International Journal of Future Generation Communication and Networking
Vol. 13, No. 1, (2019), pp. 1616 - 1622

Techniques to improve Energy Efficiency in Wireless Sensor Network

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Abstract

Wireless sensor networks (WSNs) offers a vast range of advantages to many applications by lowering their cost and reducing their overall power consumption. A WSN is an arrangement of randomly distributed devices, i.e. sensor nodes (SNs), which are interconnected having sensing capabilities to communicate and share data with some special features. Each SN is equipped with limited resources and thrown in terrain with an unconditional climate having a pre-configured set of tasks that it needs to perform. Each of deployed SN in WSN cluster faces a considerable energy issue and needs to manipulate the power consumption to increase their lifetime and make sure that they perform all the allocated tasks. Due to the unavailability of an external power source, the energy efficiency considered as one of the critical issues in WSNs. Selection of a sensor node (SN) from a wireless sensor network (WSN) cluster to serve as an aggregator or cluster head (CH), considered as an efficient method to increase the lifetime of wireless sensor network (WSN).In this paper, we are presenting the cluster head reusability scheme to enhance the lifetime of network and to reduce the average residual energy of a single WSN. The proposed algorithm is helpful in solving the problem of unbalanced energy consumption in WSNs.

Keywords: *Wireless Sensor Network; Sensor Node,Cluster Head.*

I.INTRODUCTION

Wireless sensor networks (WSNs) offers a vast range of advantages to many applications by lowering their cost and reducing their overall power consumption [1]. These additive advantages of wireless sensor network (WSN) have increased their use in many fields including advanced agriculture [2], [3] and many other, related to the automatic irrigation system for farmland [4], to improve the yield of crops. The integration of WSN in the internet of things (IoT) can be used to generate an early warning of earthquake [5]. In this context, the WSN provides a wide range of applications and considered as one of key enabling technology for IoT. A WSN is an arrangement of randomly distributed devices, i.e. sensor nodes (SNs), which are interconnected having sensing capabilities to communicate and share data with some special features [6]. These SNs are used for multimedia applications by installing a CMOS device, e.g. camera, on sensor node (SN) [7]. Each SN is equipped with limited resources and thrown in terrain with an unconditional climate having a pre-configured set of tasks, that it needs to perform. Each of deployed SN in WSN cluster faces a considerable energy issue and needs to manipulate the power consumption to increase their lifetime and make sure that they perform all the allocated tasks. Diverse solutions are presented in the literature to allow each SN in WSN to utilise their limited resources efficiently. Many energy efficient scheduling techniques are available in the literature [8], to accommodate each SN to perform well under confined power resources. Authors in [9] proposed an idea of multicore energy efficient scheduling with energy harvesting for wireless multimedia sensor network (WMSNs), by utilising lightweight processors (LWP) to manifold multiple tasks practically, without compromising on deadline. In [10] a routing protocol based on spanning tree technique using the hybrid multi-hop partition clustering, is presented to enhance the lifetime of the WSN.

A plethora of research work has been done by the research community to enhance the energy efficiency of WSN. Deploying each SN in WSN using an effective deployment scheme is considered as one of the critical methodologies to improve the energy efficiency of WSN. In connection, clustering can be utilized while considering the dense deployment of SNs to maintain an acceptable average energy consumption. In [11] a clustering methodology has been introduced that helps the

network to recuperate SNs from the futile gateway without considering, re-clustering or close down of the system to increase the overall system efficiency. Furthermore, in [12] the authors propose a constrained coverage (CC) algorithm which introduces two virtual forces to ensure that each cluster node has at least K-Neighbors, but this scheme may result in a low network coverage area and a decrease in lifetime of SNs. Similarly, in [13] the concept of virtual force is utilized for clustering, but the mechanism may lead to an unstable lifetime of WSN. The selection of a cluster head (CH) in a WSN cluster can be used to prolong the network lifetime and to maximize the communication range. Low-energy adaptive clustering hierarchy (LEACH) [14], is considered as one of the main clustering algorithms to enhance the lifetime of a WSN cluster.

