LARGE- SCALE WIRELESS SENSOR NETWORKS: A STEP TOWARDS A SMART CITY

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ABSTRACT:
THIS PAPER PRESENTS AND EVALUATES THE PERFORMANCE THAT THE SMART CITY CONCEPT MUST ENSURE. IN THIS RESPECT, WE HAVE FIRST EMPHASIZED THE MOTIVATION AND THE UNDERLYING IMPORTANCE OF THIS SCIENTIFIC RESEARCH, THE CONSTRAINTS AND THE ISSUES THAT ARISE WHEN SUCH A SYSTEM IS TO BE IMPLEMENTED. TO BEGIN WITH, WE HAVE IDENTIFIED AND DEFINED THE CHARACTERISTICS AND SPECIFIC FEATURES OF A SMART CITY. ADDITIONALLY, WE HAVE STUDIED THE CURRENT TRENDS AND CHALLENGES THAT OCCUR WHEN IMPLEMENTING A SMART CITY CONCEPT, BY CONSIDERING THE NECESSITY AND THE UNDERLYING REASONS FOR DEVELOPING THIS CONCEPT.

KEY WORDS: SMART CITY, WIRELESS SENSOR NETWORKS, LARGE-SCALE, LONG-THIN, IEEE 802.15.4.

INTRODUCTION

The Smart City concept has emerged during the past few years, entailing the integration of highly efficient solutions that would first of all ensure the increased quality of life as well as the protection of the environment. Thus, technological progress has led to the implementation of systems that can be integrated in the Smart City concept. The main contribution of this paper is the evaluation of the current trends and challenges that occur when implementing a smart city concept, by considering the necessity and the underlying reasons for developing this concept.

The development and challenges of large-scale WSN sensor networks have benefitted from the attention of several research centres, since it is a very topical issue. The architecture of these sensor networks distributed throughout the city has several characteristics: it is of the long-thin type, it can incorporate up to a few hundred nodes, spread across a wide geographical area (of the large-scale type) and has one or several central points called sink nodes, where the information is collected. A long-thin wireless network has a particular network topology that encompasses a number of linear communication paths between the

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nodes that serve as connection backbones and are meant to expand the network's coverage area.

ISSUES RELATED TO WSN NETWORKS AS PART OF THE SMART CITY CONCEPT

One of the topical issues arising with the development of WSN sensor networks is the limited integration of the number of nodes. There is indeed such a limitation, as WSN nodes dispose of limited resources as concerns their processing power, storage capacity, and, last but not least, power resources and their ability to ensure a limited transfer of information. The implementation of WSN networks on a large scale, and the improvement of their performance level are issues that must be taken into account. The main two power consuming sources of a WSN node are the communication (transmission/receipt of the bits) and the local calculations that must be conducted by the respective node. In light of these circumstances, the manner of communicating must be made more efficient as far as power consumption is concerned. A WSN node consists of a transceiver, a microcontroller with the peripherals and a power source assembled in a very small unit (Fig. 1).

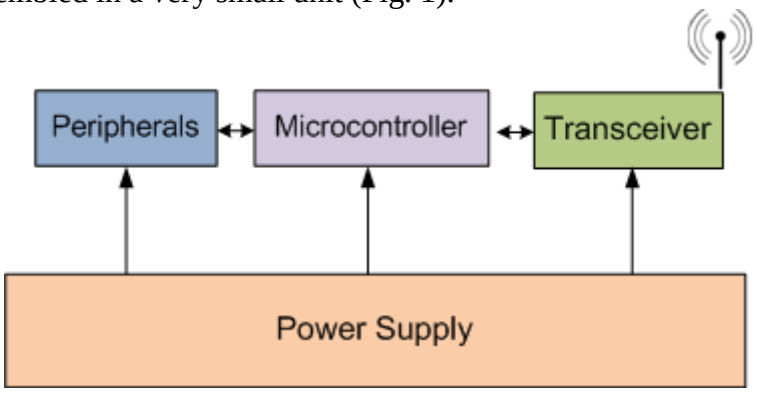

Fig. 1.WSN node structure.

