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Information Systems: Applications in Smart Cities, Smart Buildings and Smart Life

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Abstract: This paper presents a proposal for an information system for the interdependent ecosystem that includs Smart Cities, Smart Buildings, and Smart Life with connections to Smart Business and Industry. We argue for the importance of Knowledge Organization Systems - KOS for the integration of many specialized information systems and insights gained from machine learning, which in turn supports the integration and mutual reinforcement of activities in planning, building, and operating smart cities and smart buildings. These activities serve real human needs, improving the quality of life and the efficiency of life activities. Such a Knowledge Organization System would allow us to map in detail the complex interactions of the many processes, objects, and factors in the interdependent ecosystem. It would facilitate the application of artificial intelligence (AI). It would allow us to connect key human needs to available resources and to work towards a sustainable planet. The paper illustrates the interdependent ecosystem through several examples, discusses the contributions of KOS and models, presents first thoughts on how a comprehensive Knowledge Organization System might be structured, and culminates in the proposal of developing such a KOS on a collaborative platform.
Keywords: Smart Cities; Smart Building, Building Information Modeling, Data Science, Machine Learning

1. Introduction

This paper presents a proposal for advances in smart cities. Considering the emergence of the term Smart Cities from the use of technology and more specifically from information systems applied to solutions for improvements in the city. The term Smart Cities arises as the application of technology in the functioning of cities.

In parallel, we can see the growth city. The world is at a constant level of urbanization, Keeling & Mooney (2011). In 2008, the United Nations pointed out that more than 50% of people lived in urban areas, Albino et al. (2015). Cities play a key role in social and economic aspects around the world and have

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a huge impact on the environment making them a critical and key element of our future, Keeling & Mooney (2011); Zhuhadar, Carson, Daday, Thrasher and Nasraoui, (2016).

Research estimates that 65% of the world's population lives in cities, with an additional 1.3 million people moving from rural areas to urban areas each week. By 2050, more than 6 billion people will be living in urban agglomerations. The urban conglomerates continue to grow as well as the number of megacities with more than 10 million inhabitants.

A key objective in creating a "smarter" city is to provide information in real time, in order to address new challenges and manage available resources, Carrato et al. (2012).

Considering the growth of cities together with technological resources, it is important to develop systems that consider techniques of organization and retrieval to manage the amount of data available in cities. The information must be accessible to assist in the decision-making processes, mainly of investments in the cities.

The processing and analysis of information from the available alternatives is the main process in the decision-making phase. The established rules and routines guide managers in the search for information and allow them to make a more solid assessment of the context, Choo (2006).

In this context, questions arise regarding smart cities considering the importance of interoperability between the different systems in cities, communication between systems, people and managers, interaction between systems. Considering that cities contain numerous departments and sectors responsible for different aspects, and that each contains its information system, it is important to seek solutions for this integration.
This study presents an objective search for tools that improve of interaction between different systems within the Smart City.

2. Smart Cities

Smart cities use information technology and intelligent systems in planning, management and monitoring processes of the urban environment.

Cities are complex systems that require urban planners to have an integrated systematic look over its variables and correlations.

Information technology through the organization and retrieval of information makes possible the development of a systemic view that supports more assertive decision-making in strategies to develop cities.

Smart city applications highlight the emergence of a technologically competent

culture and the belief in the progressive role of technology. Mario.

Intelligent City encompasses the concept of Sustainable City that emerges from the union of economic development aligned with conservation of the environment, Komninos et al. (2015).

A city can be called "smart" when investments in human and social capital, traditional infrastructure and modern ICTs foster sustainable economic growth and a high quality of life through wise management of natural resources through participatory governance. Schaffers, et al. (2011).

Intelligent Cities as defined from the point of view of data, make optimum use of interconnected information to understand and control operations and resources. Application of information technology at different levels incorporating sensors and equipment in sectors such as hospitals, power grids, railways, bridges, tunnels, roads, buildings, water systems, dams, pipelines and pipelines. IBM (2017).

