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Smart City: Concepts and two Relevant Components

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Abstract

In the last 30 years, the Smart City (SC) definitions have changed, they expressed different meanings by different people, but still no universally accepted definition, yet. The paper aims to summarize the existing relevant definitions to and propose a concept for characterizing the smartness of a city through intelligent planning and monitoring, guided by actionable information that underpins computer-assisted decisions and institutional digital transformation. As a practical approach, the SC concept is promoted by two components namely: spatial urban territorial planning and cultural heritage via virtual exhibitions. The article highlights the schematic diagram of cross-sectoral interactions between different stakeholders grouped by roles, and the expected impact for these interactions, a proposed functional system architecture for cultural heritage digital transformation and concrete steps for virtual exhibitions implementation.

Keywords: Big Data, cloud, collaborative work, cultural heritage, mobile, Smart City, virtual exhibitions

1 Introduction

According to the United Nations, 55% of people worldwide live today in cities, and the increase is estimated to 68 % until 2050. Predictions indicated [24]. On a global scale, IDC estimated continuous increase of spending on Smart Cities rising to $158 billion by 2022 (double from $80 billion in 2018) [25].

New technology hot topics such as augmented and virtual reality, Big data analytics and discovery, broadband, cognitive/artificial intelligence, Internet of things, real-time, cloud, mobile have been adopted by all cities over the globe in their journey of creating smarter digital reality. In this way, SC drives all operational efforts with the final purpose of improving and developing the safety, connectivity, and the quality of life for their citizens [10, 19].

Nowadays, the decision-makers of forward-thinking cities adopted geographic data approaches joined with business information, transforming domain knowledge into actionable information and customer workflows into a geospatial intelligent decision support system, enabling real-time decision-making as the city grows. New organizational model boosts smarter initiatives that improve decision and collaboration between all stakeholders. Local authorities have the most important role in defining the policy framework, associated plan and regulations, the criteria that city investments must fulfil. Good management of the technological and organizational resources support integrated spatial territorial planning and monitoring of the shared responsibilities.

2 General concept

Today we are counting about 30 years since Albino [2] has mentioned SC for the first time. During this long period, SC has different meanings for different people. Based on resident's aspirations, or available resources, depending on the city development stage, and city agility to change and reform, the SC conceptualization varies a lot and constantly changes from one city to another and between continents. For example, Albino first mentioned that SC is Information Communication Technology (ICT) infrastructures of the cities [2]. Alawadhi [1] recommended steps for becoming smart and how the IT should be implemented in a designed city, but is more complex than the applied technologies.

Since "smart" has been replaced with "digital" or "intelligent" the diversity of the SC definitions exploded, and unfortunately, were not always consistent.

As we observe, there was more than one framing for a SC and we have found different dimensions. A common tenninology should be agreed so that the public knows what is being offered, the innovator's pioneer explains die benefits, and the public administration decides public funds spending with confidence in the obtained results. This SC framework requires ab'Teed standards [4, 27] and ways to make things open and public.

As we observe, the SC is more than a re was neither a single template of framing an SC nor a *one-size-fits-all* definition of it. A common terminology should be agreed so that the public knows what is being offered, the innovator's pioneer explains the benefits, and the public administration decides public funds spending with confidence in the obtained results. This SC framework requires agreed standards [7,8] and ways to make things open and public.

The vague idea about what SC really means was underlined in the literature on this topic [1, 13, 14]]. During the last two-decades, SC has changed. It first included four components: participation, education, technical infrastructure, and industry [11] and how these are related, transformed. Later, the concept was defined by six components: smart people, smart living, smart environment, smart mobility, smart economy, and smart governance [12]. Recently, McKinsey's experts named eight components that affect multiple aspects of the quality of life: engagement, community, security energy, water, waste, mobility, healthcare, economic development and housing [23]. The citizens "quality of life" has been emphasized as added value included in SC definition, therefore it has been debated a lot among specialists [17]. We propose to consider the enhanced access to the cultural heritage of a city as a specific feature of improved life quality.

