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Contribution of Wireless Sensor Networks in Domestic and Hostile Environment

Natalja Osintsev*

Fraunhofer-Institut für Holzforschung Wilhelm-Klauditz Institut WKI, Bienroder Weg 54 E, 38108 Brunswick, Germany; n.osintsev@gmail.com.

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Abstract

Wireless Sensor Networks (WSNs) are considered to be among the most rapidly evolving technological domains thanks to the numerous benefits that their usage provides. As a result, from their first appearance until the present day, WSNs have had a continuously growing range of applications. The purpose of this article is to provide an up-to-date presentation of both traditional and most recent applications of WSNs and hopefully not only enable the comprehension of this scientific area but also facilitate the perception of novel applications. In order to achieve this goal, the main categories of applications of WSNs are identified, and characteristic examples of them are studied. Their particular characteristics are explained, while their pros and cons are denoted. Next, a discussion on certain considerations that are related with each one of these specific categories takes place. Finally, concluding remarks are drawn.

Keywords: Wireless sensors, Domestic, Hostile, Applications.

1 | Introduction

A Wireless Sensor Network (WSN) is a group of spatially dispersed sensor nodes, which are interconnected by using wireless communication [1]. As seen in *Fig. 1*, a sensor node, also called mote, is an electronic device which consists of a processor along with a storage unit, a transceiver module, a single sensor or multiple sensors, along with an Analog-to-Digital Converter (ADC), and a power source, which normally is a battery [2]. It may optionally include a positioning unit and/or a mobilization unit [3]. A sensor node uses its sensor(s) in order to measure the fluctuation of current conditions in its adjacent environment [4]. These measurements are converted, via the ADC unit, into relative electric signals which are processed via the node's processor [5]. Via its transceiver, the node can wirelessly transmit the data produced by its processor to other nodes or/and to a selected sink point, referred to as the Base Station [6]. As illustrated in *Fig. 2*, the Base Station, by using the data transmitted to itself, is able to both perform supervisory control over the WSN it belongs to and transmit the related information to human users or/and other networks [7].

Corresponding Author: n.osintsev@gmail.com

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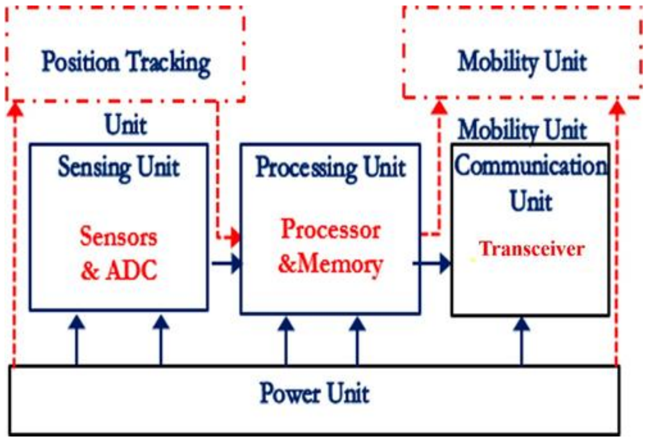

Fig. 1. The typical architecture of a sensor node used in WSNs.

2 | Literature Study

Main WSN application

Various applications of WSNs are currently either already in mature use or still in infant stages of development [8]. In this paper, WSN applications are classified according to the nature of their use into six main categories which, as illustrated in *Fig. 3*, namely are: military, health, environmental, flora and fauna, industrial, and urban. In each category, various subcategories are considered [9]. In what follows in this section, the nature of each one of these categories and subcategories is explained. Additionally, through the indicative examination of characteristic examples of them, their particular features are explained, while their benefits and problems are denoted [10]. Moreover, various methodologies and technical means that are used in these applications either for sensing or for processing purposes are discussed, while similarities and dissimilarities existing among them are identified [11].

Fig. 2. Overview of the most popular categories of applications of WSNs.

Military applications

The military domain is not only the first field of human activity that used WSNs but it is also considered to have motivated the initiation of sensor network research. Smart Dust is a typical example of these initial research efforts, which were performed in the late 90 s in order to develop sensor nodes which despite their very small size would be capable of accomplishing spying activities [12]. The technological advances achieved since then made WSNs capable of supporting various operations. In *Fig. 3*, the main subcategories of the military applications of WSNs which namely are battlefield surveillance, combat monitoring, and intruder detection, are illustrated along with the types of sensors that are most commonly used in them [13].