Smart City includes the concept of a Sustainable City that arises from the union of economic development aligned with the conservation of the environment with natural resources, energy efficiency, water, works, air. Rational use of materials and technologies.

3. Smart Buildings

To describe Smart Cities, it is important to know about Building Information Modeling - BIM. Smart building has the concept of bringing more efficiency and control to all stages of a building's lifecycle involving Architecture, Engineering and Construction - AEC.

BIM is a technology responsible for managing a large amount of information related to construction and build assts and is a repository of this information. The use of BIM technology brings challenges and opportunities around the world and is also being established and gaining prominence as a tool for the design and management of the Architecture, Engineering and Construction area, Porto et al. (2015).

The BIM technology allows a virtual model of the building to be built in an integrated way by all the professionals involved in the construction of the building. In a BIM system, an accurate virtual model of the building is digitally constructed and, when complete, contains the relevant information necessary for the construction of the building. BIM is an evolution in the design process, it allows new possibilities of visualization and processing, representation, use and retrieval of information.

The use of Building Information Modeling - BIM in the Architecture, Engineering and Construction - AEC industry is related to the use of the

information organization technique, specifically the use of ontologies as an alternative to represent reality and to create models.

With BIM, professionals can, in an integrated way, digitally construct a virtual and precise model of the building that, when complete, contains several data or relevant information necessary for the construction, manufacturing and other activities for realization of the construction, besides the geometry found in the CAD three-dimensional model or two-dimensional drawing, Eastman et al. (2008).

Thus, the use of BIM technology means a new working methodology that integrates architects, engineers and builders, altering and dynamizing the information cycle. According to Pereira Junior and Baracho (2015), BIM technology can be considered an evolution in the entire construction process as it allows new possibilities of construction, design, planning, visualization, representation, processing, use and retrieval of the information contained in geometric representation and the link with the attributes of the database

The BIM technology provides Architects and Engineers with features that facilitate the representation and visualization of a building, allowing the modification of its elements in a direct and intuitive way, with a lot of similarity to the reality in the construction site, Lee et al. (2006), as a virtual building.

BIM models allow the centralization of construction information through the use of a single model, with information arranged in integrated files and connected online. Thus, many professionals can record their decisions and share them with others. The modifications proposed in a specific project, or part of the project, automatically propagate updates to other projects or other parts. A BIM model should be used in an integrated, consistent and ideally collaborative way among all the professional partners - architecture, structure and facilities - to be considered fully utilized.

The BIM technology proposal is based on the management of the information contained in the entire planning process.
Important research in BIM in a broader context of the life cycle of buildings.

4. Smart Life - Cities - Urbanism - Quality of life

Following the ideas presented of smart city and smart buildings, a smart life definition must include information technology and computer systems that impact positively people's way of living.

Cities are complex systems that have many variables and correlations that need to be well defined and identified by architects, engineers and urban planners. The use of IT opens up options for greater use of information, consequently a systemic vision for decision-making in development strategies of cities.

Smart city and smart building systems interact, for example, if a building includes a heat storage facility, it can draw on city energy supplies at hours of low use, making the city energy supply system more efficient.

This concept of Smart City as a means to improve the quality of life has been gaining prominence in political decisions. Neirotti, et al. (2014)

5. Knowledge Organization System - KOS

The focus on the representation and organization of information is essential to ensure good information retrieval.

The representation involves individual consensus and groups, cognitive aspects, and is essential for the processes of acquisition, organization, storage and retrieval.

The process of representation and classification is inherent to the natural way that human beings organize information. All the time we are classifying things according to the individual and cognitive knowledge of each one. The process of information retrieval has two paths: the first focus is on the creation of knowledge organization systems to structure the information and frame a particular search within the pre-established parameters. The second focus is to answer questions based on natural language without any type of standardization or pre-established formatting.

