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Smart Cities Typology

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This paper has been divided into four parts. First section is a short introduction to the topic where both city and smart city definitions are proposed. Second part shortly describes most important variables, which influence smart city model. In the third part there is presented a wide typology for smart cities, which aims at appropriate nomenclature and the definition standing behind the name. Each definition refers to pure form of described model, but in the reality smart cities mutate and models may become combined unique versions. In the fourth section a few challenging issues referring to smart cities implementation and management have been identified and discussed.

Literature reviewed for the purpose of this paper describes the phenomenon mostly from the general or very technical point of view. As far as smart city phenomenon is not widely embedded in a scientific literature there have been reviewed not only academic or journal papers, but also conference proceedings and reports. There have been 212 potentially important literature positions identified, form which 57 have been finally included in the bibliography. This delimitation simplified process of including only most valuable papers. Because of smart cities emerging character papers in this field are not yet commonly published in highly ranked journal, which is why such criteria couldn't be included in the research methodology.

A pragmatic approach presented in this paper refers to the rapidly changing environments of smart cities. Due to the dynamics of the phenomenon and technological aspect there has been used a foresight research method, which is called "tech mining" and means in resolution "text mining of science and technology information resources" (Porter, 2009). Method refers to basing on the literature from the widely perceived science and technology that describes technological phenomenon in a detailed manner followed by trend extrapolation in order to build theory from the business point of view. Tech mining simplifies process of bringing together knowledge from science, technology and business management and creating all-purpose unique and complex conclusions. Method perfectly underlines a future-oriented character of the phenomenon described in this paper. Tech mining mostly simplified process of smart cities terms classification, as far as from the business point of view nomenclature seems to be misunderstood in many cases.

1. City, smartness and smart city definitions

In every field of science city is defined in a different way. Furthermore, each science introduces various perspectives and approaches, which create multidisciplinary phenomenon. In this paper city is perceived in terms of

organizational metaphors as a self-regulating brain (Morgan, 2005), which is subjected to multidimensional dynamic social, economic, environmental (Lewandowska, 2014) and technological changes.

Smart cities definitions vary from each other, as far as many dimensions of the phenomenon may more or less influence authors visions. Here are a few smart definitions suggested by some scientists:

- "Implementation and deployment of information and communication technology infrastructures to support social and urban growth through improving the economy, citizens' involvement and governmental efficiency" (Bakıcı, Almirall and Wareham, 2013)
- "The use of Smart Computing technologies to make the critical infrastructure components and services of a city — which include city administration, education, healthcare, public safety, real estate, transportation, and utilities — more intelligent, interconnected, and efficient" (Washburn and Sindhu, 2010a)
- "A smart city is generally meant as a city capable of joining "competitiveness" and "sustainability", by integrating different dimensions of development and addressing infrastructural investments able to support economic growth as well as the quality of life of communities, a more careful management of natural resources, a greater transparency and participation to decision-making processes." (Bertolini et al., 2013)
- "Smart cities represent a conceptual urban development model based on the utilization of human, collective, and technological capital for the enhancement of development and prosperity in urban agglomerations" (Angelidou, 2014)
- "Smart City is a multi-disciplinary task, that involves various stakeholders from different thematic 8 areas, like politics, finance, city management and organization, and information and communication technologies (ICT)" (Petrolo, Loscrì and Mitton, 2015)
- "Generally, the smart city is the city that seeks to achieve the objectives of a future city by utilizing information and communication technology (ICT) solutions and trends." (Mohammed et al., 2014)
- „The smart city is not a conventional product, service or process innovation but, instead, is a conceptual or paradigmatic innovation in changing beliefs and creating understanding of what new ideas have to be adopted in urban policies." (Anttiroiko, Valkama and Bailey, 2014)

For the purpose of this paper, there has been introduced a smart city definition which is perceived as the phenomenon, that refers to technology adaptation in the cities in order to create a system, which could help in solving everyday social

and operational problems. Smart city derives from the smart computing concept, which describes an integrated system. The main purpose is process optimization that can be achieved, for example, by implementing automation elements in some areas. Smart cities ecosystem can be created with sensors combined with operating system, but can also include some advanced technologies like artificial intelligence. Smart cities simplify the process of decision-making, so from the business point of view stakeholders can be widely perceived as city management. The main purpose is the symbiosis stimulation, which refers to upgrading inhabitants' living standards, improving local government efficiency and positively influencing environment.

