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Conceptual Model of Information Technology Management for Smart Cities: SmarTICity

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ABSTRACT

This article presents a proposal of conceptual model for public administrations that allows analyzing the level of IT management capacity as an enabler of smart cities from a multidimensional and dynamic approach taking into account technological, institutional and innovation aspects. The model includes five domains (e-government strategy, Public Innovation, Data Management, IT Services and Infrastructure) that are described in terms of key domain areas, objectives and questions. The model was conceptually validated with four IT offices in Colombia and a pilot test was developed in the Atlantic department. A profile of information technology management capabilities was obtained from public data of the Ministry of ICT in Colombia.

KEYWORDS

Digital, E-Government, Emerging Technology, Government, Innovation, Intelligent, Public Administration, Technological Capability

INTRODUCTION

Current city dynamics are characterized by a diversity of complex problems and the rise of expectations in smart governments that set new challenges for public governance systems. Finding new forms of operation and collaboration supported by Information Technology (IT) is a key challenge for cities. These findings should achieve sustainable growth in an effective and efficient manner, guarantee integrity and build trust, improving relationships and interaction of its citizens with the state. Therefore, attention to the initiatives and projects of smart cities around the world is undeniable. Europe and Asia have been pioneers in these initiatives and have made significant progress; Latin America has recently begun to lead this type of projects as well.

A smart city can be generally assumed to be a territory characterized by the intensive use of information and communication technologies to promote collaboration, innovation and efficiency, improving the quality of life of citizens and the sustainability of the cities (Maestre, 2015). For Nam and Pardo (2011a), the goal of smart cities is to create an environment for the exchange of information,

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collaboration, interoperability and make perfect experiences for all inhabitants. Smart cities should assume innovation as a mechanism to change and improve technological tools, providing better services and creating conditions to use them better (Nam & Pardo, 2011b).

In this sense, technology management in smart cities must facilitate and promote access to information and services as a key element for their development (Maestre & Nieto,2015). Information technology capacity can be defined as an organization's ability to acquire, deploy and leverage its resources in information technologies, combined with other resources, in order to achieve its business objectives through ITs (Zhang, Sarker, & McCullough, 2008). Young (2011) defines it as the total information technology capacity that an organization must maintain in order to efficiently support its management activities and improve the performance of its business in an IT environment. IT capability brings together elements of hardware, software, services, management practices, technologies and management skills (Kettinger & Lee, 2005). The modernization of public administration by strengthening the role of ITs is one of the cornerstones of the strategy for the smart, sustainable and inclusive growth of cities (Gaulė, Jurgita, & Jolanta, 2015). Due to the growing trend of cities to adopt visions of smart cities, a model for analyzing IT management capacity will enable cities to better understand how they are evolving from technology. This will allow supporting decision makers to visualize and develop actions and strategies aimed at consolidating smart cities based on IT.

A proposal for a referential conceptual model for public administrations focused on IT as an enabling element for the advancement of this new model of cities will be presented. It is designed from the revision of 23 reference models associated with smart cities and IT management. It proposes an architecture that includes strategic, innovative, technological and operational capabilities comprising 5 domains (D), 15 key domain areas (KDA) and 38 critical variables (CV). Finally, a model is applied in the Department of the Atlantic in Colombia, assessing the capacity levels of its domains and key areas through 48 indicators, taking as reference datasets, statistics and public national reports.

RESEARCH METHODOLOGY

In order to establish a methodology for designing and developing a model for smart city focused in information technology, the research proposes a five-step procedure as illustrated in Figure 1. They will be developed in detail in the following sections:

- **Scope:** The application context and the purpose of the model are defined;
- **Conceptualize:** The domains that will be the key elements of the model are selected and described from the literature review;
- **Design:** The architecture of the model is defined, taking into account the IT management capabilities that smart cities must have, describing the goal, interrogations and key areas associated with each domain;
- **Validate:** Conceptual validation is performed with academics and socialization in three Colombian cities;
- **Apply:** The model is applied by assessing IT management capacity in a Colombian territory.

Figure 1. Research methodology

CONCEPTUAL MODEL *SMARTICITY*

The conceptual model of *SmarTICity* is proposed as a scenario to manage IT in open social context in order to approach processes of planning, development, and backing of projects that support initiatives of smart cities. This proposal should promote technological development, innovation and the integration of citizens in digital environments. The design has been conceptually proposed according to the literature review, as well as from the experience of public administration officials in Colombia. The model consists of Domains (D) and Key Domain Areas (KDA) related to IT management applied to smart cities.