Knowledge Organization Systems (KOS) are instruments used in the representation of information for the purpose of storing, classifying, organizing, retrieving and distributing. The KOS based on the modeling of knowledge, that is, the creation of semantic models, simplified descriptions of the reality of a given domain. KOS has different typologies and aims to analyze and inference data, Soergel (2008), Soergel (2009), Soergel (2015).

Knowledge organization tools allow mapping complex interactions of many processes, objects, actors and factors in the interdependent ecosystem. Applications in smart cities include relationships between different systems. The goal is to create a way to relate the main human needs to the available natural resources and infrastructure of the city, in favor of a sustainable planet.

Managing the interdependent ecosystem of Smart Cities / Smart Buildings / Smart Life requires many types of information. This information is recorded in different sectors of the city and in the most varied types of information systems. To connect the many information systems we need the right connectors and concepts defined the same way (for example, diseases) and objects (such as people, foods, buildings, streets) identified by the same identifier.

KOS can explicitly specify the semantics of the terms of a knowledge domain. This feature makes it possible to use it as a support for the definition of those

terms optimizing the communication process, as well as presenting a solution to the problems of semantic interoperability between systems.

The result of a KOS is a knowledge model, that is, simplified descriptions of the reality of a given domain, Torres, Almeida and Simões, (2017).
Finalizing this theoretical contribution is the placement of Soergel (2009) that the KOS is different in different domains of knowledge.

6. Propose

The proposal is a systematization of the parameters and the indicators of intelligent cities considering the cities and the buildings with focus in benefits for the quality of life.

Several studies demonstrate the parameters and indicators of intelligent cities that were used as basis for this study in an attempt to systematize in a more structured way.

The set of indicators were grouped into three major groups: natural resources, infrastructure and governance.

The natural resources, inherent in each place, must be preserved and used consciously considering that they are the basis for the city. Natural resources include air, water, energy and green areas that form the basic needs of humans.

The infrastructure is linked to the projects and processes built for the operation of cities based on natural resources. The city's infrastructure is planned and built over time to meet the growing needs of the population. Usually they involve a lot of resources and are complex projects to be managed. Infrastructure projects involve a lot of financial resources and make large-investment processes involving different sectors and different people and thus involve large decision-making processes.

The governance includes the processes of public administration. Cities are organizations of society and have different agents to maintain the functioning, order and maintenance of their subsystems.

This study has a proposal to associate vital systems for the functioning of cities with systems vital to human life, for example, the human needs air to survive and the conditions of a city influence the quality of the air, both by the natural resources of the climate, the topography as well as the infrastructure created in relation to the buildings and the emission of gases that directly interfere in the air quality. Infrastructure includes the following systems, Tabela 1.

Table 1: Infrastructure - Systems

Air	Environmental preservation, pollution control, gas emission reduction
Water	Quality and quantity control, rational use, reuse, sanitation
Energy	Conscious consumption, energy efficiency, generation, energy renewable
Mobility	Accessibility, transport, collective (car, bus, train, subway, boats, plane); individual, public-private, easy to walk
Cleaning	Urban cleaning, recycle, waste (collection, treatment, recycling, appropriate disposal of the waste, landfill to not recycled
Education	
Citizen	Participation, inclusion, digital inclusion, more assertive attendance
Security	
Housing	
Work	
Technology	Internet, devices, systems, IoT, Communication, Connection, open data, data transparency

It is important to highlight the last item of the infrastructure of cities that includes technology through the communication of data, open data and Internet systems of things.

The third pillar of smart cities is governance. There are several different instances that are responsible for managing cities. Governance includes transference, legislation and urban management, economic factors, social justice and public policies (FIG.1). Public administration presents problems in information retrieval for decision making. Zandbergen (2017) states that information modeling allows the analysis of large volumes of data essential for public management and emphasize the imprint of intelligent city projects for greater communication efficiency and political digitization.