Despite its large spreading, the SC semantics continues to be unclear [3, 15]. In [16] SC becomes an "activator" for changes, based on innovation. From a practical perspective, the SC concept goes much further and becomes an umbrella vision shared by all stakeholders within the SC, the public administration, private economic stakeholders, and civil society. These ways of sharing transform public administrations and their governance models. The following chapters develop the SC concept by two particular components: a) spatial urban territorial planning and b) enhancing the access to cultural heritage via virtual exhibitions.

3 Computer-supported urban territorial planning development

Driven by massive demographic and investment shifts, cities have adopted new digital and real-time situational awareness strategies for enhancing the citizen's safety and quality of life. Based on the digital maturity level, public administration bodies create a smarter digital reality to drive all digital,

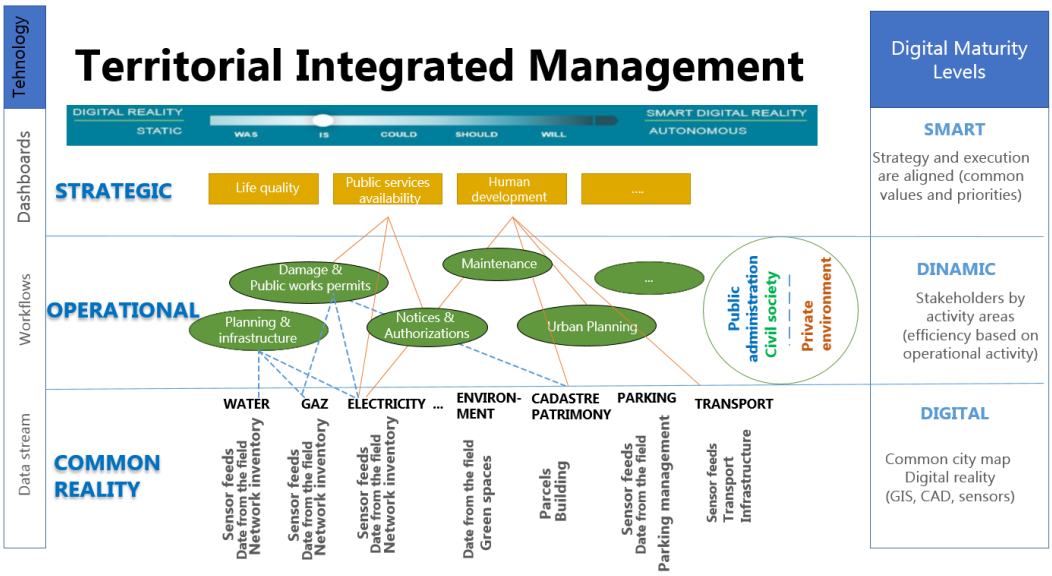

Figure 1: Conceptual schema of Computer-supported urban territorial planning development (Source: adapted after [20])

operational, and strategical efforts. The main thesis of the Digital Maturity model, as is represented in Fig. 1, reflects the integrated management capacity of the territory, shifting the attention from within the organizations to the life of the community and the relationships that are established between all stakeholders (public, civic and private organizations)[20]. In such a partnership, the role played by technology in spatial territorial planning and operationalization of SC facilitates the collaboration between all the participating actors. We can identify the following issues:

Digital community correlate Common Reality and has the main benefit that organizations are aware that they depend on each other. At this level, the activities of the participants are focused on managing the "seen" things, respectively focusing on the physical reality, each of them contributing to the unique digital map of the city.

Dynamic Community (correlation of Joint Activities) aims to achieve a higher level of performance than the objectives assumed by their own organization. These organizations are aware that, achieving an upper level of operational efficiency, they need more than sharing information with the other actors. They need to correlate their procedures between all organizations that are operating in the same community. Automatizing the online exchange of information between organizations is based on transactional packages defined based on the correlation of individual procedures between organizations. In a *Dynamic Community*, the common map is also dynamic because of the permanent updating of the situation from the ground. Often, the dynamic map will also reflect what is about to happen, not just the past. Automated services ingest new data, update data on the fly, and provide operational awareness of the impacted area.

