

# Mobile Application Services Based Upon Open Urban Government Data

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## Abstract

Mobile applications (m-apps), which are based upon open urban data, make up new ways of governmental services and information. In a large-scale study, we analyzed 471 m-apps of 24 metropolitan regions all over the world, regarding their implementation and usage development. For instance, cities like Sydney, New York, or Berlin host so-called hackathons (hacker marathons) to actively push the development of m-apps based on government data. We model a typology of these m-apps and present a unique overview of the variety of types, used eco-systems, and developers. For Android m-apps the success was measurable by the amount of counted downloads. Finally, we argue that we are still in the beginning of citizen-oriented e-government and need more research in this field.

**Keywords:** open data, smart city, m-government, mobile applications

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## 1 Introduction

More than half of today's world population lives in urbanized areas. Moreover, in most countries of the world the citizens own and use mobile devices. Especially in so-called "informational cities" (Castells, 1989) or "smart cities" (Shapiro, 2006; Hollands, 2008), which are prototypical communities in the knowledge society (Stock, 2011). In the *Apps for Smart Cities Manifesto* we read, "To harness the true potential of Smart cities, the city must become a platform, i.e. an enabler for developers, creativity and applications. In doing so, the city becomes like the Internet, i.e. a connector and an enabler for citizens, which aims to empower the citizen. Smart city applications are similar to conventional mobile applications" (Apps for Smart Cities, 2012, para. 1).

There is a huge amount of open data from official statistics (e.g., data about the age structure of citizens), from sensor-based services (e.g., data about local traffic), and from users (e.g., feedback). Open government data is not only present on the country- and state-level, but also on the level of single cities or other municipalities. Therefore, we introduce the term *open urban government data* to refer to the use of open data on the local-level. Many m-apps use this open urban government data for their services and offer new ways of access to governmental documents and records. "The public data is the fuel that makes these applications work" (Millard, 2010, p. 9).

Such urban m-apps are indicators for the evolution of "ubiquitous government" (Belanger, Carter, & Schaupp, 2005) or "smart government." "Smart Government will share resources and information and interoperate with other governments, citizens, NGOs and for-profit businesses much more smoothly than today" (Scholl, 2012, p. 324). The shared resources include "big data" as well as "accurate, comprehensive, and reliable information" (Scholl & Scholl, 2014, p. 167). The aim of such activities of e-government services development and implementation, or of "open government 2.0" is to empower the citizens (Sandoval-Almazan, Luna-Reyes, Rojas-Romero, Gil-Garcia, & Luna, 2012) and to generate new economic and social values (Jetzek, Avital, & Bjørn-Andersen, 2013). Ubiquitous apps can "make it possible to imagine and to do things with a mobile phone that were previously never associated with the technology" (Goggin, 2011, p. 151). Urban m-apps include location-based participation, "for example helping to re-design the park you're walking in, or the hospital organization which kept you waiting and you think you have a solution" (Millard, 2010, p. 8). Desouza and Bhagwatwar (2012) call such applications, which solve even complex urban problems, *citizen apps*. But the participation of the citizens goes far beyond the simple commenting on communal problems.

Some municipal governments are looking for successful m-apps, which is reflected in tremendous adaptation of hackathons (hacker marathons). In these hackathons members of government institutions and citizens come together and work on new innovations (Baraniuk, 2013; Briscoe & Mulligan, 2014; DiFranzo et al., 2011), such as the AppVenture Challenge, staged by the Infocomm Development

Authority (IDA) of Singapore (Chan, 2013). Nevertheless, the potential of urban m-apps has been highlighted by different researches on open data or mobile applications, however, there is a lack of systematic analyses in this field. In this paper we model a typology of m-apps based on open urban government data and present a unique overview of the variety of types, used operating systems, and developers in order to help governments and m-app developers to identify already existing m-apps. Thus, the study helps to clarify the state of the art of m-apps development. The extension of city-wide exchange between developers and governments could help to improve and adapt successful m-apps.

## 2 Research Background

### 2.1 Data - Open data - Open government data - Open urban government data

In our context, *data* means quantitative values resulting from measurements and other sources. *Open data* refers to data which is freely accessible online, while there are no technical or legal restrictions to reuse it (Jetzek et al., 2013). *Open government data* is defined as “open data produced by the government” (Open Knowledge Foundation, 2012, p. 16). Prominent examples of open government data on the national level are data.gov (U.S.), data.gov.uk (United Kingdom), and the European Union Open Data Portal<sup>1</sup>. *Open urban government data* is open government data on the local level like DataSF.org (San Francisco, CA) or Open.Wien.at (Vienna, Austria).

There are three types of sources for open urban government data: official statistics, sensor-based data, and user-generated content (López-de-Ipiña, Vanhecke, Peña, De Nies, & Mannens, 2013). *Official statistics* include data on population, businesses and economics, jobs, crimes and justice, health, etc. (see as an example: data.gov). Additionally, there are city-specific official data collections such as the urban forest map of San Francisco<sup>2</sup> with detailed data on trees in the city. *Sensor networks* (Kitchin, 2014) include real-time data from sensors placed in the city, e.g., street lighting, humidity, temperature, gas, electrical resistivity, acoustics, air pressure, movements, speeds, and of transponders monitoring empty spaces in car parks, data from closed circuit television (CCTV), or the progress of trains and buses along a route (Kuhn, 2011), all in all, sensor-based “big data” with relevance for the city (Bettencourt, 2014). Another type of big data is *user-generated content*, for example, GPS-based data from mobile devices (boyd & Crawford, 2012). On all these channels data is created and can be analyzed to provide services for citizens. One challenge hereby is to handle the huge amount of big data to make meaningful statistical analyses. Therefore, boyd and Crawford (2012, p. 663) ask, “Will large-scale [...] data help us to create better tools, services, and public goods?”

### 2.2 M-Government

*E-government* is a government existing on the web and characterized by functions such as information dissemination (government to users), communication, transaction, interoperability (vertical and horizontal integration) as well as participation (Moon, 2002). *M-government* implies the use of mobile technologies (e.g., smartphones and tablets) in e-government. Sometimes, especially in Korea, m-government is called *ubiquitous government* or *u-government* (Belanger et al., 2005; Cho & Chun, 2010). M-government enables location-based services (Carroll & Ganoe, 2009), which are “personalized services delivered to a mobile device user at a remote location, so citizens can get immediate access to certain government information and services on an anywhere-anytime basis. The government can use the scalable and swift wireless channels to send time-sensitive information such as terror and severe weather alerts to citizens quickly and directly” (Trimi & Sheng, 2008, p. 54). M-government services require another form of (open) data, namely *geo-referenced information* (data with spatial attributes) (de Reuver, Stein, & Hampe, 2013) and devices which are equipped with a Global Positioning System (GPS).