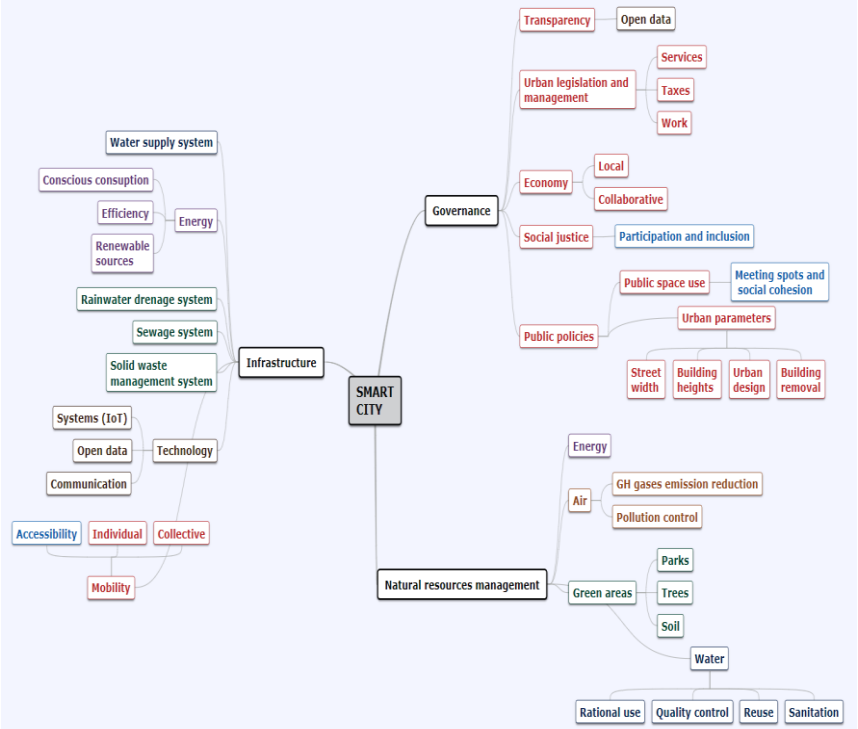

Figure 1 – Model of Smart Cities
Source: Author.

The city is made up of the buildings, the urban spaces and the people who occupy it. The information systems arise to optimize the construction systems from the design phase to the construction and, later, on the operation and maintenance of a building. Within the concept of smart buildings has the technology Building Information Modeling - BIM that encompasses all stages of building from the project to the conception of the work with an Information System capable of managing the information of the building, (FIG. 2).

