International Journal of Future Generation Communication and Networking
Vol. 14, No. 1, (2021), pp. 3346–3356

Study of Energy Efficient Resource Allocation Algorithms for Wireless Sensor Networks

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Abstract

The Wireless Sensor Network (WSN) has got much importance these days. With the tracking and monitoring activities become essential, the deployment of sensor networks through wireless medium have also increased. Although sensors are unavoidable in many fields, they got many issues pertaining to energy, routing, security, coverage, delay, architecture etc.; There are many on-going researches in the field of WSNs. The enhancement of lifetime of sensors has become an important area of research. The fact that a sensor being a micro electronic device, equipped with limited power source. The power source supplies energy needed by the device for processing. If the nodes are deployed far apart, recharging and replacing are tedious process. Apart from hardware issues, the utilization of energy also plays a vital role. The energy go waste in many cases that includes, idle listening, retransmitting, overhearing, over-emitting. This research work reviews the different localization and resource allocation techniques basic and improved its nodes energy consumption in WSN and also presents some parameter based comparative study. This study is valuable for better understanding of existing methods and improved ones, with the help of this can develop other advanced techniques.

Index Terms— Wireless Sensor Networks, Energy Efficiency, Resource allocation, RSSI, TDOA, Routing Protocols.

I. INTRODUCTION

Wireless Sensor Network (WSN) area getting popular as it needed by society for variety of application due to its adaptability to the various needful applications areas. Location and resource allocation awareness in many applications is receiving a great demand in cellular, communication, location-based applications, services and social networking. In many countries providing emergency services, it's a great deal itself due to lack of accurate location and resource allocation for providing the services.

Wireless Sensor Network is a collection of a homogenous/heterogeneous node equipped with sensor, communication and processing unit which can sense, process and send to the end user

ISSN: 2233-7857IJFGCN

using sink node. Sink node is a node connected with more than one network and act as a gateway

between outside network and sensor network. The sink node transmits only intended information by the base station It also receives query or messages which need to be run on network to fetch information network parameters, location and how the particular location can allocate to available location etc.

WSN is useful in many applications such as animal habitat monitoring, health monitoring, Energy Consumption Management, Military application, critical application whether human intervention is there or not. Many such applications where always human intervention is not possible such as ring of fire, land slide detection; rescue operation where we need to operate remotely WSN is the best solution for it.

If we want an accurate location of a deployed sensor node then we must place it correctly where event can take place. Without knowledge of location data is meaningless for critical applications such as a rescue operation, disaster management or life critical operations. Once data is sense by sensor node before it sends on network or to any other node it must know the location of its own. So each node detected the event must send the data along with its location to along with sensed information here sink node can use other techniques to find out location of all nodes by sending query over the entire network.

II. LITERATURE SURVEY

In today's world Wireless sensor network (WSN) became an essential and utmost useable technique. It offers many new applications across all areas like environment, military, agriculture, medicine, mobile communication and so forth [1]. WSN are small devices that contains nodes, each of which contains microprocessor (operating systems with energy efficiency), one or multiple sensors (e.g. acoustic, light) or (chemical sensors), a low bit rate and low powered digital radio Trans receiver equipped with a small battery too. Every sensor in WSN observes its surrounding and aim of such kind of network is to generate some global data or an inference about the surrounding to a user who could be pin pointed at the twilight of network or they can be remotely attached to network of sensor . For instance, the installation of sensor in border areas of a country to observer unauthorized intrusions, control and monitoring systems like those for surrounding of a large chemical factory or an office building.

To prolong the network lifespan and to enhance the operation of nodes in network we schedule the network nodes and awake the sleeping node when the awake node or the object node desires to sense and communicate the information in a network. Nodes or sensors of Wireless sensor network, constitute of two major operation modes one is sleep mode and the other active mode. Sleep node that falls in the category of idle state does not execute any job consuming very little energy whereas a sensor in active state performs its functions like monitoring thereby consuming energy. But an issue arises when node is in idle state even though it still consumes energy, thereby decreasing the lifespan of network.

Neal P. et. al [2] explained the significant concept in Localization Methods is that some distinctive class of sensor nodes that have prior knowledge about their location coordinates are

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deployed to find the nodes whose locations are unknown. Such nodes are known as anchor nodes. Such nodes can be fitted out with Global Positioning System (GPS) that send beacons messages with their coordinates in order to provide support to other nodes so that they can perform Localization. The GPS is classical approach for localization of nodes but to equip all nodes GPS enable is highly impractical rather to know the locations using localization algorithms. To localize any unknown node, it is necessary to know the location of nearest anchor nodes and which measurement techniques to be used.

