Perspectives on Smart Cities Strategies: Sketching a Framework and Testing First Uses

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ABSTRACT

Many cities today claim to be or to become a "smart city". The approaches and public policy foci taken by cities differ depending on the particular context of each city, e.g., size, technology strategy, political system, current challenges and history. This paper is proposing a Smart City Strategy Framework in the form of a morphological box, describing elements relevant for a smart city strategy and their possible manifestations. The framework is based on a literature analysis and the contained elements are grouped into four dimensions: city context, governance, implementation, and infrastructure. The framework can be used to compare different cities in their approach towards becoming a smart city, and we claim that it also helps city planners to develop a strategy, guiding the evolutionary and continuous processes in their smart city. To validate the applicability of the framework, we used it in the drafting and structuring of a questionnaire to city representatives that served as preparation for an international stakeholder workshop on smart cities strategies in order to find out what strategies cities are following and what their current status is. The results of the questionnaire and the workshop hinted at common patterns for smart city strategies, and shows that maturity levels as well as cultural differences need to be taken more into account in future versions of the framework

CCS CONCEPTS

• **Social and professional topics → Government technology policy**; • **Applied computing → E-government**;

KEYWORDS

Smart City, Strategy, Morphological Box, City Context, Governance, Implementation, Infrastructure

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1 INTRODUCTION

The term "smart city" has become popular and is applied to many different endeavors of city development, thereby leaving room for a broad understanding of what makes a city smart. With a view to the practical implementation of the concept, the main question is how cities do or should go about to become smart. Several academic papers [7, 18] as well as white papers from the smart city infrastructure industry [2, 19] have identified "success factors" for smart cities. While these works contribute to a better understanding of how smart city concepts are implemented, transferring approaches from one city to another using the same success factors is difficult, due to differing city contexts, in which the same factors must not necessarily be equally salient.

In this management paper we therefore adopt an open view on influential factors and establish a framework in form of a morphological box [1]. Instead of setting out best practices, the framework shows possible options of strategic smart city development. The framework can be used to compare approaches that cities are taking in their smart city efforts and may serve public administrations as a basis for formulating smart city strategies that are adjusted to context. In the remainder of this paper, we first describe the methodology of our research. In section 3 we discuss the proposed Smart City Strategy Framework in light of existing approaches in the field. In section 4 the focus is on the results of validating the applicability of the framework in practice, while section 5 provides a conclusion and an outlook.

2 METHODOLOGY

For developing and testing the Smart City Strategy Framework we adopted a mixed-method approach, including literature analysis, a stakeholder survey and findings from a panel discussion. The morphological box is based on a literature review of existing smart city frameworks and related research and forms the core of the proposed strategy framework. Morphological analysis is a well-suited method for studying and analyzing complex problem fields that are inherently non-quantifiable, contain non-resolvable uncertainties, cannot be casually modelled or analyzed, and require a

judgmental approach [26]. Devising a smart city strategy represents such a problem. In a morphological box, all important elements are listed, and for each element, possible manifestations are identified, resulting in the definition of a multi-dimensional solution space.

The Horizon 2020 EU-Japan joint research project CPaaS.io ("City Platform as a Service – Integrated and Open"; EU grant agreement №723076) [8] is creating an open and cloud-based smart city data platform. One of the main objectives of the project is to create a lasting impact in cities beyond the project's lifetime. A City Stakeholder Board has been established in the project, with representatives from the following cities: Amsterdam, Murcia, Sapporo, Tokyo, Yokosuka and Zurich. We used the City Stakeholder Board for a first validation of our hypothesis that a Smart City Strategy Framework is indeed useful for comparing cities and in discussions with cities regarding the development of their smart city strategy.

Data collection took place before and during a first city stakeholder workshop in Tokyo in December 2017. The objective of the workshop was to validate the work the CPaaS.io project is doing and to foster an exchange of experiences between the cities. In preparation for this workshop, we asked the city representatives (top and middle management) to fill out a short questionnaire to find out what strategic approach the cities are taking and where they currently stand regarding their smart city activities. The Smart City Strategy Framework was used for designing the questionnaire. 5 of the 6 cities responded. While the number of responses is too low for statistical relevance, the results still provide an appraisal of the main trends. Strategic options and choices were further discussed at the workshop, which started with a round of individual presentations by each city, followed by an open panel discussion between the six city representatives and the two project coordinators, taking also questions from the audience of 160-200 people. The presentations and workshop results are documented (cf. [16, 17]).

