relato de pesquisa

MULTIDIMENSIONAL INFORMATION SYSTEM MODEL FOR STRETEGIC DIGITAL CITIES

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ABSTRACT
Information technology and digital public services are essential components for cities providing intelligent and customized information to the citizen's needs. As one of the multiple challenges of the strategic digital city, the researching objective is to propose a multi-dimensional information system model for cities. The research methodology is based on the Model Theory, considered the circumstantial reality, helped by the bibliographical survey and the non-participative observation. The data was collected hierarchically through the Infomapping technique, and five co-related international information system models were analyzed and compared. The result presents the multi-dimensional information system model articulated to the research constructs. The conclusion reemphasized the multi-dimensional condition of information through its dynamic nature, constituting as a strategic element for information systems, and also digital cities with the creation of a virtual social dimension, based on the new interactive relations among the multi-dimension information, citizens and the city.

Keywords: *Information systems. Information technology. Multi-dimensional information. Management information systems. Strategic digital city*.

Artigo submetido em 12/08/2019 e aceito para publicação em 30/09/2021

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1 INTRODUCTION

The cities have emerged throughout humankind history over different purposes, and after the industrial revolution, the digital urbanization process consolidated. The resources of information technology arise to give vent to the needs of the city. Cities, as a reflection of their policies and their citizens' longings, walk in the same evolutionary context, as information resources lead to a convergence between humans and the things that surround them by regularly using their technological devices to store and process the volume of data produced. Technologies can drive the dynamics of cities by extracting valuable information from data that provides long-term sustainability and the creation or optimization of services for their citizens.

The demand for new digital public services, influenced by the ability of information technology resources to integrate, process and analyze the data of the city, arises as a necessity for the strategic development of digital cities. The adoption of a multi-dimensional and an intelligent information management system that interacts and connects different systems with the technological needs of citizens presents itself as an option to the dynamism of social relations in digital cities (Longo, 2011; Jara *et al*., 2013; Lacerda, 2015; Pan *et al*., 2016; Flores and Rezende, 2018; Rezende Procopiuck, 2018). With the bulwark of access to information, cities and urban areas are integrated into a technological context in which information management contributes both to cost reduction and to productivity gains in the public service sectors, insofar as it helps decision-making, understanding the multi-dimensionality of information in digital cities thus avoiding the strategic blindness described by Viktor Arvidsson *et al*., (2014).

The data and information networks that involve cities, organizations and citizens grow in line with the maturity of the Internet and the use of technologies to manage them in different systems and at different levels of decision-making. The multidimensionality of information, in turn, is not limited to the internal environment of public management because it transits through strategic information management, permeates the external environment and establishes interactions with the different actors of the municipality. An information system focused on strategic information management provides an integrated and consistent environment, capable of creating and making available the necessary information to its users, facilitating access to

information at different levels and, thus, helping decision making (Gillingham and Graham, 2016). However, the information dispersions, in the context of the Strategic Digital City (SDC), integrate an information flow model whose orderly movement and at different levels confers agility and strategic accessibility regarding the use of specific technologies (Yan and Ma, 2013; Demurjian *et al*., 2015; Sorokine, 2016; Pan *et al.*, 2016; Barth *et al*., 2017).

The research problems also arise as the city ceases to be just physical, with its constructions and streets, becoming a digital city, where the circulation of information assumes a relevant role, going beyond the common sense that refers to the idea of creating an official website of the city as a way to make the digital city. The information in digital cities is available in specific environments. Nevertheless, they are not necessarily customized to the needs of the citizens and integrated into the different virtual management networks. Public information as part of Public Policies in digital cities is available in specific environments, but not necessarily customized to citizens needs and integrated into the different virtual management networks. (Longo, 2011; Pan *et al*., 2016; Mainka et al., 2018; Rezende and Procopiuck, 2018).

The objective is to propose a multidimensional information model for the strategic digital city. Digital city is based on conceiving and realizing the technological interface as a strategic element, customizing the activities and public services, more than information access, integrating the public policies to he higher operational capacity of the public sectors, which can be aligned and also strategically customized. (Bouskela, 2016). The digital environment through which large amounts of information travels in an intelligent autonomous way, taking advantage of the opportunities associated to the extensive network of connected devices, virtualizing the relations of services in the cities (Jara *et al*., 2013; Barth *et al*., 2017) contributing to the multi-dimensional urban environment.

The research justifications are based on designing and realizing a technological interface whose destiny is to enhance the performance of the city's activities and services, disseminating informative access to the satisfaction of citizen's needs and the higher operational capacity of the various sectors of the city. It is also connected to the city public policies as strategies to support local development and social inclusion, giving citizens the empowerment to make better decisions or choose better options. Notwithstanding, justified by the advancement of democratization of public

information of the city, centring on citizenship, the formation of participatory communities, informed and knowledgeable about their social importance. As a contribution, the research can be justified to the scientific knowledge considering as well as connecting different areas; urban information system, strategic digital cities (Li *et al*., 2015; Bouskela, 2016; Barth *et al*., 2017; Rezende, 2018).

