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The ecosystem of services around Smart cities: An exploratory analysis

Alberto Abellá-García[a], Marta Ortiz- de-Urbina-Criado[b], Carmen De-Pablos-Heredero[c*]

[a,b,c]Rey Juan Carlos University, Paseo de los Artilleros s/n, Madrid 28032, Spain

Abstract

Publication of data from smart cities is nurturing a growing ecosystem providing added value services to the surrounding society. The open collaboration between ecosystem's actors (citizens, businesses, organizations and the city managers) allows the development of new data-driven services. Therefore, data of interest for the ecosystem's actors is key for the reusability of the released information and could condition the degree of citizens' final satisfaction.

1. Introduction

One of the main challenges in our existing society is dealing with cities' problems. These problems include not only overpopulation, but also transport, pollution, sustainability, security, businesses generation, etc. We, as citizens, demand increasing levels of service performance which in turn requires increasing public resources. At the same time we also claim for tax reductions. In this scenario, efficiency is a key element for achieving demanded results. On top of that, city managers are also facing the increasing demand for active participation in the governance of the cities. Thus, open government initiatives [1] are becoming increasingly popular. In this context the reuse of

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* Corresponding author.
  E-mail address: carmen.depablos@urjc.es

information could provide not only increased efficiency but also mechanisms for participation and innovation according to [2].

This article explores qualitatively smart cities' data-driven ecosystems. The main goal is to identify the role of the reusability of the information in the innovation and new services created in those ecosystems surrounding smart cities.

2. Smart cities: datasets and apps

Smart city is a broad and variable concept which can be found in several organizations as described in [3].

A smart city is according to [4]"*A city that monitors and integrates conditions of all of its critical infrastructures, including roads, bridges, tunnels, rails, subways, airports, seaports, communications, water, power, event major buildings, can better optimize its resources, plan its preventive maintenance activities and monitor security aspects while maximizing services to its citizens*".

According to [5] a smart city is "*A city well performing in a forward-looking in economy, people, governance, mobility, environment, and living built on the smart combination of endowments and activities of self-decisive independent and aware citizens*"

Based on [6] a smart city is "*the use of smart computing technologies to make the critical infrastructure components and services of a city - which include city administration, education healthcare, public safety, real estate, transportation and utilities -- more intelligent, interconnected and efficient*"

Along this article a Smart city is a public-private ecosystem providing services to citizens and their organizations with a strong support of technology.

These academic definitions contrast with those supported by companies providing smart city solutions which are more close to some governance models like the one published by [7].

Sustainable smart city

One of the most popular approaches is focused on the environmental impact of the city. Undoubtedly the main issue when this approach is the use of energy. Therefore this approach pay much of its attention to energy savings, alternative energy sources, more efficient transport means, etc. One of the main advantages of energy management is the easy accountability of investments and returns.

Sensored smart city

Another popular approach is lead by the Internet of things. In this approach sensoring the city provides a huge amount of data coming from several thousands of sensors, traffic sensors, air pollution sensors, sound sensors, humidity sensors, cameras, etc., scattered around the city. These sensors would provide critical information for tackling several issues. However managing the impressive amount of data generated by the sensors represents a challenge by itself even as big as the problem they have to alleviate or to solve. This approach is able to provide a good insight of some of the toughest problems of the city at the cost of maintaining a complex technical infrastructure.

Collaborative smart city

A third and popular approach is the one which emphasizes the ability of the citizens to participate into daily issues of the city. Digital participation mechanisms, active sensoring by the citizens, participative budgets, etc. are some of the possibilities deployed in order to improve city management. Here simple technical tools can be found in complex implementation projects. Regulations about privacy, participation, public procurement create some remarkable barriers.

Holistic approach

A holistic approach combining these three previous approaches and some other dimensions could be a way to find the best solution. By definition resources are scarce so in every case this holistic approach will have to determine which aspect of the smart city should be developed first and which one deserves the biggest part of the resources.

2.1. Smart cities's ecosystem

The city is a data-driven service provider for their surrounding society (including citizens, companies and organisations) as described in illustration 1. This information is mostly published as open data, which is a subset of the open digital contents covered by the open definition [8]. The smart city can provide these services directly by its own means or subcontracting them. The smart city publishes their digital assets letting the ecosystem to use it as the foundations for creating their added value services. The ecosystem organisations add this value by integrating other external digital assets or providing new processing of the information in order to adapt it to different target groups. This way, they deliver services to the society. On the other hand society, which is the consumer of these services, also demands to the ecosystem for new features which in turn could result into several effects. One is the demand for additional information to the smart city. It is also possible that some data needs fixing or, finally some suggestions on how to release more effectively are collected.