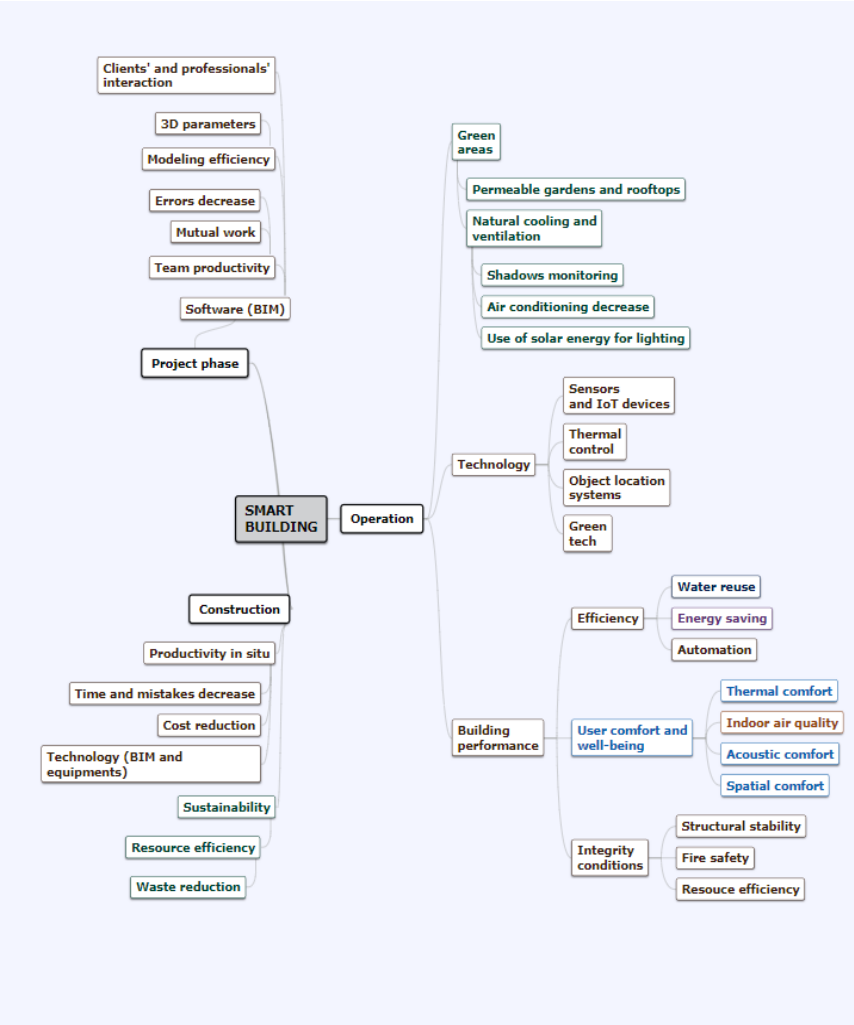

Figure 2 – Model of Smart Building
Source: Author.

Smart Life comes from placing people in the foreground and the quality of life. The city can provide and offer various parameters that, related to natural resources and infrastructure, are to offer better options of occupation and, consequently, better quality of life.

The proposal is a systematization of the parameters and the indicators of intelligent cities considering the cities and the buildings with focus in benefits for the quality of life. The quality of life of the human being is related to physical health, mental health and social knowledge and engagement. Humans

need physical health for survival and related factors come from natural resources and infrastructure. To improve the quality of life, it is important to provide for a better use of natural resources and to provide infrastructure for extracting, collecting, analyzing and disposing of these air, water and energy resources. Mental health depends on one's own knowledge, education, work and also human relationships. Knowledge and social engagement culminate the needs of the human being with knowledge and social engagement, (FIG. 3)