2 THEORETICAL FOUNDATIONS

The world is turning into an urban world. Just as the cities of industrial society arose in the mid-nineteenth century, or the cities of the service society in the second half of the twentieth century, there will be or will arise, cities typical of the information society and knowledge (Longo, 2011).

2.1 Information management

Information management is a set of structured activities that express how an organization captures, distributes and uses the information, and the function of identifying the correct use and enhancement of the information resources of an organization remains. In this same scenario emerges the information-oriented management: information-oriented management of technology, information-oriented management of content and knowledge. The emphasis of technology-driven management is translated by the efficient use of information technology, while content-oriented management focuses on information, its dynamic nature, and context. The highlighted emphasis, the construction of the logic of the informational model, should be manageable and useful to its users and in harmony with the technologies used since the condition of its use does not necessarily translate into informational value or guarantee of performance (Detlor, 2010; Valentim and Ançanello, 2018).

With the increased use of different technologies and management, the Information System (IS) gained prominence, highlighting its strategic value for decision making, becoming an integral part of city activities and public services (Rezende, 2012; Rezende and Procopiuck, 2018). Information System is defined (Laudon and Laudon, 2015) as an interrelated set of elements that collect, process and distribute information to support decision making and control of an organization. Dolci and Becker (2007),

contribute with the same line of thinking and suggest the need for a systemic process from the collection and analysis of the informational data to its distribution, contributing to the strategic decision making. Therefore, an information system can be the organized combination of people, software or procedures that store and disseminate information in an organization. The main characteristics of an IS are the relations of interdependencies between the variables that make up the said system, as well as the hierarchical levels of the data. The variables of an IS establish a relationship of synergy and coherence in all directions, vertical and horizontal. At its base are stored all the detailed data of organizational functions, including the external environment (Alaimo, 2016; Rezende and Procopiuck, 2018).

Colluding with the conceptual construction of information systems, different authors present the need for other components to carry out their tasks in an organized way. In this scenario, Lacerda (2015) and Rezende and Procopiuc (2018) add to the previous definition, the interaction element between the parts that make up the IS, forming the unitary combination. They thus converge the authors to conclude that an information system is the product of three components: organization, technology and people. The dimensions of an IS must be known as the technical aspects of the organization and the people so that its use is efficient. The information systems have acquired a strategic character included as elements of support for the operations of the public activities. The construction of an informational system starts with the use of dimensional bases for its operation, highlighting the structure of the database incorporated into the system. Still, in the construction of informational systems, the conceptual informational design uses dimensional elements of configuration, in layers and with different levels of structure, establishing inter-relations and articulation between the elements of the composition of the informational system.

The articulations exerted by the IS through the triangulation of the different informational levels, connect and assist the management and dissemination, allowing the evolution of IS for customized information architecture, making it relevant to the users of the systems in different contexts. The concept of systems evolution differs from the evolution of physical goods by dealing with changes in the same system with a focus on improvements. A form of characterization of the evolution of the IS establishes relations between the six stages of conception: I - Initiation; II - Contagion; III - Control; IV- Integration; V- Data Administration and VI - Maturity. The vision in

cycles relating concepts, structures and technologies is presented by Rezende (2015); a) Manual information system: all processes are performed manually without the use of computer resources; b) Automated information systems: mechanical, pneumatic, electrical, electronic, robotic resources are added to assist and contribute to the operation of the processes. These systems are widely used in industrial, commercial and banking automation processes; c) Mechanized information systems: no added value occurs since the processes and procedures are transferred to the computer in the same way that they functioned manually, and intelligence values are not aggregated into their processes that facilitate operations. Even so, rationalization is favoured when there is a minimized repetitive process; d) Computerized information systems: processes are aggregated intelligence values that facilitate operations and the generation of useful, timely and integrated information; e) Management and strategic information systems: they provide information, preferably computerized, to assist the decision-making processes, mainly the tactical and strategic levels of the company. The evolution of an IS, whether due to changes in requirements or the development of new information architecture, therefore, arises from the need to apply a restructuring process, which considers the nature and dimensions of the component variables of the new system and the user needs (Lacerda, 2015; Montero, 2015; Laudon and Laudon, 2015; Li *et. al*., 2015; Alaimo, 2016).

On the other hand, digital cities are institutions that are responsible for providing digital services to citizens. Municipal governments need to collect data, create a context for the information and share with citizens or stakeholders. However, most cities are unable to perform the required services due to lack of resources, deficiency of modern administrative techniques, standards of care, or even an inability to establish cooperation at the local level.

The problems faced by urban information systems and the increased demand for digital public services go through technological innovation. Access to information technology is one aspect of Urban Information System, recognized as (UIS). The Urban Information Systems, defined as an advanced information system capable of providing services to citizens based on information technology infrastructure, facilitating interactions between information, citizens, public services and managers. (Geymen *et al*., 2008; Leem *et al*., 2014; Lee *et al*., 2014; Barth *et al*., 2017). The UIS uses data generated from subjects and objects, including various urban facilities,

organizations and individuals that have been collected and compiled by municipal governments, public institutions and companies. Shared and contextualized data provide citizens and public managers with a detailed understanding of the status of urban operations, contributing to the generation of meaningful information to the citizen, optimizing public resources, reducing operational costs and contributing to the smart development of cities. The UIS derives from the integration of the information generated during systemic operations of informational, physical and human activities management in a city. In this context, urban information extrapolation generates complex relationships in the operational status, tendencies of relationships within different areas such as health, education, science, technology and culture. Therefore, the UIS provides contextualized information for each reality and plays an essential function in the development of a digital city (Longo, 2011; Sorokine, 2016; Pan *et al*., 2016; Barth *et al*., 2017).