Smart cities solutions have gained a huge popularity on a global scale in recent years and it has already mutated into a wide variety of dimensions. However, smart cities are the infrastructural solution, the phenomenon perfectly fits into prosumerism theory (Toffler, 1980), and can be perceived as a customizable combination of a software and a service. Customization is the key factor, which impacts dimensions of smart cities and finally results in creating unique versions of the phenomenon. Smart cities are given various names, e.g. virtual, ubiquitous, digital city, etc., which in fact describe the basic philosophy and strategy which stands behind these terms.

Smartness from the modern urbanism point of view refers mainly to sustainability initiatives and ubiquitous computing implementation (Gabrys, 2014). In the field of marketing management, smartness is strongly interconnected with the user. This means that smart cities design should be user-centred and should include usability aspects (Nam and Pardo, 2011). Citizen is perceived as an interactive user, who requires personalized services (Lee and Lee, 2014). Human remains to constitute the basis for city intelligence, where information and communication technologies (ICT) play the key role (Roche, 2014). Implementing more user-centred elements helps to stay in touch with the citizens, which usually is one of the main stated target by governors and policy makers (Schuurman et al., 2012) and on the other hand it simplifies the process of software development (Neirotti et al., 2014). Also managerial or business models used to extract and analyse end-user data tend to be flexible and fit in many scenarios (Mulligan and Olsson, 2013). Citizen-centric infrastructure enables process of measuring urban wealth indicator that is pivotal in general urban performance estimation (Degbelo et al., 2016). Also citizens' engagement shows the direct value of smart cities' role in its inhabitants lives (Kogan and Lee, 2014).Upgrading the value of social capital fosters citizens' activity and influences decision-making processes (Kogan and Lee 2014). In such situation there is no need for centralized hierarchy (Nam and Pardo, 2011), but initiative is highly expected from various smart cities' inhabitants.

Managing the smart city requires similar skills as if it was a conventional business based on technology. At the very beginning smart city managers should focus on a long-term strategy in order to depict most crucial elements and implement new policies appropriately. Development plan should specify if the strategy is soft (e.g. Barcelona city facilitates people's lives in many aspects) or hard infrastructure oriented (e.g. Rio de Janeiro city applied sensor based system which helps to control landslides) (Angelidou, 2014). City governors should create a dedicated team or even hire new specialist as far as implementing smart cities strategy may require some expertise. A wide variety of smart cities dimensions determine the philosophy of a particular unit. Stated philosophy shows the direction of further activities and the target. In most cases target may be perceived as automation and optimization, which aim at people, transportation, energy or water use, etc. Concrete typology of smart cities philosophy will be widely discussed in the further part of the article.

2. Variables that influence smart city philosophy

In this section there will be described only most important variables or rather critical problems, which influence smart cities' strategy choice. First factor, which affects smart city prosperity is the size of the organism. A typical smart city is a medium-sized area, which usually contains a university within its borders and this may be the crucial factor in the technologically intelligent development (Winters, 2011). Scale simply determines practices that will be used to manage the city. Infrastructural aspects and technological background of a metropolis differ significantly from those implemented by the city of 100k inhabitants. Size of the city may be the initial information to define the scale as one of the integral elements of project management.

