

# Information Systems and Smarter Cities: Towards an Integrative Framework and a Research Agenda for the Discipline

*Research-in-Progress*

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## Abstract

*Cities stand at the confluence of two global grand challenges—urbanization and climate change. Smart city initiatives around the globe seek to leverage information technology to preserve and improve quality of urban life in face of these challenges. Given its vast experience with socio-technical systems, the IS discipline can assume a leading role on this path towards a more sustainable way of living. For this purpose, we present first insights from interviews with municipal stakeholders from European cities that currently undergo smart city transformations. Building upon their responses, we develop an initial framework for information systems research within a smart city context and outline research implications for the discipline.*

**Keywords:** Smart Cities, Research Agenda, Framework, Interviews, Grand Challenges

## Introduction

The world is at a crossroads. It faces a variety of global challenges, such as climate change, the acidification of oceans, rising sea levels, and the loss of biodiversity. Cities will be critical to addressing these disruptive forces because these problems affect many them. They will soon contain the majority of the world's population, they are immense consumers of resource, and they are creative hubs. Humans have thousands of years of experience in using technology to solve societal problems and advance the quality of life. Over the last half century, information systems (IS) have been the major drivers of productivity improvement and lifestyle changes. The application of IS knowledge to cities to make them smarter and sustainable has become a pressing challenge. IS researchers could and should play a role in tackling humanity's most important challenges, as we are the scholarly discipline that studies the transformational power of digitization. Digital innovation can lead us to a sustainable societal path beyond the crossroads.

Cities are amongst the most complex forms of organizations known (Holland 1995)—and they face fundamental changes with respect to technology, human capital, and urban living practices (Neirotti et al. 2014) through *smart city* transformations. By 2020, the smart cities industry is estimated to pass a worth of \$400 billion (ARUP 2013), reflecting a global effort by smart city initiatives, with examples in New York (Mayor's Office of Technology and Innovation 2015), London (Smart London Board 2014), or Singapore (Infocomm Development Authority of Singapore 2015). At the same time, cities continue to attract a

growing share of the world's population—the United Nations Department of Economic and Social Affairs (2014) estimates two thirds of the world's population to be residing in cities by 2050. Managing this increasing urbanization with the help of information systems, smart governance, and smart living practices to achieve sustainable prosperity will be one of the defining challenges of our time.

By its own aspirations, the IS discipline is in a prime position to support these efforts. Questions of how to develop, use, and apply information systems to urban systems with their often chaotic appearance and plethora of stakeholders can only benefit from the vast amount of experience IS scholars have acquired working on similar questions in business contexts. Undoubtedly, certain IS research streams already contribute insights towards creating smarter cities, such as work on electronic government, energy informatics, smart mobility, or disaster management. Nevertheless, these subfields of the discipline often focus on important, but rather narrow aspects of smart city transformations. They lack a cohesive framework and an agenda that positions IS research as a valuable contributor to stakeholders in public administrations, industry, and citizenry. Chourabi et al. (2012) provide a starting point in that direction outlining a basic framework for smart city initiatives. Building upon their work as a foundation, the project introduced in this study seeks to develop a comprehensive research framework and agenda for the IS discipline through feedback from smart city stakeholders and IS scholars.

The paper at hand presents preliminary insights from the first steps in that effort, summarizing perspectives from smart city stakeholders at the municipal level and discussing modelling approaches and the role of IS research in view of this feedback. Following an explorative critical success factors (CSF) inquiry, we interviewed smart city coordinators in four cities funded through the European Union's (EU) Horizon 2020 Smart Cities and Communities call, one of the world's largest endeavors to foster sustainable smart city developments. Given the lack of common definition of smart cities (Neirotti et al. 2014), the first purpose of these interviews was to discern these stakeholders' perspectives on what makes a city smart. In a second step, we seek to answer the following research questions within this paper:

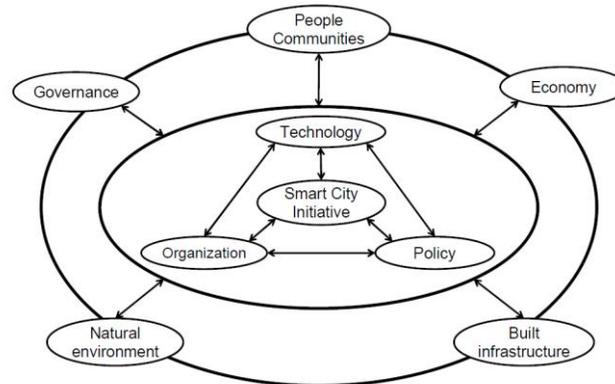
- What are critical success factors for smart city transformations?
- How can existing research frameworks be refined in order to reflect experiences from large-scale smart city projects?
- How do specific IS research streams contribute to successful smart city transformations and what are open questions that are fit to be investigated by IS researchers?