2.2 Digital, smart and strategic digital city

The primary concepts expand to the idea of a platform to foster the formation of community networks, integrating and making available online the urban information of the respective cities. One of the concepts for smart city proposed by Fernandes and Gama (2006), relates creativity and knowledge, once the smart city integrates the territorial issues interconnecting the digital, with the real, representing the first stage of the formation of smart cities. In the same conceptual and temporal line, Komninos (2008) presents the smart cities as zones or regions, where the local system of innovation is supported and updated through networks and digital applications. The use of information technology makes the functions of the smart city more open and active. The essential components of smart cities are innovation and information and knowledge. The innovation system guides the development of knowledge and technologies in entities, such as companies, universities, technology centers, incubators of activities and the digital applications of information and knowledge. They concentrate on the diffusion of information, communication, decision-making, transfer and application of technologies, collaboration for innovation. The Smart Cities are conceptualized through the collection and organization of the digital information of the city to provide an information space for

an interaction between the inhabitants and the visitors of the city (Ishida and Isbister, 2000; Li *et al*., 2003; Komninos, 2008; Stock, 2011; Dameri, 2012; Fietkiewicz and Stock, 2014; Pan *et at*., 2016; Patašienė and Patašius, 2014).

The interaction between managers and citizens must also be present in the smart city, since Smart Cities projects plan and make available information, systems and services to their managers and citizens. The plans for the implementation of the Digital City refer to the three levels mentioned in the natural, institutional and digital space of the contemporary city: people, collaboration institutions and digital tools for knowledge management and innovation. The term smart cities refer to territories of different scales that include the competence to include education, technological development and innovation procedures, digital spaces, information processing, knowledge transfer and technological instruments (Fernandes and Gama, 2014).

Considering the similarity between the conventional Digital City, Smart City, the Strategic Digital City (SDC), can be understood as an application of the resources of the information technology in the management of the municipality, as well as in the provision of information and services to the citizens (Rezende, 2018). Consequently, in this technological context exists a more comprehensive project than just offering the internet to citizens through conventional telecommunications resources, and in this way goes beyond digitally, including citizens on the world wide web. The SDC project is based on the city's strategies to meet the objectives of the different municipal themes.

Therefore, implementation requires the elaboration of the projects, Strategic Planning of the Municipality (SPM) with the municipality's objectives and strategies using municipal functions or themes; Planning of Municipal Information (PMI) and Planning of Information Technology (PIT) of the city hall and the public organizations involved. The information models of public functions or themes are the main products of the PMI project, which are prerequisites for the planning of Municipal Information Systems (IS) and Knowledge Systems (KS) and their required Human Resources (HR) profiles, whether they are local managers, municipal officials. The PIT project allows the planning of the Information Technology (IT) resources and owns municipal services offered by the municipality to the citizens (Rezende, 2012, 2018).

Strategically, the municipal themes are macro activities present in all cities and are necessary for their integrated and effective functioning. There are several

municipal themes: agriculture, science and technology, education, sports, health, safety, municipal services, transportation, among others. Each of these functions can be dismembered into modules, which can also be called municipal issues (Setim 2015, Teixeira *et al*., 2016). The integration and execution of the strategies of the city appear as a challenge to the public managers, and the information happens to play an essential tool of the integration of the different strategies of the Digital Cities.

Conceptually the term strategy is about the organization and the environment; the essence of the strategy is sophisticated; the strategy affects the functioning of the organization. The strategy involves questions related to the determined path, as well as the process of determining this path, the strategy performed almost is never the same as planned, strategies exist at different levels of the organization and hence involve an exercise in concept definition and reality analysis (Setim, 2015; Rezende, 2018). The integration and execution of the strategy emerge as one of the organizational challenges insofar as the information plays the role of a tool. When organizations prioritize the management of information, they obtain superior performance, and the strategy materializes effectively, from three perspectives: the information and definition of the strategy; the information and execution of strategy and information and integration. One of the strategic elements of cities, therefore, is related to the capacity of information management and its connections to different contexts (Arvidsson, 2014; Rezende 2018)

3 RESEARCH METHODOLOGY

The research methodology emphasized an applied nature approach of a circumstantial theoretical reality, based on the Model Theory with an emphasis on the deductive method, as well as the nonparticipatory observation of the informational systems. In this methodological setting, different concepts guided the research by approaches, models and configurational techniques, denominated comparative methods, considering a complex, longitudinal and multilevel nature. In this way, the methodological design emphasizes the quasi-mixed method, due to the use of qualitative data of the infometric mapping and relevant information, derived from non-participatory observation, for later adaptation and elaboration of the proposed model.