The power source entails certain constraints as concerns the power allocated to each procedure, to information storage, connectivity, bandwidth and calculation speed. These characteristics entail the presence of certain mechanisms for adjusting the size of the packets and meant to increase the efficiency of the network, a topology control protocol thus being necessary. In light of these circumstances, one way to improve the performance level is to design an optimal network topology. The available professional literature includes a number of papers that deal with the design of network topologies in sensor networks [1]-[6] but none of them approaches the issue of large-scale networks. The network topologies star, tree and mesh that can be implemented in a WSN network are presented in Fig. 2.

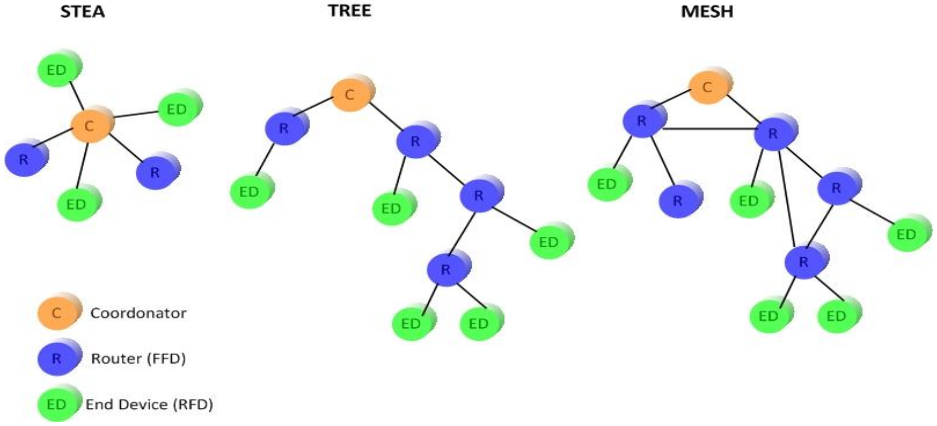

Fig. 2.WSN network topologies.

Considering the Smart City concept only the mesh network topology assures a high level of performance because of the high number of nodes distributed over a large geographical area. A previously published paper [7], evaluates the performance of topology control algorithms that can be used as part of a large-scale WSN network.

Moreover, in order to reach a high performance level, the WSN network topology (star, tree, mesh) must be selected so as to ensure the highest performance level, by taking into account the specific characteristics of the application. A previous paper [8] conducts an evaluation of the performance of the mesh and tree network topologies of a large scale street lighting WSN network that can be integrated in the Smart City concept.

Another priority in terms of WSN network development is the optimization of the routing algorithms and, implicitly, the reduction of the routing tables that must make use of as little RAM (Random access memory) memory as possible, so as to enable the integration of a very large number of nodes. Thus, it is necessary to evaluate the performance of these algorithms in order to identify the best candidate that can be integrated in a large-scale long-thin network. Another aspect that should not be overlooked is the coexistence of WSN networks and other devices that communicate within the same communication channel. Scientific research in the field provides a series of papers that focus on the allocation of the best channel for a WSN sensor network that operates in an environment that is highly affected by interferences [9] - [18], but none of them can be implemented in a large-scale WSN network. In a previous paper [19], an original ACS (Adaptive Channel Selection Algorithm) has been developed, implemented and tested in order to be integrated in a WSN network distributed across a few kilometres wide geographical area, thus helping to alleviate the issues related to the coexistence of WSN networks.

The Smart City concept entails the integration of information technologies that would improve the power consumption process, as well as other resources. Such a city should meet the needs and values of its residents, through the use of advanced IT solutions that would allow the improvement of power efficiency and contribute to the protection of the environment. Sensor networks have been a topical issue for several research centres and thus, in the past few years, we have witnessed a development of WSN specific applications and a constant development of WSN communication protocols, such as: ZigBee, IEEE 802.15.4, JenNet and 6oLWPAN.

Fig. 3 presents the general structure of the systems that have often been integrated in the Smart City concept. The papers published in the professional literature often present a centralised structure that includes a control centre that collects information within the system.