In the next section, we briefly summarize recent research streams that pertain to smart cities, outline the research project, and define the scope of this study within it. We present the results from the interviews in the third section and follow this up with a section discussing possible framework approaches. We conclude with a section of preliminary implications for IS research and an outlook on the future project development.

## Research Setting and Related Work

Neirotti et al. (2014, p.28) provide a summary of current smart city research trend. As argued above, various research streams within the IS discipline already contribute to several of these topics. Particularly research on **electronic government and governance** has established itself as a subfield within the discipline over the past decade, as outlined in Belanger and Carter (2012). A selection of recent examples includes Tan et al. (2013), who investigate the relationship between the design of e-government websites and service quality, and Scott et al. (2015), who employ the concept of public value to assess the benefit of e-government applications. Similarly, the Energy Informatics (e.g. Goebel et al. 2014; Watson et al. 2010) and Green IS (e.g. Dedrick 2010; Melville 2010) subfields have gathered traction and various research papers provide insights related to the areas of **smart grids** (Brandt et al. 2013; Flath et al. 2012; Fridgen et al. 2015; Ketter et al. 2016a), **energy efficiency** (Jagstaidt et al. 2011; Loock et al. 2013), **smart markets** (Bichler et al. 2010), and **sustainable mobility** (Teubner and Flath 2015; Wagner et al. 2016). IS research also provides insights on the relationship between information technology and **public safety**, for instance, in the context of urban crime (Bendler et al. 2014; Gerber 2014) and disaster management (Leong et al. 2015; Mendonça 2007). Recently, the **hospitality** sector has also received an increasing amount of attention from IS researchers through smart tourism research (Gretzel et al. 2015b; Gretzel et al. 2015a). Finally, there has also been a growing body of literature on **e-health** (Payton et al. 2011; Ure et al. 2009; Wickramasinghe and Kirn 2013), although without an explicit focus on urban settings.

While each of these research streams clearly intersects with the topic of smart city transformations, the discipline currently lacks an agenda-setting framework that positions possible contributions of IS research to the outside and guides researchers within the discipline. Chourabi et al. (2012) provide a basic framework of smart city initiatives as replicated in Figure 1. Smart city initiatives are positioned in the context of a set of highly influential inner factors (organization, policy, technology) and a set of outer factors (governance, people & communities, economy, built infrastructure, natural environment). While this framework is not, subsequently, calibrated through feedback from stakeholders and research and lacks a clear imperative for the discipline, it provides a starting point to initiate such a discussion.



**Figure 1. Smart City Initiatives Framework (from Chourabi et al. (2012))**

For this purpose, we conducted a series of interviews with city representatives involved in the coordination of the first set of projects funded through the EU's Horizon 2020 Smart Cities and Communities call. Through this call, the EU contributes more than 70 million euro in funding to three projects—GrowSmarter, REMOURBAN, and Triangulum—that involve nine lighthouse cities and ten follower cities (NCP Energy Germany 2015). The projects have been running since the beginning of 2015, allowing first insights into different smart city transformation processes. We interviewed Gustaf Landahl from the City of Srockholm, Sweden, Barbara Möhlendick from the City of Cologne, Germany (both GrowSmarter), Ángela Rivada Rodríguez from the City of Valladolid, Spain (REMOURBAN), and Henk Kok, advisor to the City of Eindhoven (Tirangulum).

The interviews followed an elaborated critical success factor (CFS) approach (Bullen and Rockart 1981; Leidecker and Bruno 1984) in that we did not confine our inquiry purely to surfacing CSFs but also sought to add some contextual richness. Thus, six open questions, including but not limited to CSFs, served to initiate an open discussion on experiences and insights the interviewees had collected through these and other projects in their cities. Specifically, the question were:

1. What is a smart city?
2. How will you know when your city is smart?
3. What are the critical success factors for creating a smart city?
4. What means have you identified for making your city smart?
5. What are some minor changes that a city can make that would improve smartness?
6. What are major changes that a city can make to create major a change in smartness?