Taylor et. al [3] presented even though the location awareness is important and demanding deal but estimates the accurate location is still having challenges. There are different techniques to estimate the correct location nodes. One of the natural and fundamental challenges in WSN is accurate node localization. Even though the Global Positioning Systems (GPS) are providing a correct location information but to equipped all nodes with GPS is rarely practicable and without GPS using localization algorithms are more practical for WSN.

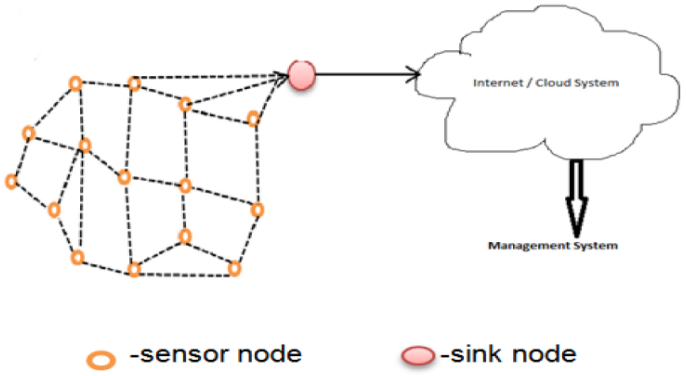

Fig 1: WSN Scenario Diagram

WSN ‘s is composed group of sensor devices with a sink for analyzing the various environmental data. The nodes in the group are generally tiny resource constrained devices i.e. limited memory and power. The primary responsibility of these tiny nodes is continuously monitoring the area of interest according to the protocol design and forwards the gathered data to the sink. The batteries of the sensor nodes are limited one and it is difficult to replace or recharge. During the while a sensor node runs out of its power, the network may get partitioned and the coverage of application area is lost. The nodes in the application environment are capable of self-configuring together and processing the information data [2]. In general, the nodes in the network are act as source, sink and router for communicating the information. The information transfers in WSNs are accomplished by means of single hop or multi-hop communication. If the distance between the source and destination is minimum then single hop communication is preferred and vice versa. The different applications of WSNs are includes border surveillance to smart home monitoring. The major source of energy waste includes idle listening, overhearing and collision. To address the energy consumption due to idle listening, adaptive/non adaptive duty cycling schemes are introduced. Various transmission power adjustment and collision free protocols are addressed the above said issues. The information collected by the nodes in the area of interest is converted to an aggregated [3] form according to the application request, for example averaging the temperature and humidity. The process of data aggregation involves the combination of observed data from different nodes at intermediate level and conveys the

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aggregated information to the sink. Since the nodes in the observation field generates certain amount of redundant data in order for ensure the accuracy.

To reduce the redundant data transmissions the generated data from different sources can be aggregated and it is done by suitable data aggregation algorithms. The cluster head/central coordinator or any intermediate node is allocated to collect the information from other nodes and do the aggregation operation [4][5]. The major source of energy waste includes idle listening, overhearing and collision. To address the energy consumption due to idle listening, adaptive/non adaptive duty cycling schemes are introduced. Various transmission power adjustment and collision free protocols are addressed the above said issues [6]. The information collected by the nodes in the area of interest is converted to an aggregated form according to the application request, for example averaging the temperature and humidity. The process of data aggregation involves the combination of observed data from different nodes at intermediate level and conveys the aggregated information to the sink. Since the nodes in the observation field generates certain amount of redundant data in order for ensure the accuracy. To reduce the redundant data transmissions the generated data from different sources can be aggregated and it is done by suitable data aggregation algorithms. The cluster head/central coordinator or any intermediate node is allocated to collect the information from other nodes and do the aggregation operation.