Economic development of the city is strongly interconnected with the GDP indicator which highly influences general development rate and may affect smart city expansion (Neirotti et al., 2014). GDP is immensely important in many areas of city development (e.g. energy demand) where intelligent solutions can widely be used (Washburn and Sindhu 2010b) so the level of economic factors indicates intelligent growth perspective. What is also important, "cities are key contributors to the national GDP" (Abdoullaev, 2011).

Smart cities are directly related to technologies, innovations and various forms of ICT solutions. Technological portfolio needs to be verified and implemented in a unique form into the particular city organism. Use of a specific technology may be an effect of cooperation with the university or R&D unit. Solutions can also be acquired in a form of specialists, knowledge workers, software, know-how,

etc. Technology is treated in a smart city as an assisting system, which supports decision-making processes on a daily basis, simplifies problem solving or may lead to efficiency improvement.

In a heart of every city are people that constitute its character. Societies have various needs, which differentiates cities from each other. People's needs show city governors potential directions in which smart cities should develop. For instance, if air in the city is highly contaminated, it is recommended to put efforts in eliminating or minimizing problem, but in parallel introducing health care programs combined with environmental protection programs. Every city governors' decision results in consequences for people, which is why smart cities must be focused on social good.

Cities struggle with various problems, which depict particular directions for strategy, development and focus. Problem may be also perceived from various perspectives, e.g. organizational (energy management) or geographical (regular snow-flurries). Particular challenges stimulate new thinking schemes and differentiate cities from each other (Harrison and Donnelly, 2011). For instance, smart cities are very popular in Europe due to eco-restructuring programs, financial resources and European Union dedicated funds (Vanolo, 2014). For sure, financial resource is only a mean on the path of achieving target determined by city governors' or inhabitants' motivation.

3. Smart cities typology

As far as almost each country tends to define the phenomenon of "city" (Lewandowska, 2014), situation of defining concept of smart cities gets more complex. Various types of cities will also evolve to multidimensional smart cites. Huge amount of smart cities homonyms may suggest that various dimensions of the phenomenon are at their very early stage and specified names may evolve in the nearest future.

In this section there is presented a typology for pure smart cities ecosystems. Many of the described terms are used interchangeably in a literature and treated as the synonyms. In fact, terms define concrete ecosystem and individual combination of social, environmental and technological aspects. Typology is presented in a table divided into four columns, where sequentially listed are: described smart city type, definition, unique smart city example and area of focus in reference to six characteristics of smart city proposed by Giffinger (Giffinger, Haindlmaier and Kramar, 2010), which are smart people, smart economy, smart living, smart governance, smart mobility, smart environment.

Discussed smart cities types can be perceived as customizable elements for creating tailored ecosystem for the particular city, where software and technology development play the key role. Targets and impacts may be widely interpreted and also problems may be differently defined and solved. Each smart city type indicates different area of focus, which in concrete circumstances remains the most important. However, smart cities that focus either on environment or industry, they always perceive people as the basic link of the value chain. Eventually, all the smart cities' initiatives influence intelligent communities development.

