The use of IoT for future smart sustainable cities: Its perspectives and challenges

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Abstract

Smart cities have emerged lately as a solution for the growing population and sizes of cities. This means that a better resources' management is needed to be developed in the same time. A combination of cities and technology is today's digital dream. We live in the age of technology and IoT (Internet of Things) plays a key role in developing smart cities. From this point of view, city planners should think seriously about this issue in order to forestall their future. The concept of smart city is related to sustainability, mentioning here many aspects such as reduction of environmental pollution, increase of energy efficiency, smart traffic management system, E-health services, etc. The main stakeholders are city's residents, its government and also private enterprises. In this paper, we identify and analyze the main aspects of the city infrastructure as an integration of IoT technologies, highlighting the main approaches and challenges.

Keywords 1

Smart City, Sustainability, IoT

1. Introduction

In their median projection, the United Nations' have concluded that by 2030, the world's population will have grown to 8.5 billion [1]. This exponential growth is and will continue to be more noticeable in cities, due to the tendency of the population to move from rural areas to cities, increasing the population living in urban areas to 66% by 2030 [2]. This rapid growth inevitably leads to more limited resources in cities, waste management, pollution and traffic management to mention a few. There are many definitions to the term, presented by different researchers. However, in this paper we refer to smart cities as the following. *"Smart city" refers to the ability of a city to grow sustainably by means of mobile computing systems and practical data management networks, leading to better management of traffic, energy, pollution, parking spaces and so on* [3].

The IoT (Internet of Things) system is a growing network of physical objects (aka "things") embedded with sensors and devices with the purpose of data collection and exchanging between devices and systems. With the increasing attention that the idea of smart cities is getting, IoT technologies have also been in the spotlight as a solution for creating them. The Internet of Things (IoT) is composed by a group of smart devices and sensors connected together to the Internet. Their dates are used for evaluation by many organizations, including here cities, companies, individuals, etc. This has been possible, in part, due to the advent of cheap processors and wireless networks (Cisco).

The development of smart cities are mainly focused on some major components, namely: the citizens (quality of life), the economy, the governance (e-government), the transportation and the environment. Despite the huge interest, there are some challenges we have yet to overcome when it comes to developing smart

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cities, which will be mentioned in the second part of this paper.

2. Smart Cities Pillars

Developing smart city systems is a large-scale endeavor. To make this possible we will make use of the three "pillars" of smart solutions [4]:

- *Internet of Things (IoT)*
- *Big Data*
- *Cloud Computing.*

Figure 1*:* An overview of smart city

IoT is defined as "a dynamic global network infrastructure with self - configuring capabilities based on standard and interoperable communication protocols where physical and virtual "things" have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network" [5].

IoT lets devices communicate with each other through different technologies such as sensor networks. It has found a wild application in automation systems with the use of IPv6-enabled architecture and smart grid systems. On the other hand, it has also found a wide application is "smart city applications" such as IP cameras, smart wheelchairs and Web of Things [6]. Recent interest in research regarding IoT in smart cities is sustainable development.

To summarize, IoT provides reliable communication remotely (no human interaction is necessary), however it needs to process a large amount of information coming from a large amount of connections in the IoT network. Providing these key elements is crucial in designing the architecture of a smart city.

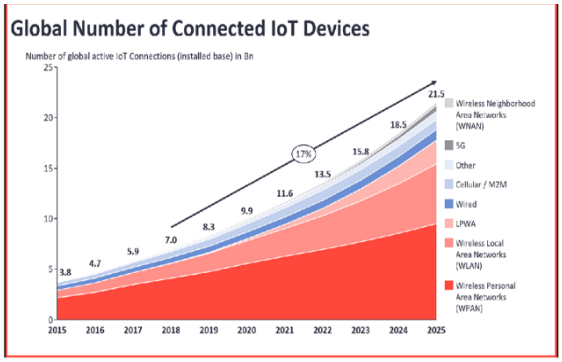

Figure 2: Number of connected IoT devices during the period from 2015 to 2025

Big Data: Data produced in IoT smart city systems, could (and most likely will) grow exponentially with time. Data is generated by a vast amount of sources such as mobiles, computers, cameras and sensors. This makes it hard for traditional data mining techniques to store them effectively. The use of big data technologies makes sure that the large amounts of data collected are processed efficiently and correctly. The application of big data is often limited by the large computational storage that is required to process these data. Quality of Service (QoS) is very important for real-time big data applications, due to its use in intelligent networks made up of many connections that require effective transfer of data. Such different connections are those with the citizens' smart phones or cars.