An acceptable amount of research work is available in the literature that exploits the LEACH protocol to increase the energy efficiency of WSN [15]. In [16] a two-step optimized zone based energy efficient protocol (OZEEP) has been proposed, which incorporates the genetic fuzzy systems (GFS) to optimize the clustering and the selection of cluster heads (CHs) in WSN. Authors in [17] suggested a routing protocol based on a novel energy-aware hierarchical cluster (NEAHC) to select CHs by introducing threshold schemes. An energy efficient adaptive selection of CH for wireless sensor networks (WSNs) has been proposed in [18], that uses the dissipated and residual energy levels in the modified version of LEACH protocol to provide a balance energy efficiency. A dynamic cluster head selection method (DCHSM) for WSN has been introduced in [19], that dynamically selects a CH based on their residual energy and dynamically changes the CH after the death of the previous CH. In [20] the authors use the approach of hesitant fuzzy for CH selection by analysing their distance from the centre of the cluster and their range from the base station (BS) location. Similarly, in [21] the concept of nominating a CH based on their position on a WSN cluster is combined with their energy consumption while assuming a uniform distribution of SNs. In connection, the authors in [22] connect the location-based approach with balanced energy consumption to select a CH. Furthermore, the concept of spare CH is introduced in [23], while considering a hybrid key management mechanism.

II.RELATED WORK

1. An Energy Efficient Cluster-heads Re-usability Mechanism for Wireless Sensor Networks [1]

Authors: Syed Kamran Haider

Publication: IEEE Conference on Network Engineering 2019

Syed Kamran Haider have proposed an energy efficient CH selection scheme to optimize the overall lifetime and average energy consumption of a WSN cluster. The proposed technique significantly increases the lifetime of WSN and provides a solution to the problem of unbalanced energy consumption in the WSNs[1]. The main highlighted contributions of the paper are as follows:

• An energy efficient scheme has been proposed that equips the BS with a group of CHs, selected from a WSN cluster.

• The idea of the mobile sink has been utilized to decrease the delay and to efficiently cater to the low power state of the CH during the hand-off stage.

• To prolong the network survival time, each CH changes its state to sleep mode and perform energy harvesting after reaching the hand-off threshold level.

• Syed Kamran Haider have incorporating the use of harvesting energy to enhance the reusability of each CH node, enduring the sleep mode[1]

2. Energy optimal scheduling of multichannel wireless sensor networks for wireless metering [9]

Authors: S. Kumar, H. Lim, and H. Kim

Publication: Electronics, Information, and Communications (ICEIC), 2016 International Conference on, pp. 1–5, IEEE, 2016

S. Kumar, H. Lim, and H. Kim addressed the issues of energy consumption and path distance from the source to the destination in MANET. They proposed a multipath routing protocol based on AOMDV called as, Power Aware Ad-hoc On Demand Multipath Distance Vector (PAAOMDV). The proposed protocol updates the routing table with the corresponding energy of the mobile nodes. As this was a multipath protocol, it shifts the route without further overhead, delay and loss of packets. The simulation results showed that PAAOMDV performs well compared to AOMDV routing protocol after introducing energy-related fields in PAAOMDV [9].

3. Earthquake early warning system by IoT using wireless sensor networks [6]
Authors: A. Alphonsa and G. Ravi
Publication: Wireless Communications, Signal Processing and Networking (WiSPNET), International Conference on, pp. 1201–1205, IEEE, 2016
In [6] A. Alphonsa and G. Ravi considered path duration and energy awareness to accomplish certain QoS constraints as to reduce the route discovery procedures. Even though energy saving and path duration and stability are two contrasting efforts and to satisfy both of them can be very difficult. The authors proposed a novel routing strategy which tries to account for link stability with a minimum rate of energy consumption. In order to verify the accuracy and accomplishment of the proposed algorithm, an optimization formulation technique was designed along with a routing protocol called Link-stability and Energy-aware Routing (LAER) protocol. The performance of proposed protocol was compared with PERRA, GPSR, and E-GPSR, in terms of packet delivery ratio, normalized control overhead, link duration, node lifetime, and average energy consumption.