Table 1. Smart cities typology

Smart city classification	**Definition/Key characteristics**	**Example of the city**	**Focus area (Giffinger, Haindlmaier and Kramar, 2010)**
Ubiquitous city (U-city)	Ubiquitous city is a combination of traditional urban space and augmented reality where virtual meets convenience (Kwon and Kim, 2007) and from the technical side it is based on high-tech ubiquitous computing (Yigitcanlar and Lee, 2014). Citizens are perceived as co-creators of the surrounding and the process of environmental and services' development is meant to be user-centred (Mechant et al., 2012). Basically U-city focuses on users (inhabitants) and meeting their needs, especially those higher (Kwon and Kim, 2007)like self-esteem and self-actualization according to Maslow (Maslow, 1943). U-city harmonizes both physical and virtual spheres.	Seoul (Korea) – U-Seoul Project	• Smart People • Smart Living
Virtual city	Virtual city differs significantly from the rest of discussed smart cities' forms. Virtual city is an abstract term, which refers to fully IT-based cyberspace (Bers and Chau, 2006). This concept of virtual environment may be also called as "global village" (Bridge and Watson, 2003). Users enter cyber reality where they can live their virtual life and become part of the community. In the terms of discussed smart city dimensions, virtual city may be used as a tool for theoretical modelling for city designers or city management. It can be also implemented as a part of social awareness strategy and treated like a e-learning tool dedicated to youth and explaining environmental construction and self-exploration (Bers and Chau, 2006; Umaschi Bers, 2001). Virtual city phenomenon may encourage civic engagement and civic conversations within platform (Bers and Chau, 2006) which may result in a initiative attitude in a real life.	Zora – "a 3D multi-user virtual environment" (Umaschi Bers, 2001)	• Smart people
Information city / Metropolitan Area Network (MAN)	Information city source data from inhabitants in general or local communities and information is publicly accessible simultaneously enabling living and working on the Internet (Nam and Pardo, 2011) Metropolitan Area Network is a group of local area networks (LANs) combined into unified infrastructure on the area of a few to tens of kilometres (Chaładyniak and Wacnik, 2009). This smart city solution aims at institutions and enables access to various data from regional server, for instance educational or governmental entities require guaranteed and safe access to data. This is a very basic and popular smart city solution, but remains to be a powerful managerial tool.	Częstohowa (CzestMAN), Toruń (TorMAN)	• Smart people • Smart living

Internet city	So far, Dubai is the only representative of this smart city type. Dubai Internet City is even perceived as a unique brand, but concept may be easily implemented elsewhere, which is why term "Internet city" is treated for the purpose of this paper in terms of ideology. Internet city is a managed entity basing on the Porter's cluster Theory (Ohlsson 2005). Internet is the basic tool to bring innovations to all spheres of life, business and economy. City governors seek to attract the investors which are believed to maintain the acumen of sustainable development. For instance, Dubai tries to create first fully e-based government (Ohlsson, 2005).	Dubai Internet City (United Arab Emirates)	• Smart economy • Smart people • Smart living • Smart governance • Smart environment • Smart mobility
Ubiquitous Eco-City (UEco-City)	Ubiquitous Eco-City is the concept initiated by the Korean government (Kim, 2010), which is form of Ubiquitous City focused on environmental aspects (Petrolo, Loscrì, and Mitton, 2015) with a main focus on environmental impact minimization (Yigitcanlar and Lee, 2014).	Sejong or Yeosu (South Korea)	• Smart environment • Smart living • Smart people
Ecopolis	Ecopolis is an urban form which highly values city impact on natural environment and tries to minimize it and manage consequences of human activity (Downton, 2009). Technological innovations are widely implemented in order to upgrade ecological, environmental and living standards (Abdoullaev, 2011). It is believed, that environment is the starting point of sustain development of the city.	Nantes (France)	• Smart environment
City as a Service/ Platform/ digital city/digital metropolis	Idea came with the trend of 'platformisation' (Walravens, 2013) and refers to a cloud-based (or according to Global Government Cloud Computing) platform, which is perceived as a stimulus for innovative city development (Sharma, 2015). "Its goal is to create an environment for information sharing, collaboration, interoperability and seamless experiences for all inhabitants anywhere in the city." (Nam and Pardo, 2011)	Chicago (USA), Helsinki (Finnland)	• Smart living • Smart mobility • Smart people • Smart environment
Connected Sustainable Cities (CSC)	Concept of CSC includes sustainable development of economic, social and environmental spheres (Lewandowska, 2014). Connected Sustainable Cities focus on an approach towards widely perceived 'environmentality' and strong interconnections between environment, technologies and life (Gabrys, 2014). Cities perceived as a stimulus for economic and innovation development indicate high demand for resources and high effect on greenhouse gas emissions and therefore they should take responsibility for their environmental impact and implement sustainable strategies (Gabrys, 2014).	Stockholm (Sweden)	• Smart environment • Smart people • Smart living • Smart economy
Wireless city	In a wireless city wifi is perceived as a propitious element in urban interactions, which enables data-based analysis and decision-making (Hampton and Gupta, 2008). This type of smart city provides wifi-enabled spots (Casier et al., 2008) or provides free wifi services on the whole urban space (Reuver et al., 2009). Widely accessible Internet simplifies process of data gathering (under certain circumstances) and citizen-based decision making. "Connected" citizens have opportunity to actively participate or at least influence smart city governance.	"Wireless Leiden" (Netherlands)	• Smart governance • Smart living
Intelligent city	An intelligent city focuses on extracting valuable data and transferring it into intelligence, which is perceived as precise understanding of most pivotal trends and issues that can be widely used to develop innovations and improve various initiatives (Juceviciene, 2010). Intelligence in terms of smart city is the most advanced level of data acquisition and extraction process, which can be easily transformed to value.	Suwon (South Korea)	• Smart living • Smart governance • Smart environment • Smart mobility • Smart economy • Smart people