Smart Community (correlation of Common Strategies) are concerned about correlating their long-term strategies with those of the community. Strategic objectives of the community, such as "quality of life", "sustainable development", "community competitiveness", "economic development of the community" are taken up in the individual strategic objectives of each organization in the community. Defining the strategy of the whole community, it becomes a fruit of the partnership among all participating actors. The strategic partnership makes the difference between the operational efficiency of the organizations and the sustainable good of the whole community. The organizations of SC are aware of the existence of other actors in the community, therefore the citizen plays an important role in the entire ecosystem of relationships. At this level, information technology tools are predominantly dashboards that facilitate the monitoring and correlation between strategic and operational levels allowing proactive identification of how daily community changes is correlated with the assumed strategic direction.

The city is a living organism, evolving at a very fast pace. Any decision made by their territorial

administrators affects all participants because all of them are interconnected.

There are many promises made by software platform providers for helping SC to create and manage a smarter digital reality. An enhancement has been provided by combining the location-based data and business intelligence, fitting the needs of digital and safety-related city developments, and delivering a "5D smart digital reality with insight into *what was, what is, what could be, what should be*, and ultimately, *what will be"* [26].

The city is the most complex ecosystem in space and time. Likewise, it is a variable ecosystem and has many aspects that are worth to be analyzed, planned, monitored and developed using an integrated spatial territorial planning approach. For a deeply understanding of the city we have taken into account different relevant domains attaching for each of them specific criteria. For example, let us consider the approval of the construction of a commercial or a residential complex. How much does this decision affect the city and on what level?

To be more efficient the last piece is about unification and integration of the platforms. The *digital intelligence platform* consists of multiple systems, solutions, and artefacts related to information and data collection, analysis, management, sharing, and delivery. The platform ingests digital assets and provides insights from these different data sources via advanced digital analytics. Increasing the ability to quickly render these insights is facilitated by artificial intelligence and machine learning embedded into the platform's advanced analytics capabilities.

The selected practical digital transformation solution is based on a multidisciplinary approach that answers to the challenge of reinventing spatial and territorial development planning. The selected smart tools contain a set of territorial development indexes, constituted as a baseline, quantitative analyzes that automatizes the drawing out of the existing situation and identify malfunctions of the analyzed territory after data loading on relevant domains (parts of urban, spatial and territorial planning). Based on the existing situation, innovation and creativity of choosing the development directions represent the main planning effort.

Based on the proposed smart tools, the process of continuous measuring and updating of indexes highlighted automatically whether conditions are improving against the baseline. Due to these smart tools, reporting outcomes becomes more transparent and impartial.

Through the collaborative process of spatial planning, the premises for optimizing the current development planning process has been improved. Therefore, it also regulates the lower hierarchical level, meantime providing coordination with the higher hierarchical plans on each national and international level.

Due to daily working processes in a collaborative inter-institutional and participative framework and a unique database permanently updated, the proposed smart tools bring novelty to the digital transformation approach.

Therefore, city spatial and territorial development planning is controlled and predictable in a quantitative way [20].

4 Computer-supported enhanced access to cultural heritage

The enhanced facilitated access to cultural heritage is the second relevant component of an SC. As one of the most dynamic sector, cultural heritage contribute with about 2,6% to EU GDP, and job offerings ("more than 8 million jobs", "The cultural sector and creative industries (CCIS) represented by highly innovative companies with great economic potential are one of Europe's most dynamic sectors contributing around 2.6% to EU GDP" [8]. The concept of "Digital Culture Economy" came into current use. The term "e-Culture is also frequently used in Europe in the context of the "Information Society", besides "e-government", "e-health" and other "e-domains" [5, 8]. Earlier seen as an opportunity, *cultural economy* generates a competitive advantage for new activities that exploit the cultural value, by using modern information and communication technologies.

The era of the knowledge-based economy requires knowledge to generate tangible and intangible values. Traditional methods for promoting the cultural heritage no longer work and more efforts are required to include the new emerging technologies in daily activities. Augmented reality, virtual reality technology, mobile applications and cloud platforms provide an effective opportunity to promote,

