the basis of all subsequent steps. The quality of this survey is hence of central relevance. Ideally, this survey should comprise all existing m-government solutions, in order to draw a complete picture of the current state of the art. Due to the growing popularity of m-government, the number of available m-government solutions has however reached a level that renders a complete survey impossible. Only in the US, public administrations offer already more than 200 m-government services and applications (U.S. Government 2014).

As a complete survey of all existing m-government solutions would go beyond the scope of this article, focus is put on a selected subset of m-government solutions. This subset has been selected such that a representative picture of the current state of the art is drawn. Selected m-government solutions have been collected from m-government portals (U.S. Government 2014), respective surveys and studies (Mobi Solutions Ltd. 2010), as well as from related scientific work (Zefferer and Teufl 2011). From these sources, 25 m-government sample services from all over the world have been selected and analyzed in detail. The selected solutions are briefly introduced in the following section.

4. SURVEY

During the past years, m-government has evolved to a global phenomenon. Respective solutions can be found in both developed and developing countries. In this section, a representative subset of m-government solutions from different countries and regions is surveyed to draw a picture of the current state of the art. The conducted survey comprises m-government solutions from all over the world. Figure 1 shows that current solutions from all five continents have been taken into account.

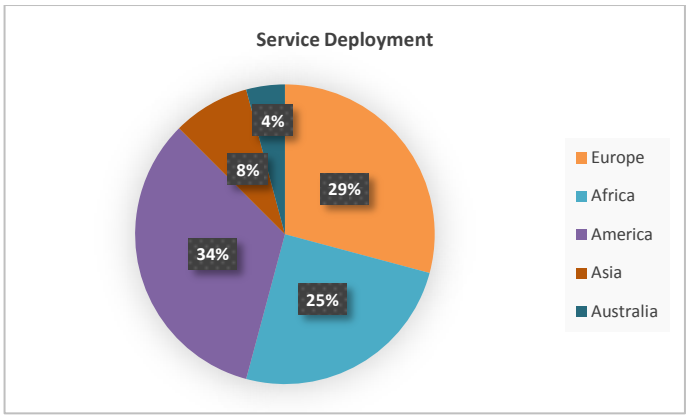

Figure 1. Origin of surveyed m-government solutions.

Especially in developing countries, m-government has early evolved to a popular alternative to classical e-government, as mobile communication networks are often better developed than wire-based communication infrastructures. Most services that have been deployed in these countries during the past years are related to the topics health care, education, and electronic payment. A representative example for an m-government service from the health-care sector is BloodbankSMS[1]. BloodbankSMS has been deployed in Kenya and assists hospitals in rural areas to report the current status of their blood repositories to national blood banks. This assures that hospitals are supplied with blood bottles in time. Another m-government solution related to health care is mPedigree[2], which addresses the counterfeit of legal drugs and medicine in Ghana. Consumers can send serial numbers printed on bought medicines to a central service via SMS. Based on this serial number, information about the authenticity of the bought drug or medicine is retrieved and returned to the consumer via SMS.

Health care related m-government services have also been rolled out in Uganda. For instance, Text2Change[3] is an SMS-based health-education program, which aims to inform people in developing countries about relevant health-related topics. Due to its success, Text2Change has already been ported to other countries as well. Improving health-care services in developing countries is also the basic goal of the African non-profit company Cell-Life[4]. During the past years, Cell-Life has started several health-related projects that make use of mobile technologies. Examples are the projects ICAP or MAMA. A complete list of all projects initiated by Cell-Life is provided on their website[4].

In addition to the improvement of health-care services, developing countries also make use of m-government services and solutions to enhance the education of children. A representative example is Text2Teach[5]. According to the project website, the mission of Text2Teach is to make a significant contribution to the quality of teaching and learning in underserved schools

[1] http://www.media.mit.edu/ventures/EPROM/research.html#bloodbank
[2] http://mpedigree.net/about-us
[3] http://www.ttcmobile.com
[4] http://www.cell-life.org
[5] http://www.text2teach.org.ph

and communities in the Philippines. Text2Teach enables teachers in underdeveloped regions to order and obtain electronic teaching material such as video clips that can be shown in class.

