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Wireless Sensor Network Mobile Element Energy Efficiency Challenges and Issues

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ABSTRACT

Wireless Sensor Networks (WSNs) mostly applied to collect data from their sensing area. The trade-off between power efficiency or battery life and the data collection accuracy is the big challenging issue meets the designing of WSNs. This paper provide brief survey on WSNs energy efficiency especially in direction of mobile element. The goal of this survey is to equip valuable information out of huge amount of research papers. Single/multiple mobile elements, Drones and Path Planning, are the categories, which considered to highlight the main constrains of WSNs designing.

Keywords: *WSNs, Power efficiency, Mobile elements, Drones, Path Planning.*

1. INTRODUCTION

Wireless sensor networks (WSNs) are a finite set of sensors deployed randomly over a field to collect some data such as home surveillance, medical care and military battlefields[1], also it gained an incredible consideration in both industry and academic domain due to its wide range of applications, such as environmental and health monitoring, remote areas and military surveillance [2] .These sensors jointly transmit the data across various levels of a network to the sink where the processing and analysis of data takes place[3].

The sensor nodes are powered by a limited battery source [4],one way to save energy in the WSN is using a mobile element (ME) which equipped with a large batteries and a powerful transceivers allowing it to collect data from the scattered nodes in the network and offload it to the base station (BS) [5].

2. SINGLE MOBILE ELEMENT

Using Mobile Elements(ME) prevent the network energy holes which happen from the difference in the traffic overload between sensors nearby the sink and sensors far from the sink, also it helps in network balancing which prolonged the life time of the network [6].

Manly there are two benefits of applying a mobile element (mobile agents) in the WSN:

1-Reducing the bandwidth consumption by collecting the data from the node from a short distance.

2- Introducing a superior degree of re-tasking flexibility WSN[7].

The authors in [8] proposed an algorithm named mobile data gathering based bounded relay hop (MDG-BRH) which predetermined the path for the mobile element among the nodes, gathering the data and send it to the BS,

The authors in [9] propose a Tree-based methods that can reduce energy consumption of the network and keep the delay low called Two Trees Clone-based Itinerary (TTCI), Maximum Degree Heuristic (MDH) algorithm has been introduced which is an enhancement of the Naïve algorithm, it creates two trees, one to facilitate mobile agents distribution in the network and other one to fuse back the collected data. The MDH algorithm has been extended to produce Distributed MDH (DMDH).

in [10] the authors propose an algorithm which could balance the load of the whole network, prolong the network lifetime and reduce the energy consumption named a Tree-Cluster-Based Data-Gathering Algorithm (TCBDGA) using a mobile sink based on tree-construction.

3. MULTIPLE MOBILE ELEMENTS

In [11] the authors proposed a new energy efficient technique in wireless sensor network data gathering using multiple mobile elements named "Energy Efficient Data Gathering Technique using Multiple Mobile Elements (EEDGMME) ", the method addressed and

optimize many related aspects to the ME shortcoming as Idle listing concept, data fusion, sensor nodes buffer overflow and visiting schedule. The scheme also enhance the packet delivery ratio, reduced overhead, lesser delay, decreased packet drop lead to the optimal energy consumption and hence enhances the life span of the network.

In [12] the authors propose a multiple mobile agents, which requires multiple planning routes named Multiple Itinerary Planning(MIP), it is based on several steps: 1- divide the network into geographical information each part may need more than one agent, 2- allocating the groups of nodes and associating the optimal number of mobile agents for each part, 3- determining the route that pass throughout the group of nodes for each mobile agent. The scheme used called the Greatest Information in the Greater Memory (GIGM), which simultaneously determined the number of mobile agents required for collecting the data from the sensor nodes, the proposed scheme GIGM-MIP balance between data size and geographic information and in total reduce the power consumption of the network.

The authors [13] proposed a data gathering method using a secondary mobile element which help the main mobile element called TINYBEE, the main ME travel near the sensors node and the tinybee move to the node and collect the data and go back to the ME as a first sink for the accumulated data, so it reduce the movement and the tour length of the ME, the process goes through four phases:1- deploying the sensor nodes, 2-Registration of path of the ME, 3- Sending the Tinybee to the nearby sensor node, 4- Data gathering and sink to the ME later the ME sink to the BS.

In [14] the authors propose a new method to recharge the static wireless sensing nodes by deploying a mobile robot with a big battery that could reach the nodes and wirelessly charge the nodes repeatedly to keep it alive for a longer time.