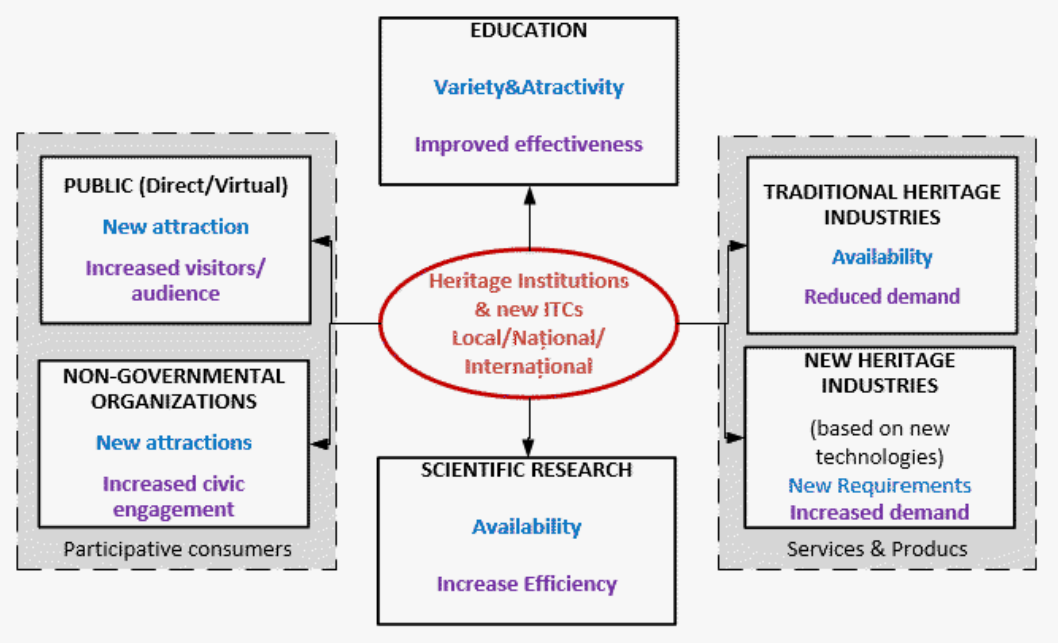

Figure 2: The cross-sectorial scheme - characteristic features of interactions and expected impact (Source: adapted after [9])

preserve and protect heritage around the world and disseminating and extracting this huge amount of information as knowledge or unseen experience.
The digitalization programs rapidly widespread the primary heritage data sources and preserve the heritage. Using new systems for visual analysis, interpretation and interaction bring to life the digital cultural heritage. At the same time, the cultural heritage researches itself through a general interpretation of large data volumes (Big Data) of knowledge, capitalizing it through innovation.

Fig. 2 is a cross-sectorial scheme. The characteristic features of interactions and expected impact represent the connections between cultural heritage institutions and different sectors of activity. Recent technological developments expand the interaction with cultural institutions and regenerate the interests of these institutions, while also enhancing the collections and design exhibitions. There are favourite domains by diversification of offered services, such as tourism, or education that become more attractive and effective.

The functional system architecture proposes a single database for the integrated solution and all the operational workflows into a single computer system offering different digital outputs for each user. One digital output that potentiates urban development is a virtual exhibition.

To facilitate the cultural heritage development of citizens in a smart city, the connections with the *Internet of Things* and mobile technologies are mandatory. Excepting virtual exhibitions created as virtual tours inside a museum or a gallery, visitors should be able to experience combined physical and virtual tours to enrich their experiences. For example, in a smart city, every monument or cultural heritage object should have beacons that send signals to nearby mobile devices. When a visitor is near a statue in the city park, he should receive a notification on his mobile device containing detailed information about those cultural objects. There are linkages between cultural heritage objects and all of them communicate directly with the visitors. Based on the visitor's route in the smart city, for example, when a tourist comes in the city to explore, he can receive on the mobile device recommendations to visit other nearby cultural sites and monuments.