Recently, mobile technologies have also been used to enable financial transactions in developing countries, where people often cannot afford own bank accounts. The mobile-money solution mPesa[6] is a popular example for a mobile money-transfer solution that enables people to carry out non-cash transactions using simple mobile technologies. It has been developed by the Kenyan mobile-network operator Safaricom and by Vodafone in 2007. Each mPesa user has an own virtual account. So-called mPesa agents act as interface between users and their accounts. In many cases, gas stations or supermarkets assume the role of mPesa agents. By means of these agents, users can deposit or withdraw money from their accounts. In addition, mPesa also enables direct money transfers between users, supports the payment of bills, and allows users to purchase prepaid airtime. From a technical perspective, transactions are carried out by exchanging SMS messages between users or between users and agents. Another example for a mobile payment solution is G-Cash[7]. Having its roots in the Philippines, G-Cash also aims to provide a mobile alternative to established non-cash payment systems.

The m-government solutions surveyed so far show that beside education and payment solutions, especially the health-care sector benefits significantly from mobile technologies in developing countries. To a certain degree, this also applies to developed countries. During the past years, health care related solutions relying on mobile technologies have been deployed in various developed countries in Asia, Europe, and America. A representative example is the service AskBrook[8], which has been rolled out in the UK. According to its website, the project AskBrook has the goal to promote the health of young people and those most vulnerable to sexual ill through providing information, education and outreach, counseling, confidential clinical and medical services, professional advice, and training. To achieve this goal, AskBrook enables young people to make use of counseling services using SMS messages. Reliance on this mobile communication technology enables those seeking for advice to avoid direct personal contact and to remain anonymous. Other health care related services from developed countries are HELP4BABY[9] or Text4Baby[10], which both support expectant mothers by providing relevant information via mobile communication channels. Especially in the US, governmental agencies additionally provide citizens a selection of tools based on mobile apps to improve health care. For instance, there are mobile apps that help citizens to calculate their body-mass index (BMI)[11] and to practice breathing exercises in order to cope with stressful situations[12].

In addition to health care related use cases, mobile technologies are also frequently used in developed countries for security-related application scenarios. Mobile solutions related to security cover several different aspects. For instance, the US Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) provides a mobile app with relevant information on weapons[13]. Protection against threats caused by forces of nature is for instance improved by

[6] https://www.mpesa.in/portal/
[7] http://www.globe.com.ph/gcash
[8] http://www.askbrook.org.uk
[9] http://www.bundeskanzleramt.at/site/cob 52664/currentpage 0/6490/default.aspx
[10] https://www.text4baby.org/
[11] https://itunes.apple.com/us/app/bmi-calculator/id292796789?mt=8
[12] http://itunes.apple.com/app/tactical-breather/id445893881?mt=8#
[13] https://itunes.apple.com/us/app/atf/id408467237?mt=8

the mobile app Hurricane, which supplies citizens with relevant and timely information on hurricanes[14]. Mobile services have recently also turned out to be perfectly suitable for the implementation and provision of disaster-warning solutions. As mobile end-user devices are usually always carried, they can be used to deliver warnings of natural disasters in time. For instance, the service SMS Tsunami Warning[15] makes use of SMS technology in order to warn people in case of approaching tsunamis. Mobile technologies are also employed in the UK to improve the security of citizens. There, the SMS-based service EmergencySMS[16] enables citizens to contact emergency numbers by means of SMS. This is especially useful for deaf and dumb people, who are unable to rely on voice-based communication. Another application scenario, where mobile technologies are frequently used to improve security, is the communication between parents, teachers, and students. For instance, the service School News Channel[17] makes use of mobile technologies to inform parents of absenteeism and changed timetables, or to deliver emergency messages. Finally, also the Canadian government relies on mobile technologies, in order to improve the security of their citizens. Concretely, they provide a mobile app called Learn to Camp[18], which supplies users with relevant information regarding secure stays in national parks.