In WSNs the in-network processing i.e., data aggregation plays a vital role for reducing the unnecessary transmissions. It leads redundancy minimization; reduced collision and enhancing the life time of WSNs. Authors [7] of this paper details the report of Elliptic Curve ElGamal homomorphic encryption algorithm and clearly noted that performance when the mapping function during the process of decryption. In this paper authors suggested the Okamoto-Uchiyama homomorphic encryption algorithm to care for end-to-end information privacy. Further the efficiency and practicability of this approach validated using Tmote Sky and iMote 2 network platforms. They prove that the proposed one utilizes lesser energy with better performance compared to the previous schemes. Authors of the paper [8] put forwarded data gathering approach in WSNs using prediction models. It devoid the superfluous information transmissions and minimizes the data transmission cost. Due to that, the energy required by the nodes is greatly reduced. In order for enhancing the energy efficiency the cluster head nodes in the given area rotated timely. Authors [9] of the paper much concentrated on data aggregation in wireless senor networks. This paper analyses the false data insertion by the nodes along with dissimilar kinds of attacks. In this approach authors suggested the end-to-end privacy, which detects the attacks earlier by verifying in each and every hop. It reduces the loading effect of sink node. The same implemented on MicaZ and TelosB mote and the outcomes are validated experimentally and simulation. Authors [10] of the paper mainly concerned about the energy consumption in the wireless sensor networks. They developed a cluster-based routing protocol intra-balanced LEACH (IBLEACH), which is a extended version of LEACH protocol. In this work they effectively balance the energy utilization of the nodes in the cluster by implementing IBLEACH. The outcomes of this approach evaluated by means of lifetime and energy consumption and the same compared with the existing schemes.

The authors of [11] presented a novel distributed Power Scheduling (PS) algorithm for continuous monitoring of WSNs. The technique takes benefit of the time scale discrepancy among sensor network re-configuration stages and data transmitting stages. In [12] the authors

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proposed an EECBSS scheme, which is a cluster based scheduling technique that balances the energy efficiency and network lifetime. It has three phases: In first phase cluster topology is discovered and CH is selected based on residual energy level. In the second phase, scheduling algorithm is presented which allocated a TDMA schedule to avoid collision. In the third phase, energy consumption model was introduced to maintain maximum residual energy level through the network. The authors of [13] have proposed an Energy efficient sleep scheduling for cluster-based aggregation, which support high rate of data transmission and reduces energy consumption.
The authors of [14] have proposed and implemented a High Energy First (HEF) algorithm which addresses the issue of predictability. It improves to be an optimal CH selection algorithm that prolong network lifetime. The authors of [15] have introduced a Power Aware (PA) technique to improve network lifetime. The idea was that every sensor area should be supervised should be monitored relatively by one SN and other SN such that the network is monitored at all-time within their functioning range. The authors of [16] have presented a LSW which is a local wake-up scheduling method and is built on ant colony based scheduling scheme to enhance sensor network lifetime. The algorithm works in two phases: In first phase, it finds a set of SNs which provides full coverage and in the second phase finds the replacements of SNs which are draining out of energy.

The authors of [17] have presented a resilient steady clustering technique (RSCT) which will maintain durability and steadiness to the sensor network by reducing the unnecessary and avoidable cluster head (CH) changes and minimizing clustering and networking overheads. The authors have introduced a new SN that acts as a standby node (SBN) in the cluster. This SBN performs the tasks of CH, whenever the actual CH moves (or dies) from the cluster. Later the CH re-elect the new SBN. This process keeps the network available and serviceable without any interruption. To address the various scheduling issues, the authors of [18] have proposed energy efficient MATSS algorithm which is multi-attribute time-slot scheduling (MATSS). The MATSS algorithm focus to prolong SN lifetime with prior available time-slot and multi-part dynamic routing (MPDR) neighbor conditions. Based on these parameters the SN scheduled as sleep and wakeup mode for each available time-slot. The SN selection performed depending on the state of neighbor SNs and energy parameter by distribution the data between them.

III. CLASSIFICATION OF RESOURCE ALLOCATION & LOCALIZATION TECHNIQUES.

In order to find a suitable localization of sensor nodes, various localization strategies have been used [4], we can at any time use wireless devices such as motive, PDA, phone, laptop etc. [4]. This is available in a variety like AOA, TOA, TDOA, RSSI and others. When the sensor nodes are evaluated in terms of their distribution of measurements and how the algorithm is to be chosen different viewpoints emerge. Localization strategies may typically be graded as central and distributed [5]. Finally, the distributed technologies can be divided into Range Free and Range-oriented Technology.

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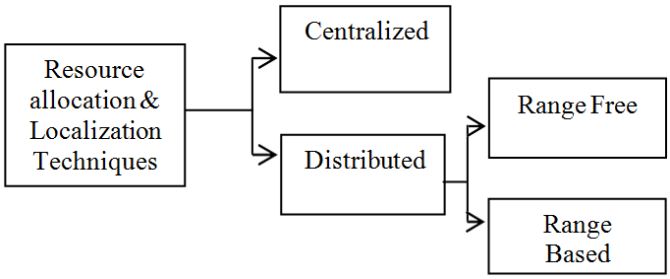

Fig 2. Classification of Resource allocation and Localization Techniques

A) Centralized Localization Techniques

In centralized localization centralized algorithm runs on central machine. All sensor node senses the information and otherwise send it to the central machine where processing can be done using localization algorithm. The processing node or machine has information of every requesting nodes location and here network topology of the network is easily known to the central node. Traffic explosion, congestion and computational complexities when larger no of sensor nodes are involved this are few drawbacks in centralized localization System. In centralized approach node only needs to sense the information and send it to central processor no need to store it on node. Let m1 be the message in bits needed to be encode in $y_1^{(k)}$ for some l then total amount of information is need to transported is $O(m_1nk)$ bits. When this all bits gone through the multiple hops to reach gateway, let's say worst case K hops. The worst-case cost can say as $O(m_1nk^2)$ bits [12].