On the other hand, the quantitative data, numbers and levels, of the infometric interactions for the formation of graphs and convergent information networks through Social Network Analysis, which allow a meta-inference of the data, that is, a conclusion generated from the exploration and integration of the inferences obtained from all the methods employed (Teddlie and Tashakkori, 2009; Yin, 2014; Severino, 2017).

The research phases were: 1) the literature review; 2) identification of the constructs of related models; 3) development of the new model for the strategic digital city. To deepen the understanding of the scientific production in the area, a research of the terms and booleans equivalent smart city, digital city, urban information city, was developed in February of 2018 in the Web of Science database. The hierarchization of the results provides a disconnection between the scientific productions represented Table 1.

Table 1 - Boolean hierarchical search results in the Web of Science base

Positions / Criteria	1st	2nd	3rd	4th
Research Area	Smart City (Computer Science) (47,70%)	Digital City (Computer Science) (47,52%)	Urban Inf. System (Computer Science) (47,52%)	Urban Management (Urban Studies) (26,06%)
Year of Publication	Smart City (2016) (33,39%)	Urban Inf. System (2014) (14,28%)	Urban Management (2016) (12,32%)	Digital City (2010) (7,96%)
Country	Digital City (Republic of China) (57,96%)	Urban Inf. System (Turkey) (25,01%)	Urban Management (Republic of China) (22,79%)	Smart City (Italy) (16,15%)
Authors	Urban Inf. System (DURDURAN, SS) (7,14%)	Digital City (ISHIDA, T) (2,74%)	Urban Management (WANG, L) (0,65%)	Smart City (NESI, P) (0,50%)

Source: authors based on Web of Science (2019)

The investigation method followed the assumptions of Yin (2014), through quasi-mixed methods that will be supported by Social Network Analysis Methods and Configurational Comparative Methods (Teddlie and Tashakkori, 2009), nonparticipatory exploratory observation (Severino, 2017) of information management systems related to the development of a new model of multidimensional information system for the SDC.

The research variables identified in the correlated models, and by the infometrics analysis of the indexed production in the scientific base used, make up the protocol for the development of the new model and are linked to the three constructs: multi-dimensional information; public services and strategic digital city.

4 PROPOSED MODEL AND DISCUSSIONS

The proposal of a multi-dimensional information management model for the strategic digital city considered the correlated models identified and studied for digital cities and smart cities, focusing on the strategic information elements of the respective systems. In this context, the related Yountaik Leem Models, developed at the National Hanbat University, South Korea, 2014, the Yunhe Pan Model developed at Beijing University, China in 2016, the Model of Alexander Sorokin developed at the University of Tennessee, United States of America in 2016, the Model of Julia Barth, developed at the University of Duesseldorf, Germany in 2017.

The construction of the proposed model under the theoretical bias and supported in the experiences of the related models, led to an anticipated conceptual analysis of the connecting elements for its composition. Consequently, elements that did not present an intersection with the information for the development of the strategic digital city were naturally discarded while still in consonance with the objective of the research. Information emerges as a central and strategic element for digital cities since it allows the connection of different levels of information to the strategic management of the city.

4.1 The proposed model developed

The investigations for modelling a multi-dimensional information system began in the revision of the thematic literature, and the informational multidimensionality emerged as one of the elements of virtual information systems. The concept of Virtual Enterprise of this author appears to the extent that it presents the access, interconnection and sharing of the same informational base by different organizations, supported by systems and computer networks that use information technology as a strategic tool.

In this technological scenario of the multi-dimensional management of information for the digital city, the first versions of the model appear, through the convergence of the elements, Public Policies, Strategic Management and Urban Information Management in a common point: informational management in different dimensions in the strategic digital city. The preliminary versions of the proposed model presented the interconnections of the composition elements, as a point of convergence for information management in the strategic digital city. Also, in a preliminary context, the intermediate version of the proposed model was elaborated, an interpretive variation of the first version, focused on the spatial view of the relations of its constructs, considering the strategic digital city as central element of the model, interconnecting strategic management, information, urban management, strategic blindness (Arvidsson et al., 2014), and the multidimensionality of information.

The final version of the model developed converges theoretical bias, supported by the experiences of the related models, led to an anticipated conceptual analysis of the composition elements. Hence, elements that did not present an intersection with the information for the development of the strategic digital city were discarded. Hence, elements that did not present an intersection with the information for the development of the strategic digital city were discarded. Nevertheless, the objectives remain aligned with the research.

With the proposed model, information emerges as a central and strategic element for public policies and digital cities since it allows the connection of different levels of information to the strategic management of the city. The Strategic Management elements were disconnected from the model, since their concept is equally accepted as the element strategic digital city, the aspect Strategic Blindness,

also its conception is implied to the strategic management, whose amplitude surpasses the research objective, that presents methodological cut in the multi-dimensional character of the information as a vital element of information systems for digital cities.