4. DRONES

Recently the authors in [15] propose a new method to collect the data from the scattered nodes over a big area by using a swarm of drones UAV (Unmanned Aerial Vehicles) which can acquire an accurate data that are dangerous or difficult to access by traditional methods.

The algorithm used was based on The multiple Traveling Salesman problem (TSP) heuristic approach by planning the path and minimizing the travel duration of each UAVs.

the authors in [16] propose an energy-efficient technique to prolong the wireless sensor networks lifetime using unmanned aerial vehicle (UAV) which can move close to each of the sensor nodes (SNs) and gather their data and thus reduce the link distance for saving the SNs' transmission power.

The energy consumption of the network is minimized by optimizing the wake-up schedule of the SNs and UAV's trajectory, the proposed scheme showed significant network power saving as compared to benchmark methods.

The authors in [17] propose a projection-based method named Compressive Data Gathering (CDG) which used the UVAs to collect data from cluster heads among the cluster nodes in the wireless network that help in avoiding the nodes from transmissions over a multi-hop communications thus extend the lifetime of the network.

5. PATH PLANNING

Path planning is a key role in data gathering in WSN, by optimizing the path for the mobile agents which they do specific tasks like performing in-network data aggregation and taking sensor readings[18], the mobile agent could reach the sensor nodes closer therefore the sensor nodes does not need to transmit for a far distance, so it will consume less power and that will prolong the overall life time of the network.

In [19] the authors classified the path planning for the mobile nodes to collect data from the sensors in the WSN, The planning path methods classified into two types:

1- Single-Hop Data Collection Path Planning, the schemes mentioned were: k-means clustering algorithm, TSP-DC which uses straightforward simulated annealing algorithm, greedy algorithm named Spanning Tree Coverage Algorithm, a heuristic tourism-planning algorithm, unmanned aerial vehicles (UAV) with Spiral path planning (SPP) algorithm and the Resource Constrained Shortest Path Problem (RCSPP) with UAVs.

2- Multi-Hop Data Collection Path Planning, the schemes mentioned were: a rendezvous-based solution for delay-constrained data collection with a mobile sink using Iterated Local Search (ILS) a heuristic algorithm, weighted rendezvous planning (WRP) algorithm based on RPs, obstacle-free network and obstacle network using multiple constraints routing problem protocol(MCPP) a heuristic algorithm, A delay-bound efficient path design algorithm (DBMSPS) with delay constraint, Energy density based trajectory (EDT) algorithm based on improved algorithm called delay aware energy density based trajectory (DAEDT), an algorithm called node-density-based clustering and mobile collection (NDCMC) using optimal nearest-neighbor algorithm, Ant Colony Optimization-based mobile sink path determination (ACO-MSPD), Virtual region based data gathering algorithm (VRDG) using data gathering units (DGU) and efficient path planning

for reliable data gathering (EARTH) also enhance EARTH (eEARTH) algorithm.

The authors in [20] illustrate the different types of mobile elements (MEs) as: Relocatable Nodes, Mobile Data Collectors (MDCs), Mobile Sinks (MSs), Mobile Relays (MRs), Mobile Peers and Representative scenario. The illustrations(figure 1-5) are a reproduction from the original, the final illustration titled (figure 6) is new and it shows the drones ME.

