International Journal of Distributed Systems and Technologies
Volume 14 • Issue 1

Enhancing Network Lifetime of Duty Cycle-Based WSN With Mobile Sink Using Ambient Energy Harvesting

Dalila Boulerial, University of Oran 1 Ahmed Ben Bella, Algeria*
Bouabdellah Kechar, University of Oran 1 Ahmed Ben Bella, Algeria
Ali Benzerbadj, University of Ain Temouchent Belhadj Bouchaib, Algeria

ABSTRACT

In order to guarantee a successful data collection process in wireless sensor networks with mobile sinks (WSN-MS), two primary objectives must be reached: 1) enabling the mobile sink to retrieve the maximum amount of data and 2) making sure that the network operates as long as possible. The first problem has been solved previously by proposing an innovative solution HXMAC. To address the second problem, on which this paper focuses, ambient energy harvesting is used to continuously supply power to each sensor node. Thus, this paper's main contribution is to propose EH-HXMAC (HXMAC with energy harvesting), which is based on all these improvements: seamless handover, duty cycling optimization, and mainly energy harvesting capability. EH-HXMAC has been evaluated using Cooja Contiki simulator. Obtained results based on the evaluation of the proposal EH-HXMAC clearly show its suitability as a good solution to promote unlimited lifetime for WSN-MS.

KEYWORDS

Duty Cycling, Energy Harvesting, Handover, HXMAC, IoT, Wireless Sensor Networks

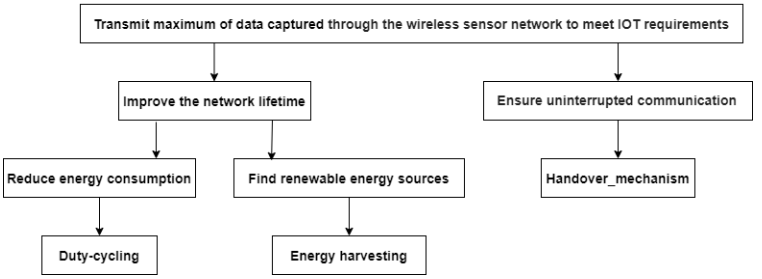
INTRODUCTION

Wireless sensor networks with mobile sink (WSN-MS[1]) are a set of sensor nodes that collect information of different natures from the ambient environment, such as humidity, temperature, and pressure, etc; and transmit them to a mobile sink, which in turn will transport them to a base station. Such type of networks has attracted the attention of several activity sectors, in particular those which require continuous monitoring of a certain environment such as health (Pirbhulal et al., 2016), agriculture (Ahmed et al., 2018), industry (Madni, 2008), smart cities (Zanella et al.,2014), monitoring (Ahouandjinou et al., 2017), etc.

Unfortunately, despite their realism, their robustness, and their considerable contribution, WSN are challenged by several problems due to the sensitive and vulnerable nature of nodes, such as failures, breaks, and the exhaustion of the battery whose changing is almost impossible due to the hostility or the inaccessibility of the deployment area. Thus, the solutions based on ambient energy harvesting to permanently supply the sensor nodes have appeared and have become a hot topic nowadays. Figure 1

DOI: 10.4018/IJDST.317413 *Corresponding Author

Figure 1. The main enhancements of a WSN to meet IoT applications



depicts the main conditions that a WSN should provide to meet the requirements of Internet of Things (IoT) applications.

In a WSN, the exhaustion of a node's battery implies the malfunction of the entire network and, consequently, the failure of the data collection which has sometimes sensitive nature (e.g., data used in military security applications). To overcome this problem, this paper proposes a solution that consists of improving the HXMAC protocol (Kechar & Hamamine, 2018) by integrating the collection of ambient energy from several sources. The photovoltaic energy (Beeby et al., 2010) (Kauer & Bellanger, 2020) is the most important source of energy (see Table 1). The wind (Drouilhet et al., 1995) (Slocum et al., 2019) can provide quantities of energy compared to those given by the sun. Thermal energy (Kashyap et al., 2019) (Al-Huniti & Al-Nimr, 2020) is mainly reserved for applications exploiting human energy as well as energy from machines. Vibratory energy (Mitcheson et al., 2008) (Yamane et al., 2019) varies depending on the proximity and nature of the source of vibration which is estimated at around 10 10^{-3} to 200 10^{-3} mw/cm^3 . The radiofrequency radiation (Li et al., 2020) extracted from the transmitters present on the ground (2G, 3G, 4G, FM or Wi-Fi) provides a low amount of energy. Sensors have then the possibility of obtaining energy permanently from several sources, thus ensuring a longer lifetime of its battery and therefore the whole network. On the other hand, our solution integrate the duty cycling mechanism, which consists of switching between the two states (sleep/wakeup) to reduce energy consumption, if the residual energy is not sufficient, or energy extraction is difficult due to certain environmental factors (e.g., cloudy weather).

The second objective of the proposed protocol is to allow the mobile sink to gather the maximum amount of the data stored at the sensor nodes that are permanently supplied by ambient energy, using the handover mechanism (Kechar & Hamamine, 2018). This will ensure an improvement of the packets received number.

The rest of this paper has the following structure: Section 2 proposes a state-of-the-art about the newest related work. EH-HXMAC technique is described in Section 3. The results of the simulation performed using Cooja/Contiki simulator are presented in Section 4. Section 5 concludes the paper and gives some directions for future work.

STATE OF THE ART

Several research works have been carried out on ambient energy harvesting from its various sources. (Sharma et al., 2019) have proposed a new approach to address the problem of limited power availability by analyzing data communication results at the network layer level with different irradiance values. (Sharma et al., 2018a) have conducted a survey of solar energy harvesting in wireless sensor network SEH-WSN nodes on four axes: (sensing, computation, communication, and energy harvesting). (Sharma et al., 2018b) have proposed a collector which uses miniaturized photovoltaic modules, and which dynamically adapts to variations in light intensity, and its measured electrical consumption