Health care and security are however only two out of many use cases and application scenarios, in which reliance on mobile technologies can be useful. Further examples that illustrate the usefulness of m-government in developed countries are the Austrian solution RIS:App[19], which provides Austrian citizens instant mobile access to relevant laws and regulations. In Canada, mobile apps are provided and frequently used to support citizens in filling forms in order to apply for grants[20]. Finally, mobile apps are also frequently used to facilitate the reporting between citizens and public administrations. For instance, the Dutch solution Buitenbeter[21] and the US solution iBurgh[22] enable citizens to efficiently report issues is public space by means of mobile apps.

Especially in Europe, mobile technologies are also frequently used to implement solutions related to electronic identities (eIDs) and electronic signatures. Respective solutions have for instance been deployed in Austria, Estonia, Finland, or Turkey. During the past years, two basic approaches to realize eID and electronic-signature functionality with the help of mobile technologies have evolved. So called SIM-based solutions make use of the user's SIM for this purpose. Relevant eID data and cryptographic keys for the creation of electronic signatures are stored on the user's SIM. A SIM-based eID and electronic-signature solution called Mobiil-ID[23] has for instance been rolled out in Estonia. As an alternative to SIM-based solutions, server-based solutions have emerged during the past years. These solutions render the use of SIMs unnecessary, as they store and process relevant data in a secure central hardware module. Mobile technologies are used to authenticate users and to authorize access to centrally stored eID and electronic-signature data. A prime example of a server-based eID and

[14] https://play.google.com/store/apps/details?id=com.cube.arc.hfa
[15] http://www.sms-tsunami-warning.com/pages/contact-us#.VKj6n3vis7E
[16] http://www.emergencysms.org.uk/index.php
[17] http://schoolnewschannel.com.au/snc.php
[18] http://open.canada.ca/en/apps/learn-camp
[19] https://www.bka.gv.at/site/cob 52564/currentpage 0/6490/default.aspx
[20] http://open.canada.ca/en/apps/how-apply-grant
[21] http://www.buitenbeter.nl/english
[22] https://play.google.com/store/apps/details?id=com.yinzcam.iburgh
[23] http://www.id.ee/index.php?id=36881

electronic-signature solution is the Austrian Mobile Phone Signature[24], which has been in productive operation in Austria since 2010.

In general, it can be observed that the number of provided m-government solutions is steadily increasing. This applies to both developing and developed regions of the world. Although the provided survey covers only a subset of all existing m-government solutions, it still draws a representative picture of the current state of the art. In order to systematically identify current trends and to derive necessary future actions, the surveyed solutions are systematically analyzed in the following section.

5. ANALYSIS

The conducted survey of current m-government solutions shows that the term m-government actually covers a broad spectrum of services and applications. Depending on the respective use case, provided services and employed technologies differ significantly from each other. In order to enable the identification of commonalities and the derivation of relevant trends, the 25 surveyed m-government solutions are analyzed in this section according to different criteria. Concretely, the following five criteria are used.

- **Country:** The context, in which an m-government solution is deployed and provided, typically influences its goals, functionalities, and employed technologies. Hence, its origin country is a relevant criterion of each m-government solution.
- **Information Flow:** Similar to e-government services, also m-government solutions implement some kind of information exchange between citizens (C), governmental agencies (G), and non-governmental organizations (N). Accordingly, m-government solutions can also be classified and analyzed by means of their implemented information flow.
- **Provider:** Even though the term m-government implies that services are provided by governmental agencies, this is often not the case in practice. Especially in developing countries, services are often also provided by non-governmental organizations. The provider of and driver behind an m-government service is hence another interesting classification criterion.
- **Field:** As the term m-government is quite abstract, it covers solutions from various fields of application including health care, payment, or justice. Hence, the concrete field, to which an m-government solution can be assigned, is another relevant classification criterion.
- **Client Technology:** All m-government solutions have in common that they rely on some kind of mobile client technology. In most cases, they make use of the user's mobile phone and employ technologies featured by this device. With the emergence of smartphones, the set of available technologies that can be used to implement m-government services has significantly increased. The concrete technology used for the provision of m-government services is hence a relevant classification criterion that can be used to systematically analyze surveyed solutions.