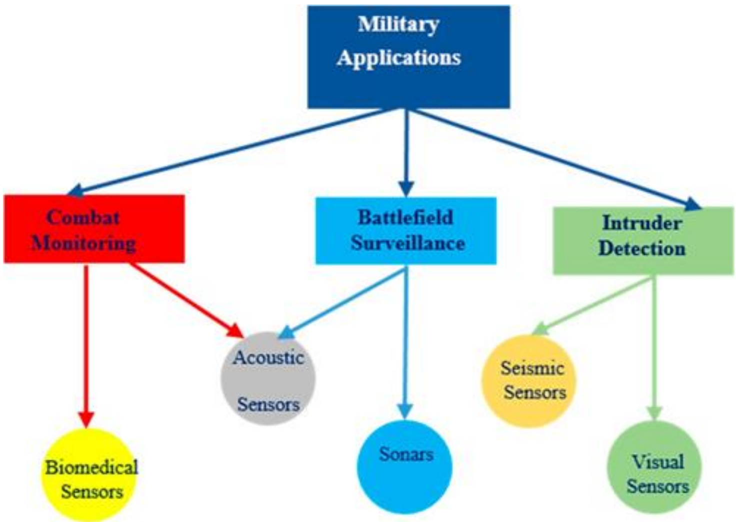

Fig. 3. The subcategories of the military applications of WSNs and the types of sensors they use.

Health applications

In the health domain, WSNs utilize advanced medical sensors to monitor patients within a healthcare facility, as a hospital or within their home, as well as to provide real time monitoring of patient's vitals by utilizing wearable hardware [14]. In *Fig. 4*, the main subcategories of health applications of WSNs namely patient wearable monitoring, home assisting systems, and hospital patient monitoring are illustrated along with the types of sensors that are most commonly used in them [15]. WSNs that have been developed for these types of health applications are examined in the following subsection.

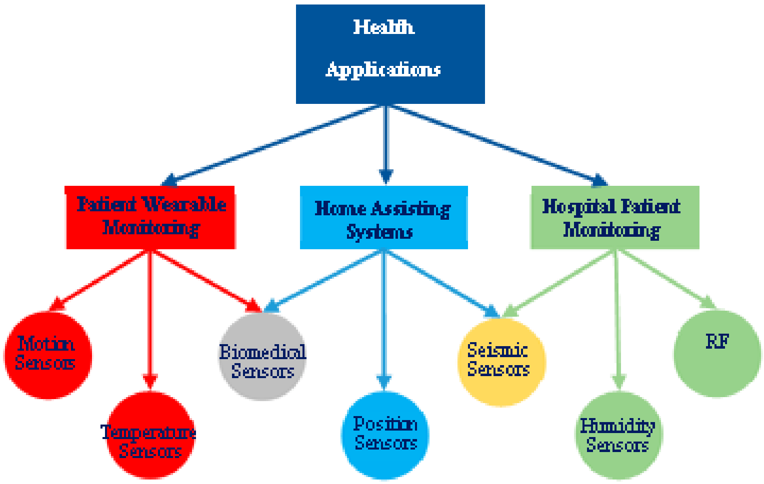

Fig. 4. Health applications through WSN.

Environmental applications

Environmental applications that demand continuous monitoring of ambient conditions at hostile and remote areas can be improved with the utilization of WSNs [16]. In *Fig. 3*, the main subcategories of environmental applications of WSNs, namely water monitoring, air monitoring, and emergency alerting, are depicted along with the types of sensors that are typically used in them. WSNs that have been developed for these types of environmental [17].

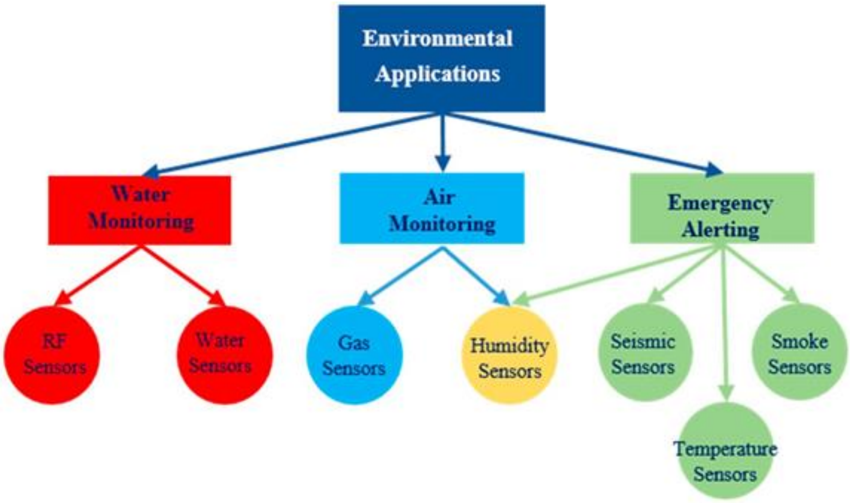

Fig. 5. The subcategories of the environmental WSN applications.

Industrial applications

WSNs can be applied in various industrial applications to solve many related problems. In *Fig. 6*, the main subcategories of industrial applications of WSNs namely logistics, robotics, and a machinery health monitoring are illustrated [18]. These specific categories of applications are studied in the rest of this subsection.