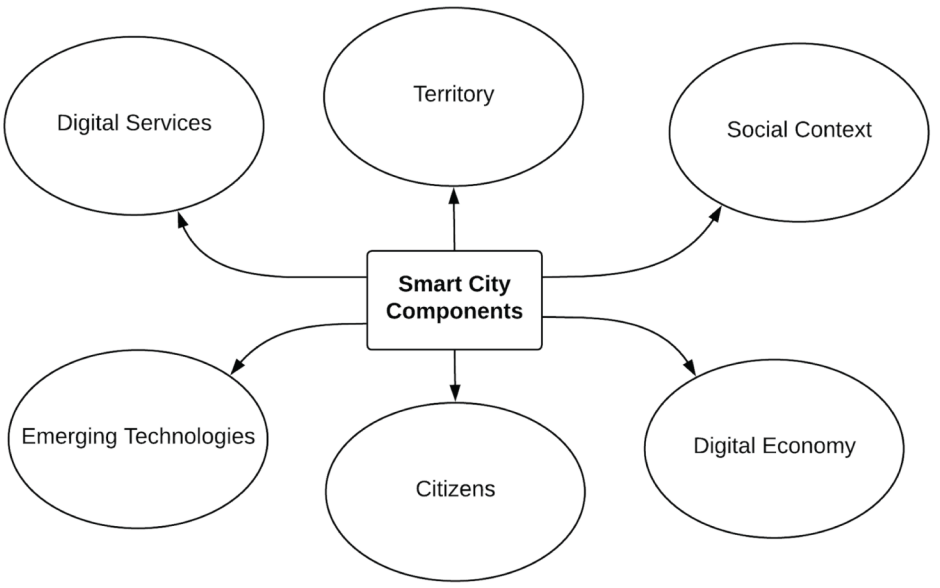
Structural Components of a Smart City

The idea of the smart city is relatively new has been taking force in the last decade, therefore, it is in evolution and is characterized by being a broad concept since in general it is conformed by a complex combination and interaction of social, institutional and technological factors. The components have been proposed from literature review in smart cities mainly presented by authors as (Nam & Pardo, 2011a) and (Neirotti et tal, 2014), maturity models and evaluation models (Table 2). For the model, six structural components are considered: Social Context, Digital Economy and Citizens, territory, Digital Services and Emerging technologies, as shown Figure 2. These components are the starting point for conceptual model and are expressed through the domains and key areas proposed through strategic, operational, technological and innovation capabilities.

Territory

It is the physical, social and cultural space in which it seeks to generate transformation processes through the use and appropriation of information technologies. This territory is designed to promote the generation of synergies between the state, productive sector, academia and civil society in order to design and implement strategies for social and economic development using these technologies, strategies supported in public policies, standards, Regulations that generate more favorable contexts for the long-term sustainability of these initiatives.

Figure 2. Smart city components



Social Context

Addressing the issue of people and communities as part of smart cities is critical because smart city projects have an impact on the quality of life of citizens and seek to respond to the desires and needs of these communities. Smart cities allow city members to participate in city governance and management, so they are agents of change in society and to a large extent are key players that can significantly influence their success or failure.

Digital Economy

Consisting of telecommunications infrastructure, ICT industries (software, hardware and ICT services) and the network of economic and social activities facilitated by the Internet, cloud computing and mobile, social and remote sensor networks. The digital economy is a facilitator whose development and deployment takes place in an ecosystem characterized by the increasing and accelerated convergence between diverse technologies, as it is the context of smart cities in which they generate impacts in the economic and social fields. In the first, we consider its effect on productivity, economic growth and employment. In the second, there are the impacts on education, health, access to information, public services, transparency and participation.

The Citizen in the Digital Context

Citizens play an important role in the context of intelligent environments, since they must be able to adapt to the new dynamics and cultural and social change that are promoted from these initiatives, where collaboration and partnership between citizens and governments is the basis of the strategies that support them. It is also important to emphasize their social inclusion in soft infrastructures (knowledge networks, organizations, crime-free environments), urban diversity and cultural mix, social and human capital and their participation in knowledge generation through educational and generation institutions R & D capabilities (Nam & Pardo, 2011a).

Digital Services

They are the mechanisms of communication and interaction mediated by IT between administrations and citizens through which they offer the possibility of accessing online services and processes, conducting transactions and consulting information related to the city. This is perhaps one of the most developed tendencies in the cities, it is evident that there is an increase in the creation and availability of online procedures that allow the citizen to optimize the times by avoiding the presence in the public offices, the reduction of Costs of transfers and administrations have updated and available information. Payment of taxes, online appointments, obtaining documents and certificates are some examples, however there is a challenge in updating the technologies that support these services, for example the migration or expansion of access channels not only web but applications Mobile phones.

Emerging Technologies

It is generally seen that cities have taken advantage of the availability of their technological resources to advance strategies that clearly target a public sector or service (mobility, health, safety, environment, etc.). To this end, some of the emerging technological trends that support the development of smart cities are identified: Big Data, Data Analytics, Open Data, Cloud Computing, Apps Mobile, Public Connectivity are key trends.

Although each of the components exposed is important, this work will focus mainly on the technological and institutional components: Emerging Technologies, Digital Services and Territory.

Purpose and Scope

The purpose of the model is to understand the role of information technologies in the development of smart cities from a multidimensional and dynamic approach. Its scope is described in Table 1.

Table 1. SmarTICity model scope

Criteria	Characteristic	
Emphasis	*Specific Domain*	*General*
	Smart Cities	Information Technology Management
Interested	Local and national governments	Companies, Academy and citizens
Audience	*Internal*	*External*
	Local and national governments	Companies, Academy
Application Method	Self-assessment	Consulting
Application	A city, territory or entity Colombian Cities	Various cities, territories or entities Latin-American Cities