4. A study of supercapacitor charge redistribution for applications in environmentally powered wireless sensor nodes [5]
Authors: H. Yang and Y. Zhang
Publication: Journal of Power Sources, vol. 273, pp. 223–236, 2015
H. Yang and Y. Zhang proposed an energy efficient routing protocol that conserves energy of the mobile nodes enhancing the lifetime of the MANET. It is an On demand routing protocol based on adaptive fuzzy threshold energy (AFTE). The experimental results were compared with the Load-Aware Energy Efficient Protocol (LAEE) protocol proposed by the same authors. The results clearly showed that AFTE performs better compared to LAEE. The average network lifetime was enhanced upto 13% considering first node failure, 15% considering 50% node failure and 23% considering 100% node failure compared to LAEE [5].

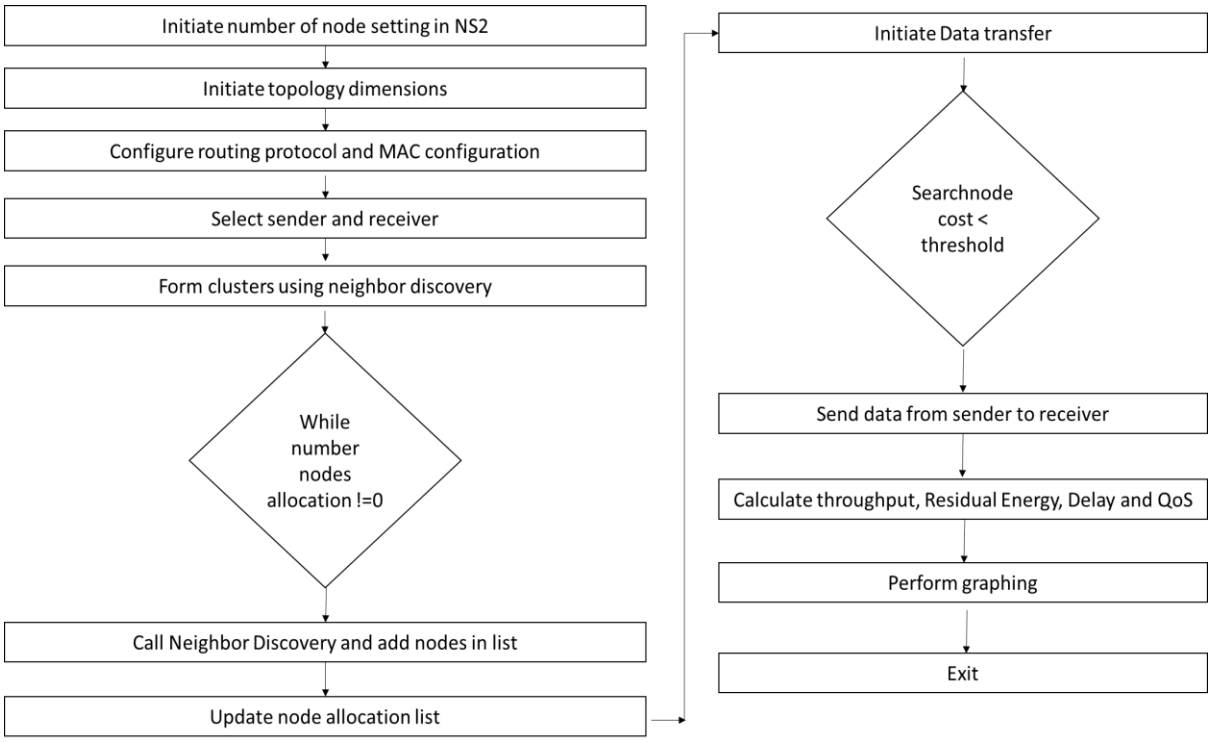
5. High performance flexible sensor based on inorganic nanomaterials [4]
Authors: B. Hu, W. Chen, and J. Zhou
Publication: Sensors and Actuators B: Chemical, vol. 176, pp. 522–533, 2013
B. Hu, W. Chen, and J. Zhou concentrated on the route discovery process effect on the data loss, communication overhead and energy consumption. For these reasons, they proposed a particle swarm optimization (PSO) based lifetime prediction algorithm for route recovery in MANET. This technique predicts the lifetime of link and node in the available bandwidth based on the parameters like the relative mobility of nodes and energy drain rate. Using predictions, the parameters are fuzzified and fuzzy rules were shaped to decide on the node status. This information is made to exchange among all the nodes. Thus, the status of every node is verified before data transmission. Even for a weak node, the performance of a route recovery mechanism is made in such a way that corresponding routes are diverted to the strong nodes. The simulation results indicate that the proposed technique minimizes the packet loss and communication overhead [4].
Sharma et al. proposed an energy efficient reactive routing protocol that uses the received signal strength (RSS) and power status (PS) of mobile nodes. Proposed Link Failure Prediction (LFP) algorithm used the link-layer feedback system to update active routes. Comparing the results of the proposed algorithm with existing algorithms, in terms of energy consumption, link failure probability, and retransmission of packets, the proposed algorithm outperform the existing algorithms [4].