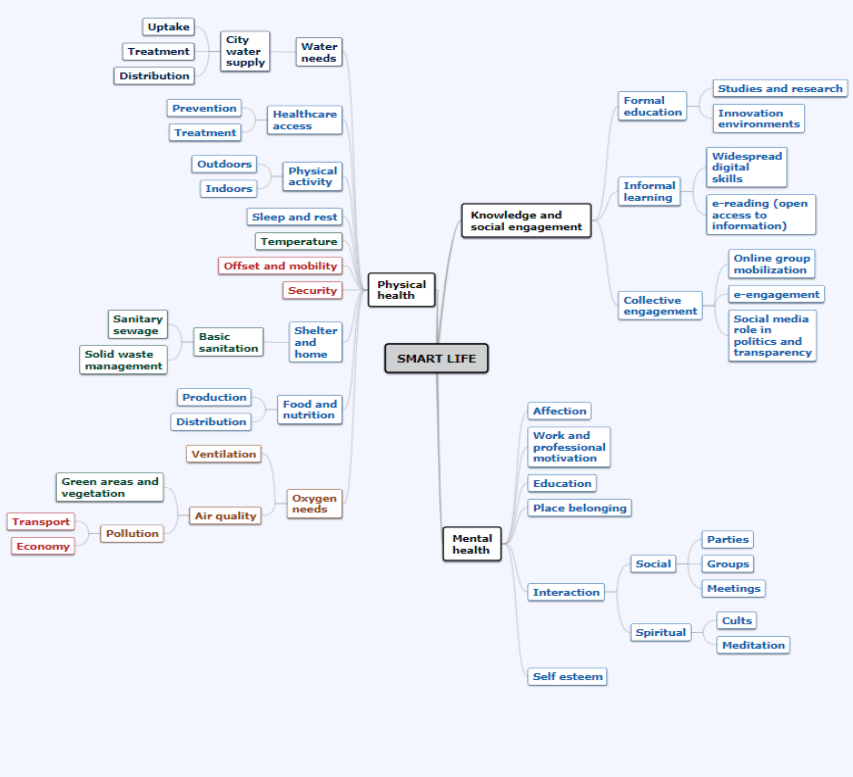

Figure 3 – Model of Smart Building
Source: Author.

An example of a car accident situation will be described. The city of Belo Horizonte has different systems to record the occurrence of an accident. In addition to different departments of the city are responsible for different items of the accident. For example, a system records the accident of data relating to the vehicle including, model, brand, year of manufacture, origin; another system reports subjectively questions or tests made to drivers such as the use of safety and alcoholic beverages in addition to the description of what happened. It should be noted here that the description of the accident occurs in a completely subjective manner according to the impression or intent of each person reporting

the accident. Another system records location and data on the location the street maintenance situation, positioning and flow in relation to the city. Another system triggers the first aid system by looking for available and closest hospitals and ambulances to more efficiently handle the accident. Another system has the control and situation of the city hospitals.
Here is an example of structuring different tables and their attributes.

Accident Reporting (Vehicle, Date, Time, Origin, Seat belt use, intoxicated, road condition, Description...)
    Accident (Type, Description,...)
    Regional (Code, Description,...)
Vehicle (Number, Owner, Code, Type, Year, Mileage...)
    Situation (Code, Description,...)
    Socorro (Type, Description,...)
Site (Type, Street, Number, Neighborhood, ...)
Person (CPF, Name, Gender, Date of Birth, Age, ...)
    Qualification (Code, Description, ...)
    Severity (Code, Description, ...)
Eletronic Health System (CPF, Type of blood, Diseases,...)
Traffic Regulation (Streets, Traffic Signs, Estimated time,...)
Hospitals (Name, Location, Number of Rooms, Ambulance, ...)

7. Conclusions

The premise of city growth and information systems may be particularly important for areas of deep and consistent nature. This search for innovative solutions permeates the concepts of information systems and cities with a focus on the process of human needs.

The purpose of this research is to develop parameters for the construction and operation of intelligent cities and intelligent buildings, to support the integration and mutual reinforcement of planning activities, to consider human needs, to improve the efficiency of life activities and to lead to better quality of life for all. This will allow us to relate the main human needs to the available resources and to work for a sustainable planet.

This research presents guidelines to support future research such as: development of a very large causal map showing the effects and interactions between the many factors in the interdependent ecosystem; define planning of any component of the system considering its effects throughout the system; consider explicit relationships between the Smart City functions and the Smart Building functions they support; to gather data types from different sources, including data from sensors, external database data, and knowledge items (statements), either by creating a massive integrated database or by making data sources interoperable, all of which is enabled by consistent terminology or mapping; Planning and execution of the Smart Cities and Smart Buildings

functions.

An Integrated Knowledge Organization all processes and factors in the interdependent ecosystem Smart Cities / Smart Living supports integrated / interoperable information systems which in turn supports the comprehensive planning and operation of Smart Cities that interact with Smart Buildings and enable Smart Life

References

Albino, V., Berardi, U., Dangelico, R. M. (2015***). Smart Cities: Definitions, dimensions, performance, and initiatives.*** Journal of Urban Technology, 22 (1) (2015), pp. 3-21

Baracho, Renata Maria Abrantes. Organização e recuperação da informação pilares da arquitetura da informação. *Tendências da Pesquisa Brasileira em Ciência da Informação*, v.9, n.1, 2016.

