The Socio-Technical Impact of the Current Disruptive Technologies on the Smart City Concept Realization

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Abstract

Humanity is entering an entirely new era, which is defined by such a phenomenon as the fourth industrial revolution. In this case, society will naturally find ways of technological progress. This article discusses the concept of Smart city, which is an effective junction between human and technology. The article also discusses the technologies underlying Smart city, as well as an example of the successful connection of such technologies in the most important infrastructure of urban life-transport.

1. Introduction

It is not just corporations that are seeing rapid changes due to major global challenges, such as globalization, climate change and digitalization. Societies, cities and regions are also experiencing these changes. Today, 55% of the world's population lives in urban areas, a proportion that is expected to increase to 68 by 2050 [UN18]. Thus, the speed and complexity of change also challenge leadership, organizational structures, R&D activities, education and training, and value chains. Ecosystem-based development is considered to be an option that will facilitate management of change at governmental, national, regional and company level.

The World Economic Forum report [WEF18], following the work of Klaus Schwab, terms the period of accelerating innovation in science and technology as the "fourth industrial revolution". The technologies of the fourth industrial revolution have generated growing interest in the opportunities they offer as well as concern about governance, regulation and ethics. Combining artificial intelligence (AI) with big data – not to mention exponential accumulation of data itself – has created a fascinating world of communications and machines [Sal17]. As a result, the Industry 4.0 framework defines the context for digitalization and industrial Internet of Things (IoT). This framework contains the connectivity of devices for effective value chain management using sophisticated data collection as well as data-based optimization and analysis. For this reason, industry 4.0 also provides a detailed and solid framework for development work related to smart cities [Lom16] because activities related to data collection, interpretation and analysis (in support of rational decision-making and planning) are central to creating smart city services in the value chain network.

The section 2 describes the concept of smart city, and its symbiosis with digitization and legislation. The section 3 stops attention on the specifics of some of the modern technologies included in our lives in connection with Industry 4.0, while the section 4 shows the example of integration of RFID and blockchain in the process of dispatching control. Section 5 discusses the results and gives guidelines for further research in this field.

2. Smart City Concept Digital Symbiosis

The smart city concept derives from the intersection of studies in urbanism and information and communication technology (ICT), combined with the dimensions of creativity and humanity [Nam11]. The smart city concept represents new ways of organizing city functions and urban life for environmental purposes, based on

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digitalization [Öbe17]. In the field of ICT, rapid development of software, hardware and networks has made it technologically possible to connect people and the facilities that serve their everyday needs in cities [Per17]. Thus, the smart city concept brings together technology, government and different layers of society, utilizing technological enablers, such as the internet of things (IoT) and artificial intelligence (AI). These enablers, in turn, facilitate development of various aspects of the smart city, including, e.g., transportation, governance, education, safety and communications. Thus, different and often complementary aspects of a smart city encompass an efficiency, technological advancement, sustainability and social inclusivity [Van14]. General trends in this kind of development include the transition from global to local production and consumption, a change from competitive to collaborative manufacturing and service provision, and a move from shareholder-based businesses to multiple stakeholder viewpoints [Her13].

The smart city concept integrates the ICT, physical IoT, and IoT-devices to optimize the efficiency of city operations and services [Per16]. Transportation is an important part of the concept of smart cities, and the main goal is to ensure safe and effective mobility of individuals and goods in a way that minimizes the CO2 emissions. Thus, transportation should not be viewed as simple "moving people and goods from one place to another" [Wen15], but transportation should be understood as a service, in which timely delivery of people and goods in target destination is emphasized.

Smart city development requires not only technological enablers but also a new way of thinking among cities, businesses, citizens and academia, which includes key development stakeholders. In this manner, close collaboration between universities and the private sector must be maintained, and the main objective should be shared learning [Ruo18]. This kind of long-term cooperation creates a background for new co-innovation and co-evolution.