Table 2. Studied reference models

Model Type	Model Name
Evaluation model	Smart cities Ranking of European medium-sized cities. (Giffinger et al., 2007)
	Smart Cities in Europe (Caragliu, Del Bo, & Nijkamp, 2011))
	Coverage Index (Neirotti et tal, 2014)
	Mapping Smart Cities in the UE (Manville et al., 2014)
	Index IESE cities in motion (CGE, 2015)
	The smartest cities (Cohen, 2012)
	Getting Smart about Smart Cities Recommendations for Smart City Stakeholders Recommendations for Smart City Stakeholders (Alcatel, 2012)
	Assessing Smart City Initiatives for the Mediterranean Region
	Smart City Playbook
	City evaluation model based on the concept of smart city (Moreno Alonso, 2016)
	Study Methodology for Smart Cities (Branchi, Matias, & Fernandez, 2013)
Best management IT practices	ITIL- Information Technology Infrastructure Library
	TOGAF: The Open Group Architecture Framework (The Open Group, 2009)
	ZACHMAN Framework--- (Zachman, 1987)
Government Enterprise Architecture (GEA)	GEA United Kingdom Government Reference Architecture (British Standard Institute, 2012)
	GEA - USA The Common Approach to Federal Enterprise Architecture---(USA Government, 2012)
	GEA-Colombia The Colombian Government Enterprise Architecture Framework---(Morales, Torres, Parra, & Campos, 2014)
	GEA- Australian Government Architecture Reference Models---(Australian Government, 2011)
	GEA for New Zealand (GEA-NZ) Framework GEA (Government New Zealand, 2015)
Smart Cities Maturity Model (MM)	MM- Scottish: Smart Cities Maturity Model and Self-assessment tool (Scottish Government, 2015)
	MM- IDC: Smart City Maturity Model-Assessment and Action on the Path to Maturity (Yesner, 2011)
	MM- BSI Smart city framework – Guide customer service to establishing strategies for smart cities and communities (British Standard Institute, 2014)
	MM DELOITTE Capability Framework and Maturity Model (Deloitte, 2015)
	MM-India Smart Cities Maturity Model (SCMM) (Mani & Banerjee, 2015)

The model has been initially developed Colombia from experience in government IT office. The audience of model are initially the Local (city) and National Government, but it can be applied in similar contexts as developing countries, mainly Latin-American.

Domains

For the selection of the domains, a literature review was carried out by taking 23 reference models distributed in evaluation models, best practices of IT management, experiences of government enterprise architectures and models of maturity of smart cities as referenced in Table 2. The most relevant domains are identified and selected from these models, taking into account the context of interest: technology management and smart cities.

In reference to the previous models, the mapping of the most common domains of application and that may be of interest for the proposed model are:

1. **Domains or Dimensions:** Strategy or Business, Data or Information, Applications or Services, Infrastructure, Others (innovation, users, culture);
2. **Fields of Application:** Economy, Governance, Environment, People, Habitability, Mobility.

As a consequence of the literature review, the proposed conceptual model is composed of five domains that are shown below.

Electronic Government Strategy

It contemplates the information referred to the objective of IT and information services provided by the State and its articulation with legal or regulatory frameworks. It also contemplates identification of the actors of the processes and their respective needs and/or expectations.

Public Innovation

The application of methods, policies, products and services that contribute to the processes of the state, facilitating the relationship of citizens with public sector entities.

IT Services and Processes

These are the processes and services available to citizens that support the development of procedures, requests, consultations and access to data, information and knowledge of public interest.

Data Management

Refers to the set of processes for the acquisition, processing, storage, management and analysis of large volumes of data of all types: structured and unstructured that will make strategic decisions for the city.

IT Infrastructure

Refers to the hardware and software infrastructure and its facilities that allow the storage, processing and securing of applications and data.

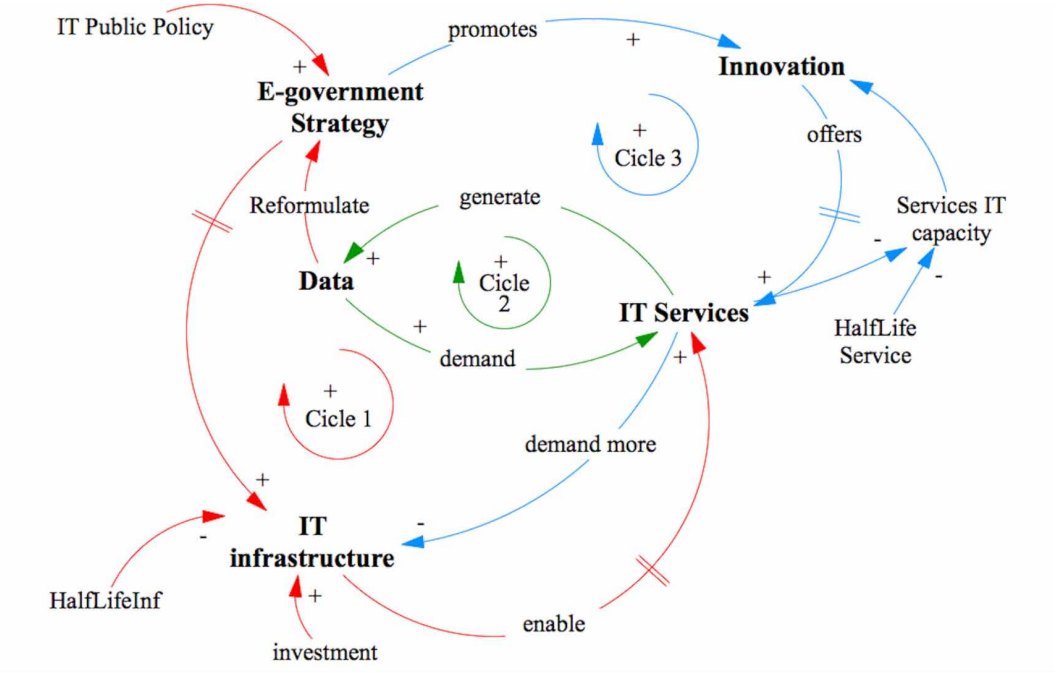
Dynamic Representation of the Model's Domains

To explain the relationship of the model's domains, a causal diagram is presented in Figure 3, in which influential relationships and feedback cycles are expressed. These explain the general dynamics of the model proposed from the Systems Dynamics.