The proposed IT systems are based on three content functional dimensions: *production, management, and presentation* as follows:

1. Content production includes *a) acquisition of raw data* using UNESCO methodology, international guides for metadata (administrative, technical, descriptive, on access inhibitors and restrictions of use that consist of protection of intellectual property, protection of personal data, restrictions on use and copying etc.) and specialized technologies (remote sensing, photogrammetry, 3D laser scan, GPS

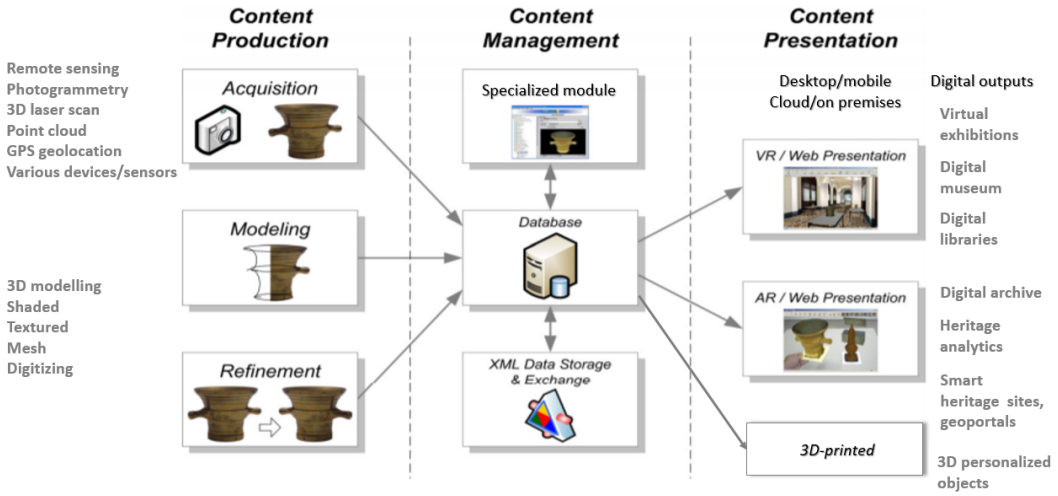

Figure 3: The functional system architecture (Source: adapted after [21])

geolocation, 360-degree video, various data acquisition devices, provided by different sensors/beacons), *b) modelling* (using 3D modelling, shaded, textured, mesh, digitizing) and *c) refinement*. The content production is the functional component allowing automatic or manual data and information data capture through high standard hard - and software components, based on long-term activity plans, time and resources and detailed description of digitized materials.

2. Content management includes *a) specialized applications for internal workflows or processing* is the functional component of the system that computerizes internal workflows. With the help of the geospatial platform, there are configured workflows that support internal flows on different fields of activity. By request can be implemented preconfigured modules, but also a new one for new functionalities; *b) data storage & archiving* is the functional component of the system that allows the storage, archive or exchange of information based on metadata and institution to whom they belong, in order to be accessed and used in applications or exchanges and include Big Data; *c) data processing* is the functional component of the system that allows the retrieval of data from different formats, including by georeferencing (e.g., georeferencing of cadastral plans), geometric and technical validation of information and uploading to the database. This functionality is usually performed with specialized desktop tools based on advanced algorithms; *d) interoperability* is the functional component of the system that offers the opportunity to communicate with other computer systems (if any) or to allow partners to access the system and operate on internal workflows. Public administration makes available to different partners (public or private companies, suppliers, designers, etc.) computer applications or services components that allow collaborative work and automation of inside and outside data workflows between partners. Communication system means the implementation of web services (XML) for the exchange of data and information with other computer systems.

3. The content presentation includes *a) the use of data and information* is the functional component of the system that offers the possibility of reporting and analyzing the data and information in the system. In addition to data viewing with the help of different dashboard tools for each type, *b) information display/consultation* is the functional component that offers the opportunity to communicate with citizens or other institutions. This component implements different digital cultural heritage outputs. Exposure of data is realized through a process of extracting data sets and information intended for the visiting public based on free or specific rights. It is also possible to implement the GeoMarket geoportal for the sale of data sets to interested third parties (private companies, designers, researchers, other institutions etc.). Also through this component, the processes of consulting and collecting feedback are provided for the internal workflows via public consultation.

The virtual exhibitions implementation stages differ depending on the deploy type of application that is used [5]. There are many tools used to implement virtual exhibitions, some of them paid and others open source. Depending how the virtual exhibition is implemented, the curators can decide which tool/technology to use. For example, MOVIO is an open-source tool used in many cultural

institutions to create virtual exhibitions as web applications, available online, but which can have a responsive interface that adapts on every mobile device. In order to be completely mobile and to benefit from the software and hardware characteristics (sensors, location, NFC, and so on) of a mobile device, a virtual exhibition should be created as a native mobile application, on the Android and iOS operating systems. In this case, the visitors can combine the physical and virtual experiences, for example, when they scan QR codes allocated to cultural objects inside a physical exhibition.