### 2.3 M-Apps Based Upon Open Urban Government Data

Open urban government data show their assets to advantage when combined among each other or with further open tools such as Google Maps in the sense of *mashups* (DiFranzo et al., 2011). Such linked data will break “data out of the silos” (Shadbolt & O’Hara, 2013, p. 73) and “facilitates the provision of innovative services” (Shadbolt & O’Hara, 2013, p. 72). Ding, Peristeras and Hausenblas (2012) identified three stages of the development of applications which are based upon open government data. (1) In the “open stage”, governments put their datasets online in reusable formats. (2) In the “link stage”, participants combine and link different datasets using declarative links (e.g., a standard vocabulary or

<sup>1</sup> <https://open-data.europa.eu/de>

<sup>2</sup> <http://urbanforestmap.org/>

concept mapping). (3) Finally, in the “reuse stage”, developers build - normally in the form of a mashup - the desired m-apps.

Nowadays, there are different mobile-device operating systems (mainly Google’s Android and Apple’s iOS, but also less prevalent ones such as Microsoft’s Windows Phone, BlackBerry 10) and no single standard for them. Hence, it is possible to create Web Applications optimized for the usage on mobile devices, however, these m-apps need to be designed for each operating system separately. Hitherto, little research has been done on m-apps based on open urban government data and there is lack in empirical scientific evidence upon the quality and quantity of those applications.

### 3 Research Framework

According to OECD and ITU (2011), we are in need of application developers (programming the interfaces between the device and the network) as well as content developers and enablers (compiling content into mobile-ready formats) for the development of m-apps. Citizens become “data pro-sumers (both consumers and providers of data)” (Charalabidis, Loukis, & Alexopoulos, 2014). Designing m-apps by end-users “can require significant technological innovation” (Desouza & Bhagwatwar, 2012, p. 109). Concerning this matter, it will be interesting to see whether it is possible to change the users’ behavior “from apathy to adoption” (Schaupp & Carter, 2005) and further to co-development and co-implementation of e-government services. Thus, we will analyze whether citizens or organizations change their role from consumer to a prosumer, and define our first hypothesis as follows:

H1: Not only government agencies, but also citizens develop m-apps based on open urban government data.

At e-government’s participation level, “crowd participation” (Garcia, Vivacqua, & Tavares, 2011) leads to real-time m-participation of the citizens resulting in new forms of citizen engagement in the city’s development (de Lange & de Waal, 2013). The critical success factor and key driver of mobile government services - including services for emergency and disaster management (Aloudat, Michael, Chen, & Al-Debei, 2014) - is the service’s perceived usefulness (Hung, Chang, & Kuo, 2013). One could think that m-apps that cover more topics (e.g., museums, hospitals, news) and features in one are more useful. Thus, we hypothesize:

H2: M-apps with many topics or features are more often downloaded (than those which cover one topic entirely) because they are more useful.

Combining the aspect of becoming a prosumer and of service’s perceived usefulness, we assume:

H3: M-apps which are developed to improve the city and ask for citizen participation (e.g., reporting broken lights) are more often downloaded than m-apps without this feature.

There co-exist m-app stores which support four operating systems: iOS, Android, Windows Phone, and BlackBerry 10. However, the second and third hypotheses are limited to Android m-apps because this app store is the only one providing download numbers.

Some developers create m-apps in order to reach all smartphone users for more than one system. Others develop mobile Web Applications which may be retrieved by any smartphone using a web browser independently of their operating system. Government agencies as service providers have to serve as many citizens as possible. Considering the fact that there is no standard operating system of mobile devices (Tilson, Sorensen, & Lyytinen’s, 2012), we hypothesize:

H4: Government agencies develop equal m-apps for different operating systems to reach a wide range of smartphone users.

### 4 Data Collection

To find a good starting point for our empirical research, we applied a subset of “Informational World Cities” (Mainka, Hartmann, Orszulok, Peters, Stallmann, & Stock, 2013; Mainka, Hartmann, Peters, & Stock, 2014). Due to the language barrier, Asian cities were excluded from this investigation except for Singapore and Hong Kong, where the commercial language is English. Online translation tools like “google translate” are not working sufficiently enough to translate Chinese or Japanese sentences. Thus,

the m-app descriptions could not be analyzed by the indexers. In total, 24 city governments from the USA, Canada, Australia, Europe, and Asia are included in our corpus (Table 1). From prior projects we know that all those metropolitan regions are on their ways to become prototypical cities of the knowledge society, so to speak “top class” Informational World Cities with enhanced infrastructures, e.g., ICT infrastructure.

Amsterdam (The Netherlands)	Hong Kong (China, SAR)	Paris (France)
Barcelona (Spain)	London (United Kingdom)	San Francisco (U.S.A.)
Berlin (Germany)	Los Angeles (U.S.A.)	Singapore
Boston (U.S.A.)	Melbourne (Australia)	Stockholm (Sweden)
Chicago (U.S.A.)	Milan (Italy)	Sydney (Australia)
Dubai (U.A.E.)	Montreal (Canada)	Toronto (Canada)
Frankfurt (Germany)	Munich (Germany)	Vancouver (Canada)
Helsinki (Finland)	New York City (U.S.A.)	Vienna (Austria).

Table 1: List of Analyzed Cities.

The corpus is based on m-apps which are listed at government websites and work with government data or government interaction like [data.gov.sg/AppShowcase/AppList.aspx](http://data.gov.sg/AppShowcase/AppList.aspx). This is a special website of the government of Singapore which lists applications and projects resulting from open data use. Considering that some websites are not as easy to find, we wrote emails to the corresponding authorities and asked for further information about m-apps based on government data. To avoid duplicates in our dataset, we restricted our corpus to m-apps which are developed for one city only - this filters popular m-apps like TripAdvisor, which is not based on government data but sometimes also listed at government’s website. The research was conducted between April 5th, 2014 and June 13th, 2014 and relies on the data which was available online at that time. To answer our hypotheses, a qualitative content analysis was needed (Krippendorff, 2004; Neuendorf, 2002).

In order to identify the topics and features of an m-app, we established a coding scheme for each topic based on the classification system by Desouza and Bhagwatwar (2012). All detected topics and features will be explained in the results. Three indexers coded the data using the information of app stores and government websites. Every m-app has been analyzed by two indexers independently from each other. If there was inter-indexer consistency, the selected topics were marked; if there was no joint consensus, the indexers discussed their decisions and reached a compromise. To detect successful and popular m-apps, we used the amount of downloads as an indicator. This is a specialty of the Play Store<sup>3</sup> where Android applications are available. There are no exact figures but data intervals. The other app markets do not show download numbers. Therefore, we were only able to analyze the download numbers of Android m-apps.