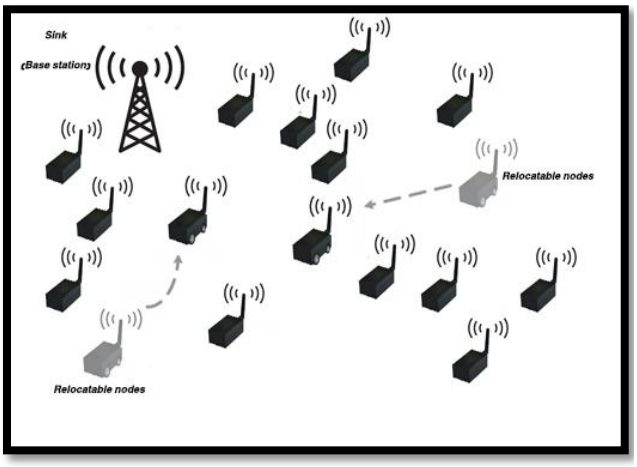

Fig. 1. Illustration of ME with relocatable nodes

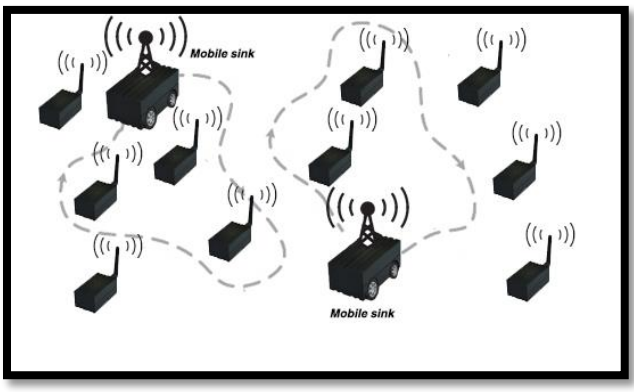

Fig. 2. Illustration of Mobile Data Collectors (MDCs) with mobile sinks

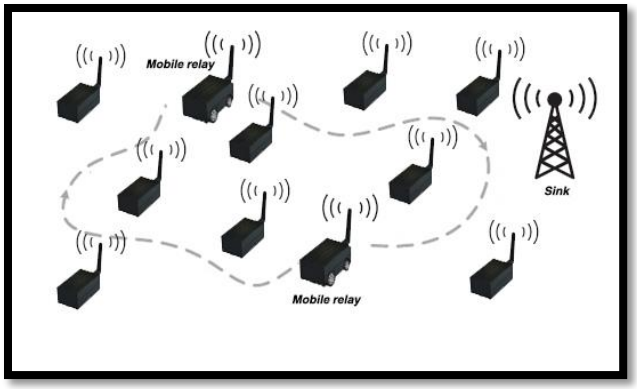

Fig. 3. Illustration of Illustration of Mobile Data Collectors (MDCs) with Mobile relays

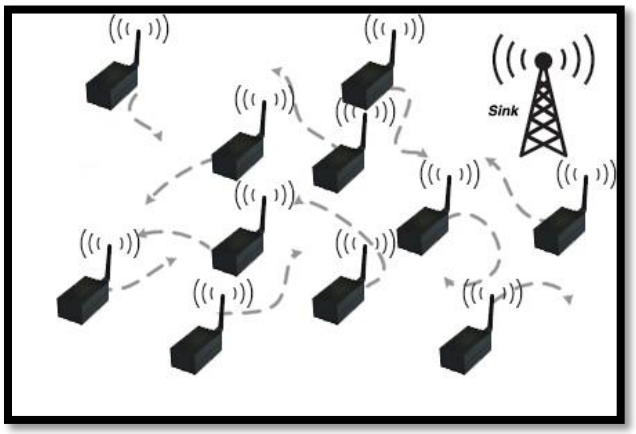

Fig. 4. Illustration of ME with mobile peers

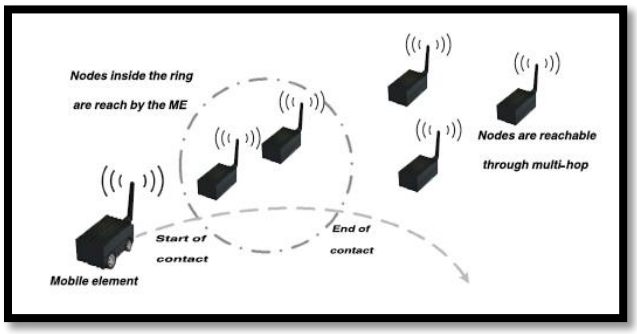

Fig. 5. Illustration of ME data collection representative

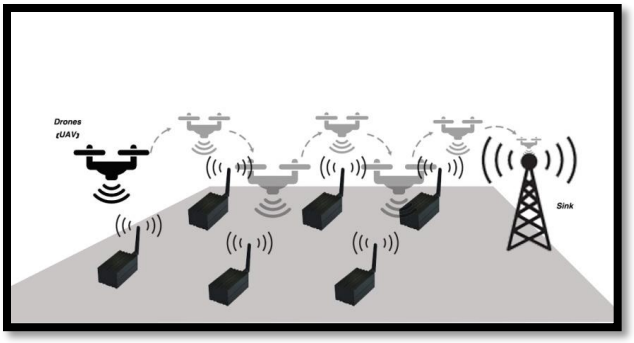

Fig. 6. Illustration of drones ME

4. CONCLUSIONS

In this research, a rapid glance shed on some of the famous WSN mobile elements energy efficiency protocols and methods which helped in extending the life of the network, no comparing or comprehensive reviewing are provided nor another kinds of elements which could affect the energy efficiency of the WSN like the routing protocols or machine learning approaches, which might be tackled in the future.

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