4.2 The proposed model constructs

The proposed Multi-dimensional Information Management model is constituted by three constructs: Multi-dimensional Information, Public Services and Strategic Digital City. Each construct is composed respectively of different variables. They are Construct Multi-dimensional Information, availability of information; type of information management; type of information architecture; Construct Public Services: number of public services; the name of public services; types of public services. Construct Digital City Strategic: name of the theme; the number of topics; the name of strategy and number of strategies.

The conceptual basis of the model arises from a bibliographical reference survey, from the analysis of related models, from the incorporation of new information technologies, despite their multi-dimensional capacity and the results of the exploratory studies, developed in systems of information management in cities digital images. The proposition of the model, considering the originality of the present study, urges the convergence of the strategic digital city with the combination of information in its multi-dimensional conception, thus reiterating the arguments presented in a specific chapter that dealt with the articulations of the themes and originality. The model proposed and named as an Information Management Model for the strategic digital city is constituted of constructs and variables that, in turn, when they articulate, converge to a multi-dimensional model integrating different information systems, consolidating its dynamic character.

The Information conceived in its architectural state as a pattern of matter and energy organization to which some meaning has been attributed. The multi-dimensional nature of the information provides different possibilities for connections to different City Information Systems. The dynamic character of the information duly attributed to the particular construct is represented by cubes and its possibility to rotate around its axis, exposing different faces and spatial arrangements to each variation, its multi-dimensional capacity.

4.3 The multi-dimensional information construct

Three variables formed the multi-dimensional information constructs. I) information availability variable: it comprises the structure of public information available, its specific connection to the citizen, and the dynamic customizations for the personalization of meaning. This variable converges contextualized data to the citizen who in turn constitutes information, whose dynamicity of its connection in different interpretative contexts, typifies its capacity of significance. Therefore, the informational multidimensionality that shapes the need for the search, the specificities of the management systems or the parameters of customization. II) Types of Management: it understands the different types of systems, specificities, complexities and capacity of the interrelationship management information in specific contexts. The management type variable relates but is not restricted to the systems used by the CDE for handling information at different levels such as (ERP) Enterprise Resource Planning; (MIS) Management Information System; (AS) Administrative Systems; (DBMS) Database Management Systems; (DW) Data Warehouse; (AI) Artificial Intelligence; (SE) Specialist Systems; (DM) Data Mining; (TPS) Transaction Processing Systems and (DSS) Decision Support Systems.

The multidimensional capacity of the respective variable urges in its ordered arrangement of each system of origin that composes the complex system of the city without losing the context of the customization of meaning to the citizen. III) Information Architecture Type: understands the different types of informational architecture for the development of digital cities focusing on intelligent systems, which include, but are not limited to; Functional Layer Architecture; Reference Architecture; Domain Architecture. The variable information architecture type arranged in a perspective of the spatial structuring of informational modelling, with the purpose of analyzing the different informational interconnections in a specific context of the strategic digital city. The functional architectural type in two-dimensional layers identified in Leem et al., (2014); Lacerda, (2015); Pan et al., (2016) confirm that the layers communicate and promote the city's functionalities. The Management layer interacts with the features, the Security layer prints reliability to procedures. Both provide articulation to the other layers involved and their respective elements of composition. However, the model expresses a two-dimensional directional action of the use of city information and management

systems, since data can receive different contexts and constitute different information for different citizen users.

On the other hand, the proposed model starts from the dynamic and multidimensional nature of information, with emphasis on customization, in this context proposed through informational multidimensionality, which shapes the need for search, analogous to the faces of a cube and its different combinations, to the specificities of the city management systems, or even to the parameters of its limitations. Therefore, the proposed model starts from the dynamic and multidimensional nature of information, with emphasis on customized information on public services.

4.4 The public services construct

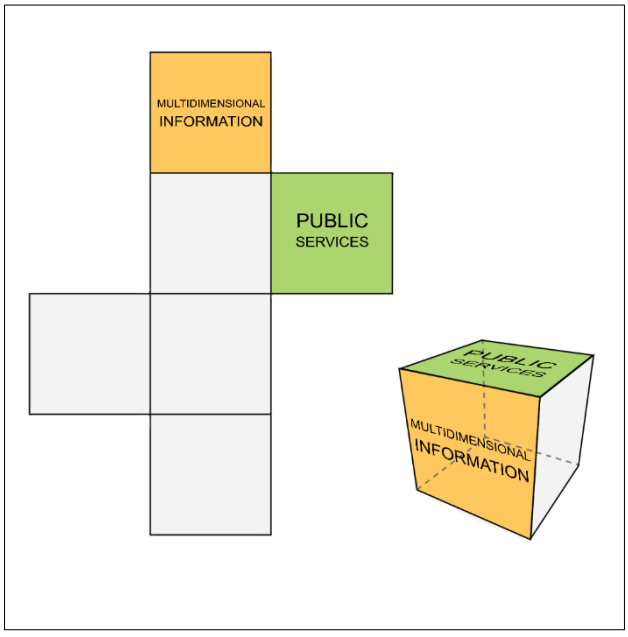
Considering the constitutive definition of the strategic digital city, where public services are available to the citizen, the CDE is developed in an infrastructure-based environment, virtual of a social and technical nature that in turn incorporates itself into the specifics of its citizen actors through their desires, demands and convictions. The public services construct, proposed by the present informational management model, are essential components for the development of the strategic digital city (Rezende and Ribeiro 2018) and are offered with the aim of providing citizens with a quality of life through the strategic informational accessibility, customized to the individual needs and collective.

