Toolkits for Smarter Cities: A brief Assessment

Auriol Degbelo[1], Devanjan Bhattacharya[2], Carlos Granell[3], Sergio Trilles[3]

[1] Institute for Geoinformatics, University of Muenster, Germany
degbelo@uni-muenster.de
[2] NOVA Information Management School (NOVAIMS), Universidade Nova de Lisboa, Portugal
[3] Institute of New Imaging Technologies, Universitat Jaume I, Spain

Abstract. The literature has offered a number of surveys regarding the concept of smart city, but few assessments of toolkits. This paper presents a short analysis of existing smart city toolkits. The analysis yields some general observations about existing toolkits. The article closes with a brief introduction of the Open City Toolkit, a toolkit currently under development which aims at addressing some of the gaps of existing toolkits.

1 Introduction

A review of smart cities documentations and literature reveals two distinct ways of using the term "toolkit". While some documents describe smart cities toolkits [1] as platforms to evaluate smart cities based on parameters such as the social paradigms of the tools in these toolkits [2], many other smart cities have propped up the definition of toolkit as a generic collection of utilities, applications and guidelines for citizens to wield tools and available smart city facilities, create further utilities, share developments and products, and maintain their own city in a smart way [3]. Mostly toolkits are not reported in literature as they are software packages available online for access and use: for instance a search for "toolkits for smarter cities" returns no relevant publication about toolkits in Google Scholar and Microsoft Academics Search as of June, 2016. Hence a comparative study of existing toolkits for smart cities is needed, as well as an evaluation of their pros and cons in order to propose a more effective solution that could be used and shared by citizens towards an engaged development of their cities. Though some reviews exist in the literature regarding smart cities (e.g., [4]), few so far have specifically looked at toolkits. This article is a preliminary work addressing this gap.

Existing toolkits are briefly assessed in Section 2 along different dimensions such as topical coverages, institutions developing them, openness of their components, maintenance, publication format and publication year. We also shortly introduce the design and early development of the Open City Toolkit (OCT) in Section 3. Being developed in the realm of the ongoing GEO-C project (`http://geo-c.eu`), the OCT is conceived as a collection of tools, services, specifications and guidelines to empower citizens to participate in and shape the future of their cities, and to deliver services based on open data that are useful for citizens, developers, businesses and governing bodies alike [5].

2 Toolkits for smarter cities: a brief assessment

The concept of smart cities has been changing from a top-down and mostly technological-driven approach, towards a bottom-up process that facilitates participation and collaboration among city stakeholders [6]. In this latter respect, the city is an ecosystem in which smart applications, open government data, and new modes of participation are fostering innovation [7]. As van der Graaf [8] pointed out, toolkits play an important role in this context and have two possible benefits: (a) they assist in systematically outsourcing certain design tasks from public institutions to users (i.e., citizens); and (b) toolkits tend to reduce the threshold for engagement by enabling and facilitating user participation in product or service development corresponding to their individual needs.

Table 1 summarizes the features of the toolkits analysed. The inclusion criterion was that toolkits' authors/publishers specifically mention the goal of making cities smarter in the toolkit's scope. The mention "n/a" in a column means "not applicable" or "information not available" or both; the mention "partly open source" indicates that *only some* toolkit components are freely accessible for re-use. Some toolkits were considered during the analysis but do not appear in Table 1, either because they do not specifically address smart cities, or because they are still at a very preliminary stage of development. These are: the Downtown Developer Toolkit (`http://bit.ly/1OSeOcH`), the City of Pittsburgh's Vacant Lot Toolkit (`http://bit.ly/28zKez9`), the GeoSmartCity cross-platform toolkit (`http://bit.ly/1S2TyPX`), the Data driven Interactive Smart City decision support toolkit (`http://bit.ly/28zKbmV`), the Farming Concrete data collection toolkit (`http://bit.ly/1Yo4EGI`), the Green City Development toolkit (`http://bit.ly/1YmHEHT`) and the Mixities Toolkit (`http://bit.ly/1Om6TIv`). All urls mentioned in this paper were last accessed on June 15, 2016.

The CLAIRE toolkit (`http://bit.ly/1WMOusF`) is a visual analytics toolkit which aims to create and implement roadmaps, stakeholder management and engagement, model-based scenario planning, as well as a smart energy system evaluation. According to the toolkit's brochure, CLAIRE is currently used in the EU FP7 City-zen project (`http://bit.ly/1xERnfY`).

