ABSTRACT

Sensor nodes of Wireless Sensor Network (WSN) possess very limited power resources normally a battery and a solar cell could exist in some cases, which requires efficient usage of these resources to extend the network’s lifetime. Accordingly, several research areas have been investigated to prolong the network longevity. Clustering was proposed to WSN as one of these areas that could help in decreasing the amount of consumed energy. A number of clustering algorithms were devised but to the authors’ knowledge, this is the first work to consider clustering in Multimodal WSN, where a node can report more than one feature e.g. temperature and humidity. We compared the two general clustering algorithms K-Mean and Fuzzy C-Means to LEACH-C and LEACH, which are two clustering algorithms specially designed for WSN. Fuzzy C-Means and K-Means showed better performance using the techniques proposed in this work over LEACH-C and LEACH.

Keywords: Clustering, Fuzzy C-Means, K-Means, Low-Energy Adaptive Clustering Hierarchy (LEACH), Low-Energy Adaptive Clustering Hierarchy-Centralized (LEACH-C), Multimodal, Wireless Sensor Network (WSN)

INTRODUCTION

Wildfires have caused hectares of forests’ areas to vanish; they have caused a massive effect on the ecosystem in those areas especially for the wildlife. Wildfires starters could be a tiny cigarette thrown by a camper or sunlight focused on old dead leaves. They are rarely detected in their early stages and they spread with a tremendous speed, which make them even more difficult to fight. A number of wildfires were being fought for days due to the high dense trees beside the wind speed and direction, which can help much in the propagation of the fire across the forest area. If we managed to detect fires in their very early stages this could provide a drastic change in the situation compared to detecting the fire after it has already spread. A proposed solution for detecting the fire in its early stages would be spreading temperature sensors which can detect any increase in the temperature and report their readings to a central decision point, which can give an alert about possible fire caught in this or that area. Normal wired temperature sensors will not be practical in this case as it is not feasible to lay down thousands of kilometer length of cables between each sensor and the base station to which it is reporting. Wireless sensors are a very practical solution in this case. However, we do not just want normal wireless sensors...
that can just detect a change in the phenomenon it is monitoring and sends the results back to the base station; on the contrary, we need an intelligent network, which will allow sensors to communicate to each other and provide very precise and complete view of the monitored area. Wireless Sensor Network (WSN) (Dargie, et al., 2010) provides the previous features and much more.

WSN is a network of sensor nodes that communicate with each other wirelessly. They detect readings over the monitored region and report them to a central point called the “Sink Node”. The sink node is responsible for collecting the data received from different sensors to perform the analysis and generate the results according to which a decision is taken to react upon the received readings.

Sensors in WSN are deployed in a large number and over a wide geographical area, which could be hazardous in some situations for a human to apply some maintenance for after deployment. They operate on a limited power resource, which is usually a battery and a solar cell could exist. The number of sensors and the wide area that could be hazardous in some situations, impede the ability to recharge or replace the limited power resource. For this reason a great amount of research have been devoted to introducing new methods and techniques by which the power consumption in WSN could be minimized to retain the network lifetime.

Of the most sources of power consumption in WSN is the communication over the wireless media which induced researchers to investigate methods that could decrease the amount of data transferred between the nodes and the sink node either by decreasing the amount of communication messages or by compacting the amount of data in each message. Several areas were approached for dealing with the limited power resources in WSN e.g. application level (Jorge et al., 2008), MAC (Ilker et al., 2006) where optimizing the medium access control protocols is considered, data processing (Dini et al., 2010; Zhou et al., 2009), data aggregation (Nandini et al., 2010; Patel et al, 2009) where data from more than one sensor are combined to generate less data ready for the wireless transfer, routing (Jamal et al., 2004; Xu et al., 2002), which manages sending the data through the paths with the least cost, scheduling (Ruzzelli et al., 2005) and clustering (Ameer et al., 2006) which splits nodes into groups and only one sensor of each group is assigned the responsibility to communicate with the sink node.

Clustering (Chatterjee et al., 2002; Zhou et al., 2009) is one of the main areas that has been investigated thoroughly for WSN as it has a major impact on the longevity of the network’s lifetime. In the absence of clustering each deployed node will have a direct communication with the sink node, which practically resides at a long distance from the deployed nodes so, whenever a sensor detects a reading it will send a message to the sink node and the transmission power should be increased compared to transmitting a message to the near proximity of the node as the sink is located in a far position to the transmitting sensor. If we analyzed the sensor side, we will find that there has been a great degradation in the sensor’s power resource since it transmits messages constantly at a high transmission power over a wireless medium which causes a fast drop in the sensor’s energy level. From the sink node side a large number of messages are received from all reporting sensors but looking closely to the messages’ content it could be noticed that most of the messages received from sensors in a near proximity to each other are very similar as due to their locations they are mostly detecting similar readings, which means that beside the large amount of energy consumed in the transmission the sink node has received mostly redundant data which could be replaced with the messages received from one sensor residing in the same region.

Clustering is simply the operation done on a group of sensors to fetch this one sensor that reside in the same region and that sensor will be assigned the communication role with the sink node instead of having each sensor communicating directly to the sink node. Clustering allows all the nodes deployed to undergo a splitting operation by which the nodes are divided into
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