From the responses to these questions, we derive an initial framework (Figure 2). This development is moderated through our considerations of the current state of IS research efforts in related fields and the Chourabi et al. (2012) framework. The initial framework will subsequently be refined through an alignment process (Ketter et al. 2016b) that iteratively updates the framework with feedback from stakeholders—not just representatives from municipalities, but also industry representatives, policymakers, regulators, and citizens—and from IS scholars through conference, workshop, and seminar discussions. This paper provides an overview of the interview responses in the next section, which is followed by initial framework considerations.

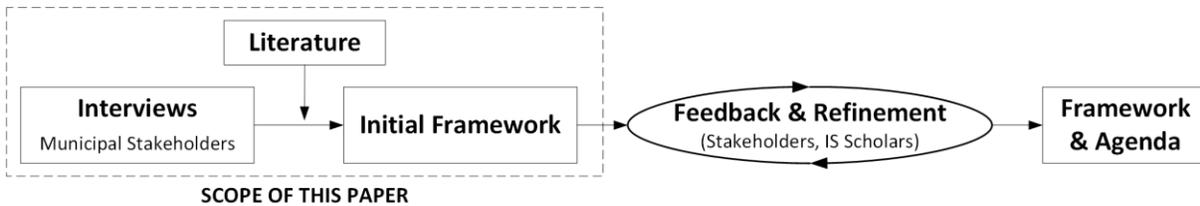


Figure 2. Research setting

## Insights from Stakeholder Interviews

We summarize the responses to the first three questions in Tables 1 through 3 with each interviewee represented by his/her initials: GL (Gustaf Landahl), BM (Barbara Möhlendick), HK (Henk Kok), and ARR (Ángela Rivada Rodríguez). The responses to the first question, what a smart city actually is, provide four different perspectives that are linked by certain common themes. First, a smart city is a city that has become better at *meeting the needs of its citizens* (GL, HK, ARR), particular in world with accelerating technological progress. This aspect outlines a shortcoming of the Chourabi et al. (2012) framework as it does not contain any reference to the eventual objective of a smart city initiative. Second, municipal administrations need to improve management by working across departments instead of a single-minded focus on one's own objectives (GL, BM, ARR). This is certainly an area to which the e-government stream within the IS discipline can substantially contribute. The third theme is the involvement of citizens within the communities (BM, HK, ARR). This does not just include engaging citizens, but also enabling them to use smart technologies and contribute to the smart city transformation. The fourth theme is a *resource perspective*. This refers on the one hand to the sustainable and efficient use of limited resources (GL, BM, ARR). On the other hand it implies considering empowered citizens as a resource for such smart transformations.

These themes reoccur when considering the responses to the second question (Table 2). For instance, a company in Eindhoven developed a smartphone app that encourages citizen participation to improve the overall quality of life in the city (HK). Additionally, the app documents these improvements and allows a *measurement of the success of the smart city transformation*. Such a regular assessment is important, either through management indicators (GL) or other forms of documentation as provided by the app (HK). A topic related to the issue of measurements and transparency is *Open Data* (BM). On the one hand, Open Data is considered a tool to realize a more transparent administration and to create an ecosystem of companies that use these data to provide novel and beneficial services. On the other hand, this very

Table 1. Responses to “What is a smart city?”

GL	<ul style="list-style-type: none"> <li>City that puts a lot of effort into becoming better with respect to <i>management</i>, the efficient use of <i>financial resources</i>, and <i>meeting citizens' needs</i></li> </ul>
BM	<ul style="list-style-type: none"> <li>The city is connected.</li> <li>Integrated city quarters an integrated planning of these quarters</li> <li><i>Administration does not work in silos</i> and uses ICT tools</li> <li><i>Citizens are involved</i>, they represent a <i>resource for smartness</i>.</li> <li>A city that intelligently handles <i>limited resources</i> and transforms them intelligently into sustainable city development</li> </ul>
HK	<ul style="list-style-type: none"> <li>A smart city brings rapid technological change and <i>citizens' needs/welfare</i> in balance, enables people to work and cope with technology.</li> <li>Smart city consists of smart technology and <i>people that need to be able to work with it</i>.</li> </ul>
ARR	<ul style="list-style-type: none"> <li><i>Administration works across areas, in multidisciplinary teams</i>.</li> <li>A city that enables <i>local participation</i> and global replication</li> <li><i>Improves quality of life of citizens</i> through better public services (resilience, health, sustainability, efficiency, safety)</li> </ul>