City 2.0	City 2.0 is related to the concept of Web 2.0 and it's social-focused participation fundamentals, but also technological and democratic issues resulting in the idea of Urban Planning 2.0 (Anttiroiko, 2012). Philosophy of the City 2.0 is to create a citizen-friendly infrastructure based on sustainability and innovation development including urban governance (Szelągowska, 2014).	Memphis (USA)	• Smart people • Smart living • Smart environment
City 3.0	City 3.0 is related to the concept of Web 3.0, where people are meant to be co-creators (Barassi and Trere, 2012). Using ubiquitous infrastructure City 3.0 is constantly learning and leads to the situation of systematic intelligence (Anttiroiko, 2012).	–	• Smart people • Smart living • Smart governance
High-Tech City/ MSC City (Multimedia Super Corridor)	High-Tech cities are usually part of a big agglomeration and tend to influence region development. "Suburban" high-tech cities aim at creating larger high-tech zones and try to encourage international corporations, specialists, but also their families (Bunnell, 2003). Such high-tech cities or zones are developed as a part of national or regional plans of economic and sustainable growth.	Putrajaya or Cyberjaya (Malaysia)	• Smart economy
Augmented City	Augmented city combines both physical and virtual spaces that constitute one, where high-technologies (mostly applications) play the key role as they blur the border between the physical and virtual sphere (Aurigi and Cindio, 2008). Just to mention a simple solution, AR glasses may be used by tourists and give the additional virtual layer providing information, geo-tags and other functionalities (Manovich, 2006). VR glasses may be also useful for the architectures or builders in order to visualize particular solutions or resolve geodetic problems.	Hong Kong (China)	• Smart people • Smart living
Sensing City	Citizens engagement through the process of sensing the city may influence both citizen-centric development and creativity (Gabrys, 2014). Sensing city is built on an infrastructure of citizen-sensor network, which highly stimulates processes of citizen initiative, e.g. active observations, reporting, analysing (Sheth, 2009). Such smart city initiative may be implemented in order to generate crowdreaching value offering crowdsharing opportunities may be widely used by institutions to monitor citizens and take care of them (reporting helth parameters, guaranteeing security, etc.) (Kamel Boulos et al., 2011).	Christchurch (New Zealand)	• Smart people • Smart living
Sharing/Shareable Cities	The concept of sharing city is related to collaborative consumption phenomenon. Sharing economy is perceived as a key in the city development and is thought to resolve many economic and social issues (Heinrichs, 2013).	Seoul (South Korea)	• Smart economy • Smart people • Smart living
Programmed/ Programmable city	Situation in which environment is programmed, system reacts in a concrete way (system has specified inputs and outputs) when interacting with surrounding and processes are automated and human participation is possible through electronic devices (Gabrys, 2014). Concept may be efficient in big-sized cities and metropolis, where time-consuming processes automation may help in budget savings.	Moscow (Russia)	• Smart environment • Smart living • Smart mobility

Most of the discussed smart cities types don't exist yet in reality as pure examples, but constitute an idealistic model depicting development direction. For instance, City 3.0 is hard to be completely understood, as far as meaning of its roots – phenomenon of Web 3.0 – still hasn't been precisely defined. There are also moot situations, like sharing or shareable cities, due to the fact, that sharing economy arouses controversy and to some extent is commonly negated.