6. 3D virtual viewer on mobile device for wireless sensor network-based rssi indoor tracking system [3]
Authors: Smail,W.-Y. Chung, B. G. Lee, and C. S. Yang
Publication: Sensors and Actuators B: Chemical, vol. 140, no. 1, pp. 35–42, 2009
Smail et al. proposed an energy-efficient multipath routing protocol, called Ad hoc On-demand Multipath Routing with Lifetime Maximization (AOMR-LM), which preserves the residual energy of nodes and balances the consumed energy to increase the network lifetime. They used the residual energy of nodes for calculating the node energy level. The multipath selection mechanism uses this

energy level to classify the paths. Two parameters are analysed: the energy threshold and the coefficient. These parameters are required to classify the nodes and to ensure the preservation of node energy. The AOMR-LM protocol improves the performance of MANETs by prolonging the lifetime of the network. This novel protocol has been compared with both AOMDV and ZD-AOMDV. The protocol performance has been evaluated in terms of network lifetime, energy consumption, and end-toend delay [3].

7. Secure wireless multimedia sensor networks: a survey [8]
Authors: L. A. Grieco, G. Boggia, S. Sicari, and P. Colombo
Publication: 2009 Third International Conference on Mobile Ubiquitous Computing, Systems, Services and Technologies, pp. 194–201, IEEE, 2009
L. A. Grieco, G. Boggia, S. Sicari, and P. Colombo analyzed two factors that influence the transmission bandwidth: the signal strength of the received packets and the contentions in the contention based MAC layer. These two factors may cause more power to be consumed during data transmission. They proposed a power aware routing protocol called MTPCR. It discovers the desired routing path with reduced power consumption during data transmissions. It does so by taking into account the situations in which, the transmission bandwidth of the routing path may decrease, resulting in much power consumption during data transmission because of the mobility nature of the mobile nodes in MANET. MTPCR analyzes the power consumption during data transmission with the help of the neighboring nodes and using a path maintenance mechanism to maintain optimal path bandwidth. This mechanism helps to reduce the power consumption more efficiently during data transmission along with the number of path breakages. The proposed routing protocol was compared with multiple routing protocols including (AODV, DSR, two power aware routing protocols (MMBCR and xMBCR) and multipath routing protocol (PAMP)). The comparison was conducted in terms of throughput, energy consumption during path discovery, energy consumption during data transmission and network lifetime [8].