[24] https://www.handy-signatur.at/

Based on these criteria, all 25 surveyed m-government solutions are systematically analyzed and compared with each other. For each solution, the five criteria are assessed separately. Obtained results of this assessment are illustrated in Table 1. Based on the comparisons provided in Table 1, current trends in m-government can be derived. This is detailed in the following section, where basic findings are discussed.

Table 1. Comparison and analysis of surveyed m-government solutions.

Service Name	Country	Information Flow	Provider	Field	Client Technology
AskBrook	UK	N2C	N	mHealth	SMS
ATF	US	G2C	G	mSecurity	Mobile App
BloodbankSMS	KE	G2G	G	mHealth	SMS
BMI Calculator	US	N/A	G	mHealth	Mobile App
Buitenbeter	NL	C2G	G	mAdministration	Mobile App
EmergencySMS	UK	C2G	G	mSecurity	SMS
G-Cash	PH	C2C	N	mPayment	SMS/Mobile App
HELP4BABY	AT	G2C	G	mHealth	Mobile App
How to Apply for a Grant	CA	G2C	G	mAdministration	Mobile App
Hurricane	US	N2C	N	mSecurity	Mobile App
iBurgh	US	C2G	G	mAdministration	Mobile App
ICAP	ZA	N2C	N	mHealth	SMS
Learn to Camp	CA	G2C	G	mSecurity	Mobile App
MAMA	ZA	N2C	N	mHealth	SMS/Voice
Mobiil-ID	EE	N/A	N	Infrastructure	SIM Application Toolkit
Mobile Phone Signature	AT	N/A	N	Infrastructure	SMS
mPedigree	GH	C2N/N2C	N	mHealth	SMS
mPesa	KE	C2C	N	mPayment	SMS
RIS:App	AT	G2C	G	mJustice	Mobile App
School News Channel	AU	N2C	N	mSecurity	SMS
SMS Tsunami Warning	Global	N2C	N	mSecurity	SMS
Tactical Breather	US	N/A	G	mHealth	Mobile App
Text2Change	UG	N2C	N	mHealth	SMS
Text2Teach	PH	C2N/N2C	N	mEducation	Various
Text4Baby	US	G2C	G	mHealth	SMS/Mobile App

6. FINDINGS

Table 1 shows a direct comparison of the 25 surveyed m-government solutions with regard to five relevant criteria. From this comparison, several findings can be derived. These findings are discussed in the following subsections in more detail. Obtained findings will later be used to derive current trends and future actions to be taken.

6.1 Fields of Application

The term m-government can be seen as an umbrella term for services and solutions from different fields of application. Examples for such fields are mHealth, mEducation, or mAdministration. We have analyzed the surveyed m-government solutions in order to

investigate, to which field of application they can be assigned. Obtained results are illustrated in Figure 2, which shows how many of the surveyed solutions can be assigned to which field.

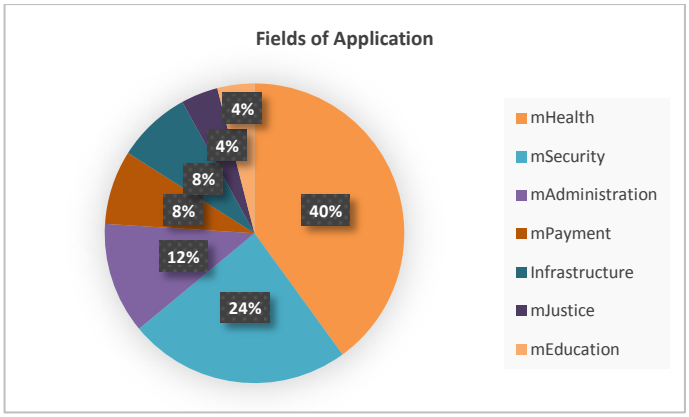

Figure 2. Assigned fields of application.