In [6] it is presented a methodology to choose the most adequate IT solution. Taking into account the continuous and rapid evolution and technological trends in IT&C, such as Artificial Intelligence, Big Data Analytics, Cloud and Mobile Computing, and their impact on society and decision-making [7]], one can expect that SC is continuously enriched by offering new services to the community and the business environment. Examples of such services, architectures and implementation methodology are carefully capitalized in [22].

5 Conclusions and further research

The paper suggests an extension to the existing SC concept based on a Digital Maturity model implemented through a complex computer-assisted decision and institutional digital transformation. This model proposes the development of innovative intelligent services starting from the holistic view for the two components: a) urban spatial territorial planning and b) expanding access to cultural heritage via virtual exhibitions. Different actors participate in sharing the experience for implementing the strategic view of the public administration and developing visual and physical examination of the space-based on virtual and augmented digital reality. SC's public administration embraces collaborative and participative work for growing their maturity level. In their race for smartness, the standards constitute a foundation for information and services exchanges between all stakeholders.

Digital transformation is an irreversible process for the user experience and sharing process and is under continuous development. Yesterday's futuristic technology becomes more accessible and affordable today. The new range of devices become available for purchase by individuals. The complex types of Big Data sets, the dynamicity of the scenarios for their use, constrains the traditional tools/ data management and processing applications to evolve. Extracting, retrieving and analyzing information in a timely manner, ease of use and at low costs are mandatory today. Mobile and cloud is already a reality. Consequently, radical, new and exciting cultural heritage services for citizens are waiting to be generated. All these digital enhancements develop new lines of business, new skills and jobs and contribute directly to the human capital transformation.

In further research, we are looking for developing a quantitative indicators-based model for benchmarking and monitoring urban planning. Innovative solutions for user interaction and experience in the field of cultural heritage inspire us to develop new roadmaps for implementing artificial intelligence, data analytics and other emerging technologies such as IoT and digital twins as functional modules in our system architecture schema. Financing funds for the projects and new potential national or international partners, willing to cooperate with mutual benefits (going to the next level of applying the researcher results to a beneficiary), will be another challenge for the future.

References

[1] Alawadhi, S.; Aldama-Nalda, A.; Chourabi, H.; et al (2012). Building Understanding of Smart City Initiatives. *Lecture Notes in Computer Science*, 7443, 40–53, 2012.

[2] Albino, V.; Berardi, U.; Dangelico, R. M. (2015). Smart Cities: Definitions, Dimensions, Performance, and Initiatives. *Journal of Urban Technology*, 3–21, 2015.

[3] Caragliu, A.; Del Bo, C.; Nijkamp, P. (2009). Smart Cities in Europe. *Journal of Urban Technology*, DOI: 10.1080/10630732.2011.601117, 18(0048), 2009.

[4] Chourabi, H.; Nam, T.; Walker, S.; et al (2015). Understanding Smart Cities: An Integrative

Framework. *45th Hawaii International Conference on System Sciences*, IEEE Computer Society, 2289-2297, 2015.

[5] Ciurea C.; Filip F.G. (2019). Virtual Exhibitions in Cultural Institutions: Useful Applications of Informatics in a Knowledge-based Society, *Studies in Informatics and Control*, 55-64, 2019.

[6] Filip, F.G. (2012). A Decision-Making Perspective for Designing and Building Information Systems. *International Journal of Computers Communications & Control*, 7(2), 264-272, 2012.

[7] Filip F.G. (2020), DSS—A Class of Evolving Information Systems. In: Dzemyda G., Bernatavičienė J., Kacprzyk J. (eds) Data Science: New Issues, Challenges and Applications. Studies in Computational Intelligence, Springer, 869, 253-277, 2020.

[8] Filip, F.G.; Ciurea, C.; Dragomirescu, H. et al (2015). Cultural heritage and modern information and communication technologies, *Technological and economic development of economy*, 441-459, 2015.