Cycle 1: Strategy-Infrastructure-Services and Data

Through the formulation of IT public policies, the strategy of Electronic Government provides the necessary conditions for the development of smart cities. The technology that will be available is a

Figure 3. Influence model SmarTICity - System Dynamics



fundamental element, to the extent that the institutional, economic and physical actions of a city enable the required infrastructure. Infrastructure capacity can be affected due to the obsolescence of the same (IT average life) or by lack of investment. Carrying out the strategy requires more infrastructure, which in turn will support more IT services in the city (such as on-line paperwork, applications, etc.) so that citizens can have easier access to these services. Likewise, through the use of IT services, more data is generated on each of the transactions and services used, in which the analysis of this data will facilitate decision making and thus reformulate the strategy as needed.

Cycle 2: Data-Services

In addition, the amount of data generated may require more or better IT services in order to facilitate their analysis. This cycle has a higher speed than the other two cycles.

Cycle 3: Strategy-Services-Innovation

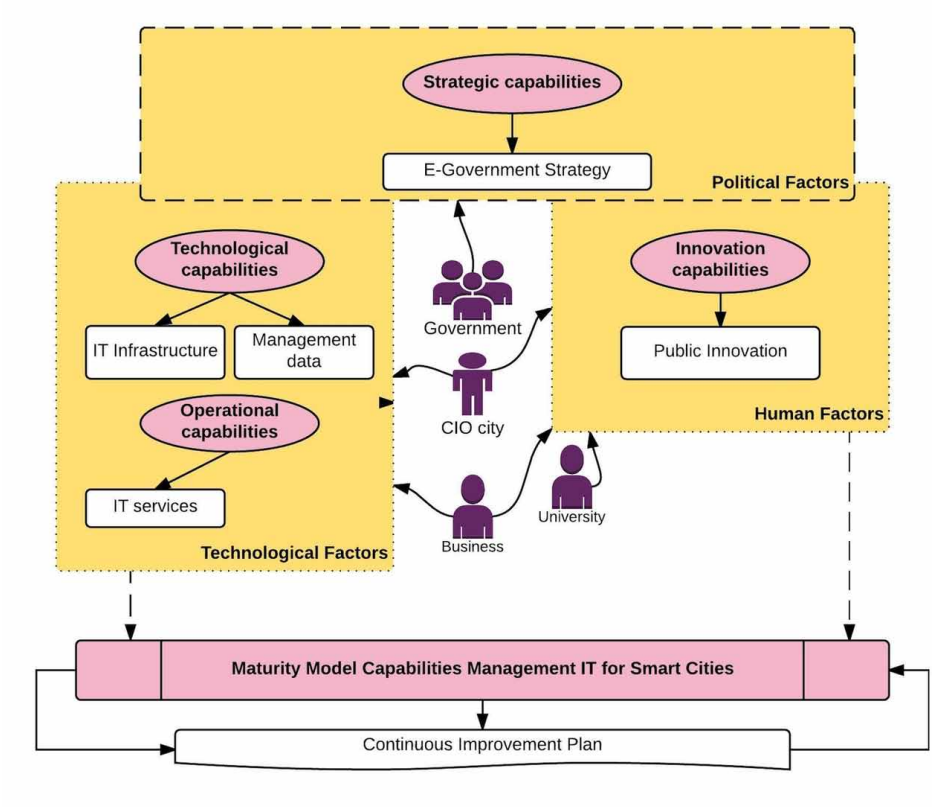
In addition to infrastructure, the strategy requires an operation through IT services. These services can start to lose capacity if they are massively used by citizens, accelerating their average life, or if they are not supported by investments. This loss of capacity can be compensated by promoting public innovation in which new, improved and innovative services can overcome the loss of service capacity or meet the demand for new and better IT infrastructures.

Architecture of SmarTICity

Once the domains of the model are defined, they are grouped in strategic, technological, operative and innovation capacities of the city around information technologies, as presented in Figure 4.

From each of the proposed capacities, the key areas describing the domain as a whole are detailed. Key Domain Area, Goals and questions that give meaning to the model are generated and described in order to have an input for the valuation tools.

Figure 4. SmarTICity architecture



Electronic Government Strategy

Goal

City's capacity to organize a coherent vision of e-government, coordinate stakeholders and ensure that IT projects and portfolios align with their needs. Also, it is important to have a clear institutionalization for the changes involving electronic participation and stakeholder collaboration.

Key Areas

- **Governance:** Ability to promote an IT culture and policy that directs, promotes and executes the strategies and objectives of a smart city;
- **IT Plans:** Strategies and actions aligned with the institutional objectives of the city oriented to generate value and contribute to the achievement of the strategic objectives;
- **IT projects portfolio:** Tangible projects organized to comply with the city's tactics and IT strategies.

Questions

Does the city have an IT strategy aligned with sector strategies, the National Development Plan and institutional strategic plans?

Does the city's IT policy definition set the guidelines for achieving the goals proposed in the IT strategy?

Does the city have the relevant human resources to leverage IT projects?

Is the formulated IT strategy aligned with the institutional objectives of the city?

Does the defined IT Projects portfolio execute tactics and strategies for the development of smart cities?

IT for Public Innovation

Goals

Capability to create, generate and adopt new technologies in order to improve the quality of life of citizens. In order to do so, human capital (whether from government, universities and companies) must be well prepared to generate favorable conditions for the installment of an ecosystem of open innovation to add public value to the services of the city.