In addition to the results illustrated in Figure 2, further findings can be derived by taking other analysis criteria into account as well. For instance, it becomes apparent that mobile government is especially popular and frequently used in the health-care sector. From the 25 surveyed solutions, 10 solutions (42%) can be assigned to the field of mobile health (mHealth). Respective services can be found in both developing and developed countries. Especially in developing countries, mobile solutions are also frequently used in the field of education. There, mobile technologies are used to compensate shortcomings of wire-based ICT infrastructures and to supply schools and teachers with required teaching material.

The conducted analysis has also revealed that in developing countries, mobile technologies are frequently used to provide cash-less payment systems. This way, cheap alternatives are offered for those, who cannot afford an own bank account. Most of the solutions provided in developing countries rely on rather simple technologies. This way, they can also be used with simple handhelds and are hence accessible for a large target group.

In developed countries, mobile technologies are increasingly used to implement and provide eID and electronic-signature functionality. This especially applies to Europe, where electronic signatures have a strong legal basis (The European Parliament and the Council of the European Union 1999).

Finally, obtained results also show that security-related services often make use of mobile technologies, e.g. to notify citizens about natural disasters in time or to provide users with security-relevant information in specific situations. For these solutions, the always-on characteristic of mobile end-user devices is crucial.

In summary, the conducted survey and the applied analysis have shown that m-government is actually an umbrella term for mobile solutions from various fields of application. Even though there are considerable differences between developing and developed countries, obtained results show that mobile technologies have the potential to improve electronic services from various fields all over the world.

6.2 Technologies Employed

From a technical perspective, technical requirements of provided m-government solutions are of special interest. We hence had a more detailed look on the specific mobile technologies that are employed by provided solutions. Obtained results are illustrated in Figure 3.

Analysis of all 25 surveyed solutions turned out that SMS is still one of the predominating technologies employed by current m-government solutions. This especially applies to services in developing countries, where mobile broadband communication networks are sometimes still rare. However, there are also several services in developed countries that still rely on the rather old and outdated SMS technology.

Another trend that could be observed from the surveyed solutions concerned the use of mobile apps. Unsurprisingly, mobile apps turned out to be on the rise especially in developed countries, where smartphone penetration is already high. In developing countries, where smartphones are often still rare, mobile apps are also slowly adapted. However, in these countries simple technologies like SMS are usually the preferred choice.

Alternative technologies such as voice transmission or solutions based on the SIM Application Toolkit are also sometimes used by m-government solutions. However, they are mainly used for specific tasks and use cases and are applied by specific solutions only. Mobile apps and SMS technology represent the backbone of nearly all surveyed m-government solutions.

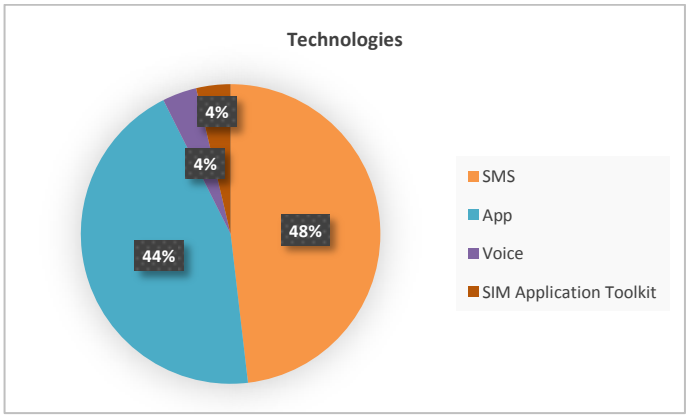

Figure 3. Technologies employed by surveyed m-government solutions.

6.3 Service Providers

The term m-government implicitly suggests that m-government services are typically provided by governmental agencies. In practice, this is not always the case, especially in developing countries. There, m-government solutions are often provided by NGOs as well, as governments and public administrations often do not have the resources to deploy m-government services on a large scale.

This is also backed by findings obtained from an analysis of the 25 surveyed solutions. As shown in Figure 4, 52% of all surveyed m-government solutions have been provided by non-governmental organizations.