3 THE SMART CITY STRATEGY FRAMEWORK

3.1 Previous Work

Frameworks can be useful to characterize smart cities: They can be used for describing and benchmarking the activities of different cities, but also by listing and categorizing factors, they can guide city officials devising a strategy or monitoring its implementation. In the last decade various authors attempted the categorization of smart cities activities with different motivations. Griffinger at al. [15] defined characteristics in which a city can be active (e.g., economy, governance, living) and used the framework for ranking cities' activities. Another early conceptualization of smart cities by Nam & Pardo [23] distinguishes three fundamental components: Technology factors, human factors, and institutional factors and relates them to strategic principles a city needs to follow to realize its smart city vision. Angelidou [3] compared European cities and looks also at the role of technology and human capital advancement. In addition, she looks at measures for developing the business sector as well as what she calls networking activities in the sense of partnerships, alliances, marketing and digital presence. Gil-Garcia et al. suggest a comprehensive view on smart city elements along the four dimensions technology and data, physical environment, society and government [13]. Effing & Groot [10] suggest a framework listing possible strategies for government-, citizen- and network-based initiatives depending on the ambition regarding participation. Furthermore, Chourabi et al. [7] distinguish between inner factors (e.g., technology, organization, policy), that have a direct effect on the success of a smart city initiative, and outer factors (e.g., people communities, the economy or the environment). Jaekel [20] proposes a maturity model for smart cities along different components (e.g., governance, stakeholder management, leadership, participation, innovation environment, digital business models, business cases). Many other smart city models and related benchmarks have been proposed, Anthopoulos et al. [4] provide a good overview.

3.2 The Four Dimensions of the Smart City Strategy Framework

By developing a Smart City Strategy Framework, our purpose is to support the strategical process in a city aiming at becoming smarter. The most important elements of the framework can be grouped into four dimensions, as shown in Figure 1: The city context, governance, implementation and infrastructure.

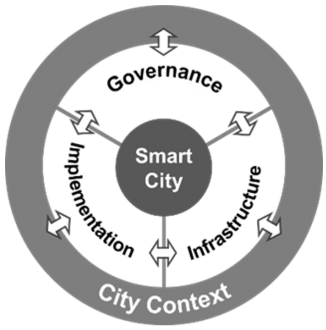

Figure 1: Dimensions used in the Smart City Strategy Framework

The morphological box forms the core of the proposed analytical instrument. Table 1 shows all elements identified for each dimension, as well as possible manifestations for each element. In the following sections we are discussing each dimension with their respective elements.

3.2.1 City Context. The city context forms the basis on top of which a smart city strategy can be developed. The context of a city, e.g., its size and structure is an often neglected aspect in other frameworks. The human factors [23], and in particular people's knowledge [25], are also an important part of the city context. The first element is the size of the population. Large cities with a population of more than 1 million people living within the city limits are most often named when talking about smart cities [5], but significant smart city initiatives are underway in much smaller cities as well. In fact, in Europe most smart cities tend to be smaller, even though the larger ones are often more mature [22]. Secondly, the development stage of a smart city influences the possible strategy. Jaekel [20] distinguishes between greenfield (e.g., Masdar City in the UAE), and retrofitting, i.e., existing and largely built cities like most European and US cities. We have added a third possible manifestation of this element termed 'brownfield' for instances where a

Table 1: Elements of a Smart City strategy and their manifestations

Domain Elements	Manifestations (1-5)				
City Context					
Population	< 50'000	50'000 - 100'000	100'000 - 1 mio.	1 - 5 mio.	> 5 mio.
Development Stage	Greenfield (New City)	Retrofitting (Exist. City)	Brownfield		
Political System	Authoritarian	Representative Democracy	Direct Democracy		
Education Level	< 20%	20-40%	40-60%	60-80%	> 80%
Pressures	Demographic	Environmental	Fragility	Financial	Economic
Governance					
Governance Model	Government-driven	Industry-driven	PPP		
Citizen Involvement	None	Open Communication	Co-creation		
Motivation	Technology	Quality of Life	Economic Prosperity		
City Role	Customer	Facilitator	Lead & Control		
Process Responsibility	No overall resp.	City	City-sponsored 3rd party	Independent 3rd party	
Business Sector Dev.	Financial incentives	Biz incubation services	Technology transfer	Commercialization services	
Approach	Project	Program	Initiative		
Regional Cooperation	City-only	with bordering region	Inter-City cooperation		
Implementation					
Implementation Model	Anchor	Platform	Beta City		
Application Domains	Single domain	2-3 domains	6 main domains, coord.	Stakeholder-defined	
Performance Measures	Project-based	Dashboard			
Infrastructure					
Data Infrastructure	Per Project	Closed API	Open Data Portal	Linked Data	
Networking Infra.	Per Project	City-wide WLAN	City-wide IoT Network		
Cloud Infrastructure	Per Project	City-wide platform			