Key Areas

- **Triple Helix:** Collaboration agreements between university, company and government to generate new institutional and social formats in the production, transfer and application of products and services;
- **Innovation Ecosystems:** Spaces with favorable social, cultural and economic conditions where companies generate R & D & I based on collaboration to provide solutions through processes, products or innovative services to the city;
- **Science and Technology Activities:** Human resources with skills and competences that favor the processes of public innovation in the city.

Questions

Are there regulations that facilitate the university-company-state relationship?

Does the city have the human capital to generate innovations that contribute to smart cities?

Are TI activities encouraged through clear policies and regulations?

Is there a real articulation between university, company, and state?

IT Services and Processes

Goals

Capability to offer innovative citizens online services based on IT technologies and processes. These technologies are incorporated into key city services for citizens, such as transportation, health, education, environment, employment, public services and security.

Key Areas

- **Online Services:** Mechanisms for communication and interaction mediated by IT between administrations and citizens through which they can access online services and processes, conduct transactions and consult information related to the city.

Questions

Are technology services aligned with the smart city strategy?

Is access guaranteed to citizens through the available technological services?

Are there mechanisms to guarantee the availability of technological services?

Is the use and efficiency of the available technological services evaluated?

Data Management

Goals

Capability of availability and use of public data by citizens and organizations to produce valuable information. It also includes all the captured data of devices and sensors that organize useful

information for the city and the dashboard and analytical business models, to allow better and timely decisions.

Key Areas

- **Open Linked Data:** Set of best practices for the publication and connection of open and structured data on the Web that allows the exploration of new relationships between data and the development of new applications for the city;
- **Analytics:** Predictive and prescriptive techniques used to analyze and transform large volumes of data into information for making decisions in the city;
- **Dashboard:** Integrated dashboards that manage volumes of information that allows real-time and predictive analysis to support decision making.

Questions

Is the open data available to users in the city?
Are there strategies for updating the city open data?
Are there clear strategies for the development of open data policies in the city?
Can decision-making be facilitated for the city by analyzing the generated open data?

IT Infrastructure

- **Key Areas:** Interoperability, IT Operation, Sensors, Public Connectivity

Goals

Capability to have hardware and software to access web services, public Wi-Fi connections (hotspots), hosting and all the necessary resources to provide data processing, which allow storage, information exchange, data capture, etc., thus supporting decision making based on the data:

- **Interoperability:** Strategy of government organizations to share information and integrate information and business processes through the use of common standards and best work practices;
- **IT operation:** Configuration, integration and maintenance of infrastructure hardware and software to protect resources and ensure their availability and integrity;
- **Sensors Device:** It refers to the different devices that are able to capture different signals from the environment, convert them into data and transmit them through the networks to computers of the centers of control and management of the cities;
- **Public Connectivity:** Communication infrastructure, which can be a combination of different data network technologies that use transmission via cables, fiber optic and wireless networks (Wi-Fi, 3G, 4G or radio).

Questions

Does the city have the necessary infrastructure to offer services that the IT strategy demands?
Can the availability and correct functioning of the provision of services to citizens be ensured?
Are emerging technologies incorporated to support the technological infrastructure in smart city projects?

VALIDATION OF SMARTICITY

A first version of the model was conceptually justified by academics in the area of IT management. This process is detailed in the article "Validation of architecture of information technologies in

smart cities" by Maestre and Nieto (2016). The model was adjusted from the one initially proposed considering the results.

Subsequently, a validation was discussed with officials from the secretariats and IT offices of three Colombian cities: Barranquilla, Bucaramanga, Barrancabermeja, through the Secretariat of Informatics and Telecommunications of the Atlántico Governorate (AT), the IT Secretariat of Barrancabermeja (BC) and the IT Office of Bucaramanga (BU). The following information was obtained through a survey and interviews:

1. The relevance of domains, key areas(KDA) and critical variables (VC) proposed by a valuation of 1 to 5 (1 lowest and 5 highest);
2. Officials assign a weight (distributed by 100%) to each critical variable proposed for each KDA, in order to appreciate their importance. Table 3 shows the results obtained.

APPLICATION SMARTICITY

The model was applied to the Secretariat of information technology and telecommunications of the Atlantic of Colombia. This entity is in charge of directing IT policies and strategies in the cities that make up this territory. An evaluation was made on the KDA to evidence the progress of a territory with respect to the proposed model and to analyze the possibilities and limitations of its application.

Colombia's online government index (GEL) from 2015 is taken as the main source of data. This is a quantitative instrument that shows the state of progress of the entities in the implementation of IT in the public administration of the country, as well as sources such as Management Report of the Ministry of Information Technologies, National Administrative Department of Statistics (DANE), the report of the Observatory of Science and Technology of Colombia (OCyT) and the website of the department. In this case, the mapping of indicators of each of the available sources with each of the KDA was done, and 48 indicators (KPI) that were considered relevant for the evaluation of the key domain areas of the model were selected.

From the data collected, a level of capacity of the KDA is assigned, by means of a valuation from 0 to 3, as follows:

Capacity Level 0: Capabilities are not made nor exist to achieve the results of the KDA.
Capacity Level 1: Activities develop incipient capabilities for the domains. Processes have the possibility of some initial results in the KDA.
Capacity Level 2: Systematization of processes (orientations, training, implementation plans) that represent the KDAs. There are some formal evaluation mechanisms and evidence of short-term results.
Capacity Level 3: Institutionalized and innovative processes, systematic process monitoring, change management and continuous improvement plans.

The CL (capacity level) of each KDA was obtained from the collection and evaluation process as shown in Table 4 and described in Table 5.