## 5 Results

In this section we present the results of our analysis of the exemplary cities as guided by the aforementioned hypotheses. First of all, we have to categorize the variety of m-apps found for the 24 cities and provide an overview of common topics and features. After presenting the state of the art of m-app development based on our analysis we will examine the before mentioned hypotheses.

### 5.1 Typology of M-Apps

Using the classification system by Desouza and Bhagwatwar (2012) we quickly reached its limits and decided to extend their model from classes to “types of applications” because, firstly, one m-app may fulfill the limitations of more than one class, and secondly, we are not able to describe a full classification of m-apps because of the limited corpus. Therefore, we defined six types of applications that represent m-apps of different thematic dimensions, and eight features which can be used independently of contents (Figure 1). The definition of all types and features will be described in the following paragraph.

<sup>3</sup> <https://play.google.com/>

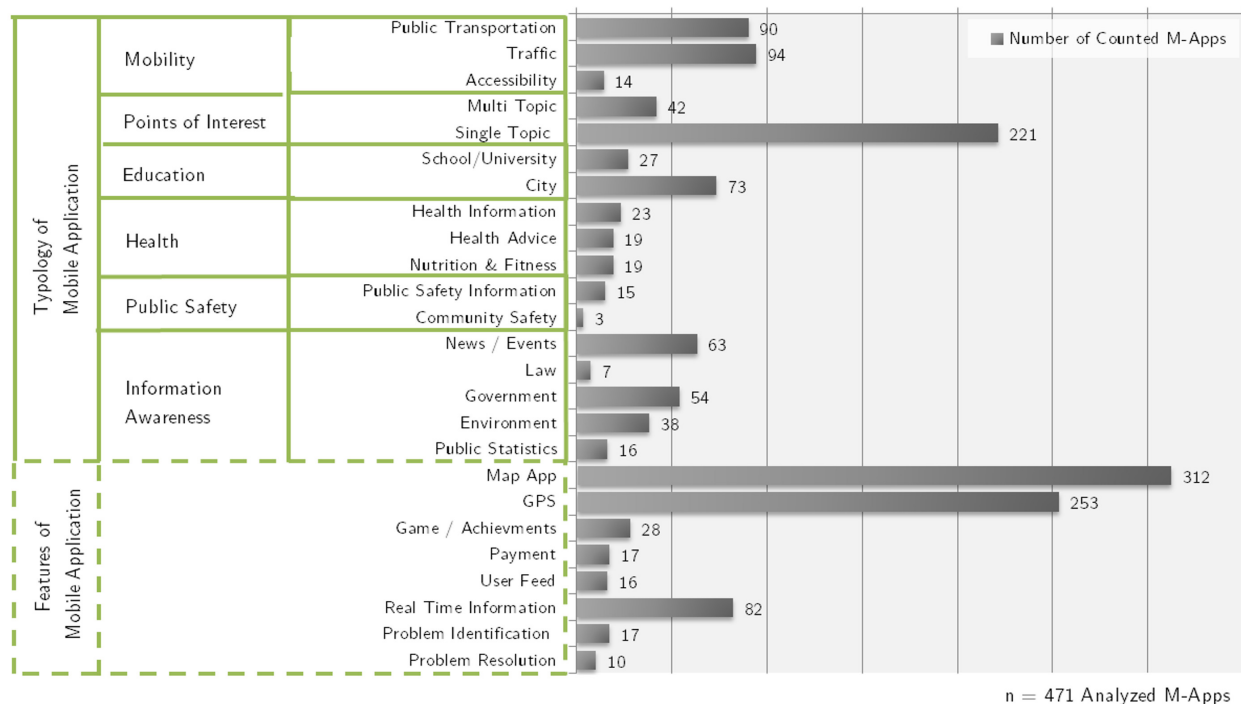


Figure 1: Typology and Features of M-Apps and Amount of Counted M-Apps

*Mobility* applications are those providing their users with information and orientation on *Public Transport* (e.g., Metro plans) or *Traffic* (which includes traffic jams and routes). If there is information available about *Accessibility*, e.g., for handicapped persons, the application is also listed there. Applications provide *Points of Interest (POI)* when they refer to events and places for tourists or local people. We distinguish between applications with *Multi Topic* (e.g., parks, museums, and police stations) and *Single Topic* (e.g., just parks) information. M-apps of the type *Education* refer to education about the *City* itself or special *School/University* applications that are developed by schools and universities for their students or parents. *Health* applications provide their users with information about surgeries, hospitals and emergency aid. There are also m-apps that give *Health Advise* or address *Fitness & Nutrition*. Applications in the category *Public Safety* include *Information* on police stations, emergency calls, etc., or work by *Community Safety*, e.g., users inform about the safety in their neighborhood. *Information Awareness* can appear in different ways. There are applications that break *News* and others that inform about *Laws*. Sometimes the *Government* wants to inform its citizens about urban issues. *Environment* and *Public Statistics* are also topics that m-apps deal with. In the further analysis, we will use the term type in reference to the detected topics of this typology.

Many m-apps combine their content with additional features like a *Map* and *GPS*, which includes Google Maps or open city maps; *Game/Achievement*, e.g., a quiz or a puzzle, or on the achievement side points for reaching special goals; *Payment* where users can purchase parking or public transport tickets; *User Feed* options to get in contact with the government or developers; and *Real Time Information* which provides immediate data directly after its collection. Applications with the features *Problem Identification* and *Problem Resolution* are intended to make the city more secure, clean, and livable. Users can, for example, report a problem like a broken street light. If the goal is solely *Problem Identification*, there will be no feedback on the resolution of the problem. If *Problem Resolution* is intended as well, users will, e.g., be informed by the appropriate department when the problem is solved.

## 5.2 Distribution of Types and Features of Urban M-Apps

In this section we present the available m-apps for each operating system; in section 5.4 the popularity of the different topics and features will be limited to Android apps only. All in all, we detected 471 m-apps the cities' governmental websites link to. These m-apps were dedicated to 17 subtypes and eight features (see Figure 1). Single Topic as a subtype of the rubric Points of Interest is the category that most m-apps were dedicated to, with more than 200 in number. Since we analyzed m-apps concerning specific cities, this is not surprising. All of those cities are world cities with many POIs, like museums, theatres, bus stops, swimming pools, etc. The m-app "NYC Condoms" (New York), for example, shows its users the

nearest venues for FREE NYC Condoms. However, only a few m-apps refer to POIs with different topics (Multi Topics), like cultural facilities, sport facilities, etc., in one application. These applications are often developed by tourism boards or agencies. Similar to the amount of Single Topics m-apps, a high amount of m-apps can be assigned to Public Transportation (90) and Traffic (94). Like POIs, Mobility service is an important need in larger cities, not only for the everyday life of its citizens, but also for tourists.