**Table 2. Response to “How will you know when your city is smart?”**

GL	<ul style="list-style-type: none"> <li>We have <i>management indicators</i> that are reviewed every four months</li> <li>A smart city is essentially a positive city with a positive mindset. The goal may never be reached, but the city goes through <i>constant improvement cycles</i>.</li> </ul>
BM	<ul style="list-style-type: none"> <li>It is about changing minds in the administration. All city employees work towards a unifying, common goal, and are not just focused on own area.</li> <li>As city employee, I have access to all administrative data related to a specific development project (data on the entire set of conditions relating to particular city quarter).</li> <li>Faster data access for citizens</li> <li>Open Data (most data generated through tax funding, so it should be made accessible to city to create an ecosystem)</li> <li>Caveat: fear of measurability</li> </ul>
HK	<ul style="list-style-type: none"> <li>The use of technology leads to improvements in the lives of citizens (raise quality at same price or achieve same quality cheaper).</li> <li>Use <i>IT to measure improvements</i>. The app BuitenBeter was developed in Eindhoven and allows citizens to take a picture of something wrong/broken in the city and send it to municipality. A central data hub that filters/forwards information to correct department and the problem is often fixed within reasonable time. Citizens are engaged with follow-up email and city employees like it, too, because it provides very precise information on what is broken (location, picture). The app enables documentation of improvements over time.</li> </ul>
ARR	<ul style="list-style-type: none"> <li><i>Capacity for carrying out smartness is there on a daily basis</i>, not just through projects</li> <li>Breaking down barriers between departments</li> </ul>

transparency is not entirely cherished within the administration, reflected in a fear of increasing measurability and accountability. In fact, a debate on the problems associated with reducing government performance assessments just to Big Data indicators has recently been initiated within the public administration literature (Lavertu 2015). The responses to the second question also provide insights on the *nature of a smart city transformation*, which is described as a process, not a project. This process is represented by iterative improvement cycles (GL) and seeks to build up a capacity or resources within the city to carry out smartness on a daily basis (ARR).

Taking the responses to the third question (Table 3) into account, we summarize these themes into a set of success factors critical for smart city transformations:

- **An administration without barriers.** It is necessary for municipal administrations to transcend departmental thinking and follow holistic approaches to smart city projects. This requires not just organizational changes, but also effort to change minds at the individual level.
- **Leadership and local involvement.** Smart city transformations need to be supported by all stakeholders within the city—citizens, businesses, and municipal employees. However, they also require leaders in the community to commit and provide structure to the project through, for instance, strategies.
- **Technical infrastructure.** Smart cities require a technical infrastructure that enables smart solutions, including broadband, connected devices, and data hubs. The existing infrastructure also needs to be rethought with respect to additional features, such as street light posts that also offer vehicle charging, provide Wi-Fi, and collect information (HK).
- **Transparency and empowerment.** In principle, digitization enables not just public administrations, but also urban life as such to become more transparent through open government and open data. The accessibility of urban data can set the foundation of an entire ecosystem of new services. At the same time, for an inclusive smart city, citizens across all social backgrounds and generations need to be educated and empowered to handle technological progress and thrive in a smart city.