[9] Filip, F.G.; Donciulescu, D. A; Filip C. I. (2001). A cybernetic model of computerization of the cultural heritage, *Computer Science Journal of Moldova*, 101-112, 2001.

[10] Filip, F.G.; Zamfirescu, C.B.; Ciurea, C. (2017). *Computer-Supported Collaborative Decision-Making*. Springer International Publishing AG, 2017.

[11] Giffinger, R.; Fertner, C.; Kramar, H. (2007). *Smart Cities: Ranking of European Medium-sized Cities*, Vienna: Centre of Regional Science, 2007.

[12] Giffinger, R.; Gudrun, H. (2010). Smart Cities Ranking: An Effective Instrument for the Positioning of Cities?, *ACE Architecture, City and Environment*, 7–25, 2010.

[13]] Ioniţă, A.; Enache, M.; Munteanu, A. (2015a). *The concept of Smart City and the models of geospatial knowledge development in the society based on geospatial information technology and its governance*, within the research program "Modeling geospatial knowledge in the society based on geospatial information technology and its governance", 53 pages, TR ICIA, 2015.

[14] Ioniţă, A.; Enache, M.; Munteanu, A. (2015b). *Examples of good practices in modelling geospatial knowledge in the Smart City, in the society based on geospatial information technology and its governance*, within the research program "Modeling geospatial knowledge in the society based on geospatial information technology and its governance", 42 pages, TR ICIA, 2015.

[15] Nam, T.; Pardo, T. A. (2011). Conceptualizing smart city with dimensions of technology, people, and institutions. *Proceedings of the 12th Annual International Conference on Digital Government Research*, DOI: 10.1145/2037556.2037602, 2011.

[16] Paskaleva, K. A. (2011). The Smart City: A Nexus for Open Innovation?. *Intelligent Buildings International* , 153–171, 2011.

[17] Shapiro, J. M. (2006). Smart Cities: Quality of Life, Productivity, and the Growth Effects of Human Capital. *Review of Economics and Statistics*, 324-335, 2006.

[18] Vein, C. (2017). *Why we need smart cities*, [Online] Available: https://www.digitalpulse.pwc.com.au/why-we-need-smart-cities, Accessed 30 January 2020.

[19] Visan M.; Mone, F. (2018). Big data services based on mobile data and their strategic importance, *7th International Conference on Computers Communications and Control (ICCCC 2018)*, Oradea, 276-281, 2018.

[20] Visan, M. (2019). Spatial and territorial development planning: digital challenge and reinvention using a multi-disciplinary approach to support collaborative work*, 7th International Conference on Information Technology and Quantitative Management (ITQM 2019)*, Procedia Computer Science, 162, 795-802, 2019.

[21] Visan, M.; Filip, F.G. (2018). Knowledge, Innovation add Heritage – Cross - sectorial support for Smart Development and Human Capital Transformations, The Romanian Economy. A Century of Transformation (1918-2018), *Proceedings of International Conference Economic Scientific Research - Theoretical, Empirical and Practical Approaches (ESPERA 2018)*, Peter Lang Academic Publishing Group, 2018.

[22] Visan M.; Ionita A.; Filip F. (2020). Data Analysis in Setting Action Plans of Telecom Operators. In: *Dzemyda G., Bernatavičienė J., Kacprzyk J. (eds) Data Science: New Issues, Challenges and Applications. Studies in Computational Intelligence*, Springer, 869, 97-110, 2020.

[23] Woetzel, J.; Remes, J.; Boland, B. (2018). *Smart Cities: Digital solutions for a more livable future.* McKinsey Global Institute, [Online] Available: https://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/smart-cities-digital-solutions-for-a-more-livable-future, Accessed 31 January 2020.

[24] [Online] Available: https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html, Accessed on 31 January 2020.

[25] [Online] Available: https://www.idc.com/getdoc.jsp?containerId=prUS44159418, Accessed on 31 January 2020.

[26] [Online] Available: https://www.hexagongeospatial.com/white-papers/creating-a-smarter-digital-reality-for-smart-cities, Accessed 30 January 2020.

[27] ISO 37120:2018 (2018). *Sustainable cities and communities — Indicators for city services and quality of life*, [Online] Available: https://www.iso.org/standard/68498.html, Accessed 30 January 2020.

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