DISCUSSION

About the Conceptual Model

According to the results of empirical validation, a good reception is shown by the academics and officials who participated. Some findings are presented below:

Table 3. Results conceptual validation

Domain	KDA	Critical Variable	Average Relevance	Assigned Weights		
				AT	BU	BC
e-government strategy	Government	Normative	4.25	30%	40%	50%
		Institutionalization	4.38	50%	40%	25%
		IT Government	3.81	20%	20%	25%
	IT Plans	Strategic Alignment	4.38	50%	60%	60%
		Monitoring	4.25	50%	40%	40%
	TI projects portfolio	Pertinence	4.67	30%	20%	50%
		Monitoring	4.17	30%	30%	30%
		Achievement	4.33	40%	30%	20%
IT Public Innovation	Triple Helix	Strategic Alliances	4.11	50%	50%	50%
		Normative	4.33	50%	50%	50%
	Innovation Ecosystems	Normative	4.33	40%	40%	40%
		IT Cluster	4.67	60%	60%	60%
	IT Activities	Formation	4.78	30%	30%	40%
		Human Resources	4.54	30%	30%	20%
		Investment	5	40%	40%	40%
IT Infrastructure	Interoperability	Organizational	3.63	40%	40%	30%
		Semantic	3.63	30%	20%	40%
		Legal	3.75	30%	40%	30%
	IT operation	IT risks	3.94	30%	40%%	30%
		Security	3.75	30%	30%	30%
		Continuity	3.56	40%	30%	40%
	Sensors	Availability	4.38	30%	40%	40%
		Use	3.75	40%	30%	30%
		Coverage	3.75	30%	30%	30%
	Public Connectivity	Availability	4.33	30%	30%	40%
		Use	4.38	40%	40%	30%
		Coverage	3.5	30%	30%	30%
Data Management	Open Linked Data	Quality	3.25	40%	40%	40%
		Availability	3.5	20%	30%	20%
		Exploitation	3.42	40%	30%	40%
	Analytics	Big Data	4.38	40%	40%	35%
		Social Media	3.88	30%	20%	35%
		Business Intelligence	3.5	30%	40%	30%
	Dashboard	Use	3.5	50%	60%	50%
		Indicators	3.5	50%	40%	50%
IT Services	Online Services	Access	3.75	30%	30%	50%
		Use	3.83	40%	40%	30%
		Service Levels	3.38	30%	30%	20%

Table 4. Capacity level assessment

Domain	KDA	#KPI	CL
E- Government Strategy	Project Portfolio	3	**2**
	IT Plans	2	**0**
	Governance	4	**1**
IT Public Innovation	Innovation Ecosystems	2	**2**
	Triple Helix	1	**0**
	Activities Science, Technology	3	**2**
On line Services	Basics Services	4	**2**
	On line Services	10	**2**
Management Data	Open Linked Data	6	**2**
	Analytic	1	**0**
	Dashboard	1	**0**
IT infrastructure	Interoperability	1	**2**
	Public Connectivity	1	**1**
	Sensors Device	1	**1**
	IT Operation	8	**2**

- The model contemplates several aspects besides technological and operative ones, like strategical and innovational, that contribute to the integrity of the model;
- In terms of the relevance of the KDA and CV, it can be seen that the Data Management domains register the least acceptance of the respondents, on the other hand the domains of strategy and innovation seem to be the most relevant for the government offices;
- Although the inclusion of variables of innovative topics such as big data, business intelligence and sensors did not prove to be predominant practices in the near future, it is pertinent that cities begin to plan and take on the challenge of implementing them in the medium and long term;
- The difficulty of the model could be in the availability of indicators and quantitative data that is very scarce, in particular for some very new areas associated with smart cities like those associated to Big Data, Business Intelligence, Interoperability, Sensors and others;
- The model proposed is seen as useful to Colombian cities since, although there are some instruments available to the Ministry of Information and Communication Technologies of Colombia, it facilitates the holistic and systemic evaluation of IT, making a base line for the cities and formulating plans of continuous improvement regarding smart cities.

About the Model's Application

While available open data is an important input into the analysis and assessment of IT management capabilities for cities planning to become future smart cities, some limitations are described below:

- When mapping available indicators, some key areas do not have sufficient indicators, some are not the most representative or there are no indicators or information available to make the assessment (for example: Interoperability, Dashboard, among others);
- Some indicators evaluate Boolean type, without giving margin to intermediate levels of capacity;
- In some cases, the indicator is not understandable: for example, the Interoperability Platform (it is not clear if the use or existence is measured);