completely new district is built within an existing city. The political system is a related element. The construction of a completely new smart city is easier in an authoritarian system, which tend to favor top-down development strategies with less citizen involvement. Much importance must also be given to education and knowledge of the populace [3, 23, 25]. People's education level impacts how citizens should best be addressed. As a measure for the education level, we use the percentage of the population with tertiary education. The values represent the percentage in the respective country according to [28]. And finally, the main pressures that a city faces have to be taken into account, as they are the drivers behind a smart city initiative and also influence the motivation of the city as well as the implementation model chosen.

3.2.2 Governance. This dimension covers the strategic aspects how the smart city is run, like motivation, governance model and institutional factors [23]. There are different routes towards becoming a smart city. Jaekel [20] distinguishes different approaches (project, program, initiative). A widely adopted governance model for smart city activities are public-private partnerships (PPP). It has been claimed that the use of a PPP model is an important success factor [29, 30], however, also government- or industry-driven models are possible. Related to this element is the city's role in the process: does it act as customer, as facilitator or is it in a leading and controlling role?

Many applications can only be successful if accepted by the citizens [9, 29]. Hence citizen involvement is another element that needs to be looked at. It can take different forms. To what extent and how citizens are involved also depends on the motivation behind becoming a smart city: If quality of live is the main motivation, citizen involvement is certainly more important compared to a technology-focused motivation.

Upscaling pilots to productive applications is a crucial but often difficult task [29]. We have thus added business sector development as another important element in the governance dimension. Angelidou et al. [3] mention three possible manifestations: financial incentives, assisting start-up companies through business incubation services, and finally technology transfer and commercialization services.

The smart city doesn't stop at its municipal borders. The final element we have identified in the governance dimension is thus regional cooperation: While initially cities may only look within their borders, collaboration with the bordering regions or within the metropolitan area is important for many applications, for example in the smart mobility domain. Furthermore, many cities also profit from the exchange of information, experiences and learnings with other cities (e.g., [11, 24]).

3.2.3 Implementation. When going towards implementation, a city needs to decide which implementation model to follow: According to Green [14], there are three main routes: the anchor model, where one application is implemented after the other, the platform model, where first a platform is deployed as an enabler, and applications are sorted out later, and the "beta city"model, with a focus

on experimentation. This last model is often applied when involving citizens through co-creation processes. Next question is what application domains to focus on. Some cities take a coordinated approach in all six domains defined by Griffinger et al. [15], others in just a few, or even only a single one. Finally, smart city activities should be monitored and controlled. Performance measurement can happen on a per-project basis or using consolidated dashboards.

3.2.4 Infrastructure. Technology and data are key components for the smart city [13]; in this dimension we are mainly looking at the available infrastructure. Depending on the maturity level [20] of the ICT infrastructure, different smart city applications can be implemented. We list three different elements: data infrastructure, networking infrastructure, and cloud infrastructure. In very mature smart cities, such infrastructure is available and can be used by all applications, in other cities such infrastructure is put in place on a project basis and may not be available for other applications. Regarding data infrastructure, many cities have Open Data policies, making data available through Open Data portals, some even offer the data as Linked Data [27]. Networking infrastructure is another key element. Some cities provide a city-wide open WLAN, and others even provide an Internet of Things (IoT) network; for example, Amsterdam and Zurich have open LoRaWAN networks [6] set up by technology enthusiasts. A public cloud infrastructure in the form of a common platform to manage the smart city process, to give access to data ranging from statistical data to real-time sensor readings to interested parties, and to run analytical functions is not available yet in most places, but R&D developments are moving in that direction [12, 21].

4 USING THE SMART CITY STRATEGY FRAMEWORK IN PRACTICE

We have applied the Smart City Strategy Framework for comparing the six cities involved in the CPaaS.io project along the framework dimensions. The city context elements were mainly derived from desk research, while elements related to governance, implementation and infrastructure were assessed based on the survey and the panel discussion.