Carrato, T., Nesbitt, P., Kehoe, M. ***Providing insight, oversight, and smooth collaboration***. IBM Institute for Business Value (2012)

Choo, C. W. (2003). *A organização do conhecimento: Como as organizações usam a informação para criar significado, construir conhecimento e tomar decisões*. São Paulo: Senac.

Eastman, C. et al. (2008). *BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers, and Contractors*. New Jersey: John Wiley & Sons, Inc., 2008. 490p.

HALPER, Fern; HURWITZ, A. *What is big data?* IBM Strategy, 2012. Disponível em: <http://www01.ibm.com/software/data/bigdata/>. Acesso em: 28 jun. 2018.

IBM Global Business Services. *Infraestrutura para as cidades inteligentes.* USA, 2011. Disponível em: <https://www.ibm.com/developerworks/community/blogs/ctaurion/entry/infraestrutura_para_a s_cidades_inteligentes?lang=en>. Acesso em: 28 jan. 2018.

Keeling and Mooney, (2011). *Transportation and economic development, why smarter transport is good for jobs and growth*. IBM Institute for Business Value-IBM Global Business Services Executive Report.

Komninos, N; et al (2015). "Smart city ontologies: Improving the effectiveness of smart city applications", *Journal of Smart Cities*, Vol. 1, 2015, pp. 1-16.

Lee, G. et al. (2009) Specifying parametric building project behavior (BOB) for a building information modeling system. Automation in Construction, n. 15, p.758-776, 2006. Disponível em <http://www.elsevier.com/locate/autcon>. Acesso em: 20 mai. 2009.

Neirotti P, de Marco A, Cagliano A. C, Mangano G, Scorrano F. (2014). *Current trends in Smart City initiatives: Some stylised facts*. Cities. 2014;38:25–36.

Porto, M. F.; Baracho, R. M. A.; Franco, J. R. Q. (2015). *Paradigmas de utilização da tecnologia BIM para projeto arquitetônico e de engenharia* In: 4o. Seminário Ibero-Americano Arquitetura e Documentação, 2015, Belo Horizonte. Anais do 4o. Seminário Ibero-Americano Arquitetura e Documentação. Belo Horizonte: Mestrado em Ambiente Construído e Patrimônio Sustentável MACPS e IEDS, 2015. v.1. p.1 – 12.

Schaffers, Hans; Ratti, Carlo; Komninos, Nicos. (2012) *Special Issue on Smart Applications for Smart Cities.* New Approaches to Innovation: Guest Editors' Introduction - Journal of theoretical and applied electronic commerce research; 7(3); ii-v; 2012-12.

Soergel, D. (2008) "*Digital libraries and knowledge organization systems*", In: S. R. Kruk, ed., Semantic Digital Libraries, Springer, 2008, pp. 9 -39.

Soergel, D. (2009) "*Knowledge Organization Systems*", Over-view, 2009.
Soergel, D. (2015) "*Unleashing the Power of Data Through Or-ganization: Structure and Connections for Meaning, Learning and Discovery*", Knowledge Organization, 42(6), 2015, pp. 401– 427.
Torres, Simone; Almeida, Mauricio B.; Simões, Maria. (2017) Princípios para modelagem de domínios em sistemas de organização do conhecimento (SOC). In: III Congresso ISKO Espanha-Portugal, III, (2017), Coimbra. Anais eletrônicos III Congresso ISKO Espanha-Portugal.
Zandbergen, D. (2017). "*We Are Sensemakers*": The (Anti-)politics of Smart City Cocreation. Public Culture 1, Durham, v. 29, n. 3, p. 539-562.
Zhuhadar, B. Carson, J. Daday, E. Thrasher, O. Nasraoui. (2016). *Computer-assisted learning based on universal design, multimodal presentation and textual linkage*. Journal of the Knowledge Economy, 7 (2) (2016), pp. 373-387