In order to analyse these services some existing standardized categories have been taken into consideration. According [9] the smart city services are classified into 12 categories as energy, transport and mobility, health services, governance and citizens, among others. And ISO standard 37120:2014 [10] which supported by the World Council on City Data, includes smart city indicators that are classified in two groups -city services and quality of life-, 21 categories, and 100 indicators.

Figure 1. Data-driven ecosystem around a Smartcity

Smart cities are generating and compiling huge amount of data produced by their sensoring, their internal administrative processes and their participative tools. Current trend is to publish these data in new reusable streams and datasets encouraging the surrounding ecosystems to create new and innovative services based on them. In this context it is possible to find very different business models for those services. Some of them charge a fee, while others are free to use, or others use a freemium approach. It is also possible to find some of them based on donations, crowdfunding or even on more exotic sustainability options.

The reuse of public sector information (PSI) impacts definitely in our society. The economic impact in the overall of PSI reuse has been extensively analyzed with very different results. In EU, figures ranges from 0.25% of GDP [11] to 1.7% GDP [12] if several market conditions were met. Indisputably a substantial part of all this potential will come from the smart cities. Although smart cities are publishing much more information, for the sake of this article it will only be analysed those information coming from open data portals officially owned by the cities.

2.2. Smart cities's dataset

Reusability is the ability of a dataset to be used for alternative uses beyond its original ones as it is recognized in the SHARE-PSI 2.0 Consortium in 2015. Reusability of digital assets (i.e. data) is the base of a successful ecosystem of innovative services around a smart city data. In order to qualify data reusability of any public data source, MELODA metric has been developed by the authors. In the last available version of the metric (version 3.10), datasets coming from the public sources of data are qualified according to four dimensions: legal licensing, accessibility, technical standards and data model and for everyone a weight is assigned. Composing with a formula these four dimension marks, it is obtained a global valuation of the reusability of the dataset [13]. Note that accessibility refers to the ability of the datasets of being accessed easily for external reusers and it does not include
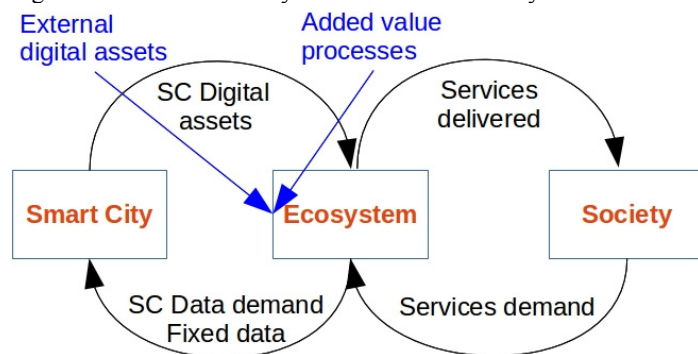
those conditions which makes easier or possible for disabled people to access to information as described in WAI standards

Data sources are always referred to some kind of information. For the purpose of this article, it is used the classification of MEPSIR report [11] which defines seven categories: Transport, Geographic, Social, Meteo, Business, Legal, and Other. Additionally two characteristics of the datasets are also analysed, timeliness and geolocation. Timeliness is the updating characteristic of the information, and specifically if the information could be considered real-time. Real-time data is released 'as soon as' the information is generated, without real consolidation processes (or with real-time consolidation). It does not mean that it should be released in seconds after generation (some processes could take weeks, months, etc.) but it is quite common to be that way. It is especially relevant for the information coming from the sensoring of the city. Geolocation refers to those datasets which include attached information providing geographic positioning of the data. Thus it is possible to group data based on its location, in districts, zip codes, etc.

Sampling

For the exploratory analysis, sampling between some of the main cities of EU belonging to an EU wide city association (http://eurocities.eu) has been carried out. Most of them are also involved into some other initiatives for smart cities like R+D EU projects, other EU / local smart cities associations, etc. For every city in this Table 1's list, it has been explored to find two resources. First is the cities' open data portal, and once available, it has been identified those datasets with the biggest number of downloads, when available, and for every one of these, it has been identified and compiled its main characteristics.

And the second searched resource, this list of cities is a list of featured apps reusing smart city data. Sometimes these apps are listed into the same open data portal, sometimes they are in specific smart city apps' portals. In the cities' apps portal/section, when available, up to three apps were randomly sampled. For those sampled apps, some data were gathered from its author, data source use, goals, updates, timeliness, geolocation, etc.

It is also remarkable that although 90% of the sampled cities have an open data portal for the city, only 60 % of the overall have a specific portal/section in its web dedicated to the applications created based on the smart city data as described in Table 1.