4.1 Perspectives on Smart Cities: Six Cities in comparison

Subsequently, we compare the 6 cities along selected dimensions of the Smart City Strategy Framework. The most important points are summarized in table 2. It is worth noting that currently only one of the cities involved in the project stated to have a smart city strategy (Sapporo). Most other cities are still in the process of developing a smart city strategy, and one city claims that they have abandoned their efforts for such a strategy because the field changes too rapidly and any strategy would quickly be outdated (Amsterdam). The perceived challenges for establishing a smart city strategy are mainly related to cultural change, political will, coordinating stakeholders and financial and personnel resources, while technology is less of an issue. However, all but one city have a strategy regarding Open Data.

4.1.1 City Context Dimension. From a city context perspective, there are many similarities between these 6 cities. They all are at a similar development stage – all are existing cities that need to be retrofitted to become smart, even though in the case of Amsterdam we can also see a brownfield approach in some new development areas –, they all have a well-educated population with 60-80% having received tertiary education, and they all have a democratic political system – mostly representative democracies, only Zurich has a direct democratic system where people are used to participate and vote regularly on many political issues.

Differences between the cities appear when we look at the population and the pressures these cities are facing. Size-wise, Zurich, Murcia and Yokosuka are similar with little more than 400'000 inhabitants, however, Zurich is the largest and economically strongest city in Switzerland, Murcia is a regional capital and Yokosuka can be regarded as belonging to the greater Tokyo area. Tokyo itself, with around 13 million people of which two thirds live in the 23 special wards that in English often also are called cities, is by far the biggest city. Amsterdam and Sapporo are somewhat in between: Amsterdam with about 800'000 people is the national capital, while Sapporo with over 2 million people is a provincial capital. This shows that the population size does not equal its regional importance, which in turn may affect the strategic approach a city is or should be taking towards becoming smart.

Smart city is often associated with saving natural resources, however only two cities (Murcia and Zurich) mentioned environmental pressures as one of their main pain points. Instead, infrastructural, economic and demographic pressures are more important for the cities surveyed.

4.1.2 Governance Dimension. For all cities, improving the quality of life of its residents – and potentially also its visitors – is the main motivation for becoming a smart city. Economic prosperity, ecological footprint, innovation, resilience and finally technology play also a role for one or two cities. However, as Amsterdam stated, innovation and technology can also be seen just as means or enablers to address the real motivation, i.e., to improve quality of life. This enforces what had been said also in the panel discussion: Smart city is not a technology issue; technology is merely used to achieve overarching goals.

Establishing smart city initiatives typically requires cooperation between different stakeholders. For the surveyed cities, the city administration and private companies play the most important role, followed by academia. Somewhat surprisingly private citizens were not seen as important actors by the survey respondents, even though later in the panel discussions, many cities talked about the importance of co-creation and bottom-up approaches. One possible reason is that cities may believe that start-ups and organized entities like NGOs are more important for this, rather than individual citizens . That the city is one of the main actors is also reflected in what the respondents say about the role that the city should play in its smart city activities: Most favor the one of initiator and facilitator. Only Yokosuka acts solely as user and customer. This contrasts somewhat with the governance model used. While a PPP model is often proposed in literature for cooperation, this is hardly used in our sample. Only Amsterdam is fully betting on a PPP-approach, for all others, the model is currently still government-driven. This may be due to cultural differences between Europe and Japan, but a more likely explanation is the different maturity levels regarding smart

Table 2: Comparison of the six cities along the framework dimensions

	Amsterdam	Murcia	Sapporo	Tokyo	Yokosuka	Zurich
City Context	Pressures: Cultural, Economic, Infrastructural	Pressures: Economic, Environmental, Infrastructural	Pressures: Economic, Demographic	Pressures: Infrastructural	Pressures: Demographic, Infrastructural	Pressures: Demographic, Environmental, Infrastructural
Governance	Initiator and facilitator role, predominantly PPP model and co-creation, start-up support	Initiator and facilitator role, government-driven → PPP model, and co-creation	Initiator and facilitator role, government-driven, little to no citizen involvement	Initiator and facilitator role, government-driven → PPP model, citizen involvement planned	Customer role, government-driven, little to no citizen involvement	Initiator and facilitator role, predominantly government-driven and co-creation
Implementation	Beta city, applications defined by stakeholders	Platform, applications defined by stakeholders	Platform, 2-3 focus domains	Anchor → Platform , applications defined by stakeholders	Anchor, 2-3 focus domains	Platform, applications defined by stakeholders
Infrastructure	Open Data Portal, IoT network	Open Data Portal	Open Data Portal	Open Data Portal being set up	Project-defined	Open Data Portal, IoT network

city development: Amsterdam has the longest smart city history, and both Murcia as well as Tokyo want to move more towards a PPP-model. The maturity level also plays a role in other elements: Amsterdam is actively cooperating with other cities, they have set up a large smart city initiative with many independent projects, and the process is coordinated by an independent 3rd party. In the other cities, it is still the city that is responsible overall, they use a project-based approach, and regional cooperation is still minimal, i.e., with the bordering region if at all.

