

IN-DEPTH ANALYSIS OF SMART CITY IN MODERN AGE

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Abstract: The current term and concept of Smart City is nowadays not clearly defined. This article provides a robust analysis of Smart City research papers with focus on terminology and definitions. The reviews of current literature and summary of the different definitions of Smart City should help with future researches thanks to the clear definition of this area. The created summary leads to the main and common points, what Smart City is or should be.

Keywords: Smart, Modern, Digital, City, Internet of Things, Analysis

1. INTRODUCTION

The city development was always a hot topic. Improving the quality of life, services in the city, education of the people and many other factors or areas, should be a main topics and tasks of the cities. Nowadays we are seeing many new terms in the area of city research and development as a digital city, smart city, future city, modern city and others. Our analysis shows the exponential growth of interest in the research area of Smart City (see Figure 1). Smart City is nowadays a vision of

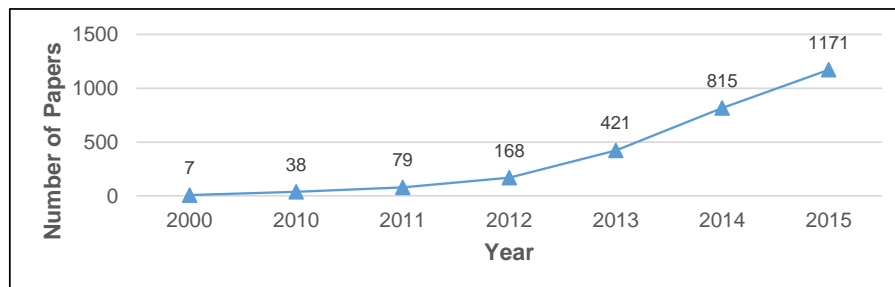


Figure 1: The growing number of papers dealing with Smart City issue merged by years (data source Web of Science database [1])

future city. However, this vision is changing based on the individual opinions on what Smart City is. The individual opinions might be impacted by geographic location, area of interest, social level, development level, education and many other factors. This lead to the fact, that it is no universally accepted definition of a smart city.

This article deals with the terminology and issue of smart city. We provide a summary and reviews of current literature, where we try to find common points in the definitions of Smart City, it's needs or challenges. This should provide a common and basic definitions for future steps in the development and research in Smart City area.

2. SMART CITY DEFINITION

Considering the situation in Europe, The European Union see Smart City issue clear. The city is becoming smarter with the partnership of the ICT, energy and transport sectors integrators. These partnerships aim to implement innovative solutions and ideas to tackle issues as congestion, air pollution, high energy costs and to achieve better mobility, cleaner urban environment and energy efficiency. Smart City should be build in the beneficial way for citizens, the city budget and the environment [2]. This definition is coming from the challenges defined by internal needs or processes in the city. However, if we should generalized the term of Smart City then we should not consider the variables, which are often changing as i.e. needs of the cities.

The second common definition of Smart City is to divide it into a different areas of interest as i.e. smart economy, smart mobility, smart governance, smart environment, smart living or smart people as in [3]. This definition or look to Smart City is very similar as the first definition with same problem. We cannot generalized the term of Smart City if we will consider local needs or areas of interest.

If we look closely to the current research papers, the clear united definition of Smart City is hard to find. We can find different definition of Smart City [4–10] and also different names for Smart City as a wired city [11], virtual city [12], ubiquitous city [13], intelligent city [14], information city [15], digital city [16], knowledge city [17], learning city [18], sustainable city [19], green city [20] and many others [21]. We can see that Smart City does not have only many different definitions, but also many different names. The Figure 2 shows five most frequent Smart City names used in professional research papers over the last years. We will keep the name Smart City, as already well known and

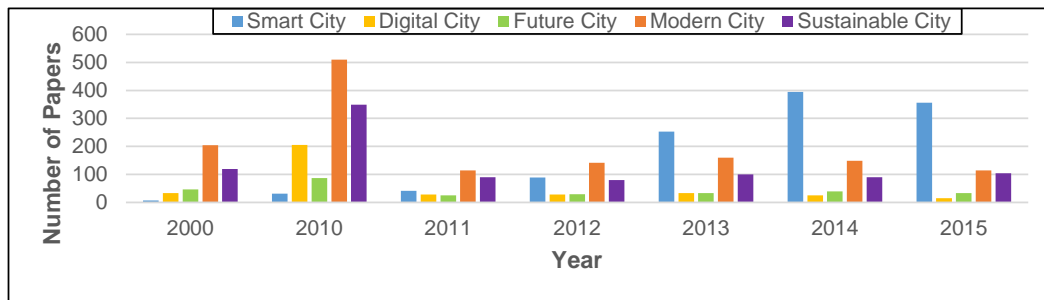


Figure 2: Frequency of different names of Smart City in published research papers merged by years (data source Web of Science database [1])

most frequent name in the professional community, and try to connect it with most common terms used in the professional papers. We analysed 815 articles from Web of Science database, the analytical algorithm is on Figure 3. The most common terms connected with Smart City in research papers

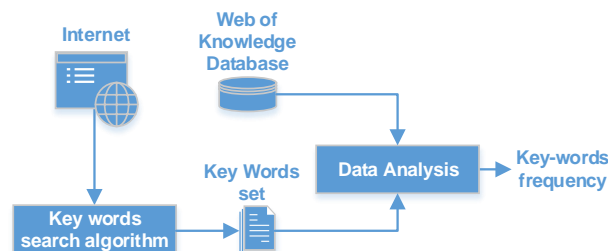


Figure 3: Schematic of our key-words frequency analysis in professional research papers

from Web of Science database are follows (in brackets is frequency of the term): technology (319), data (296), network (289), information (281), development (246), management (232), infrastructure

(185), resources (117), quality (116), knowledge (90), people (82), costs (79), innovation (79), reduce (69), digital (67), security (59), collect (58), connect (54), learn (50), vision (38), health (35), economy (32), green (30), companies (29). This shows that the interest of professional research community in Smart City focus mostly on the technology, data, networking and informations, where we can see the data and informations as same term. Most of the terms are depended on the informations/data and without it is not possible to provide sufficient solutions. This leads to the point that Smart City should be based on the informations.