The transition towards smarter cities involves changing and evolving stakeholder roles [Lom16]. Citizens should no longer be considered as merely users but rather as stakeholders with an active role; as participants, collaborators and developers in the city's activities. In the same manner, technology should no longer be considered as an asset but as a dynamic enabler in smart city development. Moreover, in this framework, business is no longer viewed as a provider but rather as a collaborative partner. These new roles, together with the ecosystems formed by smart cities, establish a framework for a new kind of development in urban areas. In this framework, it is important to understand that smart city development does not mean merely providing new digital services for citizens. Rather, it is a transformative process involving city structures, governance and functions, as well as interaction and collaboration between city stakeholders [Van14].

Smart city initiatives have recently been merged into a model to make cities better places to live in. The smart city can thus be considered as an ideal of sustainable urban living. It is nevertheless a rather vague concept, defined in various ways depending on the context of smartness [Öbe17].

According to Giffinger & Suitner [Gif15], the concept of a smart city should incorporate at least one of the following dimensions:

1) **smart economy** related to, e.g., innovation, entrepreneurship, flexibility or productivity;

2) **smart mobility** in the context of sustainable resource management and transport systems;

3) **smart governance** with implications for participation, decision-making and transparent governance structures;

4) **smart environment** that is understood to provide attractive, natural conditions and a lack of pollution, as well as sustainable management of resources and energy;

5) **smart living and quality of life**; and

6) **smart people** in terms of qualifications, creativity, education and flexibility [Van14].

The Internet has transformed the world economic landscape, and this transformation is expected to continue with the IoT. Rifkin confirms this trend in his concept of zero marginal cost, which emphasizes connectivity in his anticipation of a collaborative economy that will replace the capital system in its current form – with the IoT as the main driver [Rif14]. The rapid progress of smart cities is also paving the way to a more collaborative world [Kan09].

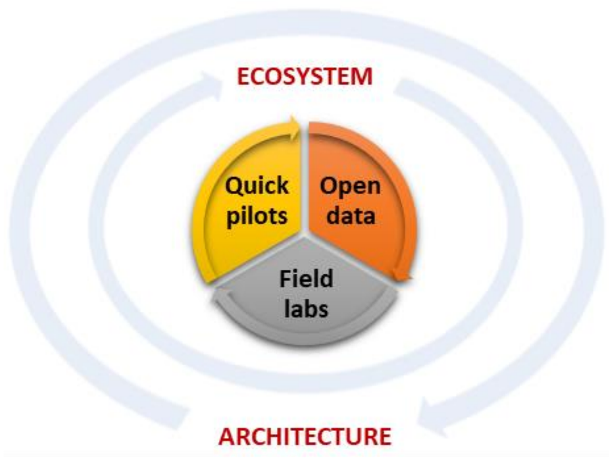

Figure 1: The birth of innovation in digital ecosystem [Ruo19]

Figure 1 displays the essential framework for a digital ecosystem in smart city transformation [Ruo19].

In this framework, the general architectural layer enables the involvement of private sector partners. At the same time, the players in this framework form an ecosystem that consists of inhabitants, tourists, companies and the city itself.
Technology architecture should be agreed upon. Municipalities should create an open architecture that private partners can integrate to, but that still meets the needs of their citizens. Again, private-sector partners can support cities in this effort.
In rapidly changing digital environment, it requires clear and commonly understood vision. To describe the elements and layers, by which digital economy thinking has support, it is possible to draw a pyramid (Figure 2).