Table 5. Description

DOMAIN	KDA	CL	CL Description
E- Government Strategy	Government	1	There is a public policy of Electronic Government that facilitates the management and adoption in the public administrations of the city, but it is not formally implemented. The public administrations of the city have IT managers, with limited human, physical and financial resources. There is awareness of IT governance issues.
E- Government Strategy	IT Plans	0	There are no capacities or information.
E- Government Strategy	IT Projects	2	There are emerging structured and standardized monitoring mechanisms and procedures that have been partially developed. There are some measurement and follow-up results, but not all IT projects. The culture of monitoring and measurement is being established through training and formation. There are some metrics and indicators.
IT Public Innovation	Triple Helix	2	UEG initiatives are projected and promoted. Some projects are generated for specific needs. Some spontaneous but consolidated collaborations are emerging. The city partially adopts the policy and some norms through plans and projects for its implementation. There are some indicators to evaluate in general the progress in its implementation
IT Public Innovation	Innovation Ecosystems	0	There are no capacities or information.
On line Services	Online Services	2	Services are identified in a more conscious way, taking into account the needs of the city from within the government. The transactions are oriented to perform some procedures, access and download information through institutional portals. Citizens can do paperwork, queries through institutional portals, mobile apps and emerging technologies. The services have minimum guarantees of quality, availability and security. There are several online services available, which are used by citizens in a systematic way
Management Data	Open Linked Data	2	They partially comply with the characteristics of public, free, online, machine readable, open license. Some of the formats are structured, access is easy and data is downloaded, very few offices in the city have availability of datasets, although the available ones are characterized by easy access and discovery. There is awareness of their existence, some strategies started from the cities for exploitation and use. Possible stakeholders (other offices, academy and companies) are disclosed. There are some initial projects or experiences.
Management Data	Analytics	0	There are no capacities or information.
IT infrastructure	Interoperability	2	Information exchange services are provided or consumed according to the type of information exchange service and evaluate the results of the provision of information exchange services and compliance with agreed service levels. The city consumes and provides information exchange services, in accordance with the standards and recommendations proposed in the regulations. The entity uses the elements provided by the common language for the exchange of information in some information exchange services. The city develops or adopts the legal mechanisms for the provision and consumption of information exchange services.
Management Data	Indicators Table	1	The importance of scorecards for the collection and centralization of information is recognized, but they are not used for decision-making or do not exist.
IT infrastructure	Public Connectivity	1	There is awareness of the need to have Wi-Fi zones to improve community access to the internet.
IT infrastructure	Sensors	1	There are no established procedures for the use of devices. The use of devices is sporadic and informal.
IT infrastructure	IT operation	2	A risk management policy is defined. When and how to conduct risk assessments is documented. Responsibilities for IT security are clearly assigned, managed and implemented. Security policies and practices are complemented by specific safety references and standards. IT security enablement is planned and managed to meet security risk needs and profiles. The IT continuity plan is documented and based on system criticality and impact.

- In many cases, the maximum value in the indicators, according to the sources, does not imply a real maximum capacity level, particularly in some subjects such as innovation or interoperability in which it is known that the capacities at country level are incipient or very limited.

In spite of the limitations, it is important to emphasize that an analysis could be made taking as reference official and public information from the datasets. Also, an interesting exercise in the use of open data for research projects was generated, which is one of the objectives of the dissemination and publication of the projects. Furthermore, from the architecture of the model it is possible to

find or define relevant indicators to each of the KDA and CV of the model to make quantitative and qualitative assessments of the IT capacities in a city as shown in the application case.

Among the application findings, it can be seen that the model allows an initial diagnosis of IT management capabilities. Among the results of the case study, we can see a greater capacity of management associated to the domains of infrastructure and service. There are significant advances in the domain of strategy and innovation but, on the other hand, the weaknesses are predominant in the data domain. These results are justified given that the issue of data management is a problem that has recently been addressed in government agendas from the issues of big data, analytics and open linked data. Technical and human capabilities are incipient. A better capacity in the strategic domain would be expected, since the national government has been promoting e-government programs through public IT policy. These programs have had a positive impact that is evident in different international rankings such as E-Government Index and E-participation Index in which Colombia has been making significant progress. On the other hand, in the domain of innovation through the center of public innovation of Colombia, actions have been advanced in relation to the forming of human resources and in strengthening the strategies to consolidate relations between university-company-state through policies and incentives.

CONCLUSION

Current approaches to smart cities are varied, most of which focus on areas of application like targeting the expected impact, and others focusing on the aspects of information technology as an enabling factor for these initiatives. Based on the proposed conceptual model, it is possible to generate added value from the governance and IT management approach of the cities, taking into account technological and operational capacities and strategic and innovation capacities in order to understand the role of technologies in the development of smart cities from a holistic and systematic perspective. Likewise, the model can become an evaluation tool to guide decision making from the assessment of key areas and critical variables proposed.

With the advance and emergence of new trends in the field of IT (big data, cloud computing, open data), these can increasingly offer better and greater facilities to cities, to innovate in the provision of services and establish new dynamics between citizens and governments. Thus, a model of a smart city must be flexible, dynamic and innovative in such a way that technology becomes a mean and not the end of them.

In applying the model, it is expected that certain capacities will be developed: increased organizational capacity, use of information as a strategic asset, improved access to data and information, institutionalization of data management, information and knowledge, promotion of a culture of digital access and innovation through information technology in cities. These capacities will consolidate the construction of smart cities especially in developing countries, which have more limited capabilities from the technological point of view.

For future works, it is expected to define evaluation mechanisms as maturity models, indexes or rankings, based on the architecture of the proposed model. This will allow the instruments to diagnose, plan and evaluate the advances of IT management capabilities, allowing cities to favor initiatives or projects of smart cities.

REFERENCES

Alcatel, L. (2012). Getting Smart about Smart Cities Recommendations for Smart City Stakeholders. Whitepaper. Retrieved April 20, 2016 from http://enterprise.alcatel-lucent.com/assets/documents/120605_FINAL_M2012042836_Getting_Smart_about_Smart_City_EN_MarketAnalysis.pdf

Australian Government. (2011). Australian Government Architecture Reference Models. Retrieved May 14, 2017 from http://www.finance.gov.au/policy-guides-procurement/australian-government-architecture-aga/aga-rm/

Branchi, P., Matias, I., & Fernandez, C. (2013). City & technology: An analysis matrix to serve citizens. *Paper presented at the International Conference on New Concepts in Smart Cities: Fostering Public and Private Alliances (SmartMILE)*, Gijon. doi:10.1109/SmartMILE.2013.6708179