B) Distributed Localization Techniques

On other hand in distributed system the algorithms run on the nodes where computational processing takes place. In this system sensor nodes get help of anchors and localize themselves. Once they localize themselves then they can start making help to localize other nodes too for fixing their positions this node such nodes call as pseudo nodes. Estimation quality of pseudo anchors are based on how many anchors they taken during localization. Link failure and node failure always happen in distributed localization but due to its fault tolerant nature distribute that failure cost in all sensor nodes equally. Distributed Localization is used for large networks whereas centralized localization is used for small networks. When we want to minimize the communication cost between nodes, we choose this approach as minimum communication cost between cluster head and gateway. Our main motive to minimize the communication cost which is always higher than the processing cost in WSN. In WSN Distributed Localization can be broadly classified as Range-based and Range-free localization.

i) Range Free Localization:

a) DV-Hop Localization Algorithm

Dragos Niculescu et al. of Rutgers, USA, originally proposed a position algorithm for DV-Hop [4] based on a protocol to route the remote vector [5]. Several scholars and research institutions have done comprehensive work on the algorithm for locating DV-Hop. The unknown node coordinates are corrected using the least square method. DV-, as it was suggested by

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Niculescu D, is the same range free localization algorithm and others [6]. A DV- algorithm's main concept is the node transition data with its surrounding nodes. A beacon message containing the anchors with Hop count values is transmitted on each anchor node. In the hop count region where it accepts and discards the highest numbers in hop count field, each receiving node holds the minimum value. The conventional vector distance routing approach also works in the same way. All nodes are told by other WSN nodes; hold the minimum distance value and delete maximum values.

b) Approximate Point in Triangle (APIT)

The theory of the APIT triangle method in this freely placed algorithm [5] assumes that n anchor nodes will connect to the unknown node, that the algo must cross the various triangles and determine the centroid of the triangle coincide zone as a predicted position of the unknown node.

c) MultiHop

In the multi-hop network technology, link graph can be measured [5]. Multi-dimensional scaling (MDS) by using networking data as the link is across all nodes.

In practice the multi-hop location methods are therefore subject to a variety of problems, including a high degree of computational complexity, low tolerance to not regular topological structure, low positioning precision, and so on. These problems have to be solved in location so Guo is proposing a new approach to the enhanced position algorithm for multi-hops [12].

d) Centroid

Bulusu N initially suggested the centroid algorithm. and others [10]. In this algorithm, the position of all sensor nodes and the range of communication are given by all anchorsEvery unknown node on the network listens to a certain predetermined interval t and gathers messages from various nodes. The locations of all unknown nodes are in contact with the center detection from all identified anchor positions [14].

In this localizer technique, the location of the sensor node is calculated at anchor node positions. Here, the message of the anchor node diffused is a location data with this sensor information node, which calculates its place in a center of all anchors linked to the sensor node. When the expected sensor nodes location is given, N is the anchor node that is attached to the sensor node. It is a easy and cost effective approach, but it also has a great error gap in estimating sensor node position and is not suitable in real time applications or sensitive applications where the sensor nodes need to be accurately located.

e) Gradient

In this gradient localization algorithm, using multilateration the location of unknown nodes can be determined. It also maintains the hop count while sending information, initially it sets to zero and it increments as it moves to the other nodes. But this basic gradient algorithm gives less accuracy So D. Qiao [11] presented revised descent gradient which present 2 distance-based localization algorithms for WSN. Initially the locations of sensors are unknown and by using beaconing or some other way it fetches the relative locations of sensors. To locate the all nodes,

ISSN: 2233-7857IJFGCN

need to know information of the absolute locations of three or more sensors/anchors. The gradient descent algorithms achieved excellent localization accuracy and have better performance than existing gradient localization algorithms [12].

ii) Range Based Localization

Range-based localization schemes are distance estimating techniques based on the angle calculation. The obtained Signal Strength Indicator (RsSI)[3][4]. The obtained Signal Strength Indicator (RSSI), Angle of Arrival(AOA), Time of Arrival(TOA), and Time Difference of Arrival (TDOA). The measuring power of the transmitted signal is measured on RSSI interface between the transmitter and the recipient. A spread loss is often measured and converted to a distance calculation [13].