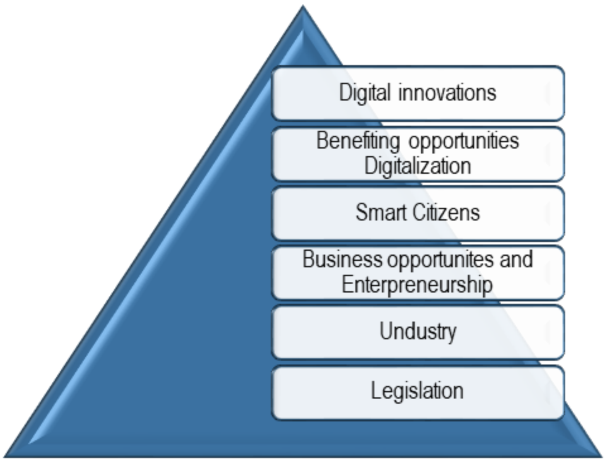

Figure 2: Layered model of public sector enabling formation of digital economy

The layers describe the operations of the public sector, which support and enable effective and digitalized formation of digital economy.
Legislation creates rules for the co-innovation and operations generated and new business opportunities (government). It is seen rather as enabler than restrictor.
Legislator has the role of offering common rules, generic standards and interface regulations, which enable effective re-use for disposed components and digital technologies. Governments are able to guide by taxation the operation to a direction, which clarifies and enables it.
The legislation should contain such details that digital technologies for cities and rural areas are able to used successfully. When legislation support and allow the use of digital technologies risks to start business are lower and predictability is better.
It is possible to find new approach to use for digital technologies when these technologies deliver them to the customer by efficient way. For this issue it can be propose the virtual platform which could combine the information about different players and from different structures forming triangle – Smart City symbiosis, digitalization and legislation [Iva19]. New service innovations will be born through digitalization and business opportunities will increase within circular value chain with better planning.
On the above mention, it is possible to suppose that triangle consists of the Smart City symbiosis, digitalization and legislation in frame of Smart City platform. This Smart City symbiosis can involve stakeholders and players at all levels (companies, authorities of different levels and municipalities, smart and digital technologies and legislation agencies and experts) to develop a methodology and software platform to facilitate the exchange of information that can support Smart City symbiosis networks, create and support pilot projects and replicate their results at local and regional levels.
In the same time such platform can support the movement different digital technologies to rural areas as well that it is quite important for both small and long distributed countries. Such model as a challenge has to be design on the triangle, presented on the Figure 3, and supporting the usage of digital technologies for both social issues and business as well.

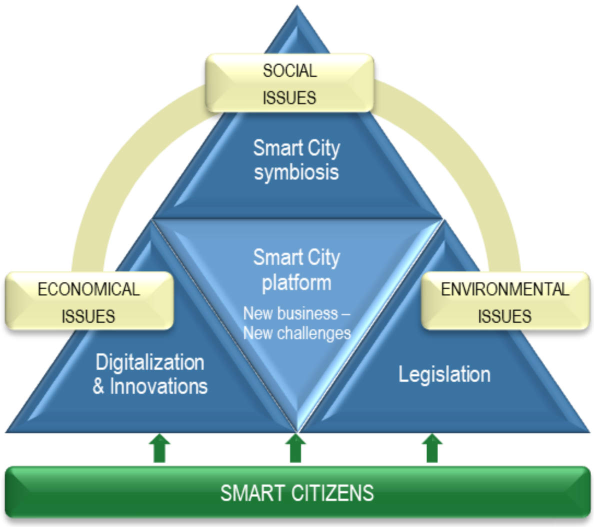

Figure 3: Smart City symbiosis, digitalization and legislation as forming triangle

The concept of smart city is based on information and everything related to it, its collection, storage, processing, and management decisions in different infrastructures of the city, which were discussed above.

3. Current Disruptive Technologies on the Light of Information Activities Schema

The schema of basic information activities that emerged at the dawn of the development of computer science in the mid-60s of the previous century (Figure 4), it continues to dictate the ICT development today.
The difference is that while at the beginning these activities described the simple processes of small information applications, nowadays, behind each of them, are technologies that dramatically change our way of life.