In contrast to Real Time, Map, and GPS, the features Payment, Game/Achievement, Problem Identification, Problem Resolution, and User Feed are far less often offered, which underlines the importance of navigation in the analyzed cities (see Figure 2 and 3). Three hundred and twelve m-apps provide a Map, 253 GPS and 82 Real Time Data (Figure 1). Likewise, the number of m-apps which combine the features Real Time, GPS, and Map are the highest for the subtypes Single Topic, Traffic, and Public Transportation. In addition to the afore-mentioned features, Payment is mainly available for m-apps typed as Public Transportation or Traffic and the most m-apps with gaming features are offered for the purpose of Education in regard to the City and POIs with a Single Topic. A mentionable example is the m-app “Anne’s Amsterdam” (Amsterdam) which shall give citizens and tourists an understanding of what happened during the World War II and guides through Amsterdam with focus on that period of time. This m-app provides gaming-elements by challenging its users to collect items which can be used to create an album about Amsterdam.

User Feeds are primarily used for the subtypes Single Topic, Government, and Public Transportation. The features Problem Identification and Resolution are most offered in m-apps of the type government information. Often those m-apps using User Feed for government information awareness additionally provide Problem Identification and/or Resolution. For example, the m-app “Boston Citizens Connect” is offered by the City of Boston, MA to report on social issues, like potholes, graffiti, etc. The specialty of this m-app is that citizens can watch the status of their request.

In general, the subtypes which provide the most features are Public Transportation and Traffic. Examples are “FahrInfo Berlin”, a Berlin m-app for timetable information, planning routes, and ticketing and “ComfortDelGro Taxi booking” (Singapore) which allows users to book a taxi depending on their current location (GPS). The subtypes to which the fewest m-apps are dedicated to are Laws, Accessibility, and both subtypes of Public Safety. Since we know more about the variety of citizen m-apps, now we want to investigate whether our hypotheses H1 to H4 meet the results of the data.

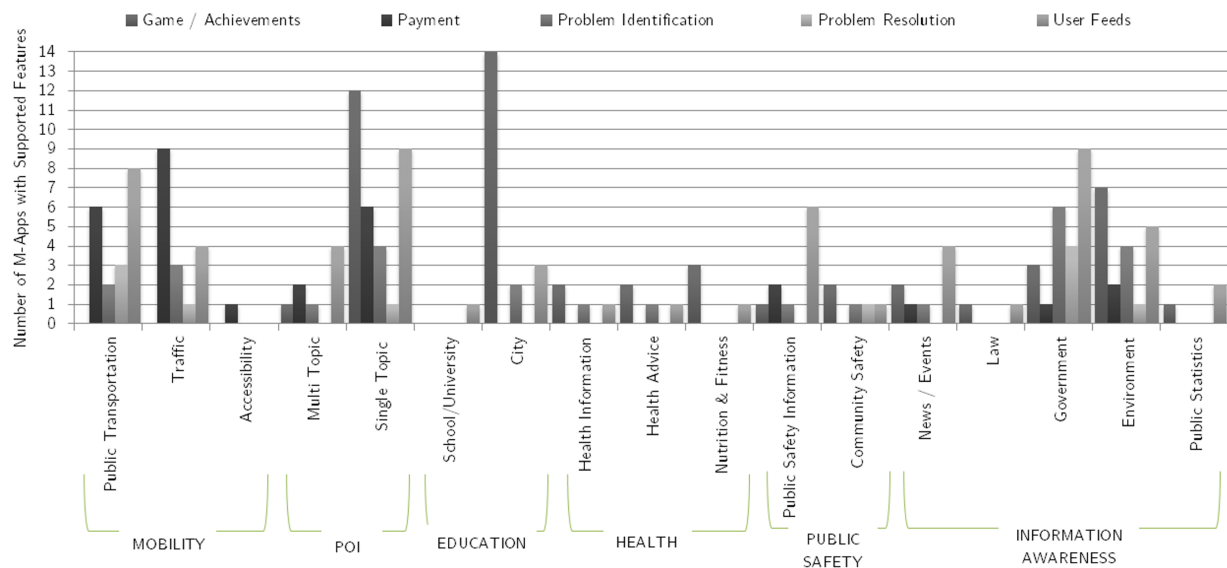


Figure 2: M-App Types in Relation to the Features Game/Achievements, Payment, Problem Identification, Problem Resolution, and User Feeds.

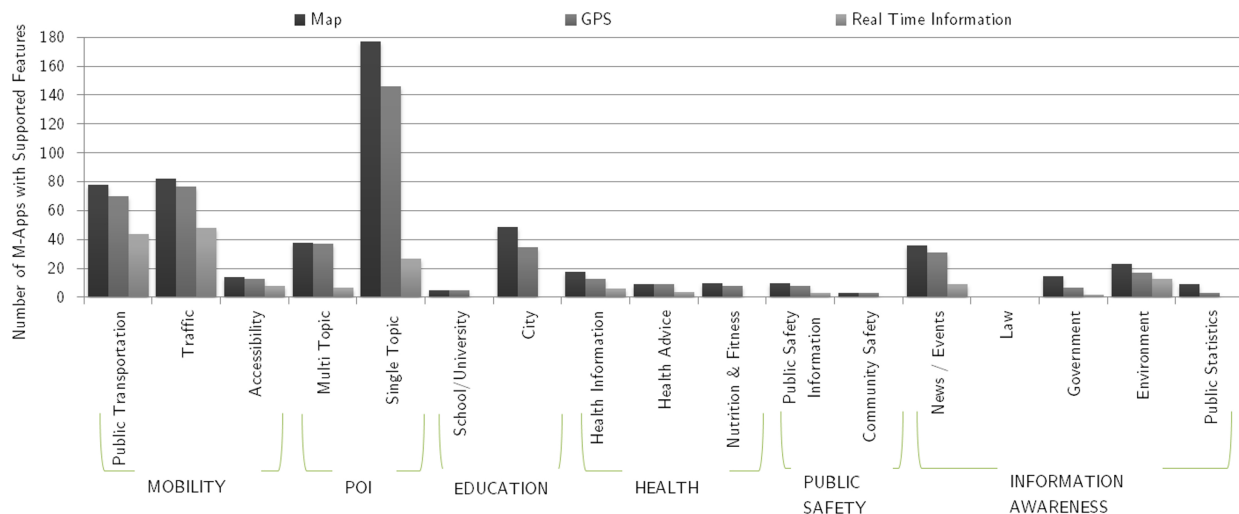


Figure 3: M-App Types in Relation to the Features Map, GPS, and Real Time Information

### 5.3 Developers of Urban M-Apps

Not only companies can develop applications but also every citizen with programming skills can develop m-apps. For example, Vienna offers many m-apps developed by private persons like Christian Fessler<sup>4</sup>, who used the city's open data for the m-app "Museen Wien". However, not in all cases the developer description is clear enough to distinguish between governmental agencies, companies, and citizens, who may develop applications just because they are interested in. Especially the difference between companies and citizens is difficult to determine, since citizens can start a business with their successful m-apps and name it with their personal names, although they pursue commercial purposes. Therefore, only governmental developers, like the city's government itself, a governmental department or institution, or other developers, who mentioned that they work in corporation or on behalf of the city's government, are considered as "developed by government agencies" in our analysis. For example, the "Ajuntament de Barcelona" which developed most of Barcelona's m-apps is recognized as a government agency as well as the "Environmental Protection Department of HKSARG" (Hong Kong).