In this context, the public services construct of the digital city developed with three variables: the number of public services; the name of the public services and the types of public services. Also, represented by the figure of a cube to provide a three-dimensional understanding of its participation in this model proposal. The variables that integrate the construct are IV) Number of Public Services: it comprises the number of virtualized public services of the municipality and made available to citizens through its different information management systems, integrated or not to the same management base. The digital city, in its strategic context of articulation of the mentioned virtualized public services, remains as the gear of data recovery by municipal theme and recurrence of the autonomy of will of the citizen actor. However, the multidimensional nature of the information and the capacity of articulation in different systems implies to the municipal public services the possibility of

customization of meaning, beyond the synchrony of data in Websites, to an arrangement and availability of multidimensional services relating informational specificities to different management systems. V) Names of the Public Services: it comprises the respective names of the municipal public services virtualized and made available to the citizens, of regular order and not repeated, through its different information management systems, integrated or not to the same management base. The variable Public Services Name, through its singular character and non-recurrence, brings the informational convergence of recovery that in turn discards duplication of public services in different management systems. VI) Types of Public Services: identifies the municipal issues in which public services attached, their information repository, the preference and specificities of the citizen's search.

The public services of the CDE, in a multidimensional strategic character, dynamically compose the model with the construct information represented in Figure 1.

Figure 1 - Multidimensional Disposition of Public Services



Source: authors (2018)

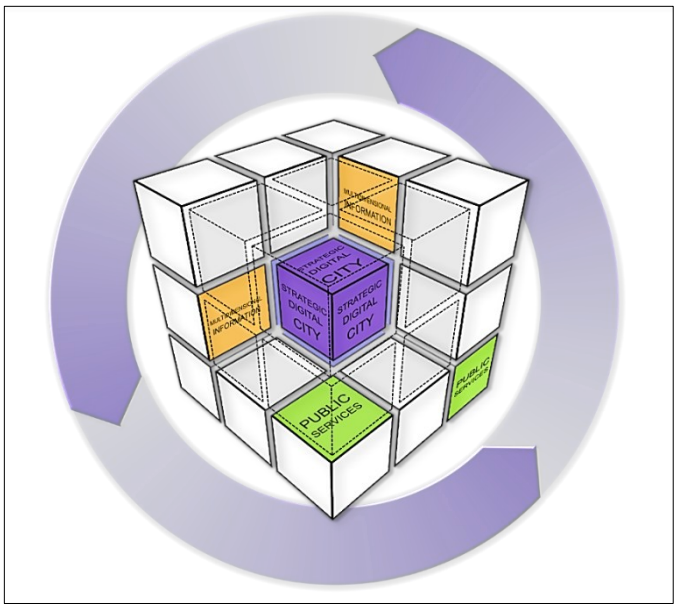
The local themes, concerning the suggested model, represent the link of the public services offered by the City (Rezende and Ribeiro, 2018), with the possible qualitative customizations, considering dynamic and multidimensional information criteria.

4.5 The strategic digital city construct

The strategic digital city construct was formed by four variables relating to strategic digital city issues and public policies. The variables listed are in line with the conceptual framework defined for the CDE, which can be understood as the application of information technology resources in the management of the city and also in the provision of information and services to citizens. The Informational model through its specificities and variables articulate different information management systems from the application of technological resources represented in cube format, providing evidence of interconnections and contexts of the construct composition variables. The alignment of the themes with city strategies, when dynamically articulated, gives the city's information systems the ability to process data in customized information to management needs.

The SDC construct attends to the specificities of multi-dimensional information, evidencing the structures of the proposed model, considering the combination of the variables.

Figure 2 – Strategic digital city construct



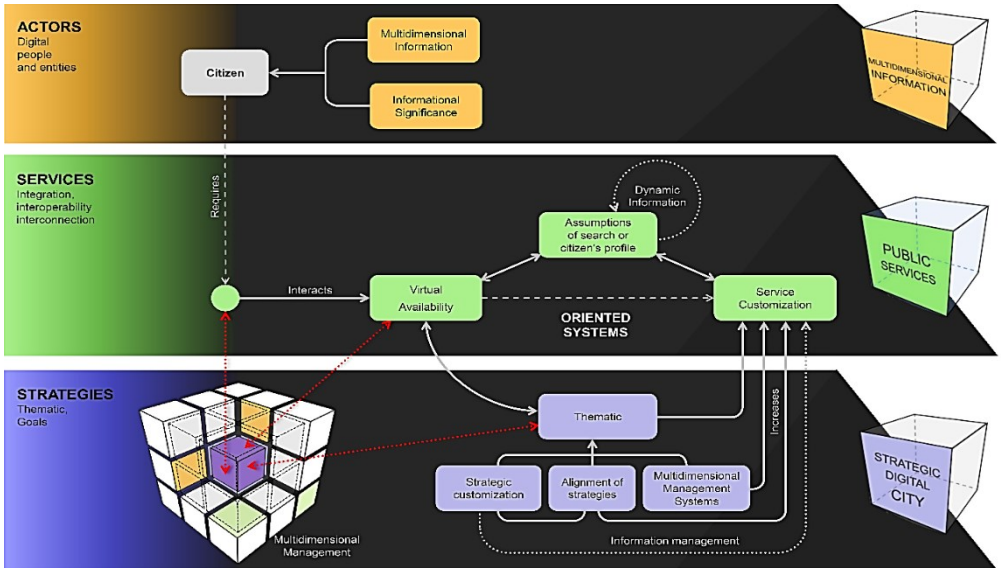
Source: authors (2018)

