Coverage and Energy Efficiency Optimization for Randomly Deployed Multi-Tier Wireless Multimedia Sensor Networks

Taner Cevik[1], Alex Gunagwera[2]

[1]Department of Computer Engineering, Istanbul Aydin University, Istanbul, Turkey
[2]Department of Computer Engineering, Istanbul Sabahattin Zaim University, Istanbul, Turkey

Abstract: In this study, a novel multi-tier framework is proposed for randomly deployed WMSNs. Low cost directional Passive Infrared Sensors (PIR sensors) are randomly deployed across a Region of Interest (RoI), which are activated according to the Differential Evolution (DE) algorithm proposed for coverage optimization. The proposed DE and the Genetic Algorithms are applied to optimize the coverage maximization using minimum sensors. Only the scalar sensors that are yielded by the coverage optimization process are kept active throughout the network lifetime while the multimedia sensors are kept in silent. When a scalar sensor detects an event, the corresponding multimedia sensor(s), in whose effective coverage field of view (FoV) that the target falls, is then activated to capture the event. The analysis of the network total energy expenditure and a comparison of the proposed framework to current approaches and frameworks is made. Simulation results show that the proposed architecture achieves a remarkable network lifetime prolongation while extending the coverage area.

1. Introduction

Remarkable development and advancement in digital electronics, wireless communications and, most importantly, in the micro-electro-mechanical systems (MEMS) has resulted in the creation of small sized, multifunctional, low-cost sensor nodes. These nodes have the capability to process data, communicate and also sense physical phenomena. Sensor networks are born when a collection of such tiny nodes are used at once to achieve a common goal. A large number of such untethered sensor nodes hence fosters the so-called WSNs [1]. Sensor networks today are more improved than traditional sensors. Traditional sensors could generally be deployed in two ways: either in such a way that the sensors themselves were significantly far away from the phenomenon to be sensed. Here large sensors equipped with complex mechanisms to differentiate the targets from the environment were used. Or a couple of sensors only responsible for sensing could be deployed. The communication topology in this case and the sensor positions are carefully engineered. The sensors regularly transmit sensed data of the phenomenon in question to central nodes where the data is combined and computations are carried out [2].

However, in WSNs today, sensors can be scarcely or densely, depending on the type of application, deployed right next to or directly into the phenomenon. Their positions also do not necessitate predetermination or being set up. This feature permits random sensor node deployment in inaccessible areas or situations where it is impractical, if not impossible, to predetermine sensor positions such as rough terrains, disaster struck zones, battle fields and the like. Given the nature of some deployment environments, especially the inaccessible ones, sensor nodes are required to have the ability to configure themselves. This is hardly a problem nowadays, though, owing to the fact that they are equipped with programmable microprocessors.

As previously mentioned, sensors are capable of gathering, processing, transmitting and receiving data. Sensors are equipped with Radio Frequency (RF) circuits that enable sensors to transmit and receive data. Consequently, sensor hardware today is manufactured considering the RF circuitry of a given sensor e.g. WINs, whose architecture utilizes radio links for communication [3], µAMPS [4] is equipped with a transceiver that uses Bluetooth and also has frequency generator, some are designed to conserve as much power as possible, e.g. [5] uses a one-channel RF transceiver thereby consuming less power.

Heterogeneous WSNs are networks that are comprised of varying sensor nodes. The heterogeneity could be due the capabilities of the sensors or in terms of more abstract metrics such as energy, computation ability, speed and so on and so forth e.g. [6] suggests clustering for networks with energy heterogeneity. The varying sensor nodes could differ in such a way that some sensors would be responsible for acoustic capabilities, others seismic variations, thermal, infrared and so on and so forth. Such sensors make possible the monitoring of various ambient conditions ranging from temperature, humidity to pressure.

This variety has made it possible for WSNs to be applied in a wide range of fields and thus, pronounce the importance of Sensor networks. In fact, just as [1] envisioned, WSNs are already an integral part of our lives today. The application areas of WSNs today include:

Environmental applications: such as volcano monitoring, early flood detection, earthquake prediction to mention but a few.

Health applications: sensors can be embedded in the patient or in the environment where the patient is enabling medical personnel to monitor the wellbeing, behavior and/or progress of patients (patient monitoring). They can also be used in research health research projects e.g. [8] presents the retina project that was aided by the US department of energy.

Industrial applications: wireless sensor networks are used to monitor machine conditions in industries today. They help in what is referred to as preventive maintenance to detect cracks, or similar poor mechanical conditions. Some of these conditions are too small or subtle for the human eye to notice. Other uses include structural health monitoring e.g. in chemical industries where they help measure