Figure 4 presents the numbers of m-apps developed by government agencies and non-government persons or institutions. This numbers vary greatly between cities. For example, Hong Kong offers the highest number of m-apps and most of them are provided by government agencies. Barcelona and Dubai offer similar results: Most of all presented m-apps are developed by a government agency. In contrast, none of the m-apps found on Vienna's and Chicago's government websites could be recognized as ones developed by a government agency.

<sup>4</sup> <http://chrfessler.blogspot.de/>

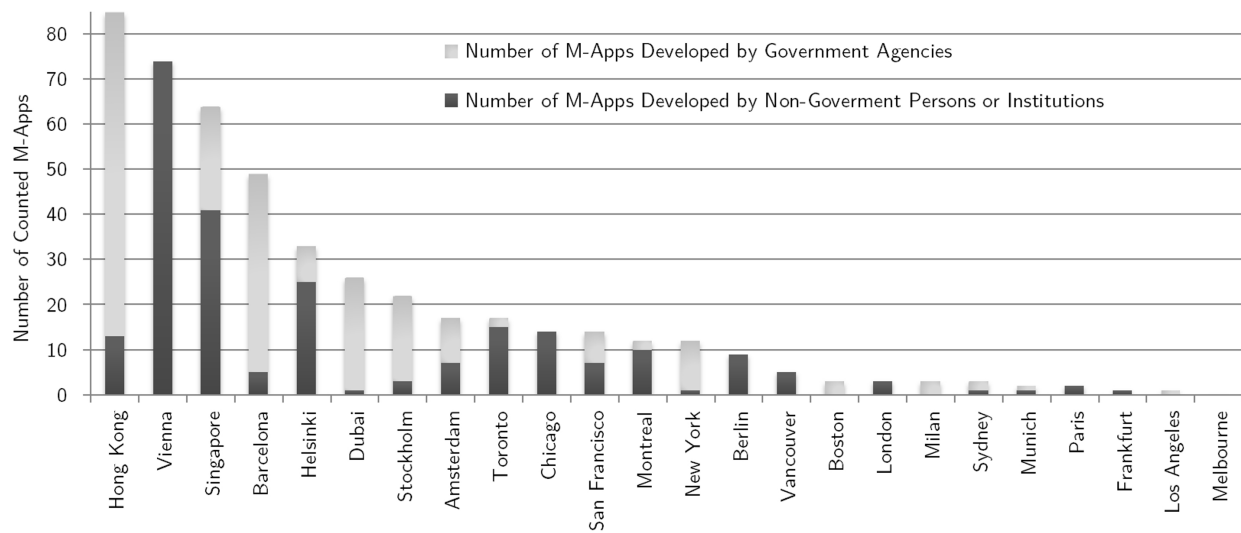


Figure 4: Developer of M-Apps: Government Agencies vs. Non-Government Persons or Institutions

#### 5.4 Popularity of Urban M-Apps

The popularity of m-apps can be measured by the amount of downloads. Since downloads mean that smartphone users have used an app at least once. The Android Play Store is the only app market that offers this information. If one would like to identify the popularity of iPhone apps, the only hint is given by a popularity list. The iPhone app market iTunes offers a popularity list for every category in its store. However, there is no information about the amount of users who may have used an app. Thus, it is possible that the “best” app in one category could just be downloaded 100 times, whereas the “best” app in another category was downloaded more than one million times. Therefore, we decided to refer in this section to Android m-apps only, which means that our second and third hypotheses are analyzed only for this app store as well.

Most of the Android m-apps (24%) have been downloaded between 1,000 to 5,000 and 10,000 to 50,000 times. Figure 5 shows the download numbers for the different types of applications. The download numbers of Android m-apps for a specific type have to be viewed in regard to the total number of m-apps of that type. For example, more applications of the type Point of Interest are downloaded than of Mobility since the total number of offered POI m-apps is larger. With the exception of the type Mobility, the highest numbers of m-apps for all types were downloaded between 1.000 and 5.000 times. For the type Mobility we see that there are a lot of very successful m-apps. Sixty percent of these m-apps have been downloaded at least 10,000 times, whereas only 35% of m-apps assigned to be more important for citizens. For m-apps of the type Education it is more critical to achieve a very high download number, only 15% have 10,000 downloads or more. There is only one m-app that has more than 1,000,000 downloads, namely “MyObservatory” (Hong Kong), which provides meteorological data. It is only dedicated to one type, which is Information Awareness.

Between all considered Android m-apps, there are only two that have been assigned to four different types. The first one, “Barcelona Official Guide” serves the types Mobility, Points of Interest, Education, and Information Awareness. It has been downloaded between 10,000 and 50,000 times. It combines information on events and interesting places with Public Transport connections. The second one, “mDubai”, which has been downloaded 5,000 to 10,000 times, is listed in Points of Interest, Health, Public Safety, and Information Awareness. This application offers news and events of the Dubai Government, as well as e-services, information on hospitals, and many other important locations.

Beneath the comparison of the diverse types of the downloaded m-apps, the diverse features of those applications can be compared (Figure 6). Between all m-apps that have been downloaded at least 10,000 times (85 m-apps), 60% use GPS. On the other side, only 5% of applications with less than 500 downloads offer GPS. Other features, like Game/Achievement (4%), Problem Identification (4%), or Problem Resolution (1%) are not very common among the top downloaded m-apps. Further, 24% of the successful applications do not even have any feature. Only 3.5% of the top Android applications have more than three features. Fifteen percent provide exactly one feature, 35% have two features, and 22% three features. As a result, more features do not imply more downloads.



Amongst the analyzed features we assigned to the m-apps, Payment is a rather rare feature. For citizens it is a comfortable possibility to pay via an application. But such applications work with sensitive data which comes with several risks. In total, only 17 out of the analyzed 471 m-apps work with the feature Payment.