Nowadays, the main methods for data or information collection are with using the information and communication technologies (ICT) [22]. In the ICT is currently the Internet of Things (IoT) considered as a global infrastructure, which will lead for big data collecting with minimal human intervention [23]. We should then consider the IoT as a basic infrastructure for Smart City, which will lead to the following challenges:

- IoT implementation - The common definition of IoT is still missing, variation of standards, technologies and solutions are considered, but common solution is also missing [23].
- Security - we need to precisely define, which information will be open and how we will authorize the access to the other data [24].
- Data analysis - collected data are unusable if we are not able to analyse them sufficiently [25].

If we will have solved the data collection challenges with it's analysis and distribution, then the other processes could start. The collected informations might be after used for interactive education and learning, citizens security, health protection and care, innovation solutions, quality improvement, environment cleaning (green solutions), urban management, private use (companies and market solutions) and many others areas [25]. Each of this solution or area will bring into the area of Smart City new challenges, but they should be seen as a challenges of internal processes of the city and not as a main challenges for Smart City concept.

This lead to the definition of Smart City based on professional interest. Therefore, Smart City should be a city, where the informations and data are collected from the different kind of sources and with different kind of systems. These data should be effectively collected and distributed only to the authorized individuals. These data are after analysed and used for making the city processes more effective. This should lead to the improvement in the various interest areas of the city. Considering the IoT concept, the several parameters should be considered: power and cost efficiency (millions of devices are considered), security (personal, trade and critical data might transmitted), technology performance (urban areas, closed environment) and many others. Several communication technologies might be used for this task. Following list shows the overview of current technologies which might be used for information/data harvest in city:

- **LPWA - Low Power Wide Area**, it is a new group of wireless telecommunication technologies designed for IoT use-cases, it offers long range, low costs and energy efficiency. Nowadays, the research and development is in radio-communication area, but not limited for other solutions. The concept was developed for areas with millions communicating devices, where is considered only lower needs for security, data-rate speed and in some cases even only one-way transmission is considered. This means areas as a trash-can monitoring, parking monitoring, other sensors applications, remote long-range metering and other applications, where we need simple low-bit rate transmission with low energy and cost parameters. This technologies are i.e. LoRaWAN, LoRa, SIGFOX, Weightless or NWave.
- **NB - Narrow-Band** or also **Narrow-Band IoT** are group of IoT technologies, which are considered also for long-range use-cases. Compared with the LPWAN technologies, they offer similar range, licensed band, competitive speed, higher security, higher reliability and QoS. However,

they have also higher power needs, costs and lower penetration. These technologies have different use-cases, we should use them there, where we need secure and reliable communication and when we do not need low-power or low-cost solutions. These technologies are coming mostly from 3GPP standard - NB-IoT, LTE-MTC (LTE-M), NB-LTE-IoT.

- **SRN - Short-Range Networks**, it is a group of short-range wireless networks technologies. These solutions have its place in end-customers applications, as i.e. Smart Home solutions. They provide from cost-effective solutions, energy efficiency solutions to big-data rate solutions and they are mostly limited only with the short-range use. These technologies are i.e. ZigBee, WiFi, Bluetooth, Z-Wave or Thread.
- **Others** - There are many other technologies as i.e. PLC (Power-line communication), OP (Optic-Fibre), other radio or wireless technologies, other wire technologies. These technologies have very specific use-cases and they should be considered for specific areas of communication in Smart City (infrastructure connectivity, smart grid solutions, etc.), but these technologies have for use-case of millions of devices too many limitations, because they were not developed for main IoT concept of high amount of devices.

3. CONCLUSION

We provide the robust analysis of current terminology in the area of Smart City. We analysed hundreds of professional research papers to find out the common terms. We defined Smart City term in three contexts - Europe Parliament, Western Country look and Professional look. The main definition of Smart City is based on the key-words frequency and it comes from the main principals and connections in Smart City terminology. We introduce also the main needs for Smart City as a future city vision, together with challenges and its possible solutions. The Article should be used as a guide for future researches in the area of communication technologies for Smart City.

The analyses show that the informations and data are the basic tool for the city improvements and Smart City realization, where the Internet of Things should be considered as a main infrastructure for collection these data or informations. The data are the key tool for making all the city processes more efficient. We are not able without informations or data analyse the situations, challenges and create more effective solutions. This show that the realization of the ICT infrastructure - Internet of Things, is a key challenge for Smart City concept, from the data/information point of view.

We see Smart City as a concept of city, where data are wisely collected, analysed and shared. These data should be used for improvements, bigger efficiency, higher life quality and also for dealing with everyday challenges in the city. However, Smart City should be considered as a vision for people and not for technologies. This means to always give a significant value to their opinion and their needs. We should always start with right question "What we really need" and not with "What we can", i.e. in a context of data harvest, where the citizens lost their freedom thanks to the over sensed city.

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