Cloud computing: Cloud computing is tightly bound with big data. It is a good solution for processing large amounts of data. Cloud computing provides a common network-based platform for many cloud users to share resources.

3. Overview on the Sustainability of Smart Cities

The notion of sustainability is derived from the need for change, in order to make people's live better ones. It means a more attractive, inclusive and balanced city for its residents and tourists.

Figure 3: The concept of smart sustainable city

Allen and Hoekstra highlighted the scale based on which the sustainability can be measured and assessed [7]. It does not exist a global urban scale. Sustainability is an old term for urban planning discipline and it has been always discussed in literatures. The same logic stands also for smart cities. This concept will be connected closely to the field of urban planning. It offers a good balance among supply and demand on the other hand.

Referring to APA, there are some outcomes required to guarantee sustainability in urban planning:

- The equality among all groups should exist;
- The communities should be "resilient, diverse and self-sufficient."
- We should have a healthy environment, in terms of social and economic aspects.

From this point of view, the concept of sustainability goes beyond natural resources; it is related to many aspects of society. This paper looks into the use of IoT in urban field, in order to transform a city into a sustainable smart one. The urban planners should connect the concepts of smart cities and sustainability together. IoT plays a key role in the process of smart city's sustainability. Its application is realized from sensor networks, that collects data from different parts of the city, for example environment, traffic, health, etc. These sensors work with a device called an actuator. This data will be used and evaluated, in order to optimize, manage or predict certain future situations. This collected information is very important in order to improve the performance or resources' use. When the number of sensors is big, the fog computing is used in order to get the data from sensors in a secure way and closer to the place it will be processed. In this way, it can be used in an efficient way to update different processes.

4. IoT challenges

Despite the huge interest, there are some challenges we have yet to overcome when it comes to developing smart cities. First off, lack of ***investment and cost.*** Smart cities are a great opportunity to save money. Examples include Barcelona, which is estimated to save billions of dollars in energy cost using new smart systems, such as smart city lights, that light up and dim using motion sensors [8]. However, to reap these benefits, there needs to be an initial investment either by the public or private sector and the budget it would require is quite large. Another challenge to take into consideration is ***privacy.*** Citizens interact with the smart systems, however a lot of them are inclined to be skeptical of them because of privacy and confidentiality concerns. Another aspect is the security aspect. Smart systems offer the benefit of automatization, at the risk of cyber-attacks. All of these concerns open the door for more research and mindfulness when developing smart systems. Furthermore, these network sensors use ***energy*** and the total amount of energy used is one of disadvantages. ***Fault tolerance*** is another challenge to be considered related to IoT use in the field of urban planning. The resilience of the network based on sensors, to the failures of the system should be considered. In smart cities everything is interconnected [9]. Each of its "nodes" presents its own vulnerabilities. A single vulnerability can affect the whole system and affect the citizens' security [10]. For example, an attacker may be able to connect to the electric power system and alter public transportation with thousands of passengers aboard. Or they might launch false alarms, modify traffic lights and so on, all of which have serious security implications. This is why it is very important to develop reliable solutions. ***Data management:*** Treating the huge amount of data collected in smart cities is a challenge. One viable solution is that smart phone data can be used to develop a variety of urban applications [11]. For example: mobile phone data can be used to estimate road traffic volume.

5. Conclusions

Given the exponential growth of populations, most notably in cities and the implications this has in regards of limitations in resources and services, smart city systems have emerged as a solution and have become very popular concepts all across the world. Taking smart and sustainable action in developing these solutions is crucial, and this includes taking into account.

This, however doesn't mean there are not still a lot of areas in need of more research, most importantly: cyber-security, data management, sustainable energy use to name a few, etc., which are presented above.

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