The second set of questions inquired about specific means the respondents’ cities have undertaken towards smartness as well as minor and major changes they would recommend to cities just embarking on smart

**Table 3. Response to “What are the critical success factors for creating a smart city?”**

GL	<ul style="list-style-type: none"> <li>• Cross-sectoral work</li> <li>• Sharing experiences with other cities</li> <li>• New technology (ICT)</li> <li>• Cooperating with others (industry)</li> </ul>
BM	<ul style="list-style-type: none"> <li>• Changing minds</li> <li>• Leadership and bottom-up support</li> <li>• Data transparency within the administration and to the outside</li> </ul>
HK	<ul style="list-style-type: none"> <li>• Smart citizens that are aware of changing world and enabled to participate</li> <li>• Smart government that limits too much power in the hands of a few, be it parts of government itself or tech companies</li> <li>• Infrastructure enablers to provide connectivity (e.g. street lights not just for lighting, but also for Wi-Fi, electric vehicle charging, and as providers of information through sensors)</li> </ul>
ARR	<ul style="list-style-type: none"> <li>• Breaking down barriers, multidisciplinary teams</li> <li>• Political leadership</li> <li>• Smart City strategy that outlines steps for transformation</li> <li>• Tools for citizen engagement, not only technology</li> </ul>

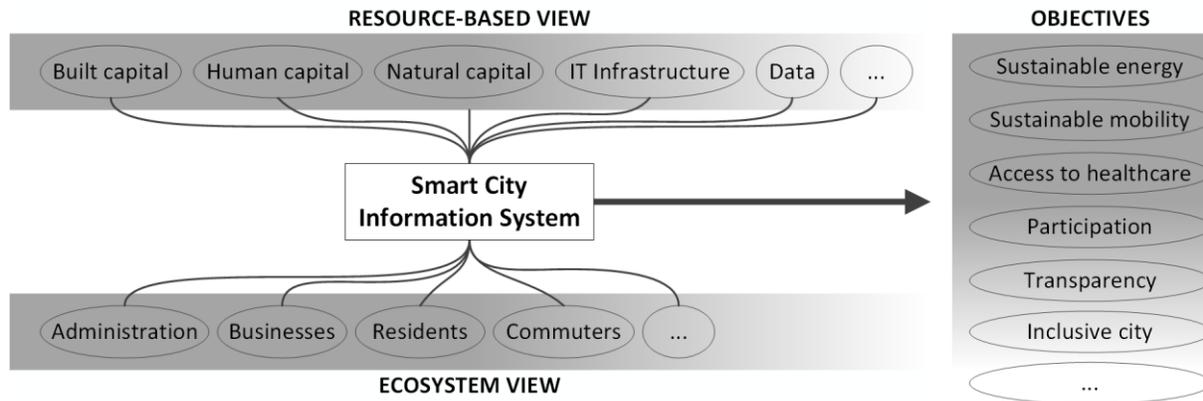
city transformations.<sup>1</sup> From their responses, we derive four recommendations. *First*, policy changes within the municipal administration that enable cross-sectoral work need to be implemented. These changes should be accompanied by investments into staff positions (e.g., within the CIO’s department) that specifically focus on the smart city transformation and bring the policy changes into practice. *Second*, the city needs to build up an adequate IT infrastructure. This concerns both infrastructure within the administration (to facilitate transparency and open data) and within the city as a whole (fiber-optic Internet access). *Third*, project selection should involve citizens and follow their most pressing needs. Citizens need to be actively engaged and involved throughout the transformation; they need to identify with the city and the changes. *Fourth*, the city needs to be opened as an experimental place. New ideas should be tested within a small testbed part of the city and subsequently scaled up if successful. Recently, several IS publications have discussed results from such living lab approaches in a smart city context (Butler and Hackney 2015; Krogstie et al. 2013).

## Developing an Initial Framework

The interview responses summarized in the previous section provide first insights on the current state of smart city transformations and how IS research can support this process. From a modelling perspective, two approaches come to mind when considering the recurring themes within the responses. First, cities are **ecosystems**, both in the literal (Douglas et al. 2011) and the figurative senses (Newman and Jennings 2008). Naturally, it stand to reason to think of the city as an ecosystem with a variety of organisms or stakeholders and interactions between these. IS research is no stranger to ecosystem perspectives, particularly in context of digital platforms and business (e.g. Basole and Karla 2011; Ceccagnoli et al. 2012; Cranefield et al. 2015; Tiwana 2016), but also more recently as a framework setting for smart tourism (Gretzel et al. 2015b).

Second, all respondents mentioned in some form or another resource considerations—the efficient management of financial resources, the need for adequate IT infrastructure, or the necessity of empowered citizens as a resource for smart city transformations. The resource-based view of the firm (Wernerfelt 1984) is well-established within the IS discipline (e.g. Bharadwaj 2000; Mata et al. 1995), so it is natural to extend it to the **resource-based view of the city**. Finally, as discussed previously, a research framework should also consider the **anticipated outcome** or the **stated objective** of a given smart city initiative since preserving and improving quality of life and the provision of services to citizens is the core purpose of smart city transformation.