The multidimensional context in which the strategic digital city construct is represented, represented by the figure of a cube and its faces, demonstrates its dynamic ability to orient the compositional variables of the systems described as VII) Number of Themes: map the number of themes or functions that are necessary for the

integrated and multidimensional functioning of the city, considering that such themes can be broken down into subsystems, VIII) Name of the Thematic: identify the names of the themes or functions necessary for the integrated and multidimensional functioning of the city, considering that such themes can be IX) Number of Strategies: map the number of strategies of the construct, with the respective theme that compose the strategies for the integrated and multidimensional functioning of the city, X) Name of the Strategies: relate the names of the strategies of the construct, and their respective themes to the integrated and multidimensional functioning of the digital city.

The strategic digital city through its constructs and its variables described above, articulates the multidimensional information model, considering its capacity for customization, connection to different complex systems and dynamicity. The conjugation of all constructs and variables results in a hierarchical system, named as Planned Composition Structuring.

Figure 3 - Planned Composition Structuring



Source: authors (2018)

The spatial structure, characteristic of multidimensionality, is represented in the model developed through the articulations of the constructs and variable. The research variables promote informational ordering in city information systems. In this context, data is the means of connecting the different information managers in different systems and hierarchical levels, which in turn compose the complex multidimensional information management systems of the city.

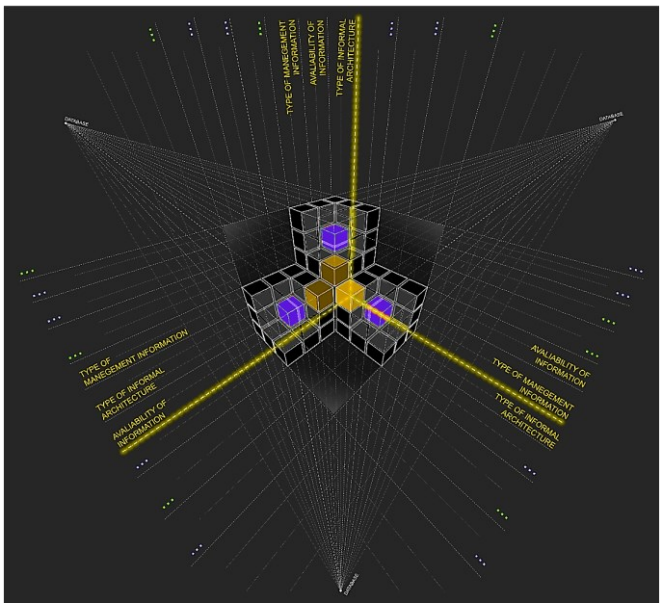
The data customization into information, on the other hand, goes beyond the barriers of information systems and hierarchical levels customarily used. The dynamicity and multi-dimensionality of information composition offer different meanings to the citizen when requested by the same UIS, converging to customized information each consult. Considering a specific scenario focused on the dimensionality of information and its planned representation in cubes characterizing the constructs, which in turn are composed by different variables and articulated in different axes, the representation of the research elements, in an ordered and customized information context citizen of strategic digital cities. An information management system is composed of different systems that are not necessarily linked.

4.6 The multi-dimensional information system model

The multi-dimensional information system model for strategic digital cities continues exceeding the technological resources of the digital city because it has concentrated on information and their connections with the strategic public policies and services. Each construct represented by the fraction of a cube is arranged dynamically to connect to another construct, according to the variables surveyed, ordering information in dimensions. The digital city is strategic in that it orders the informational composition of variables, respecting its multidimensionality and the context of the citizen user.

Considering the multi-dimension overlapping cube, the process of construction of the model was analogously conceived where the data move through the city management systems in line with the themes of public policies.