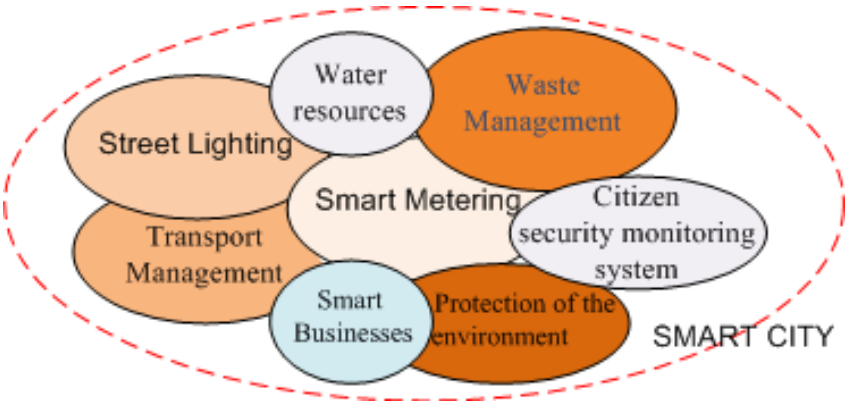

Fig. 3. Structure of the Smart City concept.

Thus, note the presence of certain clusters (ecosystems) that are interconnected and enable: monitoring the air quality, adaptive control of street lighting (allowing for a reduction of power consumption and ease of access for maintenance processes), monitoring waste,

citizen security monitoring system, smart businesses and, last but not least, protecting the environment.

THE SMART CITY CONCEPT

A Smart City maximizes the benefits for city administrators and for its residents, all the while minimising the negative effects on the environment and the economy. The desire to implement these systems is increasing, both in developed and developing countries, as more and more people acknowledge the advantages and the changes in their lifestyle that such a city can bring about.

An intelligent city clearly improves lifestyles, and is highly efficient in terms of resistance to natural disasters and protection of the environment, also contributing to its sustainable economic development.

In many countries, these cities are needed in order to manage the unwanted changes occurring in the environment as well as to avoid or diminish the negative effects or uncontrolled urbanisation [20]. In planning their development, cities must focus their attention and efforts on how to improve economic performance in the long term. Therefore, in order to achieve long term development, they must anticipate and identify the causes that may generate potential problems in the future, thus reducing the occurrence of certain risks. The advantages brought about by the development of the Smart City concept include the stimulation of the economic environment by encouraging and attracting investments.

The management infrastructure of the Smart City concept can be observed in Fig. 4, including: factories, railway stations, hotels, hospitals, schools, households, financial institutions, recycling units and electrical power stations.

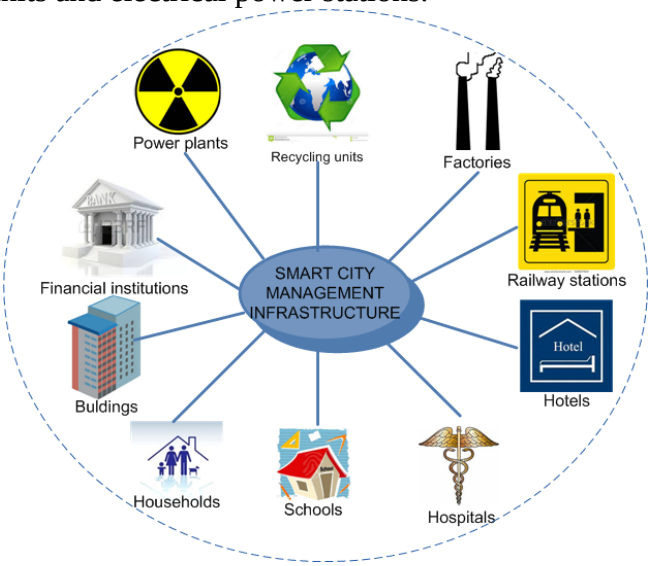

Fig. 4. The management infrastructure of the Smart City concept.

CONCLUSION

This paper analyses the current status of large-scale sensor networks that can be integrated in a Smart City concept, by evaluating the communication means that can be implemented in a large-scale WSN network. Additionally, we have evaluated the Smart City concept and the performance of the communication protocols used in wireless sensor networks (WSN), so that the system could allow for as high a number of nodes as possible, distributed across a wide geographical area.

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