<sup>1</sup> Due to the page limit, we only provide a summary of the responses



**Figure 3. Proposed Framework for IS Research on Smart Cities**

Both views, resource-based and ecosystem, complement each other and we argue that they provide a comprehensive representation of the city as perceived by a researcher. Hence, we propose a framework that combines them and positions the smart city information system in context with them, as illustrated in Figure 3. The resource-based view refers to the various types of resources a smart city can rely on. This includes all forms of capital, such as built capital (buildings, streets, power lines), human capital (capabilities and knowledge of the population), or natural capital (rivers, lakes, parks). We position IT infrastructure as an explicit resource due its exceptional relevance. A similarly relevant resource is without doubt data. The ecosystem view, on the other hand, provides insights on the stakeholders within the city—the city administration, businesses, and residents, but also, for instance, commuters. At this stage, neither the lists of resources nor of stakeholders are exhaustive, and we consider it as part of the refinement process to add to these lists.

A smart city information system connects stakeholders and leverages resources to achieve specific objectives, a selection of which is outlined in Figure 3. For instance, if we consider the BuitenBeter app described by Mr. Kok (Table 2), this app connects people in the city (residents, commuters) with the administration. It relies on the availability of specific IT infrastructure within the city—smartphones, connectivity, and a data hub that processes suggestions to the appropriate departments. It does so to achieve a specific objective, namely fixing broken things in the city.

## Implications for the Discipline and Outlook

### *The Human City*

The most forceful theme we noted during the interviews was the common orientation of smart city initiatives towards a specific goal: preserving and improving the quality of life of the people in the city. Ms. Rivada Rodríguez succinctly stated that first and foremost *a smart city must be a human city*. This is particularly noteworthy as current smart cities research often prioritizes technical artifacts and ignores some of the social aspects of the large technical systems and information infrastructure that they will require. Many of the technical issues of standards and design are challenging and there will be a strong push for technically focused research and development. It is important, however, to draw social researchers into this relatively new area of technical innovation. Social scientific research perspectives will be critical to challenging many of the common assumptions about smart cities. Moreover, some of the social and economic implications, such as issues around privacy, could undermine efforts towards smart city transformations if not thoroughly considered. Further social and ethical issues that need to be explored when introducing smart city technologies include, for instance, data protection and ownership, informed consent, control (centralized vs. decentralized power and choice) and inequities across digital divides.

### *Towards a Research Agenda*

Given its extensive experience at the intersection of socio-economic and technological developments, it should not be the objective of the IS discipline to just contribute to these research issues, but rather to

**Table 4. Prospective IS Research Agenda on Smart Cities (Adapted from Walsham 2012)**

	<i>Traditional Orientation</i>	<i>IS Research on Smart Cities</i>
<i>Unifying vision for the IS field</i>	Helping organizations use ICTs effectively	The relationship between digital technologies and urban life, governance, and economy.
<i>Settings</i>	Business and government	Urban communities, technology companies, local authorities, SMEs, citizens and other stakeholders who co-create smart solutions to urban problems using creativity, local knowledge and smart technology.
<i>Goals and objectives</i>	Improved effectiveness	Enabling the different urban stakeholders to perceive, conceive and experience the urban space in completely new ways.
<i>Methodology</i>	Dominance (in the US-based journals at least) of positivism	A familiarity with a range of different methodological approaches and theoretical lenses applicable to emerging technologies and how they can change urban life and systems
<i>Other disciplines</i>	Drawing theories and approaches from other disciplines	Genuine interdisciplinarity: working together

become a major driving force behind them. To achieve this, the discipline needs to extend its field of study to non-traditional research settings and methodological diversity (Walsham 2012). Following Walsham's thoughts on a future research agenda for the IS field, we adapt it to reflect the particular challenges of the smart city context.

Both framework and agenda serve as starting points to initiate a discussion and an alignment process during which we will integrate additional feedback from stakeholders and scholars. We particularly intend to extend the current European focus to a global perspective as smart city projects often reflect the different problems cities in developed and emerging countries face.

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