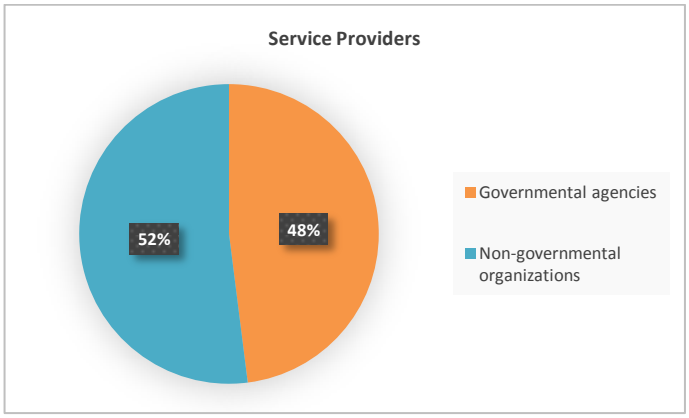

Figure 4. Providers of surveyed m-government solutions.

6.4 Information Flows

Similar to e-government solutions, different types of m-government applications can be distinguished. In this context, the information flow between involved parties can be used as distinguishing feature that characterizes the different types of m-government services. This approach has for instance been followed by Nariman and Yamamoto (2008), who use this feature to define three categories of e-government services: *Informational e-government* refers to services implementing a passive representation of data. *Responsive e-government* aims to make commonly requested information and forms available around the clock. Finally, *transactional e-government* enables citizens to complete entire tasks electronically at any time.

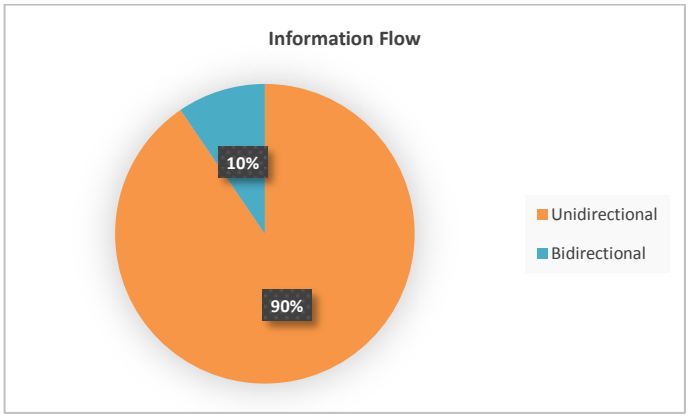

Figure 5. Types of surveyed m-government solutions.

Applying this categorization scheme to the surveyed m-government solutions yields interesting results. For instance, the conducted survey has revealed that most services are rather simple, unidirectional, and purely informational. This means that provided services either enable citizens to send information to public organizations or enable a governmental agency to deliver information to citizens. Services supporting a bidirectional communication and implementing full transactional procedures are still rare. This applies to both developing and to developed countries. Furthermore, obtained results show that even the few bidirectional services that have been surveyed neither include a reliable user authentication nor the provision of written consent based on legally binding electronic-signature schemes. Both concepts are usually required in classical transactional e-government services. However, these concepts have not been found in any of the surveyed m-government solutions.

Obtained results are also illustrated in Figure 5. From this figure, it becomes apparent that unidirectional, i.e. informational, m-government solutions are still predominating. At the same time, there is an obvious lack of transactional m-government solutions that enable citizens to complete entire tasks electronically using their mobile end-user device.

7. TRENDS AND FUTURE ACTIONS

From the findings obtained from the conducted survey, several general trends can be derived. From these trends, a set of actions can be derived, which should be taken in the future to further improve and leverage m-government. Trends identified and actions derived are discussed in the following subsections.

7.1 Trends Identified

The conducted survey on current m-government solutions has yielded several useful findings with regard to relevant fields of applications, technologies employed, service provision, and types of provided services. From these findings, the following four general trends can be derived:

- **Trend A:** Powered by the popularity of mobile technologies, m-government has turned into a global phenomenon and is enjoying increasing popularity in many countries all over the world. This includes developing countries, which employ mobile technologies to compensate deficits in fixed-line communication infrastructures, as well as developed countries, where m-government gives citizens another opportunity to get in contact with governments and public administrations.
- **Trend B:** Due to the increasing spread of smartphones in developed countries, there is currently a trend towards solutions based on mobile apps. Legacy technologies such as SMS are still used but replaced or complemented by cutting-edge technologies, as soon as these technologies are sufficiently spread in the target group.
- **Trend C:** Especially in developed countries, m-government is increasingly used rather as a complement than as a replacement for classical e-government services. M-government solutions based on mobile apps employ cutting-edge technologies to provide services with additional benefits.