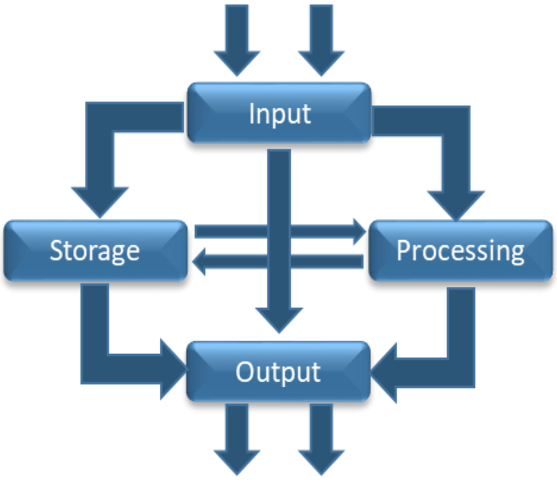

Figure 4: Main information activities [Bar66]

Some of these innovative technologies are:

- RFID – one of the methods for automatic identification and data collection;
- Blockchain – a new method for storing information in the distributed network with assuring protection;
- Data centers and cloud technologies – data centers have their roots in the big computer halls of the early days of the computer industry. However, with the development of cloud technologies, they have radically changed the view of the storage of data and services today;
- Internet of things – system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.
- HPC and grid computing – a processing ground of these ensemble which in combination with the other technologies became a solid base for enormous growing of the last one:
- Artificial Intelligence.

In this article, we will focus on RFID and Blockchain technologies and the added value of their relationshipin case of assuring reliable, transparent and reliable dispatching control of goods transport.

3.1. RFID Technology

RFID (Radio Frequency Identification) – a method of automatic identification of objects in which data stored in so-called transponders or RFID tags are read or written by means of radio signals. [Lah05]
Any RFID system consists of a reader and a transponder (RFID tag). Most RFID tags consist of two parts. The first is an integrated circuit (IC) for storing and processing information, modulating and demodulating radio frequency (RF) signal and some other functions. The second is the antenna for receiving and transmitting the signal.
There are several ways to organize RFID tags and systems: by operating frequency; by power supply; by type of memory; or by execution. Figure 5 shows the example of application of RFID technology in transport.

Figure 5: Example of application of RFID technology in transport [RFID17]

RFID tags are already part of our daily lives. This is a cheap and effective way to collect and store data that finds multiple applications and will expand the niches of use in the future. Examples include: tracking goods movement (Walmart is one of the largest users of this technology for such purposes); tracking citizens' movements through RFID chips in their passports (used in countries such as Japan, the United States, Norway, and Spain); automation of highway systems for payment of toll taxes; putting in tires for the transmission of traffic information to the on-board computer; locating around cities or historic places to convey tourist information on mobile phones to visitors and so on.

3.2. Blockchain Technology

Blockchain falls under the umbrella of Distributed Ledger Technology aimed to store, distribute and facilitate the exchange of value between users, either privately or publicly based on the consensus of replicated, shared, and synchronized digital data geographically spread across multiple sites, countries, or institutions without central administrator or centralized data storage.
Blockchain is a digital public registry protected from unauthorized access, which keeps records of transactions in a public or private peer-to-peer network. Distributed among all nodes of the network, the registry continuously records the history of operations with assets between peer (of the same order) nodes of the network in the form of blocks of information. All approved transaction blocks are connected in a chain from the initial block to the last one added, hence the name of the technology — blockchain (Figure 6).