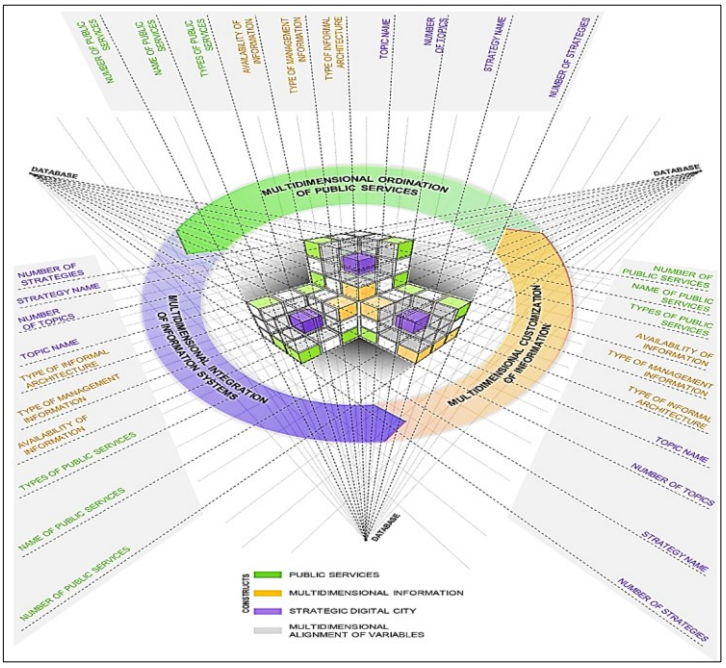
Figure 4 - Overlapping multidimensionality analogous model



Source: authors (2018)

However, the natural evolution of the research advanced to a composition of a model with articulation, with all elements of research, including constructs and variables. The demand for adaptation of the model emerged with the different management systems linked to different public policies. Informational significance in different management systems of the strategic digital city accompanies the dynamics and mutation of information in different levels, approaches, proportions, representativeness and customized contexts of citizens. The multidimensional informational composition variables through their data in different contexts, take customized paths in management systems according to the profile of the citizen user. The strategies, when integrated with the management systems, make up a multi-dimensional system customizing information, whose meaning feeds the own management system represented by Figure 5.

Figure 5 - Multidimensional information management model for the strategic digital city



Source: authors (2018)

The data retrieval and information consolidation in multidimensional information systems in strategic digital cities are carried out through surveys in the city database, whose articulation is conditioned to the specificity of the research by the citizen and limited to the respective system of information management. The respective articulation of the information, considering its strategic character, is translated by the capacity of the ordering of the different variables that compose the systems and their interconnections with the specificities of the citizens. In this specific condition, the customization of information is parameterized in one of the constructs, the strategic digital city, considering the expansion of the conceptual conformation defined by Rezende (2018).

The digital city through the proposed informational management model appended to the conceptual conceptions of information, described as a strategic element of the city, confers multidimensional articulation to information management systems, considering the capacity of significance of each information to the different users, thus translating into customized information, unlike a directional search in a database.

5 DISCUSSION AND APPLICATION

Regarding the previously comparative analysis presented constructs and their elements of composition, the model proposed in the two suitably chosen cities can be applied into any city, using these or other constructs adhering to local public information policies. The access to information in its digital format was mapped thought the websites.

The model can be applied in different cities as well as in different countries. It is also worth highlighting the presence of specific data management systems on a single basis, a common strategy for the two cities. In the same scenario, the same type of information systems available connected to the digital public services offered was identified. The infomapping can also identify the multidimensional character, as inseparable from its dynamic nature, as regards the structure of digital information availability. Nevertheless, the research experience converges to the same two-dimensional model in layers and consequently does not decode the full capacity of contextualization and multidimensional information flow by different public services customized to various citizens and retrieved from the same database. Public information, as public services were equally indexed and compared in the two cities experienced, presented linearity of supply and a static informational character. Therefore, the model can be applied in different information systems, cities and countries.

6 CONCLUSION

The pertinence of the developed model lies in the use of information as a multi-dimensional element for the strategic digital city through its spatial arrangement capacity avoiding the strategic blindness. The distribution of the city data and its variables can allow the integration of the IS and the customization of the public services offered considering the different themes of the composition.

The proposed information systems model is connected, aligned and customized to citizen's needs. The data creates information and differentiated significance to each citizen.

The objectives were achieved considering the new perspective of view offered for the multidimensional information model developed. The perspective starts from the dynamic information, regarding the multi-dimensional conceptual, interactive and customized realities of public services, and digital city. Furthermore, multidimensional information, public services, and the SDC as public policies can dynamically interact, providing intelligent and personalized information systems, adhering to the needs of its citizens and contributing to the improvement of life quality in a specific technological context. The number of correlated models identified in the survey and used was one of the limitations of the model developed. On the other hand, considering the methodological orientation and the experience adopted, the model did not present structural constraints, since it was designed based on the scientific reference literature, converging to an original form.

The contribution of the new multi-dimensional information management model to SDC consisted of the use of information in its dynamic context, the possibility of informational customization and the multi-dimensional interconnection of digital city management systems, whose architecture plays a relevant role for access to information and strategic digital city development connecting public policies into the citizen's needs. The model innovated in that it exceeded the traditional use of information in directional queries, with a limitation of responses in a data repository of the city. It also presented the capacity of ordering and customization of data, although with different meanings for different user citizens, hence making multi-dimensional, digital, strategic and customized city management systems with a high degree of significance, according to the specificities of every citizen.

Regarding future works that can advance from the proposed model, the expansion of the number of variables and the deepening of the studies of strategic elements of public policies in the informational systems of the digital cities can be a path. The conclusion reiterates the virtualized relations between citizens and cities, who unite in the search for the best quality of life, seek to understand and implement solutions aligned to the potentialities of a multi-dimensional information model.

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