- **Trend D:** In Europe, mobile technologies gradually replace established technologies such as smart cards for the realization of eID and electronic-signature functionality. However, m-government services that include eID or electronic-signature functionality are still rare.

7.2 Actions to Be Taken

The findings obtained from the conducted survey draw a representative picture of the state of the art of m-government. At the same time, trends in m-government derived from these findings indicate possible future directions and developments. Without doubt, m-government will continue to play an important role in many countries all over the world. However, the obtained findings and identified trends show that m-government does still not employ the full potential of mobile technologies. Many services still rely on rather old technologies such as SMS and are hence extremely limited. Even those solutions making use of cutting-edge technologies and basing on mobile apps are in most cases limited to the provision of simple tools and unidirectional informational services. The lack of m-government services that implement full transactional services and include a reliable user authentication based on national eID infrastructures as well as a provision of written consent by means of legally binding electronic signatures can hence be identified as main issue and shortcoming of current m-government.

Accordingly, the further development of m-government solutions towards transactional services can be identified as most relevant challenge that needs to be overcome in the near future. Only if full transactional procedures can be realized and used on mobile end-user devices, m-government will become a serious alternative to classical e-government. To accomplish the transition to transactional m-government, we hence propose the following future actions to be taken.

- **Action 1:** Existing eID and electronic-signature solutions that are already integrated into and used by transactional e-government solutions need to be adapted such that they can also be used on mobile end-user devices. In their current form, these solutions are usually not applicable on mobile end-user devices, as their underlying security concepts have been designed for classical devices such as desktop computers and laptops. These solutions must be revised such that their security requirements are met even when being applied on mobile end-user devices.
- **Action 2:** To keep track of ongoing developments and improvements, upcoming mobile technologies need to be continuously assessed and evaluated. This way, new approaches to implement transactional m-government services with the help of mobile cutting-edge technologies can be identified early.
- **Action 3:** For many years, mobile end-user devices have been legitimately assumed to be secure. This situation has changed with the introduction of smartphones and powerful mobile operating systems such as Android, which are prone to malware and popular targets for attacks (Enck and Octeau 2011). As transactional m-government services potentially process security-critical data, the development of transactional m-government solutions must go hand in hand with continuous security assessments and the development of appropriate security concepts.

The three proposed actions define the next necessary steps towards the provision of transactional m-government solutions. If these actions are adequately taken, current restrictions to unidirectional and informational mobile services can be released. This way, m-government can be taken to the next stage of development and can finally evolve to a serious alternative to classical e-government.

8. CONCLUSIONS

During the past years, m-government has evolved to a relevant sub-discipline of e-government. As it enables the integration of additional technologies, m-government provides various opportunities. At the same time, m-government also raises several new issues that need to be addressed adequately.

In this article, we have contributed to the positive development of m-government by surveying its current state of the art and by proposing future actions to be taken. The conducted survey has shown that m-government is on the rise all over the world but still suffers from several limitations. Due to these limitations, most m-government solutions are still rather simple, unidirectional, and purely informational. The lack of appropriate eID and electronic-signature solutions that can be applied on mobile end-user devices has been identified as main barrier for transactional m-government services. Accordingly, the development of eID and electronic-signature solutions that comply with the specifics of mobile end-user devices has been identified as relevant future action to be taken. The continuous assessment of upcoming mobile technologies and the development of suitable security concepts have been proposed as accompanying actions.

By analyzing the current state of the art and by proposing concrete actions to be taken, this article represents a first step towards transactional m-government. Taking the proposed actions and developing concrete solutions that further pave the way for transactional m-government solutions are continuative tasks that are regarded as future work. Although this article defines a first important step only, it already contributes to the necessary emancipation of m-government from classical e-government.

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