Sometimes particular city is representing so far the only unique version of the smart city, e.g. Dubai Internet City, which may be even perceived as a brand itself. Looking up to Dubai, smart city project may be implemented with the intentions to attract investors and promote region, which can be extrapolated to other sectors of industry like tourism or HoReCa.

4. What happens when smart city is brought to life?

Factors determining smart cities philosophy have already been discussed and in this section there will be described areas, which may be affected or influenced after smart cities strategy is implemented. "The implementation of a smart city is based on sets of projects, which address these predefined priorities and objectives" (Anthopoulos and Fitsilis, 2013). Eventually, people, or rather intelligent, communities constitute an ultimate value, for which developing particular smart cities focus areas makes sense.

One of the key challenges is to choose partners. Building and maintaining smart cities infrastructure means establishing partnerships with technological companies, distributors, R&D units or corporations providing complex services. Good example may be the smart city of Amsterdam, which in itself may be called a partnership between 70 diverse entities (e.g. Cisco, IBM) that together deliver stated targets (Angelidou, 2014) Business partners may also be perceived as investors.

There are researches underlining that the quality of life is correlated to the citizens' education-level and areal employment situation (Shapiro, 2006). According to this thesis, smart cities struggling with the problem of draining population can focus on improving living quality aspects, which in result can contribute to retention upgrade. Living standards will be defined very individually and may vary from educational opportunities to everyday convenience solutions level. In terms of smart city perceived as a group of services (Ballon et al., 2011), improving living standards can also mean widening services portfolio.

Technology based solutions always remain problematic due to the risk that particular elements may fail. Considering the fact, that smart cities implement many radical innovations, situation may be more complicated according to social adaptation. From the sociotechnical perspective solution can be neglected or even rejected in a particular society, which should be considered during smart cities strategy planning. For example, educational practices may help to improve social awareness (e.g. consistent data policies) and avoid misinterpreting technology-based intentions.

For the smart city also organizational methods itself are challenging. Gil Garcia and Pardo have already classified factors which may affect e-governance and these are mostly internal problems typical for conventional organizations, e.g. resistance to change or organizational diversity (Gil-García and Pardo, 2005). As regulatory aspects guarantee feel of safety to the community, it may even require some legal changes to be introduced. Basically, formulating, implementing and understanding policies is a constant process of creating law. People should also be aware of their rights and some educational initiatives are highly recommended.

5. Summary

Smart cities solutions require huge investments in infrastructure, software, people, know how, and many more. Technology-driven perspective is expected to revolutionize or at least change the way ecosystems function. It's a challenging, long-term strategy as far as it's embedded in a dynamically changing environment where political, economic, social and technological aspects may play important role. The point is that technological development forces radical changes on many ecosystems which is why smart cities should be perceived as a natural consequence of globalisation and ICT development. Every change entails the risk and in a situation of high-tech infrastructure the main threat appears to be data safety. Risk management, which is often omitted by many companies, should constitute the basic tool for monitoring and scenario-based reacting in a smart city ecosystem. Hermetic technological infrastructure guaranteeing cyber security combined with city governors' sophisticated managerial skills are fundamentals of success drivers. Once again according to Giffinger's list of characteristics (Giffinger, Haindlmaier and Kramar, 2010) smart cities should tend to utopian balance between six spheres of people, economy, governance, environment, living and mobility.

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