Table 1: Performance of range free localization Schemes

Parameters	**DV-Hop**	**APIT**	**Monto-carlo**	**Centroid**	**Gradient**
Packet Delivery Ratio	>9.9	>9.8	>9.75	>9.4	>9.41
Throughput	Good	Good	Good	Average	Average
End to end Delay	>.015	>.017	>.016	>.021	>.019
Energy Consumption	Less	Less	Average	Good	Fair
Cost	Medium	Low	High	Low	Low
Overhead	Average	Small	Large	Little	Large

a) Angle of Arrival (AoA)

The AoA approach is often known as the arrival path [13]. The AOA evaluations can be made either by the phase reaction of the receiver antenna or by the amplification reaction of the transmitter antenna. The signal enters the unlocalizing node from the anchor node, and then takes the position of the angle calculating node.

b) Time of Arrival (ToA)

The time at which the radio signal arrives (TOA or ToA), also called the time of flight (ToF), from the transmitter to the remote receiver. The time of arrival is based instead on the time differential between leaving one station and arriving at the other on the actual date of your arrival. In comparison with TDOA. The distance can be determined directly from the time of arrival as a signal with a given speed. Data from two base stations limit the position to the position circle of the location. Data from the third base station must be calculated to determine the precision of the position to a single point. Many radiolocation systems, including GPS, use

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ToA. Also, In Time of Arrival (ToA) methods are time of radio signal and speed of wavelength will go together between un-localize node and anchor node. The amount of change between the time of signal received at the receiver end and the starting time of the signal from sender end is called as one way round propagation time measurement or Time of Arrival (ToA)[12].

c) Time Difference of Arrival (TDoA)

Time Difference of Arrival (TDoA) is a normally come with instrument based device. Here, all nodes are fitted out with a microphone and speaker. Systems may use ultrasound and perceptible frequencies. In TDoA, the anchor nodes transmit first a radio message. It delays some predefined interval of time, tdelay and then it creates a kind of beeps on its speaker. A sensor node with unknown location received this signal at time tradio and when the location of unknown node receives the radio signal from anchor node it turns on microphone. When location unknown node listens, beeps send by anchor node it saves time as tsound. Once they have tradio, tsound, and tdelay, the anchor node computes the location.

d) Received Signal Strength Indicator (RSSI)

In RSSI, signal strength is used to determine the distance between sender and receiver at the receipting end [13]. Signal propagation loss is also computed and converted into distance estimation. The power of signal strength is decreased, as the distance between sender and receiver is increased.

e) PSO Algorithm

The solution consists of a swarm of particles, exploring a "n-dimensional" hyperspace to find the global solution (n represents the optimum number of parameters to be determined). A particle I occupies position X_{id} and velocity V_{id} in the dth dimension of the hyperspace,$1 \leq i \leq s$ and $1 \leq d \leq n$. The objective function $f(x_1, x_2,.., x_n)$ is used to test each particle. A particle near the global solution has a less (higher) cost (fitness) than a particle further away. PSO works to reduce the cost (fitness) function (maximize). The location of the particles I with their lowest cost (pbestide) is stored in the best world version of PSO. The speed V and position X are modified in each iteration k. The update process is repeated iteratively until an optimal gbest is achieved or a specified number of kmax iterations are reached.

Table 2. Measurement Techniques comparison for Range Based

Parameters	**AOA**	**TOA**	**TDOA**	**RSSI**	**PSO**
Accuracy	Low	Medium	High	Medium	High
Energy Efficiency	Medium	Less	High	High	Medium
Cost	High	High	Low	Low	Medium

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Computational Complexity	Low	Low	Low	Low	Average
Hardware Overhead	High	Low	High	Low	Medium

IV. CONCLUSION

In this paper an extensive review of different localization techniques in Wireless Sensor Network has been studied and compared. This new PSO based methods give best results along with some new challenges such as Low cost hardware, energy efficient algorithm, location accuracy, NLOS, Node Density, Performance parameters of the algorithm. This paper gives a comparative study of distributed localization methods based on aspects related to performance of an algorithm. But every method has its own significance. In range based method are due to hardware cost somewhat costly and sometime not fitted to network requirement. Whereas in range free methods less immune with node density. By using PSO optimization we are able to gain the maximum throughput as compare to other.

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