Cultural differences may be another reason however that citizen-involvement is handled differently in Europe and Japan. All European cities aim for co-creation with the local populace, while in Japan so far this is not happening. This may change in the future, as for example Tokyo is postulating a "Citizen-first" approach in its upcoming strategy. Finally, involving citizens directly in the value creation process is currently mainly done by the European cities. This happens in multiple forms, i.e., through communities (e.g., Smart Citizen, The Things Network), start-up support programs (e.g., Startup in Residence), labs (e.g., MiMurcia Open Innovation Smart City Lab, MiOS) and hackathons (e.g., MakeZurich). In Japan, first activities in that direction have started, like for example with the Open Data Challenge for Public Transportation in Tokyo.

4.1.3 Implementation Dimension. The different maturity levels of the cities become apparent also in the implementation model used. Amsterdam can be regarded as a "Beta City", focusing on experimentation, while the others are moving from an anchor model towards a platform model, i.e., from implementing applications one after the other to setting up an enabling platform.

The term "smart city" encompasses many possibly applications. This is also shown in the answer to the question of which application domains the city currently addresses in its activities. Even though some cities are at an early development stage, each possible answer was at least checked twice. Transport and mobility as well as, again, quality of life topped the list. Sapporo and Yokosuka focus on 2-3 domains, i.e., mobility, tourism and health in the case of Sapporo, and mobility, social inclusion and quality of life in Yokosuka. The other cities take a broader stakeholder-driven approach. In the panel discussion, it was furthermore confirmed that digitalization of government services for its citizens and businesses, but also for internal processes, is an integral part of a smart city.

The cities expect a positive impact of their smart city activities on environment, social aspects, and, in particular, the local economy. Hence the expected impact on the local economy matches one of the largest challenges that the cities are facing. In all cities, performance is measured per project; dashboards across application domains have not been deployed yet.

4.1.4 Concluding Remarks. Among the cities surveyed, the city context is comparable in some, but not all aspects: While development stage, political system, and education level are similar, there are differences however with respect to the pressures, the city size and its regional importance. In the governance domain it was surprising to find that the current activities are mostly government-driven. Only in Amsterdam a PPP model is used, even though Murcia and Tokyo claim to be moving in similar directions. In the implementation domain, there are no limitations regarding the addressed application domains, most cities are open for any type of project that has committed stakeholders. Data platforms play a crucial role in most cities; however, just Amsterdam runs an experimental platform with a vivid ecosystem. In terms of infrastructure, it is worth mentioning that four of the six cities have established Open Data portals.

5 CONCLUSION AND OUTLOOK

In this paper we have drawn upon literature on governance, implementation and infrastructure to develop and use an analytical framework for analyzing smart city strategies. The framework provides comparative ground in an international context, supports the formulation of new strategies, and elicits a number of lessons

from the very heterogeneous analyzed cases. The qualitative comparison of the six cities shows a number of similarities, as e.g. the predominance of government-driven approaches or the relevance of platforms. Context and concrete goals of smart cities activities may vary: The motivation is primarily increasing the quality of life, with technological and economic emphasis. While smart city activities still address primarily environmental pressures, demographic and economic issues are continuing to grow in importance. Citizen-involvement in the sense of co-creation is yet at a very low maturity level.

The comparison emphasizes the need for a holistic approach. Applying the framework in practice allowed us to validate and extend the framework with additional characteristics, e.g., for the elements motivation (innovation, resilience) and city role (initiator).

Future activities will focus on improving the framework to better support city planners in prioritizing options when defining smart city strategies and launching projects. Anchoring the public value approach and taking into account different maturity stages as well as cultural influences will improve the framework relevance for practitioners. Enlarging the empirical evidence with more cities and different contexts, we will be able to better study given correlations and formulate concrete recommendations for political decision makers in the public sector. A smart city addresses society's most pressing problems with new forms of problem identification, gathering of information and service delivery. The key question that needs to be addressed in strategic papers is how the city can ensure that the data needed is ready and fit for use. Indeed, it is about raising the data literacy of a city; not only with a policy, but also with people, processes and technologies. It is about modeling the value proposition in the concrete ecosystem and identifying the needed capabilities within the system in order to ensure sustainability.

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