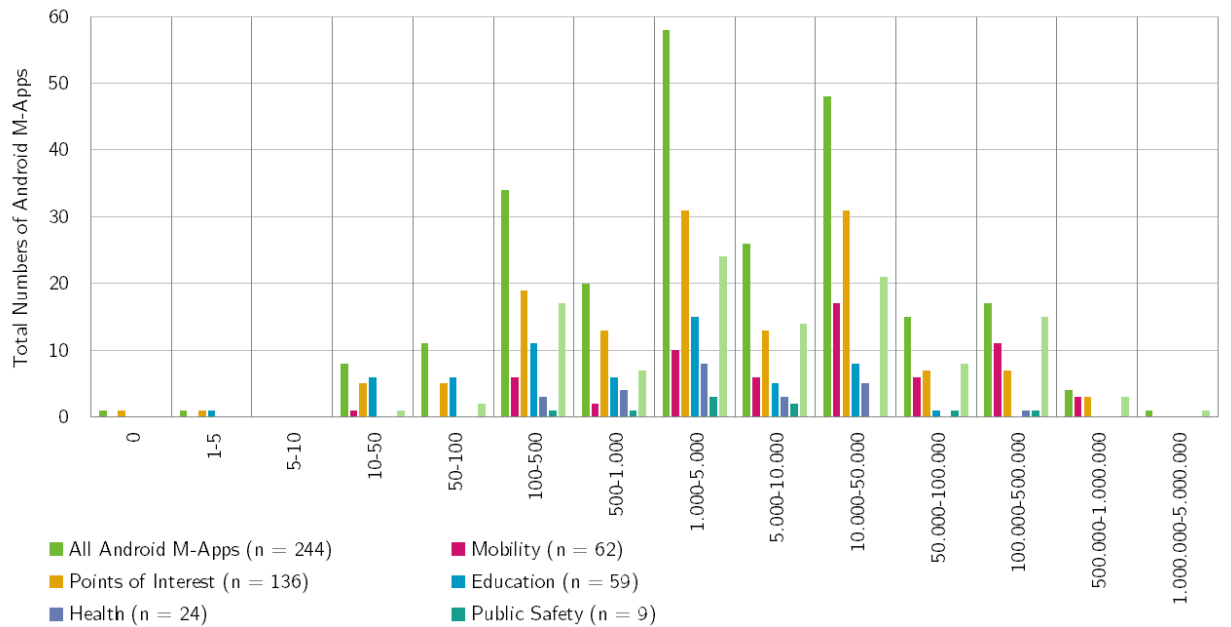
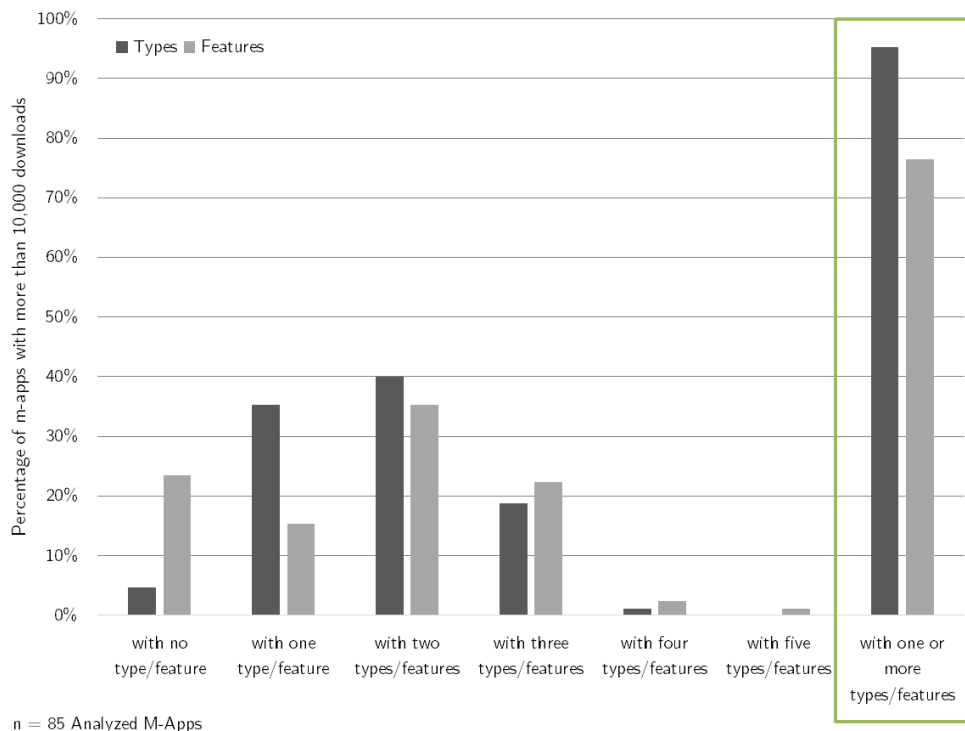


Figure 5: Distribution of Download Numbers in Relation to Types.



n = 85 Analyzed M-Apps

Figure 6: Percentage of M-Apps with more than 10,000 Downloads in Relation to their Number of Types and Features.

## 5.5 Operating Systems of Urban M-Apps

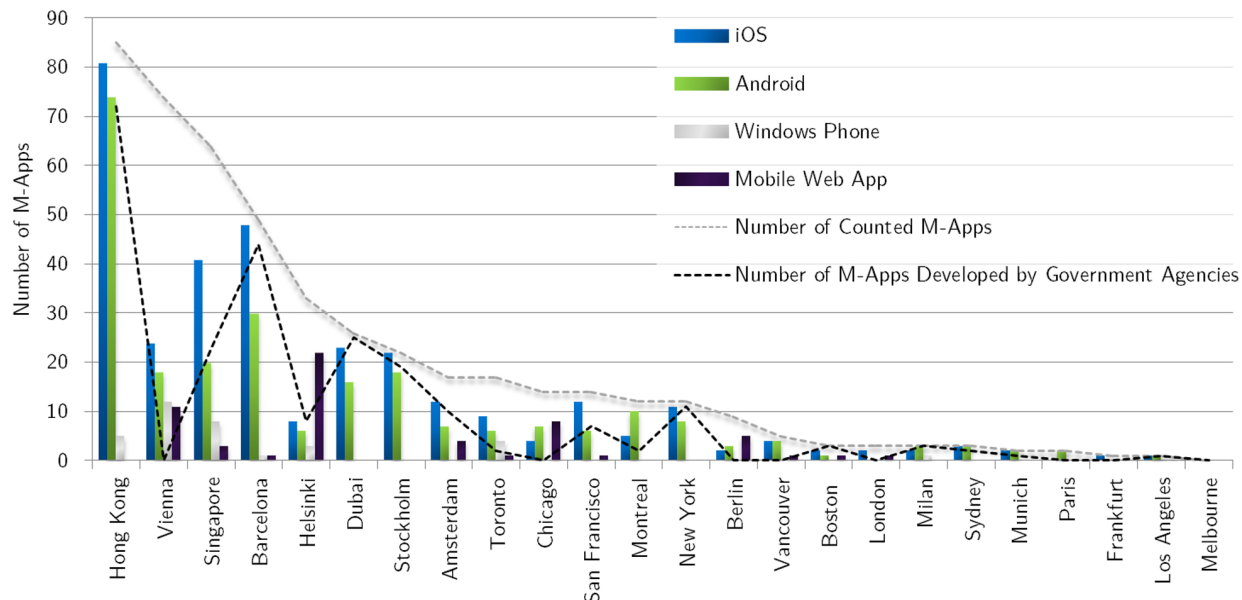


Figure 7: Operating Systems in Relation to the Analyzed City and the M-App Developer.