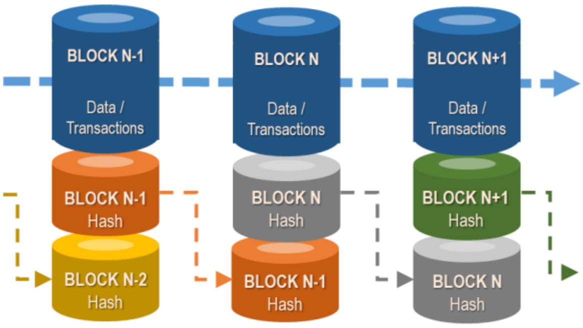

Figure 6: Blockchain process [Pol18]

Thus, the blockchain acts as a single source of reliable data, and the participants of the blockchain chain see only those transactions that relate to them. Instead of turning to third parties, such as financial and credit institutions, as intermediaries in transactions, blockchain nodes use a special consensus Protocol to agree on the contents of the registry, as well as cryptographic hashing algorithms and digital signatures to ensure the integrity of the transaction and transfer its parameters.
The consensus mechanism ensures that distributed registries are exact copies, which reduces the risk of fraudulent transactions because extraneous interference can occur in many places at the same time. Cryptographic hashing algorithms, such as the SHA256 computation algorithm, ensure that any change in the transaction input, however slight, will result in a different hash value appearing in the calculation results, indicating that the transaction input is likely to be compromised. Digital signatures ensure that transactions are carried out by legitimate senders (signed with private keys) and not by intruders.

A decentralized peer-to-peer blockchain network deprives individual participants or groups of participants of the ability to control the underlying infrastructure or destabilize the entire system. All members of the network are equal and connect to it using the same protocols. Participants can be individuals, government agencies, organizations or associations of all these types of participants. From the other side the blockchains can be public, private or federated, when two or more public or private blockchains communicate each other.
The system records the chronological order of transactions with all nodes of the network that have recognized the validity of transactions through the selected consensus model. The result is non-cancellable transactions agreed upon by all network participants in a decentralized manner.

4. Interaction of RFID and Blockchain in case of dispatching control

At the moment, the integration of RFID and blockchain is beginning to be applied on water and rail transport in the process of dispatching control. This fits well into the concept of a sociotechnical system, which has both a human factor and a technical basis.
The process of dispatching is to manage the transport situation in a certain location, control and monitoring. These processes require input on this traffic situation. The basic object for data collection will be a vehicle, for example, a ship (consider the example of water transport). The tool for data collection will be an RFID tag, which collects the following data using a radio signal antenna:

- The results of observation (receiving the absolute geographical coordinates – latitude and longitude in degrees);
- Course and speed of the vessel (in degrees);
- Wind speed (in m/s);
- Depth of water space (in m);
- Flow rate (in m/s);
- Time intervals between two observations (in s);
- Shortest distance to the nearest navigational hazard (in m);
- The angles of the demolition of the vessel by the wind (in degrees).

This information is transferred to the distributed registry. Thus, all nodes of the trusted network that are interested in traffic safety, namely: the nearest control centers, other vessels, will learn about it at the same time.
Due to the blockchain technology, this information is hashed, added as a block to the chain of blocks, which guarantees the integrity of the information. Before it entered the register, no one could change it, and the information came from its sender.

The procedure for downloading information into the blockchain is shown in Figure 7.

```
import requests
files = {'table.xls': open('report.xls', 'rb')}
r = requests.post(host = '0.0.0.0',port = 5000, files=files)
r.status_code == requests.codes.ok
```

Figure 7: Downloading procedure

The procedure for verifying the integrity of information is shown in Figure 8.

```
def check_integrity():

    files = get_files()

    results = []

    for file in files[1:]:
        f = open(blockchain_dir + str(file))
        h = json.load(f)['hash']

        prev_file = str(file - 1)
        actual_hash = get_hash(prev_file)

        if h == actual_hash:
            res = 'ok'
        else:
            res = 'corrupted'


        results.append({'block': prev_file, 'result': res})
    return results
```

Figure 8: Procedure for verifying the integrity of information

5. Conclusion

This article discusses the concept of Smart city, the areas of urban life that it affects, the description of human and technical factors. Also, the main technologies underlying Smart city are considered, their detailed description is given. An example of successful integration of some transport technologies in the process of dispatching control is given.As a result, we can say that once such technologies have begun to be introduced, then people are keeping up with the times.

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