III.PROPOSED SYSTEM



IV.ARCHITECTURE

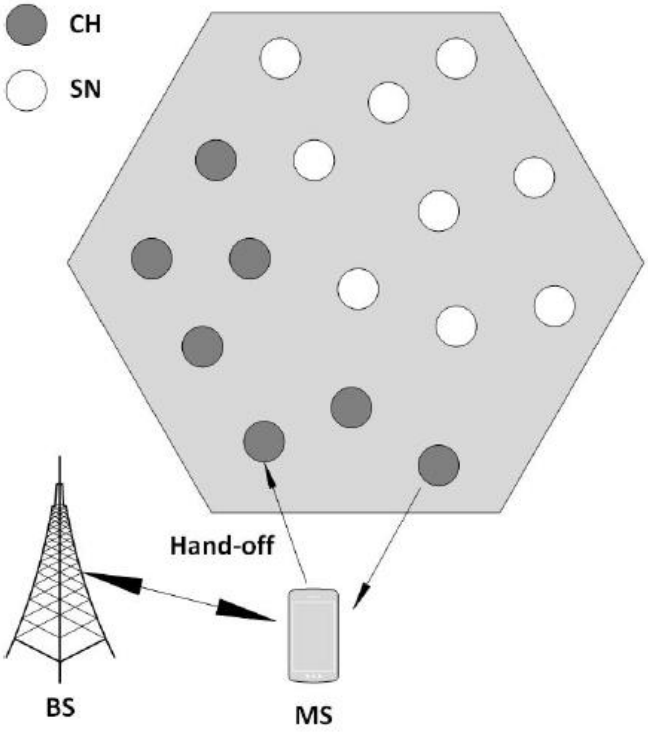


Figure (1): Basic architecture of the system[1]

An energy efficient approach to select a CH for a WSN is presented in this project. The proposed approach exploits the use of energy harvesting to increase the overall lifetime of a WSN. A Rayleigh fading channel has been considered between each CH and the BS. A group of SNs are nominated by the BS to be considered as CHs, if they satisfy the channel gain threshold α and residual energy threshold β, respectively. A list of nominated CHs by the BS are further categorized based on their channel gain gn and residual energy Rn and are tagged with a unique identification i.e. rank = 1, . . . , rn, in a descending order. The residual energy at the BS for each CH is calculated using their Pn, i.e. we have assumed that Pn and Rsn have a good correlation. Algorithm 1 provides an insight into the proposed scheme. The proposed algorithm analysis the pilot signal received by each SN and use N, gn, Pn, and Rsn as its main input. Moreover, the algorithm works in the following four stages:

• In stage 1, the algorithm compares the received power Pn of each SN with the SNR threshold γ. The SNs, that satisfies the first condition is further analysed using their channel gain and residual energy values. Again the SNs that satisfies the second condition, are nominated as CHs.

• In stage 2 of the algorithm, the nominated CHs are tagged using a unique identification, i.e. rank and are labelled in descending order, based on their residual energy and channel gain.

• The selection of a CH for WSN is made at stage 3. The nominated SNs with the highest rank is selected as a CH.

• If the residual energy of the selected CH drops below the hand-off threshold δ, a hand-off process is initiated by the BS using the cooperation of nearby mobile sink. For the experiment, we have assumed that a mobile sink is always available during the hand-off stage. After the hand-off stage, the SN changes its state to sleep mode and starts to harvest energy using the installed harvesting circuit. Furthermore, the algorithm runs in a recursive manner till the battery drainage of each SN or the unavailability of a SN to perform as CH for WSN. This recursive nature of the algorithm running at the BS helps to re-analyse the SNs performing energy harvesting.

V. METHODOLOGY

1. Setting up Network Model

Our first module is setting up the network model. We consider a large-scale, homogeneous sensor network consisting of resource-constrained sensor nodes. Analogous to previous distributed detection approaches; we assume that an identity-based public-key cryptography facility is available in the sensor network. Prior to deployment, each legitimate node is allocated a unique ID and a corresponding private key by a trusted third party. The public key of a node is its ID, which is the essence of an identity-based cryptosystem. Consequently, no node can lie to others about its identity. Moreover, anyone is able to verify messages signed by a node using the identity-based key. The source nodes in our problem formulation serve as storage points which cache the data gathered by other nodes and periodically transmit to the sink, in response to user queries. Such network architecture is consistent with the design of storage centric sensor networks.

2. Generating clusters

Ones the topology is generated neighbor discovery will be implemented to perform clustering also the distance calculation method will be used to calculate the distance between nodes so the cluster heads can be selected from the list of nodes. This step will completely initialize the topology so simulation can be started.

3. Data Transfer

We proposed a new multipath routing protocol which is a combination of clustering and neighbor. In a normal scenario, when a RREQ is broadcasted by a source node, more than one route to the destination will be found and the data packets will be forwarded through these routes without knowing the routes' quality. By implementing the proposed algorithm on the same scenario, the route selection will be totally different. When a RREQ is broadcast and received, the source node will have three (3) types of information in order to find the shortest and optimized route path with minimized energy consumption.

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