Like in Tilson, Sorensen, and Lyytinen's (2012), our findings clearly show that there are two wide-spread operating systems (Android and iOS) for m-apps. This seems to be noteworthy with regard to the specific characteristics of information markets. The more users an information service is able to attract, the more value the service will have. More valuable services will attract further users. If an information service passes the critical mass of users, network effects will start (Katz & Shapiro, 1994). Our analysis shows that there is still no agreement on one operating system. Figure 7 shows the number of all counted m-apps in comparison to the number of m-apps of a specific operating system. Android and iOS m-apps are the predominant ones amongst all operating systems. Most iOS applications are provided by Hong Kong (81), Barcelona (49), and Singapore (43). Android applications are also particularly found in Hong Kong (74) and Barcelona (30). Some m-apps are available for different operating systems, e.g., 41% of all m-apps are available for both, iOS and Android. The application "bicing" (Barcelona) has even been developed by the government for four different systems: iOS, Android, Windows Phone, and BlackBerry 10. This app shows available city bikes on a map and its distances to each other.

Furthermore, Figure 7 shows the number of m-apps developed by government agencies in comparison to the distribution of m-apps with different operating systems. It is conspicuous that in cities, where government agencies as developers are predominant (like Hong Kong), m-apps for Android and iOS are primarily offered. In total, 168 m-apps have been developed by government agencies and just ten of them were developed for Android only.

In contrast, 87% of m-apps from non-governmental developers are designed for one operating system only. That means, e.g., that only iOS or only Android users may benefit from these m-apps. Indeed, Windows Phone, Blackberry, and Mobile Web Applications are less frequently represented in the majority of all investigated cities. However, Helsinki and Vienna, which are dominated by non-governmental developers, offer a plenty of Mobile Web Applications, which can be used independently of the operating system.

## 6 Discussion

To classify m-apps like Desouza and Bhagwatwar's (2012) did in their classification model was not sufficient for the broad range of m-apps we found. Therefore, we needed to expand and redesign the defined classes used in this investigation as described in the results. As the development of m-apps based upon open urban government data is a fast moving topic, new m-apps emerge frequently. In addition, the m-app descriptions in app stores are in some cases very short, which makes it difficult to recognize all types and features the m-apps could be assigned to. These descriptions are also the information users have to rely on before downloading an application. The app stores do not have a consistent and proved categorization system either.

Our first hypothesis was whether open data provided by the government animates citizens and institutions to develop own m-apps (H1). Our results show that there is no consistent answer for all cities. In some cities all m-apps have been developed by citizens and institutions, e.g., Vienna, in the others the government agencies developed masses of m-apps, e.g., Hong Kong. Both cities offer a high amount of m-apps compared to other cities and both cities open all their digital data on a website<sup>5</sup> in a structured way. Citizens and regional companies from Vienna work with that data on their own; in Hong Kong the city invested a lot of money to produce own governmental m-apps (Nip, 2014). This shows that available open data do not necessarily lead to a high production of m-apps by citizens and non-governmental organizations. Therefore, there is need for more analyses about cultural or regional characteristics which may influence the amount of “private” developers.

The second hypothesis refers to the usefulness of m-apps. We assumed that those applications which serve many features and types are downloaded more often (than those which cover one type entirely) (H2). Our investigation shows that m-apps with one or more types or features are very popular, but it is not necessary to have any feature. Thus, we cannot prove our hypothesis. A lot of m-apps belong to the type Single Topic (POI). Like in the case of Vienna: The government offers a huge amount of data sources which are related to locations like theaters, museums, galleries, toilets, etc. There exist a lot of m-apps for different operating systems, which just locate, for example, all museums in the city, but do not tell you where the next ATM is. If you like to know this, you have to download another m-app for ATM locations. Most of those m-app services work with Google Maps. Only a few historical maps, like in Helsinki, or open maps created by the city’s government, like in Singapore, are used. However, there are no m-apps which cover the whole array of types. Furthermore, m-apps which offer a wide range of topics did not receive more downloads than those which address one topic only. Possibly, citizens prefer to download m-apps that cover their specific needs, whereas m-apps which consolidate several topics may contain unnecessary contents and take too much memory space. Another reason might be that the combination of topics and features is not yet as useful as it could be. Therefore, the reasons for that should be analyzed in future work. However, governments can find out more about citizens needs by hackathons and app competitions. Nevertheless, some m-apps are very successful in gathering high download numbers. Considering the m-apps of the three categories of the highest download numbers, it is conspicuous that most of those applications are from Hong Kong and Singapore which are the first and third placed cities regarding the total number of counted m-apps. To sum up, the limitation on Android download numbers only shows the popularity of Android m-apps. It was not possible to compare the download numbers from different operating systems. Another factor which should not be missed when dealing with this data is that the frequency with which the m-apps in general are used or deleted is not published at app stores.

We also hypothesized that m-apps which are developed to improve the city and ask for citizen participation (e.g., reporting broken lights) are downloaded more often than m-apps without this feature (H3). Our results can not verify a high correlation between m-participation (de Lange & de Waal, 2013) and the amount of downloads. The amount of downloads for m-apps with the features Problem Identification or Problem Resolution is very small. The reason for this small amount may be the fact that the citizens do not see the usefulness of these applications for their everyday life. In contrast, m-apps of the type Mobility appear to be more useful for them, since their download counts are higher. This may also explain the success of GPS and Map as a feature, which helps citizens and tourists to navigate through the city. Therefore, it can be criticized that creating value-added applications is a waste of effort since citizens are more interested in m-apps they derive personal benefits from, than the ones that further common weal. The provision of open data itself does not necessarily seem to lead to more participation. A lot of marketing efforts are needed in order to change citizens’ thinking and behavior, and to transform the society into a more participatory one. But governments can further these developments by clarifying the benefits of participation. Citizens have to realize that everyone is needed and can make a major difference. Furthermore, it should be obvious to them which specific problems they can solve.

Finally, we investigated whether m-apps developed by government agencies are available for different operating systems (H4). This assumption can be proved. Nearly all m-apps (94%) developed by government agencies support the Android and iOS operating systems in parallel. This is not very surprising since the government should grant the access to services for the whole society.