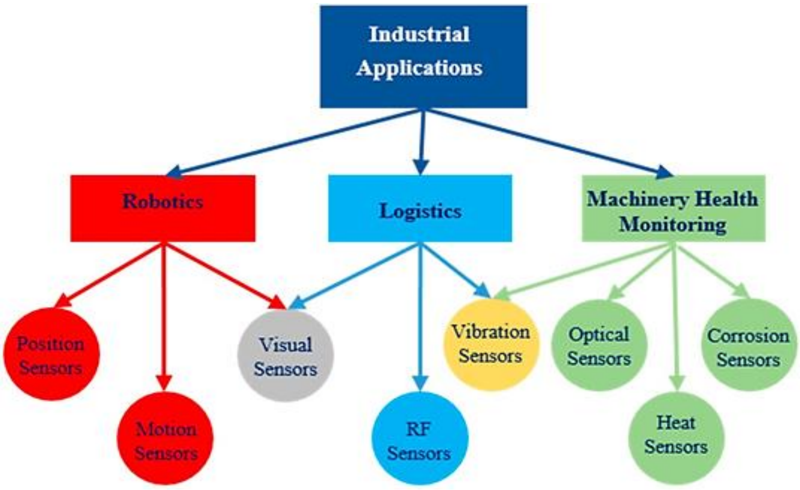

Fig. 6. The subcategories of the industrial applications of WSNs and the types of the sensors used in them.

3 | Discussions

There is no doubt that WSNs enjoy remarkable capabilities which make them ideal for an ever extending range of applications [19]. On the other hand, the operation of WSNs comes up with serious problems. Some of them are application dependent. For instance, in military applications the required physical dimensions and weight of nodes are application dependent [20]. For instance, in some surveillance applications the sensor nodes have to be extremely small in order to be undercover, while in many other military applications, physical dimensions and weight of the nodes are not considered to be important restrictions [21]. On the other hand, nodes in such applications should definitely have an adequately extensive communication range (maybe ≥ 1 km), while the area to be covered is several square kilometres [22]. Also, communication should attain optimal throughput, reliability, security, and resistance to jamming and intervention. Moreover, nodes should be robust enough to resist severe ambient conditions. Similarly, the WSN should be tolerant to the loss of a certain quantity of nodes [23].

In health applications, the physical dimensions and weight of the nodes have to be as small as possible particularly in the cases where they are wearable [20]. Conversely, there is not any need for an extended communication range of nodes or area covered. Communication should be fault tolerant, fast, and reliable while jamming should be definitely avoided because the transmission of data is absolutely vital when time critical alert information is sent. In environmental monitoring the physical dimensions and weight of the nodes are not considered to be the first requisite [21]. Instead, the construction of the nodes has to be extremely robust in order to tolerate severe ambient conditions. Also, both the communication range and the area covered should be adequately wide. Additionally, communication should be resistant to jamming because emergency alerts should be transmitted without delay. Moreover, the WSN should be tolerant to the loss of a certain quantity of nodes [22].

In industrial applications most tasks are time critical while in the industrial environment the presence of electromechanical interference is remarkable. Therefore, communication should achieve optimal throughput, reliability, and resistance to jamming and interference [23]. It may also be necessary to operate under strict security standards. The communication range and the area covered depend on the nature of the specific application and as do the physical dimensions and weight of the nodes. Specifically, sensor nodes of WSNs suffer from extremely strict energy constraints. This is because their energy is typically supplied by batteries which are usually impractical to be either recharged or replaced, since the locations of sensor nodes are usually difficult or even impossible to reach. Therefore, the attainment of energy conservation is a vital issue for WSNs. For this reason, energy inefficiencies that exist at every one of the five layers of the protocol stack of sensor nodes must be eliminated. Given that data transmission is by far the most energy consuming task of nodes, power control schemes data aggregation schemes that decrease the size of data transferred and energy efficient routing protocols [14] have been proposed. Likewise, in applications in which multimedia data are transmitted, the use of compression and restoration schemes provides a substantial reduction of communication load.

4 | Conclusions

The usage of WSNs already provides remarkable advantages for various domains of human activity. Thanks to the continuous evolution of technology both the capabilities of sensor nodes will keep expanding and their manufacturing costs will become lower. This is the reason why the range of WSN applications is expected to carry on growing. In this article, the utilization of WSNs in specific domains, namely military, environmental, flora and fauna, health, industrial, and urban, was examined via the investigation of corresponding typical examples, both novel and well-known ones. From this examination, it became evident that the usage of WSNs not only provides numerous advantages in specific domains when compared against the relative means and methods that were traditionally used, but it also introduces novel applications. Additionally, for various applications both the problems and solutions developed, were identified and discussed. The combinational utilization of relative methodologies and tools will assist both the enhancement of existing applications and the development of novel ones. On the other hand, certain problems that obstruct the usage of WSNs, such as energy limitations, congestion, connectivity loss, inadequate coverage, low QoS, and susceptible security, will remain at the center of scientific research.

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