The Citadel toolkit was developed within the EU Citadel on the Move research project. According to [1], Citadel has helped more than 120 cities across Europe to open up their data and create over 600 basic applications.

CitySDK is a "service development kit" for cities and developers that aims at harmonizing application programming interfaces (APIs) across cities. CitySDK APIs enable new services and applications to be rapidly developed, scaled and reused through providing a range of tools and information for both cities and developers [9]. CitySDK (`citysdk.eu/citysdk-toolkit`) concentrates on "participation", "mobility" and "tourism" as three of the most common interactions that citizens have with their municipality.

The European Platform for Intelligent Cities (EPIC) has been a flagship project for creating the base for smart cities (`www.epic-cities.eu`). A project developed by IBM for the EU, EPIC provides solutions to city managers and

Name	Topical coverage	Developer	Open Source?	Maintained?	Format	Year
CLAIRE toolkit	visual analytics	DNV GL	✗	n/a	n/a	n/a
Citadel toolkit	mobile apps development	Citadel Consortium	n/a	n/a	n/a	2012-2015
CitySDK Toolkit	participation, mobility, tourism	EU consortium	✓	✓	apps, maps, utilities	2012-onwards
EPIC IBM	relocation, urban planning	IBM for EU	✗	✗	Website	2011-onwards
ESD Toolkit	Tools for city governance	UK Govt	partly open source	✓	Website	2012-onwards
Hackable City Toolkit	digital media, urban planning	One Architecture, Mobile City	n/a	n/a	PDF	2015
ICOS URENIO	tourism, sensing parking, etc.	EU group	partly open source	✗	Website	2013-onwards
Organicity EU	health, safety, parking, etc.	EU consortium	✗	✗	tools	2015-onwards
Smart Citizen Kit and Platform	Citizen participation	Univ. Coll. London and others	✓	✓	Mobile, Arduino, IDE and Web	2015-onwards
Urban Tide toolkit	investment, resource planning	Urban Tide	n/a	n/a	PDF	n/a

Table 1: Current toolkits for smarter cities and their characteristics.

citizens about better managing their city using information and communication technology.

The ESD-toolkit framework (Effective Service Delivery Toolkit, `http://bit.ly/237a5K0`) is a comprehensive set of tested tools, models, case studies and guidance, many of which are freely available to support national and local agendas for pubic services. It helps local authorities develop a logical approach to "achieving more with less", improving productivity, delivering value for money, targeting socially excluded citizens and protecting vulnerable communities. As the moment of this writing, the ESD Toolkit has been upgraded to become LG Inform Plus.

The Hackable City Toolkit (`http://bit.ly/1PpBGz5`) was jointly developed by One Architecture and the Mobile City Foundation. It is a series of seven phases and eight strategies useful to deal with urban issues. The toolkit was developed based on an analysis of 84 projects which used digital media to improve urban life.

The Urban and Regional Innovation Research (URENIO, `http://bit.ly/1toa9cC`) is a university laboratory for the promotion of research and supply of scientific and technological services in the field of innovation systems and

intelligent cities. URENIO Research has created the ICOS Community in order to promote the adoption of open source solutions for smart cities. The ICOS platform offers developers the possibility to upload five types of open source applications for smart cities: generic applications, applications related to the innovation economy of cities; applications related to the quality of life in cities; applications related to city infrastructure and utilities; as well as applications related to city governance.

The OrganiCity experimenter portal (`http://bit.ly/1VX7nXa`) is a hub where registered experimenters can log in, and interact with tools they need to create and manage their work in one place. These tools share and utilise data which has been made available across Aarhus, London and Santander. The OrganiCity experimenter portal is an ongoing work that will will enable the creation and modification of 'citizen experiments', the monitoring of progress and the analysis of results in a user friendly way.

Smart Citizen (`http://bit.ly/1JLYx7H`) is a platform to ease participatory processes in cities. By connecting data, people, knowledge, and technology, Smart Citizen enables the creation of productive and open indicators, as well as tools for data capture and analysis or for social and educational experiments. Its goal is the collective construction of the city by, and for its own inhabitants. The Smart Citizen platform combines software and hardware, fostering co-creation processes so that people can create real deployments (e.g., crowd sensing initiatives in local neighbourhood, local maps of air quality or sound problems).

The Urban Tide toolkit (`http://bit.ly/25TU7st`) is a set of toolkits covering four different aspects: roadmap (i.e., establish a long term roadmap for a smart city), innovation and delivery (i.e., projects and initiatives to build innovation engines for the future), community engagement (i.e., development of smart communities) and unlocking city data and ICT (i.e., maximizing data value across departments).