All in all, we were not able to validate all assumptions. This could be due to the fact that a lot of analyzed m-apps are not very professional. As on social media websites, we have a lot of people who may engage and produce content, in this case, m-apps. Thus, we see plenty of m-apps but it is not clear

<sup>5</sup> Data website Vienna: <https://open.wien.at/site/datenkatalog/>  
Data website Hong Kong: <http://www.gov.hk/en/theme/psi/datasets/>

whether they work appropriately or provide qualified content. Apart from Paris, no city has implemented a rating for urban m-apps that could give some information about the quality of the used data or programmed application. However, taking into account that professional m-apps are also produced, a “win-win-win” situation may occur. That was, for example, the case in Austria, where a startup implemented an m-app with justice information called RIS:APP<sup>6</sup>. The government was so excited about that app that they helped to promote it. Eventually, this startup that programmed the m-app (without being paid for it) became very popular in Austria and is now overwhelmed with orders (G. Tschabuschnig, personal communication, December 13, 2014). In such a situation the government “wins” because they do not have to produce an m-app by their own; the startup “wins” because they have become very popular and established themselves in the market; and the third winner are the society and local firms, which can use that m-app free of charge. This is one of such success stories showing that open government data may help to enhance economic value, but there is still more that could be done to meet the expectations of open government development.

## 7 Conclusion

The development of urban m-apps based on government data becomes more and more popular. Not only government agencies use open data to create m-apps. The increasing number of hackathons and m-app competitions animates citizens and companies in some cities to develop useful m-apps as well. However, in the future it needs to be analyzed whether in some cities the citizens do not develop their own m-apps at all, or if their m-apps are simply not linked to governmental websites. In regard to types and features, m-apps are not yet that multifaceted as they could be. They often address only one type, e.g., Public Transportation or making detectable a specific Point Of Interest. However, we could not prove our hypothesis that m-apps which cover many types and features are amongst the most downloaded ones, since very few m-apps fulfill this condition. Nevertheless, the most often downloaded m-app covers one type entirely (MyObservatory Hong Kong). It is conspicuous that m-apps of the type Mobility are more often downloaded than others. This indicates that m-apps have to be useful, above all, in the citizens’ everyday life. M-apps with the features Problem Identification and Problem Resolution are rarely downloaded, possibly because citizens have not yet recognized these features’ usefulness. In this case, government agencies by themselves could help to promote such m-apps and should demonstrate the impact of citizens’ participation to improve transparency. Many m-apps have been developed for several operating systems. Because of missing download data it is not possible to decide whether more citizens can be reached by developing one m-app for different operating systems. Additionally, the app stores’ information is sometimes very cryptic, which makes it hard to verify the developer, the type, and supported features.

Indeed, m-apps based upon open urban data make up new ways of governmental services and information. Since we are still in the beginning of a new way of citizen-oriented e-government, more research is needed in this field. For example, the way in which data (e.g., standardized data through an API) is provided could be important to achieve citizens’ participation. In the near future, when m-apps with new features and types will be developed, the presented typology needs to be further extended.

Only a few citizens have programming skills, but our results show that there has already been done a lot of work in order to attract more private developers, like in Vienna and Chicago. Citizens use open urban government data to provide applications for the public. Those activities should not only be recognized by the city itself. Therefore, we argue that we need a systematic overview like our typology to foster the information exchange between smart cities.

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<sup>6</sup> Digital Austria Website: <http://www.digitales.oesterreich.gv.at/site/6497/Default.aspx>

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### Appendix

#### List of mentioned Applications

TripAdvisor: <http://www.tripadvisor.de/apps>

NYC Condoms: <https://play.google.com/store/apps/details?id=gov.nyc.doitt.ThreeOneOne;>

<https://itunes.apple.com/us/app/nyc-311/id324897619?mt=8>

Anne's Amsterdam: <https://itunes.apple.com/us/app/annes-amsterdam/id520476666?mt=8>

[https://play.google.com/store/apps/details?id=com.repudo.tours&feature=search\\_result#?t=W251bGwsMSwxLDEsImNvbS5yZXB1ZG8udG91cnMiXQ](https://play.google.com/store/apps/details?id=com.repudo.tours&feature=search_result#?t=W251bGwsMSwxLDEsImNvbS5yZXB1ZG8udG91cnMiXQ)

Boston Citizens Connect: <https://play.google.com/store/apps/details?id=gov.cityofboston.citizensconnect;>

<https://itunes.apple.com/us/app/boston-citizens-connect/id330894558?mt=8>

FahrInfo Berlin: <https://itunes.apple.com/de/app/fahrinfo-berlin/id284971745?mt=8>

ComfortDelGro Taxi booking: <https://play.google.com/store/apps/details?id=sg.com.cdgtaxi.frodo&hl=en>

Bicing: <https://itunes.apple.com/es/app/id303950687?mt=8;>

[https://play.google.com/store/apps/details?id=es.bcn.bicing;](https://play.google.com/store/apps/details?id=es.bcn.bicing) [http://www.windowsphone.com/es-](http://www.windowsphone.com/es-es/store/app/bicing/e4d0cc3a-8083-4bcc-b06c-f39619669826)

<http://appworld.blackberry.com/webstore/content/19182180/?lang=es>

<http://appworld.blackberry.com/webstore/content/19182180/?lang=es>

Museen Wien: <https://appworld.blackberry.com/webstore/content/21716858/?lang=de&countrycode=AT>

MyObservatory: <https://itunes.apple.com/hk/app/myobservatory/id361319719?mt=8;>

[http://www.windowsphone.com/de-](http://www.windowsphone.com/de-de/store/app/%E6%88%91%E7%9A%84%E5%A4%A9%E6%96%87%E5%8F%B0/6c0d0048-549d-4078-bc91-e3360eb3ed2c)

[de-de/store/app/%E6%88%91%E7%9A%84%E5%A4%A9%E6%96%87%E5%8F%B0/6c0d0048-549d-4078-bc91-](http://www.windowsphone.com/de-de/store/app/%E6%88%91%E7%9A%84%E5%A4%A9%E6%96%87%E5%8F%B0/6c0d0048-549d-4078-bc91-e3360eb3ed2c)

[e3360eb3ed2c; https://play.google.com/store/apps/details?id=hko.MyObservatory\\_v1\\_0&hl=en\\_GB](https://play.google.com/store/apps/details?id=hko.MyObservatory_v1_0&hl=en_GB)

Barcelona Official Guide: <https://itunes.apple.com/us/app/barcelona-guia-oficial/id594589405?mt=8;>

[https://play.google.com/store/apps/details?id=cat.triangle.bcn&feature=search\\_result](https://play.google.com/store/apps/details?id=cat.triangle.bcn&feature=search_result)

mDubai: [https://play.google.com/store/apps/details?id=com.deg.mdubai;](https://play.google.com/store/apps/details?id=com.deg.mdubai) <https://itunes.apple.com/app/id619712783>

RIS:APP: <http://www.digitales.oesterreich.gv.at/site/6497/Default.aspx>