British Standard Institute. (2012). UK Government Reference Architecture (UKRA). Retrieved May 14, 2017 from https://www.gov.uk/government/publications/uk-government-ict-strategy-resources

British Standard Institute. (2014). Customer service Smart city framework – Guide to establishing strategies for smart cities and communities Retrieved May 15, 2017 from http://shop.bsigroup.com/upload/267775/PAS 181 (2014).pdf

Caragliu, A., Del Bo, C., & Nijkamp, P. (2011). Smart cities in Europe. *Journal of Urban Technology*, *18*(2), 65–82. doi:10.1080/10630732.2011.601117

Cohen, B. (2012). The smartest cities in the world 2015: Methodology. Retrieved January 4, 2017 from https://www.fastcompany.com/3038818/the-smartest-cities-in-the-world-2015-methodology

Deloitte. (2015). *Smart Cities: How rapid advances in technology are reshaping our economy and society*. Retrieved from https://www2.deloitte.com/content/dam/Deloitte/tr/Documents/public-sector/deloitte-nl-ps-smart-cities-report.pdf

Gaulė, E., Jurgita, Š., & Jolanta, S. (2015). Smart Public Governance: dimensions, characteristics, criteria. *Paper presented at the International Research Society For Public Management Conference*, Birmingham, London.

Giffinger, R. (2007). *Smart cities-Ranking of European medium-sized cities*. Retrieved September 17, 2016 from http://www.smart-cities.eu/download/smart_cities_final_report.pdf

U.S. Government. (2012). The Common Approach to Federal Enterprise Architecture. Retrieved May 14, 2017 from https://obamawhitehouse.archives.gov/omb/e-gov/FEA

Kettinger, W. J., & Lee, C. C. (2005). Zones of tolerance: Alternative scales for measuring information systems service quality. *MIS Quarterly & The Society for Information Management.*, *29*(4), 607–623.

Maestre, G. P. (2015). Revisión de literatura sobre ciudades inteligentes: Una perspectiva centrada en las TIC. *Ingeniare,* (19), 137-149.

Maestre, G. P., & Nieto, W. (2015). Factores Clave en la Gestión de Tecnología de *management & innovation, 10*(4), 109-117.

Maestre, G. P., & Nieto, W. (2016). Validation architecture for information technology management in smart cities. *Paper presented at the 2016 11th Iberian Conference on Information Systems and Technologies (CISTI)*, Las Palmas, Spain.

Mani, D., & Banerjee, S. (2015). *Smart City Maturity Model (SCMM)- BSI*. Retrieved May 14, 2017 from http://isbinsight.isb.edu/smart-city-maturity-model-scmm/

Manville, C., Cochrane, G., Cave, J., Millard, J., Pederson, J. K., Thaarup, R. K., . . . Kotterink, B. (2014). *Mapping Smart Cities in the EU*. Retrieved May 14, 2017 from http://www.europarl.europa.eu/RegData/etudes/etudes/join/2014/507480/IPOL-ITRE_ET(2014)507480_EN.pdf

Morales, L., Torres, J., Parra, A., & Campos, D. (2014). The Colombian Government Enterprise Architecture Framework. *Paper presented at the 2014 Conference on Electronic Governance and Open Society: Challenges in Eurasia*, St. Petersburg, Russian Federation.

Moreno Alonso, C. (2016). *Desarrollo de un modelo de evaluación de ciudades basado en el concepto de Ciudad Inteligente (Smart City) [Tesis Doctoral]*. Madrid: Universidad Politecnica de Madrid.

Nam, T., & Pardo, T. A. (2011a). Conceptualizing smart city with dimensions of technology, people, and institutions. *Paper presented at the 12th Annual International Digital Government Research Conference: Digital Government Innovation in Challenging Times*. doi:10.1145/2037556.2037602

Nam, T., & Pardo, T. A. (2011b). Smart city as urban innovation: Focusing on management, policy, and context. *Paper presented at the 5th International Conference on Theory and Practice of Electronic Governance*. doi:10.1145/2072069.2072100

Neirotti, P. (2014). Current trends in Smart City initiatives: Some stylised facts. *Cities, 38*, 25-36. doi:10.1016/j.cities.2013.12.010

New Zealand Government. (2015). Government Enterprise Architecture for New Zealand (GEA-NZ) Framework. Retrieved June 14, 2017 from https://www.ict.govt.nz/guidance-and-resources/architecture/government-enterprise-architecture-for-new-zealand-framework

Scottish Government. S. C. A. (2015). *Smart Cities Maturity Model and Self-assessment tool*. Retrieved June 2, 2017 from https://www.scottishcities.org.uk/site/assets/files/1103/smart_cities_readiness_assessment_-_guidance_note.pdf

The Open Group. (2009). *Architecture Framework (TOGAF) Version 9*. The Open Group.

Yesner, R. (2011). Análisis de la ciudades inteligentes en España (white paper). Retrieved May 14, 2017 from http://www.socinfo.es/contenido/seminarios/1404smartcities6/02-IDC_Smart_City_Analysis_Spain_2012.pdf

Young, C. Y. (2011). Measuring enterprise IT capability: A total IT capability perspective. *Knowledge-Based Systems*, *24*(1), 113–118. doi:10.1016/j.knosys.2010.07.011

Zachman, J. (1987). A framework for information systems architecture. *IBM Systems Journal*, *26*(3), 276–292. doi:10.1147/sj.263.0276

Zhang, M., Sarker, S., & McCullough, J. (2008). Measuring information technology capability of export-focused small or medium sized enterprises in China: Scale development and validation. *Journal of Global Information Management*, *16*(3). doi:10.4018/jgim.2008070101

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