Table 1. Sampled cities and apps in open data portal in smart cities

Country	Cities	# Apps*	Country	Cities	# Apps*
Germany	Berlin	24	United Kingdom	London	52
	Frankfurt,** Düsseldorf,** Nuremberg**	---		Liverpool	22
France	Marseille	4		Manchester**, Brighton**	---
	Strasbourg	2	Netherlands	Amsterdam	22
	Paris** Lyon**	---	Spain	Malaga	3
Italy	Bologne	35		Zaragoza	33
	Milano	4	Switzerland	Zurich	33
	Florence**	--	Finland	Helsinki	110

**Not available data

In apps portals, interesting information could be retrieved. It could include legal licensing terms, number of accesses/ downloads number of versions/updates, last update date, data about the data sources used, size of the app, and other technical details.

Our exploratory analysis has revealed some unexpected results. First result is that the most frequent topics in popular datasets are transport/traffic and social information. Traffic (mostly real-time data of traffic density) it is not such a surprise while social category describing information about accidents, diseases, demography etc. was not expected to be based on our previous experience.

Second finding is that most of the licensing conditions tend to be compatible with the open definition [8]. It means equivalent to CC-BY 0 or CC-BY-SA (they are both types of licensing in the European Union) but with specific license conditions coming from public administrations.

Thirst remarkable finding is that the most popular access mechanism to the catalogue is provided by CKAN (http://ckan.org) which was expected, however customization on CKAN platform (it is an open source solution) restricts some interesting metadata as downloads, etc. to be automatically retrieved. Last remarkable finding is that geolocation information has been found in <u>all</u> of the most downloaded datasets found. It is also true that this research is just an exploratory analysis and therefore no conclusion can be drawn, however this percentage drives us to the exploration of new research lines.

2.3. Smart cities's apps

Mobile and web apps have been chosen as indicators of the reuse of smart cities' information for two reasons. First reason is its low cost of development (they are mostly available in any smart city). Second is their global availability for end users through the smart city apps portals or the mobile apps stores. Finally apps can reuse potentially any information released by the city and they provide an easy basic monetization mechanism through the app stores.

Smart cities' portals show very often sections compiling apps based on data released by the city as suggested at the SHARE-PSI 2.0 Consortium in 2015. However the term app could lead us to very different applications. From just simple apps which are installed through the most popular app markets, to web services accessed via mobile or desktop, to apps which compile lots of services, etc. In this paper we will be focused on the simplest apps or web services. They can be mostly identified with one single data stream (or less than 3). When there is no such portal, only those apps officially backed by the city are considered for the sampling.

Table 2 shows some of the characteristics found in the sampled apps: topics – It refers to the type of information used for the services provided by the app -- author's nature, real time and geolocation features. In terms of apps *traffic and transport* is the most recurrent topic followed by *Other information* – Note that it could happen an application to be using a type of information, in example, demography, which belongs to the *social* topic, and it provides a traffic forecast. Tourist information is one of the most popular one within the category of '*Other information*'. Most popular datasets include also transport and traffic, matching apps trend, but they also include social information. Geolocation of apps, although is a feature in all the most downloaded sampled, datasources reaches 'only' 74% of the sampled apps. Real time feature was even not so popular in the data sources but it reaches 61% of the sampled apps.

Table 2: Characteristics of the apps. *Sampling in Oct-Dec 2014

Characteristics		% Apps	Characteristics		% Apps
Topic	Traffic and transport	37%	Real time	Yes	61%
	Other	26%		No	39%
	Geographic	19%	Geolocation	Yes	74%
	Social	11%		No	26%
	Meteo	4%			
	Business	4%			
	Legal	0%			
Type	Public entity	45%			
	Developer	27%			

Business	14%
No identiy	14%

3. Conclusions

On the contrary to the release of information which is quite common in the sampled cities, collecting the applications created by the ecosystem of reusers is currently a pending task for a substantial part of the smart cities.

For those cities collecting apps in their own portal also means a remarkable maturity range. Specifically the amount of applications ranges from 2 to 110, which shows the different stages from city to city.

The fact that currently the biggest percentage of the apps in existing portals has been developed by the own city, close to a half (especially in the less populated portals) could confirm that the ecosystems around these cities are in its early stages.

An element to be addressed in further research is the return of the investment for the city (economic and social) and therefore how the ecosystems of reusers help themselves and to the city to create a sustainable business model.

Smart cities release of information is one of the most promising and complex fields to study the value creation and the impact of open data. Future lines of investigation include how to release information in order to maximize its impact and value created (social and economic) and how to make reusers' ecosystem sustainable. A more exhaustive sampling of data, together with some modelling, in progress, is expected to lead to more precise conclusions on these matters.

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