This brief assessment of toolkits leads to the following observations: the topical coverage of current toolkits is relatively broad (o1); the EU consortium (through research projects), and private companies are currently the main drivers of toolkit development for smarter cities (o2); only few toolkits make all their components freely accessible for re-use (o3); information about the maintenance of the toolkits is, in most cases, not available (o4); existing toolkits are mainly published as pdf files (or alternatively as Websites) providing a series of steps to follow to achieve a specific goal (o5); and toolkits for smarter cities are by and large at an early stage of their development (o6). (o1) suggests an interest for toolkits in a broad number of smart city domains, and augurs (along with o6) an explosion of tools dealing with smart city problems in the coming years; (o4) may have its roots in (o6). In addition, truly empowering citizens to add value to existing open data is still an open issue as there is currently no open source community driving toolkit development for citizens (o2). Also, more open source toolkits are needed to catalyse knowledge sharing as open source toolkits are currently the exception rather than the rule (o3). These observations come as

a complement to the recent review of the smart city research landscape presented in [4].

3 The Open City Toolkit

The OCT [5] is envisioned as an integrated, open source software empowering citizens, providing them with analytical tools and citizen-centric services in the context of a smart city. It is incorporating the results of the various research lines within the GEO-C project. It is designed to keep all the resulting resources (i.e., data, processes, services, guidelines, standards, ontologies, and models) along with utilities, tools and applications that make use of these resources.

By a set of tools, utilities, and applications, we mean all the complementary but much-needed functionality to support the discovery, browsing, access, edition, and visualization of OCT resources. A CKAN-based implementation fits our purpose since CKAN comes with built-in facilities for managing, browsing, and exploring resources. We have used existing CKAN extensions, customised them, and integrated them into the live instance of the OCT portal (`http://giv-oct.uni-muenster.de:5000`). Examples are search facilities to retrieve resources according to specific purposes and needs. Nevertheless, our interest lies in extensions which are helpful to manage and handle geospatial data and resources. Currently, OCT uses the *spatialUI* and *spatial_metadata*, and *spatial_query* for retrieving spatial data, and *geo_view* and *geojson_view* for visualising it. Besides, other extensions have been installed to cover extra functionalities, such as data viewers (pdf, image and text), charts using different visualizations, RDF vocabularies, local storage, API for reading, connect with google analytics, usage statistics, creation of documentation pages, and so on. Also, we have developed a CKAN template in order to customize the way to visualize the different resources that the OCT offers.

In order to facilitate the use of the OCT, a collection of tutorials is provided. These snippets are offered using an associated website, called Open City Toolkit Developer Corner (`http://giv-oct.uni-muenster.de/dev-corner`). It includes short installation instructions for different development environments (e.g., node, bower, mkdocs), as well as different code snippets, in different languages, useful for data collection, storage, retrieval, analysis and visualization using the OCT. All components that form the OCT use open source software such as CKAN and Mkdocs, and all new developments are continually published as open source software components on GitHub (`https://github.com/geo-c`).

Looking at the literature review (Section 2), there are quite a lot of toolkits that share the overall vision of the OCT in making cities more efficient and a better place through ICT by making available a collection of city applications and APIs. The OCT goes one step further and offers a collection of datasets, services, apps, and guidelines. Indeed, a defining and novel characteristic of the OCT is the concept of guidelines or city stories, as a way to deliver successful (or not) experiences of smart city initiatives addressing the second main objective of the OCT: educate people and democratise Smart City initiatives to any city.

For this reason, the OCT is taking into account different user profiles, in order to provide helpful guidelines and solutions to citizens, developers and city councils.

4 Conclusion

Though the current literature has provided a passel of surveys and reviews about concepts of smart cities, there are still few assessments of toolkits, and their role in enabling smart cities. The current work is a first step towards closing this gap. The work looked at 10 toolkits, summarized their features, and pointed at preliminary insights from their assessments. Future work along these lines could investigate the actual usage of toolkits in the smart city context and their impact (e.g., through user surveys). The work also briefly introduced the OCT which is an ongoing work aiming at providing an integrated open source platform which will empower citizens to add value to existing open data. Currently the OCT features a Developer Corner, as well as a CKAN platform which catalogs all its resources. The OCT aims to be a set of best practices which can be replicated in other sites with similar requirements.

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